



SAM/IG/2

INTERNATIONAL CIVIL AVIATION ORGANIZATION

**Second Workshop/Meeting of the SAM Implementation Group
Regional Project RLA/06/901**

(SAM/IG/2)

FINAL REPORT

(Lima, Perú, 3-7 November 2008)



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HISTORY OF THE MEETING

ii-1 PLACE AND DURATION OF THE MEETING

The Second Workshop/Meeting of the SAM Implementation Group (SAM/IG/2) was held at the premises of the ICAO South American Regional Office in Lima, Peru, from 3 to 7 November 2008, under the auspices of Regional Project RLA/06/901.

ii-2 OPENING CEREMONY AND OTHER MATTERS

Mr. Jose Miguel Ceppi, Regional Director of the ICAO South American Office, greeted the participants and expressed his gratitude to DGCA Peru, for the continuous support provided to activities developed at regional scale by the South American Office, as well as to the civil aviation authorities and national and private organizations of the ICAO South American Region. He pointed out the importance of issues to be dealt with in the agenda of the Second Workshop/Meeting, which will allow the review of the matters dealt with during the First Workshop/Meeting SAM/IG/1.

Mr. Eliseo Salcedo Mitrani, Aeronautical Security Director, on behalf of General Director of Civil Aviation of Peru, welcomed the participants, highlighting the importance of the issues to be examined at regional level, opening the meeting.

The Workshop/Meeting counted with the attendance of Mrs. Nancy Graham, Director of Air Navigation Bureau (D/ANB) of International Civil Aviation Organization, who made a presentation about Global ATM and, particularly, how the ATM community will meet their expectations and of a wider planning perspective worldwide.

The presentation on global ATM focused on performance based planning, highlighting business plan, global plans (navigation and safety), ICAO process framework, the Organization proposals related to results measurement in valid programmes, as well as tools to carry out this task.

Finally, Mrs. Graham explained the worldwide initiatives, as NEXTGEN and SESAR, that are being developed in other regions. The Meeting expressed satisfaction and high honour to count with D/ANB's attendance, prioritizing the activities developed during the event and allowing exchange of opinions about the subjects presented.

ii-3 SCHEDULE, ORGANIZATION, WORKING METHODS, OFFICERS AND SECRETARIAT

The Meeting agreed to hold its sessions from 09:00 to 15:00 hours, with appropriate breaks. The work was done with the Meeting as a Single Committee, Working Groups and Ad-hoc Groups.

Mr. Rafael Sánchez Greiner, delegate from Venezuela, served as Chairman of the Meeting and Mr. Paulo Vila Millones, delegate from DGAC Peru, as Vice President.

Mr. Jorge Fernández, RO/ATM/SAR of ICAO Regional Office, Lima, acted as Secretary, assisted by Messrs. Onofrio Smarrelli, RO/CNS, Alberto Orero, RO/ATM/SAR/AIM, from the Lima Office, and the Project RLA/99/901 experts. Likewise, the Secretariat had the support of the Implementation Groups Rapporteurs and Coordinator, to analyze de different agenda items.

ii-4 **WORKING LANGUAGES**

The working language of the Meeting was Spanish, and its relevant documentation was presented in Spanish and English.

ii-5 **AGENDA**

The following agenda was adopted:

- Agenda Item 1: Optimization of the ATS routes structure
- Agenda Item 2: Implementation of performance-based navigation (PBN) in the SAM Region
- Agenda Item 3: Standards and procedures for performance-based navigation operations approval
- Agenda Item 4: Implementation of air traffic flow management (ATFM) in the SAM Region
- Agenda Item 5: Assessment of operational requirements in order to determine the implementation of communications and surveillance (CNS) capabilities improvement for en-route and terminal area operations
- Agenda Item 6: Operational implementation of new ATM automated systems and integration of the existing systems
- Agenda Item 7: Impact on ACCs due to multiple reception of the same flight plan
- Agenda Item 8: Other business

ii-6 **ATTENDANCE**

The meeting was attended by 34 participants from 9 States of the SAM Region, 2 States of NACC Region, 3 International Organizations, ALTA, ARINC and IATA, and 2 airlines, LAN Argentina and LAN Peru. The list of participants is shown in pages iii-1 to iii-8.

ii-7 **LIST OF CONCLUSIONS**

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Agenda Item 1: Optimization of the ATS route structure**RNAV Route Implementation**

1.1 The SAM/IG/01 Meeting recognized the need for States to make sure that their respective national RNAV route implementation programs is compatible with the SAM RNAV implementation program. It also agreed to continue reviewing, implementing, modifying, or eliminating routes in the SAM Region to optimize the ATS route structure. In this regard, a series of RNAV routes were assessed for implementation. The results of the revision are shown in **Appendix A** to this part of the Report.

Status of compliance with the conclusions formulated by the SAM/IG/1 Meeting

1.2 The Meeting made a revision of the outstanding conclusions of the First Workshop/Meeting of the SAM Implementation Group (SAM/IG/1). It was noted that, according to instructions provided in Conclusion SAM/IG/1-6: *Hiring of experts for the activities aimed at improving communications and surveillance systems*, two experts had been hired to carry out the activities mentioned in items 1.3.1, 1.3.2, 1.3.3 and 1.3.6 of Regional Project RLA/06/901, concerning the improvement of ground-air and ground-ground communications.

1.3 Also, and in keeping with that agreed upon at the SAM/IG/1 Meeting (ref. par. 1.23 and par. 2.11 of the Final Report), experts were also hired to perform tasks 1.1.1, 1.1.2, 1.1.3 (PBN) and 1.2.1, 1.2.2 (ATFM) of Regional Project RLA/06/901.

1.4 **Appendix B** presents the status of compliance with the Conclusions.

Optimization of the SAM ATS Route Network

1.5 The Meeting reviewed the process carried out so far in the SAM Region regarding the optimization of the ATS route network. As a result of this process, 77 RNAV routes have been implemented, the paths of 58 routes have been modified and 7 routes have been eliminated (lower and upper airspace), giving an airspace structure that is more suitable than the one that existed before the program started.

1.6 The SAM States, with the support of the ICAO regular program and Project RLA/06/901, have focused on improving the airspace structure even more in order to achieve an inter functional air traffic management system for all users during all flight phases, and that meets with agreed safety level, provides economically optimum operations, is environmentally sustainable, and meets national security requirements.

1.7 Following a productive discussion on this subject, the Meeting considered that it would be appropriate to conduct a feasibility study in order to obtain an ATS route network that meets the new aviation requirements and that incorporates the new performance-based navigation operational concept.

1.8 Taking into account the diversity of scenarios in the Region, the Meeting considered that this would be a very complex task that should be supported by Regional Project RLA/06/901. This would permit, if necessary, the hiring of experts to make a diagnosis of the existing ATS route network, develop, if applicable, a strategy for the phased completion of this task, prepare a list of deliverables, propose a work program, identify the required data and the data collection method, define the supporting tools necessary for the performing the task, specify the reference documents required and other aspects deemed relevant for the fulfilment of the task, such as the interests of each State, the geographical characteristics, etc. In addition to the aforementioned aspects, safety-related aspects and other expectations described in Global ATM Operational Concept should be taken into account.

1.9 However, so as not to affect the PBN implementation already defined in the Roadmap and in the corresponding action plan, this feasibility study for the optimization of the ATS route network should be conducted in parallel to the current working program.

1.10 This activity will improve the efficiency of en-route and terminal area operations, optimizing the use of aircraft capacity to conduct flights as close as possible to the preferred paths. It will also increase airspace capacity, facilitate the use of advanced technologies (*e.g.*, FMS-based arrivals) and ATC decision-making support tools (*e.g.*, separation and sequencing), thus increasing efficiency. The reduction in fuel consumption will also have a positive impact on the environment.

1.11 In view of the foregoing, the Meeting requested the Secretariat to make the corresponding arrangements in order to include the feasibility study for the optimization of the SAM ATS route network as an Objective to be accomplished by Project RLA/06/901.

APPENDIX A

RESULT OF THE REVISION OF RNAV ROUTES

Puente Aéreo Montevideo-Buenos Aires

With regard to this route, Uruguay informed that it continues working with its implementation, with the aim of eliminating any communications, sectorization or radar reflections impediment for its implementation. Therefore, the proposed implementation of this route is left in stand-by.

The administration of Argentina informed they are prepared to collaborate and implement the route in question as soon as it is required.

Route RNAV VOR CRR/VOR FNO

The Uruguayan administration has observed that the route proposed maintains the same coordinates in the FIR Montevideo segment as in the current route, and that the major change would be as of the PTS (Pelotas) VOR and, consequently, the provision of the VOR PTS / VOR FNO segment coordinates is pending from the Brazilian administration.

RNAV UL 797

Bolivia and Chile implemented with the following path:

ESPACIO AÉREO SUPERIOR / UPPER AIRSPACE UL-797		
Designador Designator	Latitud Latitude	1 Longitud Longitude
Iquique	20° 34' 16'' S	070° 11' 00'' W
ILPEM	20° 57' 42'' S	068° 23' 06'' W
SUCRE	19° 00' 41'' S	065° 17' 31'' W
VIRU VIRU	17° 37' 42 s	063° 09' 00 W

UM530 in the segment VOR BRS up to VOR RBC

Bolivia and Brazil have agreed the date 12 March 2009 for its entry in force, including the updating of the letter of operational agreement between La Paz and Amazônico ACCs for the referred route. The agreed path is the following:

ESPACIO AÉREO SUPERIOR / UPPER AIRSPACE UM 530		
Designador Designator	Latitud Latitude	Longitud Longitude
Brasilia VOR	S15°52'26''	W048° 01'17''
PAPES	S14°29'29''	W049°56'56''
DADRI	S14°02'24''	W050°34'07''
DIMUB	S13°33'34''	W052°11'56''
BUBOM	S12°54'37''	W055°58'55''
PARDO	S12° 16'18''	W059°05'04''
BUVKI	S10°34'35''	W065°24'46''
DADED	S10°08'58''	W066°55'35''
Branco VOR	S09°52'19''	W067°53'44''

Guayaquil – Madrid

Ecuador, Colombia, Venezuela, Trinidad & Tobago have agreed to publish the implementation of this route on 18 December 2008, with validity date 12 February 2009. The path agreed is the following:

ESPACIO AÉREO SUPERIOR / UPPER AIRSPACE Guayaquil – Madrid UM 662		
Designador Designator	Latitud Latitude	Longitud Longitude
Guayaquil VOR	S02° 07' 42''	W079° 52'01''
ASAPO	N01° 08' 57''	W079° 13' 54''
UMGEB	N00° 21'47.18''	W077° 24'21.48''
KADED	N06° 37'01.3''	W069° 48'12.9''
CABO CODERA VOR	N10°34'24.8''	W066°03'00.2''
ONGAL	N12° 51'15''	W063° 38'46''
Fort De France VOR	N14° 35'24''	W061° 01'24''

Lima – Madrid

Peru, Brazil, Guyana, Suriname, Trinidad & Tobago have agreed to publish the implementation of this route on 18 December 2008, with validity date 12 February 2009. The path agreed is the following:

ESPACIO AÉREO SUPERIOR / UPPER AIRSPACE Lima – Madrid UM 527		
Designador Designator	Latitud Latitude	Longitud Longitude
Lima VOR	S12°00'30''	W077°07'22''
SIGOB	S08°28'16''	W073°20'18''
AKTOR	S04°00'34''	W068°44'13''
MULIP	S02°29'53''	W067°12'10''
AKNOV	S00°50'33''	W065°20'47''
DOBDA	N04°43'56''	W059°55'40''
TIM VOR	N06°29'53''	W058°15'46''
UMREM	N07°56'06.73''	W057°00'03.66''
TRAPP	N09°05'06''	W055°59'30''

Santiago – Miami

IATA, Chile and Peru have agreed to continue with the evaluation of this path. Chile and Peru will evaluate the path segment affecting their respective FIRs, while IATA will continue coordinating with these two administrations, with the administration of Colombia, and with those involved in the CAR Region.

Suspension withdrawal of UL 793 and UM 656

Brazil and Venezuela have held a bilateral meeting in order to discuss, among others, issues related with the suspension or utilisation of routes UL 793 and UM 656. To this end, both administrations have informed the following:

- It was agreed to include in addition to the proposed levels, two levels above RVSM, these levels are: FL430 for UM656 (One way) and FL450 for UL793 from SVZM to SBAZ.
- For air traffic from SBAZ to SVZM, aircraft should be levelled as follows: UL793 in position AKNOV, UM656 in position ESPIM. No change of levels will be cleared in these route segments by any of the FIRs.
- For air traffic from SVZM to SBAZ, aircraft should be levelled as follows: UL793 in position SIMUR.
- Aircraft separation for aircraft following routes UL793 and UM656, crossing common boundaries from SVZM and SBAZ, maintaining the same route and same flight level, should be separated at least 15 minutes before reaching segments subject to a contingency situation.
- A NOTAM will be prepared indicating opening of routes and in the same, the levels available for each route should be specified, flight direction and conditions of being levelled, as explained above.
- The conditions for opening routes will be disseminated on 20 November 2008, through the issuance of a NOTAM for operators, with effective date 18/12/2008 at 00:01 UTC.
- The duration of the NOTAM will be 3 months renewable until the conditions of communications failures are mitigated.

RUTA ROUTE	SENTIDO DE VUELO FLIGHT DIRECTION	FL	CONDICIONES DE TRANSFERENCIA TRANSFERENCE CONDITIONS
UL 793	FIR SBAZ ➡ FIR SVZM	FL280 – FL320 – FL360 – FL400 -- FL250 – FL270 – FL290 – FL310	NIVELADO EN EL FIJO / LEVELLED IN FIXED AKNOV
	FIR SVZM ➡ FIR SBAZ	FL330 – FL350 – FL390 – FL410 -- FL450	NIVELADO EN EL FIJO / LEVELLED IN FIXED SIMUR
UM 656	<u>SENTIDO UNICO:</u> FIR SBAZ ➡ FIR SVZM	FL260 – FL300 – FL340 – FL380 -- FL430	NIVELADO EN EL FIJO / LEVELLED IN FIXED ESPIM

Pending routes

The ad-hoc Group composed by IATA and States involved carried out a review to the routes pending coordination, and which appear in the following chart.

ROUTE	REMARKS
UL 306	Pending coordination among BRAZIL, FRENCH GUIANA, SURINAME.
UM782 UL201 UA317	Brazil will inform on the modifications resulting from the realignment of these routes.
UA307	Realignment for a direct route between Santiago (Chile) and Sao Paulo (Brazil) ARGENTINA, BRAZIL, IATA.
San Jose (C. Rica) – Santo Domingo	IATA will coordinate with NACC Regional Office and CAR SAM Regional Office will coordinate with IATA, Colombia and Panama.

Note: It has been foreseen to continue with pending coordinations with respective administrations and IATA and results of these arrangements will be presented in SAM/IG/3 Meeting.

It has been foreseen to continue with pending coordinations as shown above, and the results of this work will be presented at SAM/IG/3 meeting.

APPENDIX B

REVIEW OF THE LIST OF CONCLUSIONS OF THE SAM/IG/1 MEETING

Conclusion Strategic Objective	Conclusion Title	Text of the Conclusion	Follow-up	To be carried out by	Status	Deliverable Result	Deadline
Conclusion SAM/IG/1-1 C, D	CAR/SAM PBN Roadmap	That ICAO SAM States, in implementing RNAV/RNP, take the pertinent actions to follow guidelines contained in the CAR/SAM PBN Roadmap as shown in Appendix C to this part of the report.	Guidance so that SAM States develop their own national plans.	SAM States	Valid	National implementation plan harmonized with the CAR/SAM PBN Roadmap	Short Term: 2010 Mid Term 2011 - 2015
Conclusion SAM/IG/1-2 C, D	Revision of Table CNS 2 A of FASID	That the States members of Project RLA/06/901 review and update Table CNS 2A of FASID (<i>Aeronautical Mobile Service and AMSS</i>) presented as Appendix A to the report of this agenda item, and forward it to ICAO Regional Office before 30 May 2008.	Analysis of the activities contemplated for the improvement in air-ground and data communications	SAM States	Completed	FASID Table CNS 2 A Updated	30 June 2008
Conclusion SAM/IG/1-3 C, D	Update of Tables CNS 1Ba and 1Bb of FASID	That SAM States review and update tables CNS 1Ba (<i>ATN Router Plan</i>) and 1Bb (<i>ATN Ground Ground Application Plan</i>) of FASID being presented as Appendix E to the report of this agenda item and forward them to ICAO Regional Office before 30 June 2008.	Analysis of the activities contemplated for the improvement of ground-ground communications	SAM States	Completed	FASID Tables CNS 1 Ba y 1Bb Updated.	30 June 2008

* **Note:** ICAO has established the following Strategic Objectives for the period 2005-2010: **A: Safety** - Enhance global civil aviation safety; **B: Security** - Enhance global civil aviation security; **C: Environmental Protection** - Minimize the adverse effect of global civil aviation on the environment; **D: Efficiency** - Enhance the efficiency of aviation operations; **E: Continuity** - Maintain the continuity of aviation operations; **F: Rule of Law** - Strengthen law governing international civil aviation.

Conclusion Strategic Objective	Conclusion Title	Text of the Conclusion	Follow-up	To be carried out by	Status	Deliverable Result	Deadline
Conclusion SAM/IG/1-4 C, D	Update of Tables CNS 4A of FASID	That SAM States review and update Table CNS 4A (<i>Surveillance System</i>) of FASID being presented as Appendix G to the report of this agenda item and forward it to ICAO Regional Office before 30 May 2008.	Analysis of the activities contemplated for the improvement of surveillance requirements	SAM States	Completed	FASID Table CNS 4 ^a del Updated	30 May 2008
Conclusion SAM/IG/1-5 C, D	Adoption of Action Plan Models for the improvement of communications and surveillance systems for en-route and terminal area operations	When carrying out activities for the improvement of communications and surveillance systems for en-route and terminal area operations, the action plan models are to be taken into account for the improvement of ground-air, ground-ground communications and surveillance systems being presented as Appendices D, F and I to the report of this agenda item.	Implementation of improvements of the communications and surveillance capacities	SAM States	Completed Note: The action plans reformulated by the Meeting are presented in Appendices C and D of the Report on Agenda Item 5.	Establishment of action plan for the improvement of air-ground, ground-ground and surveillance systems	SAM/IG/02

Conclusion Strategic Objective	Conclusion Title	Text of the Conclusion	Follow-up	To be carried out by	Status	Deliverable Result	Deadline
Conclusion SAM/IG/1-6 C, D	Hiring of experts for the activities aimed at improving communications and surveillance systems.	That Project RLA/06/901, in order to contribute to the activities related to communications and surveillance improvement for en-route and terminal area operations: a) Hire an expert to carry out activities indicated in items 1.3.1, 1.3.2, 1.3.3 and 1.3.6 regarding the improvement of ground-air and ground-ground communications systems for a three-week period from 18 August to 8 September 2008. b) Hire an expert to carry out activities indicated in items 1.3.1, 1.3.2, 1.3.3 and 1.3.6 regarding the improvement of surveillance systems for a three-week period from 18 August to 8 September 2008.	Project RLA/06/901	Regional Office	Completed	Availability of a strategy for the implementation of CNS improvements in the SAM Region, based on the information collected by experts hired.	SAM/IG/02

Conclusion Strategic Objective	Conclusion Title	Text of the Conclusion	Follow-up	To be carried out by	Status	Deliverable Result	Deadline
Conclusion SAM/IG/1-7 C, D	Adoption of the Action Plan for the regional interconnection of automated systems	That, when carrying out the activities for the regional interconnection of systems, consideration be given to the action plan for the regional interconnection of automated systems contained in <u>Appendix C</u> to this agenda item.	Compliance of the action plan for regional inter-connection of automated systems	SAM States	Valid Note: The Action Plan was amended by the Meeting and is presented in Appendix B to the Report on Agenda Item 6.	Availability of regional inter-connection of automated systems	Short Term: 2010 Mid Term 2011 – 2015

- END -

Agenda Item 2: Implementation of performance-based navigation (PBN) in the SAM Region

2.1 During the SAM/IG/1 meeting, note was taken that PBN implementation would require the preparation of detailed guidance material for the States and International Organizations with regard mainly to three aspects:

- a) Analysis of the experiences of other regions;
- b) Data collection air traffic movement analysis in order to identify the main flows;
- c) Data collection and air navigation infrastructure analysis (communications, navigation, surveillance, meteorology, AIS).

2.2 These tasks could be carried out, as agreed at the First Meeting of the Coordination Committee of Project RLA/06/901 (Lima Peru, 5 December 2007), by hiring experts on the subject. In this connection, during the SAM/IG/1 meeting, the work programme was drawn up in order that a consultant could fulfil the initial tasks.

2.3 On the basis of the indicated work programme, the consultant studied and processed the aforementioned information and prepared a document clearly describing the current situation in SAM States. The work programme used for the tasks developed by the consultant appear in **Appendix A** to this part of the Report and is in line with tasks 1.1 of Project RLA/06/901.

En-route PBN - RNAV-5 Implementation Programme

2.4 The Meeting recognized that PBN implementation for en-route operations will require extensive participation by SAM States and will depend upon the completion of specific tasks, many of which will be in charge of Regional Project RLA/06/901. In light of the need for the harmonization and correct interpretation of each of the tasks connected with PBN implementation, an explanation text of en-route PBN Implementation was developed to permit a better understanding of the activities and the expected results. Its objective was to clearly define the deliverables in order to break down the large volume of work into specific activities. These activities will be used as a basis for possible adjustments in project timetables.

2.5 Note was taken that the PBN Implementation Programme established a new Action Plan that was amended to bring it into line with the results of the PBN Seminar (Lima, 17-20 June 2008) and the PBN Manual (Doc. 9613). The changes made in the Action Plan did not modify its essence and it proved possible to maintain the task dates set at the SAM/IG/1 Meeting. The proposed new action plan is set out in **Appendix B, Attachment 1** to this part of the Report.

2.6 In view of the above, the Meeting formulated the following conclusion:

Conclusion SAM/IG/2-1

PBN implementation Programme for en-route operations

That the ICAO SAM States take appropriate actions to follow the guidelines and comply with the targets established in the PBN implementation for en-route operations, which is shown in Appendix B to this part of the Report.

Development Status of the Tasks of the En-Route PBN – RNAV 5 Action Plan that should be completed at the SAM/IG/2 Meeting

2.7 **Establish and prioritize strategic objectives (safety, capacity, the environment, etc.)**

2.7.1 The Meeting observed that the Airspace Concept provides the basis for operations within an airspace and is developed to meet strategic objectives like improving safety, adjusting the services provided to air traffic growth, mitigating environmental impact, etc. The airspace concept must include details about the practical organization of the airspace, based on user characteristics and the CNS/ATM infrastructure that is available or to be implemented. Further details about the Airspace Concept can be found in the PBN Manual, Volume I, Chapter 2.

2.7.2 Two strategies can be considered for developing the Airspace Concept in the case of the En-Route PBN Implementation Programme:

- a) *Gradual implementation of new routes and realignment and elimination of existing ones* – This implementation strategy would lead to the development of several “small” airspace concepts, one for each route to be implemented, realigned or eliminated, or a coherent route implementation/realignment/elimination “package.”
- b) *Complete restructuring of the route network in a given airspace volume like, for instance, between FL 290 and FL 410* – This strategy would require the development of a complete airspace concept, including the entry and exit points of the main SAM TMAs.

2.7.3 The strategic objectives that must be met through PBN implementation for en-route operations are included in paragraph 1.1 of **Appendix B** to this part of the Report. The Meeting made the necessary changes, approved the strategic objectives to be considered in PBN implementation for en-route operations, and considered the task as finalized.

2.8 **Collection of traffic data in order to understand traffic flows in a given airspace**

2.8.1 The Meeting was of the opinion that traffic data are essential for developing a consistent Airspace Concept. Accordingly, Project RLA/06/901 used CARSAMMA data collected over the period 13 to 28 January 2008. This traffic sample is limited to RVSM flight levels (FL 290 to FL 410) since it was established to assess RVSM safety. This limitation has caused some problems for the analysis of, for example, en-route flights in the Sao Paulo TMA, which contains one of the most important flows in Latin America, that between Rio de Janeiro and Sao Paulo. In this case, most flights are conducted on FL 280 and, because of that, were not computed in the sample analyzed. Another problem occurred in the Ezeiza FIR, with flights to/from Brazil--particularly Sao Paulo and Rio de Janeiro--that were not included in the sample, probably because flights cross the boundaries of the Ezeiza FIR before reaching FL 290.

2.8.2 **Appendix B, Attachment 2** to this part of the Report contains graphs representing air traffic movement on the main ATS routes, by FIR. **Appendix B, Attachment 3** to this part of the Report reveals the volume of traffic between the principal city pairs in the FIRs of the SAM Region. The complete analysis of ATS routes and city pairs can be found at the SAM Office website. The Excel spreadsheets used can be employed to deepen the analysis of air traffic movement on ATS routes, in order to identify routes that need to be realigned or eliminated. These spreadsheets can also be used to identify regional flows and for the identification by the States of the flow at the main TMAs, always bearing in mind that the sample is limited to the airspace volume between FL 290 and FL 410.

2.8.3 Limitations posed by the samples considered in the analysis of air traffic flows made a full assessment impossible, considering that segmentation by FIRs is not appropriate for obtaining an overview of the SAM Region. Furthermore, consideration of only the flows between FL 290 and FL 410 means that a significant portion of air traffic is not assessed and hampers the analysis of TMAs in particular. The Meeting should therefore study the need for a new data collection effort and the systematic development of an air traffic movement database.

2.9 **Post PBN documentation at ICAO SAM Office website**

2.9.1 The Meeting took note that the website is an important mechanism for disseminating PBN documentation. The ICAO SAM Regional Office established the SAM PBN website format, which can be used by accessing the following address: www.lima.icao.int, e-document, ATM, PBN. In this manner, the Meeting considered this task as finalized.

2.10 **Assess PBN implementation in automated ATC systems in light of amendment 1 to the PANS/ATM (FPLSG)**

2.10.1 The Meeting took note that the changes in automated ATC systems for PBN application must be based on amendment 1 to the PANS/ATM, resulting from the work of the ICAO Air Navigation Commission Flight Plan Study Group and which was approved by that Commission at its 177th session and will enter into effect on 15 November 2012. Letter to the States AN 13/2.1-08/50 of 25 June 2008 informed them about the approval of amendment 1 to the PANS/ATM. The amendment can be found at the SAM Office website.

2.10.2 It was also observed that the amendment in question is complex and involves other aspects, in addition to PBN. In this connection, it will be necessary to decide upon a strategy for modifying ATC Automated Systems and whether the modification will be comprehensive, including all aspects of the amendment, or partial, only to meet PBN requirements. The GREPECAS ATM/CNS Subgroup will create a specific task force to deal with this matter.

2.10.3 The requirements for changes in ATC automated systems will depend upon the complexity of the airspace being considered and can involve from the simple insertion of a specific code in the controller flight progress strip to a more complete change that includes the use of specific symbols or colours in ATS surveillance targets, as a well as a system for assigning aircraft the procedures (route, SID, STAR, approach) that correspond to the fleet navigation capacity. Paragraph 5.1 of **Appendix B** to this part of the Report contains further considerations about the subject.

2.10.4 Taking into account the complexity of this task and the need for a further analysis, the Meeting was of the opinion that the target date for its finalization should be postponed until SAM/IG/3 meeting.

2.11 **Analyze aircraft and operator (pilots, dispatchers and maintenance personnel) approval requirements as established in the PBN Manual and prepare the necessary documentation**

2.11.1 Project RLA/99/901 (Regional Safety Oversight Cooperation System) was responsible for this task, which is considered under Agenda Item 3 - *Standards and procedures for performance-based navigation operations approval*.

2.12 **Assess the regulations for GNSS use and, if appropriate, proceed to their publication**

2.12.1 The Meeting noted that the use of GNSS is of key importance for all PBN navigation specifications, considering that some aircraft possess only this equipment to meet the established performance requirement and that there are some specifications that only GNSS can meet.

2.12.2 The key issue is the State policy with regard to the application of GNSS as a means of navigation. In order for the system to be used to its fullest, States must regulate its application as a primary means of navigation, even if this should require imposing some operational restrictions, such as, for example, requiring the alternate aerodrome to provide for “conventional” (VOR, NDB, ILS) approaches. Another aspect that must be considered is the need to establish a navigation reversal mode in case the GNSS signal is lost, requiring aircraft to be equipped with “conventional” air navigation systems.

2.12.3 Note was also taken that some States in the Region have already published their regulations for GNSS use and these could be taken as an example by other States to prepare their own regulations. Model documents are available at the SAM Office website. The status of regulations on the use of GNSS is shown in **Appendix B, Attachment 4** to this part of the Report.

2.13 **AIC model to report PBN implementation plans**

2.13.1 The Meeting was of the opinion that it was essential to report RNAV-5 implementation for en-route operations, in order that users can start with the aircraft and operator approval process.

2.13.2 Upon reviewing some paragraphs of the AIC, one State expressed its concern over the possibility that some operators that had some RNAV capability might not meet the conditions to obtain RNAV-5 approval. In this regard, the State indicated that it will seek an alternate solution to this problem.

2.13.3 States agreed to publish their initial AIC before **9 April 2009**. In this regard, the Meeting agreed to formulate the following conclusion:

Conclusion SAM/IG/2-2 Initial AIC

That States of ICAO SAM Region using as model the AIC presented in Appendix C to this part of the Report:

- a) publish in the AIRAC date of 9 April 2009 an Aeronautical Information Circular (AIC) informing the aeronautical community on their intention to implement RNAV 5 on **18 November 2010**;
- b) reflect in this AIC the specific situations within the airspace under their jurisdiction.

Status of compliance of the main tasks started at the SAM/IG/1 Meeting.

2.14 **Analyze aircraft fleet navigation capacity**

2.14.1 The Meeting took note that the Safety Oversight Cooperation System (RLA/99/901) is supporting the operational approval required for the PBN implementation. The operational approval process includes the evaluation of the aircraft and airline capacities for especial operations approval, such as RNAV 1, RPN 10 AR APCH, etc.

2.14.2 When analyzing the impact of the PBN implementation in the Regions and how to support it, a doubt arose on the PBN capacity of the total fleet of the Region, revealing a lack of data and also pointing the necessity to organize a data base for understand the status of all aircraft that operate in the Region, and with that, to joint in an assertive way, the PBN implementation.

2.14.3 In this regard, the Meeting approved the proposal to carry out a survey in all States of the SAM Regional, for identify each aircraft by its Registry versus its PBN capacity. Likewise, taking into consideration that this survey is addressed to all aircraft registered in each State, it is recommended to perform the survey considering phases for collecting the information.

2.14.4 Taking into account the foregoing, the Meeting formulated the following conclusion:

Conclusion SAM/IG/2-3 Survey on the Fleet Navigation Capacity

That States conduct a survey on the fleet navigation capacity, using, to that end, the form contained in **Appendix D** to this part of the Report, and send the information collected to the ICAO South American Regional Office, on the following dates:

- a) Aircraft operating commercial flights, which have more than 5 700 kg. of MTOW – 15 February 2009;
- b) Aircraft operating commercial flights, which have less than 5 700 kg. of MTOW – 15 May 2009;
- c) Other aircraft registered in the Region – 15 August 2009.

2.14.5 The Meeting recognized that it is essential to know not only the fleet navigation capacity, but also the number/percentage of operations approved for the navigation application to be implemented. In order to make this analysis, it will be necessary to collect information about the operators and types of aircraft operating in the SAM Region. Project RLA/06/901 used the CARSAMMA traffic sample collected over the period of 13 to 28 January 2008, to prepare the graphs of air traffic movement by type/operator in each FIR of the SAM Region, as shown in **Appendix B, Attachment 5** to this part of the Report. The analysis was limited to flights made at RVSM flight levels (FL 290 to FL 410), because the sample was established to assess RVSM safety. The complete analysis of operators/aircraft types can be found at the SAM Office website.

2.15 **Analyze the ground-based means of communication, navigation (VOR, DME) and surveillance available for complying with the navigation specifications and the navigation reversal mode**

2.15.1 The Meeting took note that Appendix B to this part of the Report, paragraph 1.4, contains details about CNS requirements for RNAV-5 implementation. The assessment of VOR and DME coverage in the SAM Region is a matter of key importance for the implementation, in order to identify if the infrastructure is appropriate for supporting RNAV-5 operations. If coverage is not appropriate in a given airspace, RNAV-5 implementation could be based only on GNSS and INS. The Meeting should discuss a strategy for assessing VOR and DME coverage to support the RNAV-5 navigation application.

2.15.2 A summary on the status of compliance of the tasks for PBN Action Plan for En route Operations is shown in Appendix B, Attachment 1, to this part of the Report.

2.16 **Tasks to be developed by Project RLA/06/901**

2.16.1 Project RLA/06/901 should perform the following tasks of the Action Plan, with their respective numbers, which were initiated at the SAM/IG/1 and SAM/IG/2 meetings but could not be completed. According to the en-route PBN action plan, the results shall be submitted at the SAM/IG/3 and/or SAM/IG/4 meeting:

TASK NUMBER	TASK	Completion Date
1.2	Collect traffic data in order to understand the traffic flows in a given airspace.	SAM/IG/4
1.3	Analyze the aircraft fleet navigation capacity.	SAM/IG/3
1.4	Analyze the communications, navigation (VOR, DME) and ground surveillance means to meet navigation specifications and navigation reversal mode.	SAM/IG/4
1.5	Optimize the airspace structure, by reorganizing the network or implementing new routes based on the strategic objectives of the airspace concept, taking into account airspace modeling, ATC simulations (fast time and/or real time), live tests, etc.	SAM/IG/4
2.1	Prepare a performance measurement plan, including gas emissions, safety, efficiency, etc.	SAM/IG/4
3.1	Determine the methodology to be used to evaluate airspace safety and route spacing, depending on navigation specifications, taking into consideration airspace modeling, ATC simulations (accelerated and/or real time), live trials, etc.	SAM/IG/4
3.2	Prepare a data collection program for airspace safety assessment.	SAM/IG/4
3.3	Prepare a preliminary airspace safety assessment.	SAM/IG/4
5.1	Evaluate PBN implementation in ATC automated systems, taking into account Amendment 1 to PANS/ATM (FPLSG).	SAM/IG/4

2.16.2 Regarding tasks 3.1, 3.2 and 3.3, Project RLA/06/901 shall develop detailed guidance material in order to enable CARSAMMA to carry out these tasks.

2.17 **PBN implementation model for TMA and approach operations**

2.17.1 The Meeting took note that Regional Project RLA/06/901 developed a PBN Implementation model for TMA and Approach operations to gain a better understanding of the activities involved and the expected results. The objective was to clearly define the deliverables, in order to be able to break down the large volume of work into specific activities. These activities will serve as a basis for the preparation of programme timetables.

2.17.2 It was also noted that the PBN Implementation model for TMA and Approach Operations establishes new Model Action Plans for TMA and Approach Operations, which are shown as **Attachments 1 and 2 to Appendix E** of this part of the Report, respectively. These plans were modified to conform to the results of the PBN Seminar (Lima, 17-20 June 2008) and the PBN Manual (Doc 9613). The changes made in the model Action Plans did not modified the essence of the previous action plan. In this sense, the Meeting formulated the following conclusion:

Conclusion SAM/IG/2-4**PBN Implementation Model for TMA and Approach**

That States/Territories and International Organizations use the PBN Implementation Model for TMA and Approach in the preparation of their PBN implementation programmes for TMA and Approach, shown in **Appendix E** to this part of the Report.

2.18 Flexibility with Special Use Airspace

2.18.1 The Meeting took note that Special Use Airspace was designed to enable “special” operations while minimizing impact to ordinary operations. With traditional route structures, this methodology worked well allowing SUA to be designated as active either H24 or for extended periods. They also allow a significant range of altitudes, often encompassing all suitable cruising levels.

2.18.2 However, optimized paths from PBN implementation, such as UPRs, can be severely limited by SUA. While the necessity of SUA is recognized, it is necessary to set up procedures to ensure airspace use flexibility.

2.18.3 In this regard, the Meeting was of the opinion that Air Navigation Service Providers (ANSP) must establish a coordination mechanism with their States’s military authorities in order to discuss issues such as location, altitudes and validity periods of specific SUA, thus, reaching the efficient use of airspace for all users.

2.19 Managing the Environmental Issues of Air Transportation

2.19.1 The Meeting took note that the ICAO 36th General Assembly requested the Council to encourage Contracting States to improve air traffic efficiency, reporting the progress in this area, and requested them to accelerate the development and implementation of fuel efficient procedures to reduce emissions produced by aviation.

2.19.2 The Meeting was of the opinion that it is important that States and Air Navigation Service Providers (ANSP) take on a proactive role on implementation programmes that are “pro-environment”. The ICAO airspace planning forums need to aggressively promote awareness of environment issues, pursue environmental saving initiatives, document environment benefits, promote environmental saving programmes and implement measures to reduce emissions.

2.19.3 In this regard, the Meeting considered that the specific task to measure the performance, included in PBN Implementation Project, will start the process to obtain objective data on the benefits to be reached in terms of reduction of gas emissions hazardous to the atmosphere.

2.20 Procedure Design Training for RNP Approach with Authorization Required (AR)

2.20.1 The Meeting observed the results of the Prototype RNP AR Course given in August 2008 at the FAA’s Mike Monroney Aeronautical Center in Oklahoma City. Course participants were from Australia, Brazil, Chile, Mexico and EUROCONTROL.

2.20.2 The course is designed for trained, experienced PANS OPS procedure designers. Course duration is 13 class days. The language of instruction is English. TSI will levy tuition charges; in addition, participants will need to fund their travel and lodging expenses.

2.20.3 TSI has established the following list of course dates at Oklahoma City. A minimum enrollment of six students is necessary to confirm a scheduled class.

- 3 Nov - 20 Nov 2008
- 5 May - 21 May 2009
- 9 Sept - 25 Sept 2009

2.20.4 TSI is also able to present the course at locations outside the U.S by specific arrangement with requesting agencies.

2.20.5 To request a position in a scheduled class, or to arrange presentation of the course at a location outside the U.S., the point of contact is the TSI Course Manager, Mr. Joseph Florio. Contact information:

Email: Joe.Florio@tsi.jccbi.gov
Telephone: 1 405 954 8533
Fax: 1 405 954 2649

2.21 Input from the ICAO PBN Programme

2.21.1 During the PBN WG meeting, the ICAO PBN Implementation and Resource Development Coordinator, updated the meeting on some of the initiatives ongoing with the ICAO headquarters PBN programme.

2.21.2 ICAO, in cooperation with the French DGAC and ENAC are planning a series of PBN Procedure Design Courses for experienced procedure designers in the region. Two of these courses have already been conducted in Asia. There are plans to conduct at least two courses in Spanish in the CAR/SAM region over the next one to two years in cooperation with either the French or Spanish governments, depending on availability of funds.

2.21.3 The meeting noted the ICAO Secretariat presentation on the regional Flight Procedure Programme (FPP) concept. Under this concept, a Flight Procedure Programme office would be established in a region to address shortcomings in procedure design capability in the States, including:

- a) Lack of procedure design training: initial, OJT, and/or recurrent;
- b) High turnover among procedure designers;
- c) Insufficient procedure design work in some States to attain or maintain proficiency;
- d) Lack of depth in procedure design organization to perform quality assurance (QA);
- e) Insufficient expertise in procedure design organization to provide adequate QA of procedures;
- f) Lack of procedure design and obstacle data storage automation in the States; and

- g) Insufficient regulatory expertise to oversee the procedure design service provider.

2.21.4 The FPP office is envisioned by ICAO to be a not-for-profit center of excellence in the field of flight procedure design. The FPP would employ best practices in training, automation and quality assurance with experts in the field to address the procedure design needs of the States. It would be organized as a Technical Cooperation Bureau project and managed by a full-time ICAO employee whose position would be funded from the FPO funding sources, in order to assure the States that the credibility of ICAO stands behind the project. Location, size and initial operational capability date of a regional FPP would however be based on demand for the services and the level of financial support extended by the States and international organizations for start-up and initial operating costs. It is anticipated that success of the concept will require that there be at least one donor State or organization that provides the start-up capital and operating costs for the first 2-3 years, and infrastructure support after that time. Under this concept, user fees would be introduced at the level necessary to cover the cost of the services not covered by donors.

2.21.5 The primary goal of the FPP would be to develop and enhance the States' capabilities in procedure design and quality assurance, so that they can achieve the PBN implementation goals of Assembly resolution A36-23.

2.21.6 As a follow up from a joint agreement at the 18th IATA Operations Committee meeting, the International Civil Aviation Organization (ICAO) and International Air Transport Association (IATA) have decided to form a Global Performance Based Navigation (PBN) Implementation Group. The purpose of this group is to identify and develop a systematic approach to assist in a complete and accelerated implementation of PBN worldwide. This group will have its first meeting in December 2008. The ICAO Secretariat asked the group to provide feedback on what they see as the biggest obstacles in their States, to PBN implementation. The following issues were brought out by the group:

- a) training for regulators, AIS, pilots, ATC, procedure designers
- b) training in airspace planning
- c) training in conducting safety assessments, focusing on the safety assessments required for implementing airspace changes
- d) harmonized methodology for safety assessments
- e) access to software for evaluating DME support of DME/DME flight procedures

2.21.7 This feedback will be used by the global PBN implementation group to help set priorities for action.

2.22 Special Implementation Project (SIP)

2.22.1 ICAO informed to the Meeting that in view of FAA proposal to develop a Procedure Design Training for RNP Approach with authorization required (see paragraph 2.20), a SIP will be proposed to be considered by ICAO Council, which will permit the SAM Region to carry out said course in Regional Office premises. SAM States will be informed if approval is obtained.

APPENDIX A

SHORT TERM ACTIVITIES OF THE RLA/06/901 PBN EXPERT WITH REGARD TO PBN

Results	Activities	Party responsible for each activity
1.1 Implementation of performance-based navigation (PBN) – (GPIs 5, 7, 10, 11, 12, and 21).	1.1.1. Process and analyse the information, learning about the current status in the participating States and organisations in the following priority order: RNAV-5, RNAV-1 and RNP APCH, with respect to: a) Available CNS infrastructure, with the corresponding coverage and plans for future facilities; b) Characteristics of available ATM automated systems and future automation plans; c) Aircraft fleet operating in the CAR/SAM ATS route network and its RNAV and RNP capabilities, including capacity for arrival procedures based on the flight management system (FMS) and future plans of the users; d) Airworthiness and operational approval capabilities; e) Airports that might derive operational benefits from the use of RNAV and/or RNP; f) Status of implementation of WGS 84; g) Existing SIDs and STARs connecting international airports to ATS routes; h) Real-time and accelerated simulation of operations; i) Cost-benefit analysis of facilities; j) Safety assessment models; k) Regulation of GNSS use (secondary, primary means)	ATM Expert, RO

Results	Activities	Party responsible for each activity
	l) Documentation concerning the training of air traffic controllers; m) Evaluate the impact of PBN implementation in ATC automated systems. n) Analyse existing data on air traffic movement, with a view to: i. cost-benefit analysis ii. fleet capacity assessment iii. identification of main traffic flows iv. safety assessment o) Identify the need for collection and additional data analysis. Start up date: week 1 Estimated duration: 2 weeks	

APPENDIX B

PBN IMPLEMENTATION PROJECT

EN-ROUTE OPERATIONS

SHORT TERM

SAM REGION

Introduction

The purpose of this document is to detail the activities of the Short-term Performance-Based Navigation Implementation Project for En-Route Operations in the South American Region in relation to RNAV-5 implementation. It also specifies the results that should be obtained from each of the activities of the action plan.

Project RLA 06/901 will carry out the activities of the PBN Project for En-Route Operations in the SAM Region, with the support of States and International Organizations. Project 99/901 will provide support in the areas concerning fleet navigation capacity and aircraft and operator approval documentation.

The Short Term Action Plan for En-Route Operations is shown in **Attachment 1**.

PBN Implementation – En-Route Operations - Short Term

1. Airspace Concept

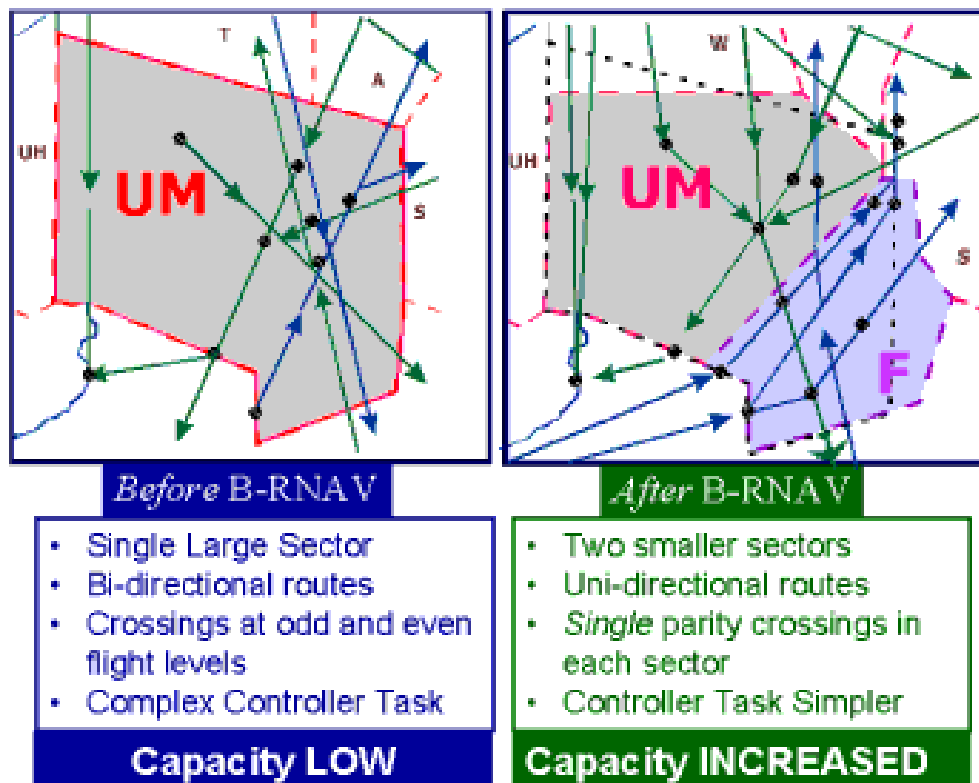
The Airspace Concept provides the scheme of operations within an airspace and is developed to meet explicit strategic objectives, such as safety enhancement, adjustment of service provision to air traffic growth, environmental impact mitigation capacity, etc. The Airspace Concept must include details about the practical organization of the airspace, based on user characteristics and on the CNS/ATM infrastructure in place or to be implemented. Further details about the Airspace concept can be found in the PBN Manual, Volume I, Chapter 2.

1.1. Establish and prioritize strategic objectives (safety, efficiency, the environment, etc.).

RNAV-5 implementation in the SAM Region will address mainly the following Strategic Objectives:

- a) Safety – At present, there is no formal airworthiness certification and operational approval process for flights in RNAV routes in the SAM Region. Implementation of RNAV-5, which is the least demanding navigation specification in terms of airborne equipment, will make it possible to formalize and harmonize the use of RNAV in new and existing RNAV routes, and will provide the necessary conditions for a complete restructuring of the route network. This will permit the development of an optimized route network, thus reducing conflict points and, as a result, increasing safety.
- b) Capacity – The reduction in airspace complexity and the resulting decrease in controller workload will enhance sector ATC capacity, thus permitting a larger number of flights.
- c) Cost-effectiveness –PBN implementation will enable a larger number of aircraft to fly their optimum flight profiles, offering users a better cost-effectiveness ratio.
- d) Efficiency - RNAV-5 application will improve operational efficiency through:
 - ✓ Improvements in airspace management via the repositioning of intersections
 - ✓ Better use of available airspace by means of a route structure that will allow for the establishment of:
 - o More direct routes (double and parallel, if necessary) to accommodate a larger air traffic flow
 - o A “bypass” route for aircraft overflying TMAs with high air traffic density
 - o Alternate or contingency routes
 - o Optimum in-flight holding positions
 - o Optimized feeder routes

- ✓ Reduction of distances flown, resulting in a fuel saving
 - ✓ Reduction in the number of radio navigation aids
- e) Environmental Protection – Increased efficiency and fuel savings will reduce noxious gas emissions into the atmosphere. Furthermore, the application of specific procedures may help reduce aircraft noise (*e.g.*, continuous descent approach – CDA).
- f) Access and Equity – PBN implementation shall not prevent the flight of unapproved aircraft in a given airspace unless absolutely necessary due to air traffic density. Access and equity are expected to be addressed in this way.
- g) Global Interoperability – RNAV application, as provided for in the PBN Manual, will guarantee global interoperability through the application of standard navigation specifications, thereby avoiding the need to obtain various aircraft and operator approvals in order to fly in airspaces that use the same navigation application.
- h) ATM Community Participation– The success of PBN implementation will depend upon the effective participation of the ATM community, with a view towards guaranteeing that the operational requirements of both the different airspace users and the service providers are met.



1.2. Collect air traffic data in order to understand air traffic flows within a particular airspace.

Domestic and international RNAV routes already handle the main traffic flows. Even so, aircraft operators continue to request new RNAV routes, which must be assessed from the viewpoint of their application, in order to be able to favour the main air traffic flows. It is important to note that the composition and mix of RNAV and non-RNAV routes add complexity to the airspace and prevent a better air traffic management in the SAM Region. The elimination of unused and “conventional” routes should be the first step toward optimizing the route network, depending upon the analysis of the fleet navigation capacity, which will be considered in paragraph 1.3 below. Furthermore, the complete restructuring of the route network in the SAM Region should be undertaken simultaneously with the route implementation, elimination and realignment strategy. This activity will require the creation of an aircraft movement database, in order to precisely identify air traffic flows in the region.

Attachment 2 contains graphic information about the use of the main ATS routes in the Region, by FIR. **Attachment 3** presents graphs showing the city pairs with the largest number of flights, by FIR. The same air traffic sample for which CARSAMMA data were collected over the period of 13 to 28 January 2008 for the RVSM safety assessment was used to prepare the graphs. As a result, only flights between FL 290 and FL 410 were considered. Full information may be obtained at the SAM Office website.

1.3. Analyze fleet navigation capacity

ICAO is developing a global system to register operator certificates and the corresponding operating specifications. This registry will offer access to information about the authorized operating specifications of any commercial aircraft and is expected to be ready within 5 years.

Given the specific requirements of the SAM Region, it will be necessary to create a PBR regional database before the deadline set by ICAO, in order to make it possible to verify aircraft PBN capacity from the registration data for each aircraft operating in the region.

A survey must first be conducted, so that Civil Aviation Authorities (CAA) can collect the necessary information for the creation of that database.

CAAs shall complete the survey by phases given the complexity of obtaining PBN information for all aircraft operating in the SAM Region. This survey shall include a specific table for each Navigation Specification, making easy and direct consultation by aircraft operators possible, in order to determine whether a specific aircraft is eligible for a given Navigation Specification based only on the list of its installed avionics. An example of the list used by the FAA, which is applicable to RNAV-1 and RNAV-2 navigation specifications, can be found at http://www.faa.gov/about/office_org/headquarters_offices/avs/offices/afs/afs400/afs470/media/AC90-100compliance.xls.

Once the database of PBN-Approved Aircraft and Operators has been created, it will be necessary to compare it with the air traffic movement in the Region, in order to determine the number/percentage of operations that would be carried out by the aircraft approved for each of the

navigation specifications that are expected to be applied in the short term (RNAV-5, RNAV-1, RNP-APCH). In this way, the feasibility of implementation can be determined. The graphs showing the distribution of air traffic movement, of the main operators and types of aircraft, by FIR, are included in **Attachment 5**. In this case, CARSAMMA data for the period 13 - 28 January 2008 was also considered. Complete information can be found at the SAM Office website.

1.4. Analyze the ground communication, navigation (VOR, DME) and surveillance infrastructure for navigation specifications, in order to comply with the Navigation Specification and the navigation reversal mode.

The ground communication, navigation (VOR, DME) and surveillance infrastructure is of fundamental importance for RNAV-5, both to permit the application of that navigation specification and to guarantee the navigation reversal mode in case of loss of the GNSS signal, considering that:

- a) The application of a single RNAV system consisting of one or more sensors, an RNAV computer, a control display unit and a navigation display (HSI, CDI, etc.) can assure the required minimum level of availability and integrity. This is acceptable if the system is monitored by the crew and if the aircraft is capable of navigating using a ground-based navigation system (VOR, DME) in case of a system failure. Therefore, aircraft must fly within the service area of one of the ground-based navigation systems, in order to permit a navigation reversal to a “conventional” system, if needed for safety purposes.
- b) Inasmuch as this is an RNAV specification that does not require on board performance monitoring and alerting systems, ATS surveillance can mitigate the requirement for greater route spacing in order to remedy possible navigation systems failures undetected by the flight crew.
- c) Another basic requirement for RNAV-5 implementation is direct controller-pilot communication, considering that, for the reasons explained in “a” and “b” above, reversion to another navigation system and/or the observation by the controller of the aircraft possible “exit” from its planned flight path, will make an immediate controller-pilot contact necessary.

A full evaluation of the VOR/DME and DME/DME infrastructure will be necessary in order to verify the possibility of implementing the RNAV-5 navigation specification with the use of VOR/DME and/or DME/DME. The information available at this time does not permit this analysis. It is important to stress that in airspace where this coverage is not available, RNAV-5 can be applied with the use of GNSS and of INS, the latter being limited to 2 hours of flight without a system update.

1.5. Optimize airspace structure by reorganizing the route network or implementing new routes based on the strategic objectives of the Airspace Concept, considering Airspace Modelling, ATC Simulations (in fast time and/or real time), and live trials, etc.

The optimization of airspace structure through a complete reorganization of the route network is the strategy that will guarantee the efficiency of en-route operations in the SAM Region. Because of the complexity and extension of the route network, however, this strategy cannot be carried out in the short term. A short-term strategy should be to optimize the existing network by implementing new routes and, particularly, eliminating unused RNAV or “conventional” routes. The SAM/IG could, after assessing the aircraft fleet navigation capacity and CNS infrastructure, recommend the exclusionary implementation of RNAV-5 within a given airspace volume, between FL 290 and FL 410, for example. If that application is possible, it will, consequently, also be possible to eliminate existing “conventional” routes and to implement a larger number of new RNAV routes to replace routes that have been eliminated, as well as to completely review all existing RNAV routes. In order to be successful with this new route structure, it will be necessary to establish well-defined departure and arrival points in the main TMAs of the Region, in order to favour the main traffic flows.

In the case of a complete restructuring of the route network, Project RLA 06/901 shall consider using the following tools:

- a) airspace modelling;
- b) Fast Time Simulation (FTS);
- c) Real Time Simulation (RTS);
- d) live ATC trials

Use of these tools is not necessary for simple airspace modifications like the implementation of a new RNAV route. But for more complex airspace changes, these tools can provide essential information for guaranteeing efficiency and safety. More information about these tools can be found in the PBN Manual, Volume I, part B, item 4.3.2.

Use of a specific methodology established in the Guide for the Implementation of RNAV Routes in the CAR/SAM Regions, approved in Conclusion 12/7 of GREPECAS/12, should be considered for reorganizing the route structure and/or RNAV route implementation, realignment or elimination.

Route implementation requires the establishment of route spacing and aircraft separation. To accomplish this, it will be necessary to hire experts to make the necessary assessment or to perform a comparative analysis, with other airspaces, for example. The studies made in Europe led to the following route spacing values:

- a) Without additional workload for the air traffic controller:
 - ✓ 18 NM for bi-directional routes;
 - ✓ 16.5 NM for one-way routes; and
 - ✓ 15 NM if aircraft in adjacent routes (opposite directions) do not use the same cruising levels and the percentage of climbs and descents is 40% or less.

- b) When monitoring through ATS surveillance is feasible and ATC intervention capacity is available, a reduction in route spacing to 10-15 NM is possible.
- c) In cases where the application of reduced spacing had been considered, data had to be obtained in order to establish RNAV performance on RNAV-5 routes in Europe.

RNAV-5 approval requirements will enable most aircraft equipped with RNAV systems to meet such requirements. RNAV-5 use does not require a navigation database and does not specify the fulfilment of ARINC 424 leg types. The RNAV-5 Navigation Specification does not meet the requirements for RNAV operations in complex TMAs. RNAV-5 may be used above the MSA, depending on path spacing requirements in the TMAs involved. The purpose of RNAV-5 requirements is to establish RNAV capacity as soon as possible, without any need for significant changes in the airborne equipment of most aircraft.

2. Develop a performance measurement plan, including gas emissions, safety, efficiency, etc.

Performance-Based Air Traffic Management is organized based on the principle that ATM community expectations can best be met by quantifying those needs. Therefore, a series of performance objectives, goals and indicators should be established that would make it possible to objectively justify projects that seek to implement performance improvements in the air traffic management system.

The estimated future performance of the ATM system will be of fundamental importance in guiding the planning of the improvements to be implemented. Research and development initiatives should be organized to foster risk analysis in the following situations:

- a) the consequences of keeping the current ATM system status unchanged. In this case, the ATM system would be subject to changes outside the scope of operation of the service provider, such as: air traffic growth, changes in the fleet mix, etc.; and
- b) the consequences of making changes that do not generate the expected improvement in system performance, therefore ceasing to meet established performance goals.

In the case of simple implementations, such as an RNAV route the Key Performance Areas (KPA) involved are safety, efficiency and environmental protection. Safety can be measured qualitatively through a safety case. This possibility will be better described in the specific point on Safety Assessment. Efficiency and environmental protection are intrinsically related, inasmuch as an increase in efficiency normally results in a reduction in fuel consumption, thereby decreasing the amount of gas emissions released into the atmosphere. RNAV route implementation must at least measure the expected savings in flying time and fuel. It is important to stress that the implementation of an RNAV route will not always result in a reduction in flying time, inasmuch as the purpose for its implementation could be, for example, to simplify TMA entry and exit flows, thus reducing the workload of air traffic controllers and, consequently, increasing ATC capacity. In this case, a longer route could possibly create the necessary conditions for the use of continuous descent approach (CDA) procedures.

In more complex implementations, such as a complete restructuring of the route network, the performance assessment will normally depend upon the use of specific tools like Fast Time Simulation, because a full and integrated assessment of the system will be needed that would be difficult to perform manually. Therefore, if the SAM/IG decides on the complete restructuring of the route network, it will be necessary to study alternatives for using the necessary assessment tools.

PBN implementation should consider at least the savings in flying time and fuel consumption, as well as the reduction of noxious gas emissions into the atmosphere. IATA has developed a fuel saving calculation template that can be used to measure system performance. This template can be obtained at the SAM Office website.

3. Safety Assessment

3.1. Determine the methodology to be used for assessing airspace safety and route spacing, depending upon the navigation specification, considering the airspace model, ATC (fast time and/or real time) simulations, and live ATC trials, etc.

Airspace safety assessment methodology may be either quantitative or qualitative. An example of a quantitative method is the safety assessment applied to RSVM implementation and post-implementation. These quantitative methods are based on the Collision Risk Model (CRM) and require the use of experts in specific areas, such as Statistics and Mathematics. CARSAMMA will be responsible for the safety assessment for en-route PBN application. However, this safety assessment would be justified only in the case of major airspace changes such as the complete restructuring of the route network in a significant volume of airspace. Examples of Collision Risk Models used in safety assessments can be found in DOC 9689 – Manual on the Airspace Planning Methodology for Determining Separation Minima.

A qualitative assessment based on the operational judgment would be more advisable in the case of lone route implementation. This type of assessment should be documented through an SMS methodology-based safety case. Doc. 9859, the ICAO Safety Management Manual, and United Kingdom Doc. CAP 760 (Guidance on the Conduct of Hazard Identification, Risk Assessment and the Production of Safety Cases) offer examples of systematic use of this methodology. The latter document can be found at the following website: <http://www.caa.co.uk/docs/33/CAP760.PDF>

Another matter to be considered is the need to calculate route spacing on the basis of the specific characteristics of a given airspace, such as passing frequency, air traffic volume, lateral deviations, etc. This method is based on quantitative methods using CRM.

3.2. Prepare a data collection programme for the airspace safety assessment.

In order to prepare the data collection programme, the SAM/IG shall decide upon the safety assessment strategy, considering whether the assessment should be quantitative or qualitative. In the case of complete route network restructuring, CARSAMMA should indicate which data are needed for the safety assessment and/or determining the route spacing to be applied in the SAM Region.

3.3. Prepare the preliminary airspace safety assessment.

The preliminary airspace safety assessment should be completed before the implementation date, in order to guarantee the necessary conditions for the start of the pre-operational phase, which normally takes one year.

3.4. Prepare the final airspace safety assessment.

The final airspace safety assessment is usually performed one year after the implementation date, which will guarantee the start of the operational phase of a route or of a route network.

4. Establish a collaborative decision-making process (CDM)

The objective of the collaborative decision-making process is to guarantee that all actors involved in the implementation participate in the different phases of the project, thereby guaranteeing its transparency and adjustment to the interests of all users and service providers.

4.1. Coordinate planning and implementation needs with air navigation service providers, airports, regulators, users, aircraft operators and military authorities.

The SAM/IG meetings coordinate most of the planning and implementation needs, bearing in mind the involvement of most of the actors that should participate in the process. Nonetheless, the participating States should ensure that the interests of actors not represented at SAM/IG meetings are also taken into account in the planning and implementation, such being, for example, general aviation, military flights, air navigation service providers (when the representatives in the SAM/IG involve only regulators), etc.

4.2. Establish the implementation date.

The implementation date is one of the main project aspects to be taken into account, bearing in mind that it may possibly be adjusted to the interests of the various actors involved.

4.3. Establish the documentation format at the CAR/SAM RNAV/RNP website.

The Internet is an important mechanism for disseminating PBN documentation to all actors involved in its implementation. The SAM/IG Meeting should decide the form to be given to the website, so that PBN supporting documents can be posted there. The South American Regional Office already has a website for the PBN: <http://www.lima.icao.int/submenu1.asp?Url=/ICAOSAMNET/AirNav-eDocumentsMenu.asp>. This website appears to be “hidden,” however, and does not facilitate access by those involved in PBN implementation in the Region.

4.4. Report advances in planning and implementation to the relevant Regional office.

Planning and implementation advances will be made known to the South American Regional Office through the reports of SAM/IG meetings. It will also be necessary to set up a mechanism to ensure the harmonization of CAR and SAM implementation. Several members from the CAR Region expressed their interest, at the Sixth Meeting of the GREPECAS ATM Committee, in participating in SAM/IG meetings with a view towards achieving joint CAR/SAM implementation by following the same RVSM implementation model. In this connection, the SAM/IG/2 Meeting should study the advisability of adopting a mechanism similar to that used for RVSM implementation for PBN en-route implementation.

5. Automated ATC Systems

5.1. Assess PBN implementation in automated ATC systems, considering amendment 1 to the PANS/ATM (FPLSG).

Making changes in the automated ATC system as a result of PBN implementation is closely related to the need of the air traffic controller to differentiate between aircraft that are equipped for operations based on RNAV and RNP navigation specifications, and those that are not. That differentiation is particularly important in operating environments where aircraft separation depends upon aircraft PBN approval. Changes in automated systems may vary in complexity, from the insertion of letters or codes in the flight progress cards and/or in the radar screen targets, to a complete change involving differentiated colours or a prior analysis before a flight plan is entered into the flight plan processing system, in order to guarantee that only approved aircraft may fly an RNAV route or perform an RNP procedure at the FPL.

Changes in automated ATC systems must consider amendment 1 to the PANS/ATM. This amendment, resulting from the work of the ICAO Air Navigation Commission Study Group on Flight Plans, was approved at the 177th Session of that Commission and will enter into effect on 15 November 2012. States were informed of the approval of amendment 1 to the PANS/ATM through ICAO State Letter AN 13/2.1-08/50, of 25 June 2008.

The amendment involves making significant changes in the insertion of alphanumeric codes relating to RNAV and RNP approval that are of key importance for PBN implementation. Considering the present flight plan limitations, most of these codes will be inserted in field 18. To sum up, the changes concerning PBN are as follows:

- a) The name of FPL field 10 is changed to “Equipment and Capabilities”;
- b) The letter “R” in field 10 is changed to mean “PBN Approval”. Navigation specifications for which the aircraft and operator are approved should be inserted in FPL field 18, using the following codes:

- RNAV SPECIFICATIONS

- ✓ A1 - RNAV 10 (RNP 10)
- ✓ B1 - RNAV 5 all permitted sensors

- ✓
- ✓ B2 - RNAV 5 GNSS
- ✓ B3 - RNAV 5 DME/DME
- ✓ B4 - RNAV 5 VOR/DME
- ✓ B5 - RNAV 5 INS or IRS
- ✓ B6 - RNAV 5 LORANC
- ✓ C1 - RNAV 2 all permitted sensors
- ✓ C2 - RNAV 2 GNSS
- ✓ C3 - RNAV 2 DME/DME
- ✓ C4 - RNAV 2 DME/DME/IRU
- ✓ D1 - RNAV 1 all permitted sensors
- ✓ D2 - RNAV 1 GNSS
- ✓ D3 - RNAV 1 DME/DME
- ✓ D4 - RNAV 1 DME/DME/IRU
- RNP SPECIFICATIONS**
- ✓ L1 - RNP 4
- ✓ O1 - Basic RNP 1 all permitted sensors
- ✓ O2 - Basic RNP 1 GNSS
- ✓ O3 - Basic RNP 1 DME/DME
- ✓ O4 - Basic RNP 1 DME/DME/IRU
- ✓ S1 - RNP APCH
- ✓ S2 - RNP APCH with BARO-VNAV
- ✓ T1 - RNP AR APCH with RF (special authorization required)
- ✓ T2 - RNP AR APCH without RF (special authorization required)

- c) The letter “G” continues to be used in field 10 to mean “Equipped with GNSS.” The corresponding augmentations should be entered in field 18, using the NAV code.

5.2. Make the necessary changes in the automated ATC systems.

Making changes in automated ATC systems is usually a complicated, expensive and slow process for most States. As a result, only changes that are deemed essential for safety and efficiency purposes shall be made. Two main scenarios are possible in the case of PBN en-route implementation:

- a) RNAV and non-RNAV routes combined – in this scenario, use of the automated ATC system would be limited to “investigating” whether the aircraft is effectively approved for flight on the RNAV route. This investigation could be made offline, through the comparison of air traffic samples with a database of approved aircraft, in the same way that CARSAMMA and the States do in the case of RVSM operations. In this scenario, aircraft separation is not considered to be dependent upon RNAV approval. In the case of RNAV routes in which the separation depends upon RNAV approval, a greater degree of ATC automation will be needed to indicate to the air traffic controller which aircraft have RNAV approval and which do not.
- b) The existence in this scenario of exclusionary RNAV airspaces (with or without special exceptions--State aircraft, humanitarian flights, first delivery, etc.) means that route spacing will depend upon aircraft RNAV approval and ATC automation will be essential to indicate the approval status of aircraft to the air traffic controller.

6. Aircraft and operator approval

6.1. Analyze the requirements for aircraft and operator approval (pilots, dispatchers and maintenance personnel), as established in the PBN Manual, and prepare the necessary documentation.

The PBN Manual, Volume II, Part B, Chapter 2 stipulates the general requirements for aircraft and operator approval for RNAV-5. EUROCONTROL and the FAA have the following documents:

- a) EUROCONTROL - AMC 20-4 - Airworthiness Approval and Operational Criteria for the Use of Navigation Systems in European Airspace Designated for Basic RNAV Operations.
- b) FAA – AC 90-96A - Approval of U.S. Operators and Aircraft to Operate under Instrument Flight Rules (IFR) in European Airspace Designated for Basic Area Navigation (B-RNAV) and Precision Area Navigation (P-RNAV).

6.2. Publish national regulations for implementing the RNAV-5 navigation specification.

The navigation specifications in the PBN Manual identify the operational and airworthiness approval requirements for the use of RNAV or RNP applications. Provision must be made in national operational regulations for checking compliance with these requirements, which may require specific operational approval.

The RLA/99/901 Project is preparing the Latin American (LAR) Regulations, whose purpose is to harmonize the operational and airworthiness approval process in Latin America. Regional documentation provided through the LARs is expected to be available shortly. Coordination between this project and Project RLA 06/901 is fundamental for avoiding a duplication of efforts and facilitating the work of the States involved. Project RLA 99/901 could at least offer guidance material for adoption and publication by the States.

One option already in use by CAR/SAM States has been to adopt documents of other States and International Organizations, as in the case of Interim Guidance 91 (RVSM) and Order 8400-12 (RNP-10).

6.3. Start the aircraft and operator approval process.

In order to meet the established implementation deadline, States should start the aircraft and operator approval process and Project RLA 06/901 should check to see whether all States effectively initiate that process, in order to harmonize the activities of the States involved.

6.4. Establish a database of approved aircraft and operators and keep it up-to-date.

The SAM/IG shall establish a strategy for creating a database of aircraft and operators approved for RNAV-5 operations, as it did in the case of RVSM implementation, bearing in mind the following objectives:

- a) When the route network is to be completely restructured, and mainly in the case of an exclusive airspace, the process will rely on a minimum percentage of approved RNAV-5 operations. In this connection, the creation of the database will be essential for analyzing the minimum percentage.
- b) Verify whether the aircraft flying RNAV routes are effectively approved for RNAV-5 operations.

6.5. Check operations through the use of a continuous monitoring programme (aircraft and procedures).

6.6. Safety must be ensured by a continuous operational verification programme regulated by the States.

7. Standards and Procedures

7.1. Assess the regulations for GNSS use and, where appropriate, proceed to their publication.

GNSS application is of key importance for all PBN navigation specifications, considering that some aircraft possess only this equipment to meet the established performance requirements and that there are some specifications that only GNSS can satisfy.

The key issue is the State policy with regard to GNSS application as a means of navigation. In order for the system to be used fully, States must regulate its use as a primary means of navigation, even if this should require imposing some operational restrictions, such as, for example, requiring alternative aerodromes to provide for conventional approaches (VOR, NDB, ILS). Another aspect that should be considered is the need to establish a reversion to navigation mode if the GNSS signal is lost, requiring aircraft to be equipped with conventional air navigation systems.

States in the Region have already published some regulations for GNSS use. **Attachment 4** shows the current status of these regulations in the SAM Region. Regulation of GNSS use is essential for all navigation applications.

GNSS use as a means of navigation is of key importance for fulfilling RNAV-5 requirements, considering that some aircraft only have this type of RNAV equipment. As a result, SAM States should consider regulating GNSS use and make any changes they deem necessary.

7.2. Finalize WGS-84 implementation.

7.3. Prepare a model AIC to report PBN implementation plans.

The AIC reporting that PBN implementation will be effected within almost 2 years will give aircraft operators sufficient time to obtain RNAV-5 approval before that date.

7.4. Publish the AIC reporting the planning of PBN implementation.

States must publish the AIC reporting PBN implementation plans, based on the model prepared by Project RLA 06/901. These AICs must be published on the same date, to be determined by States at the SAM/IG meetings.

7.5. Prepare an AIP Supplement model containing applicable standards and procedures, including the corresponding in-flight contingencies.

The AIP Supplement will contain specific operational standards and procedures for RNAV-5 implementation. Project RLA 06/901 will prepare a model similar to that developed for RVSM implementation, whose use will be considered by States based on discussions at the SAM/IG meetings.

7.6. Publish an AIP Supplement containing applicable standards and procedures, including the corresponding flight contingencies.

7.7. States should publish the AIP Supplement, based on the model prepared by Project RLA/06/901, on a common date to be determined at the SAM/IG meetings.

7.8. Review the Procedural Handbook of ATS units involved.

The Procedural Handbook of ATS units gives a detailed account of their mode of operation, in an effort to harmonize the operational procedures applied by air traffic controllers. RNAV-5 implementation will require the review of these procedures, considering in particular:

- a) Aircraft separation;
- b) Contingency procedures;
- c) New route network or networks implemented, eliminated and/or realigned;
- d) Essential radio aids for the use of a given navigation specification;
- e) New air traffic routing models (new area circulation), including uni-directional and bi-directional routes and TMA feeding.

7.9. Update letters of agreement between ATS units

Letters of agreement between ATS units should be updated (between ACCs or between an ACC and an APP), in order to reflect the new airspace structure implemented and the procedures mentioned in the previous paragraph.

7.10. Prepare an amendment to regional documentation, if necessary.

SAM/IG meetings shall assess whether amendments to regional documentation will be necessary in the light of PBN implementation for en-route operations. RNAV route implementation, elimination and realignment will undoubtedly require the amendment of the Regional Air Navigation Plan – Volume I – Basic (Doc. 8733). Nonetheless, consideration should be given to inserting a specific chapter for RNAV-5 application to en-route operations in the Regional Supplementary Procedures (Doc. 7030 – SUPPS), if a complete reformulation of the route network is decided upon as a result of RNAV-5 implementation. Chapter 17 of the European part of Doc. 7030 – SUPPS, which establishes all applicable procedures for using BRNAV (RNAV-5) is an example of this documentation.

- 7.11. Channel the proposed amendment to Doc. 7030 in the right direction, if necessary.

The ICAO South American Regional Office will, if necessary, channel proposed amendments to Doc 7030 in the right direction in time to reach the implementation deadline.

- 7.12. Revise practices and procedures for improving fuel consumption management and environmental care

This should be an objective to be sought at all SAM/IG meetings, in accordance with the environmental policy of ICAO and of the SAM States.

8. Training

- 8.1. Prepare a training and documentation programme for operators (pilots, dispatchers and maintenance personnel).

The documentation and training leading to the operational approval of aircraft operators is normally part of the operational certification process guaranteeing the use of an air navigation application. Each aircraft operator must prepare a training programme for approval by the Civil Aviation Authority, in order to obtain approval for the use of an air navigation application. The PBN Manual, Volume II, Part B contains some general training guidelines designed for Aircraft Operators that cover each Navigation Specification.

Project 99/901 will develop a training document model for operators.

- 8.2. Prepare a training and documentation programme for air traffic controllers and AIS operators.

The PBN Manual, Volume II, Part B contains some general training guidelines designed for air traffic controllers that cover each Navigation Specification.

Project RLA/06/901 will prepare a training document model for air traffic controllers and AIS operators.

- 8.3. Prepare a training programme for regulators (aviation safety inspectors).

States should offer aviation safety inspectors the necessary training to equip them to check compliance with PBN specification norms.

- 8.4. Conduct training programmes

States, service providers and aircraft operators must conduct the necessary training programmes within the stipulated period in order to guarantee implementation by the established deadline.

8.5. Hold seminars designed for operators, indicating the plans and expected operational and economic benefits.

The main purpose for holding seminars targeting operators is to urge them to equip their aircraft in keeping with established navigation specifications, within an appropriate period of time, by presenting the objectives and benefits to be attained through the planned implementation.

9. Decision to Implement

At this point in the Action Plan, three basic questions must be answered:

- a) Is the aircraft operator ready for the implementation? (9.1 and 9.2)
- b) Is the air traffic service provider ready for the implementation? (9.1)
- c) Is the implementation safe? (9.3).

A specific meeting should be held to evaluate these three key points and reach a final decision to implement.

When a final decision has been reached, each State should publish the pertinent ATS documentation, including the trigger NOTAM, seven days before the planned implementation date, in order to confirm it.

9.1. Evaluate the available operational documentation (ATS, OPS/AIR).

9.2. Evaluate the percentage of approved aircraft and operators (overall equipment involved) .

9.3. Review the results of the safety assessment.

9.4. Publish the trigger NOTAM.

10. Performance monitoring system

Following the implementation of the Navigation Application, the SAM Region will enter the pre-operational phase for a one-year period. At the end of this period, if the evaluation is positive, the Region may embark upon the operational phase. During this period, a post-implementation operations monitoring programme must be established, primarily to assess safety. Even so, a performance assessment system shall also be implemented, as stipulated in item 2 of the Action Plan. Both the safety assessment and the performance evaluation shall be carried out as a single unit and on a permanent basis. The SAM/IG meetings must discuss the viability and way of implementing a performance assessment programme on a permanent basis.

10.1. Prepare a post-implementation monitoring system for en-route operations.

10.2. Carry out a post-implementation monitoring programme for en-route operations.

ATTACHMENT 1 TO APPENDIX B**SHORT-TERM EN-ROUTE PBN ACTION PLAN (RNAV-5)
(GPIs 1, 4, 5, 7, 8, 10, 11, 12, 16, 21, 23)**

1. Airspace concept	Start	End	Responsible party	Remarks
1.1 Establish and prioritize strategic objectives (safety, capacity, environment, etc.)	June/2008	SAM/IG/2	SAM/PBN/IG (Project RLA/06/901)	Completed
1.2 Collect traffic data in order to understand traffic flows in a given airspace	June/2008	SAM/IG/2	SAM/PBN/IG (Project RLA/06/901)	In process
1.3 Analyze the navigation capacity of the aircraft fleet	June/2008	SAM/IG/4	SAM/PBN/IG (Projects RLA/06/901 and RLA/99/901) States IATA	
1.4 Analyze ground-based means of communication, navigation (VOR, DME) and surveillance to meet navigation specifications and the navigation reversal mode	June/2008	SAM/IG/3	SAM/PBN/IG (Projects RLA/06/901 and RLA/99/901) States	
1.5 Optimize airspace structure, reorganizing the network or implementing new routes based on the strategic objectives of the airspace concept, taking into account airspace modelling, ATC simulations (fast time and/or real time), live tests, etc.	SAM/IG/2	SAM/IG/4	SAM/PBN/IG (Project RLA/06/901) States IATA	
2. Develop a performance measurement plan	Start	End	Responsible party	Remarks
2.1 Draft a plan to measure performance, including gas emissions, safety, efficiency, etc.	SAM/IG/2	SAM/IG/4	SAM/PBN/IG (Project RLA/06/901)	

2. Develop a performance measurement plan	Start	End	Responsible party	Remarks
2.2 Implement the performance measurement plan	Nov/2010	Permanent	SAM/PBN/IG (Project RLA/06/901) States IATA	

3 Safety assessment	Start	End	Responsible party	Remarks
3.1 Determine the methodology to be used to assess airspace safety and route spacing, based on the navigation specification, taking into account airspace modelling, ATC simulations (fast time and/or real time), live tests, etc.	SAM/IG/2	SAM/IG/4	CARSAMMA Project RLA/06/901	RLA/06/901 in order to provide guidance material to CARSAMMA
3.2 Develop a data collection programme to assess airspace safety	SAM/IG/2	SAM/IG/4	CARSAMMA Project RLA/06/901	RLA/06/901 in order to provide guidance material to CARSAMMA
3.3 Prepare the preliminary airspace safety assessment	SAM/IG/2	SAM/IG/4	CARSAMMA Project RLA/06/901	RLA/06/901 in order to provide guidance material to CARSAMMA
3.4 Prepare the final airspace safety assessment	SAM/IG/4	Nov/2010	CARSAMMA	

4 Establish a collaborative decision-making process (CDM)	Start	End	Responsible party	Remarks
4.1 Coordinate planning and implementation requirements with air navigation service providers, regulators, users, aircraft operators and military authorities	SAM/IG/2	SAM/IG/4	SAM/PBN/IG States	

4	Establish a collaborative decision-making process (CDM)	Start	End	Responsible party	Remarks
4.2	Establish the implementation date	SAM/IG/1	SAM/IG/4	SAM/PBN/IG States	States must analyze the feasibility of the tentative date in coordination with domestic operators and military authorities
4.3	Establish the documentation format in the SAM PBN website	SAM/IG/1	SAM/IG/2	SAM Regional Office	Completed
4.4	Report planning and implementation progress to the corresponding Regional Office	SAM/IG/2	SAM/IG/4	SAM/PBN/IG States	

5	ATC automated systems	Start	End	Responsible party	Remarks
5.1	Assess PBN implementation in ATC automated systems, taking into account amendment 1 to the PANS/ATM (FPLSG).	June/2008	SAM/IG/4	SAM/PBN/IG (Project RLA/06/901)	Assign task to the Project
5.2	Implement the necessary changes in ATC automated systems	SAM/IG/2	TBD	States	

6	Aircraft and operator approval	Start	End	Responsible party	Remarks
6.1	Analyze aircraft and operator approval requirements (pilots, dispatchers and maintenance personnel) in keeping with the PBN manual, and develop the necessary documentation.	June/2008	SAM/IG/2	Regional Project RLA/99/901-Regional Safety Oversight Cooperation System	Completed
6.2	Publish national regulations for the implementation of the RNAV-5 navigation specification	SAM/IG/2	SAM/IG/3	States	

6	Aircraft and operator approval	Start	End	Responsible party	Remarks
6.3	Begin the approval of aircraft and operators	SAM/IG/3	SAM/IG/5	States	
6.4	Establish and keep up to date a registry of approved aircraft and operators	SAM/IG/3	Permanent	CARSAMMA States	
6.5	Verify the operation of the continuous monitoring programme (aircraft and procedures)	Nov/2010	Permanent	States	

7	Standards and procedures	Start	End	Responsible party	Remarks
7.1	Assess and, if applicable, publish the regulations on the use of GNSS.	June/2008	SAM/IG/2	SAM/PBN/IG (Project RLA/06/901) States	Completed
7.2	Finalize WGS-84 implementation	TBD	TBD		AIS provide information
7.3	Develop an AIC model to report PBN implementation plans	June/2008	SAM/IG/2	SAM/PBN/IG (Project RLA/06/901)	Completed
7.4	Publish the AIC reporting PBN implementation plans	SAM/IG/2	SAM/IG/3	States	
7.5	Develop an AIP Supplement model containing applicable standards and procedures, including the corresponding in-flight contingencies	SAM/IG/4	SAM/IG/5	SAM/PBN/IG (Project RLA/06/901)	
7.6	Publish the AIP Supplement containing applicable standards and procedures, including the corresponding in-flight contingencies	SAM/IG/5	SAM/IG/6	States	
7.7	Review the Procedural Handbook of the ATS units involved	SAM/IG/5	SAM/IG/6	States	
7.8	Update the letters of agreement between ATS units	SAM/IG/5	SAM/IG/6	States	
7.9	Develop an amendment to regional documentation, if necessary	SAM/IG/3	SAM/IG/4	SAM/PBN/IG (Project RLA/06/901)	

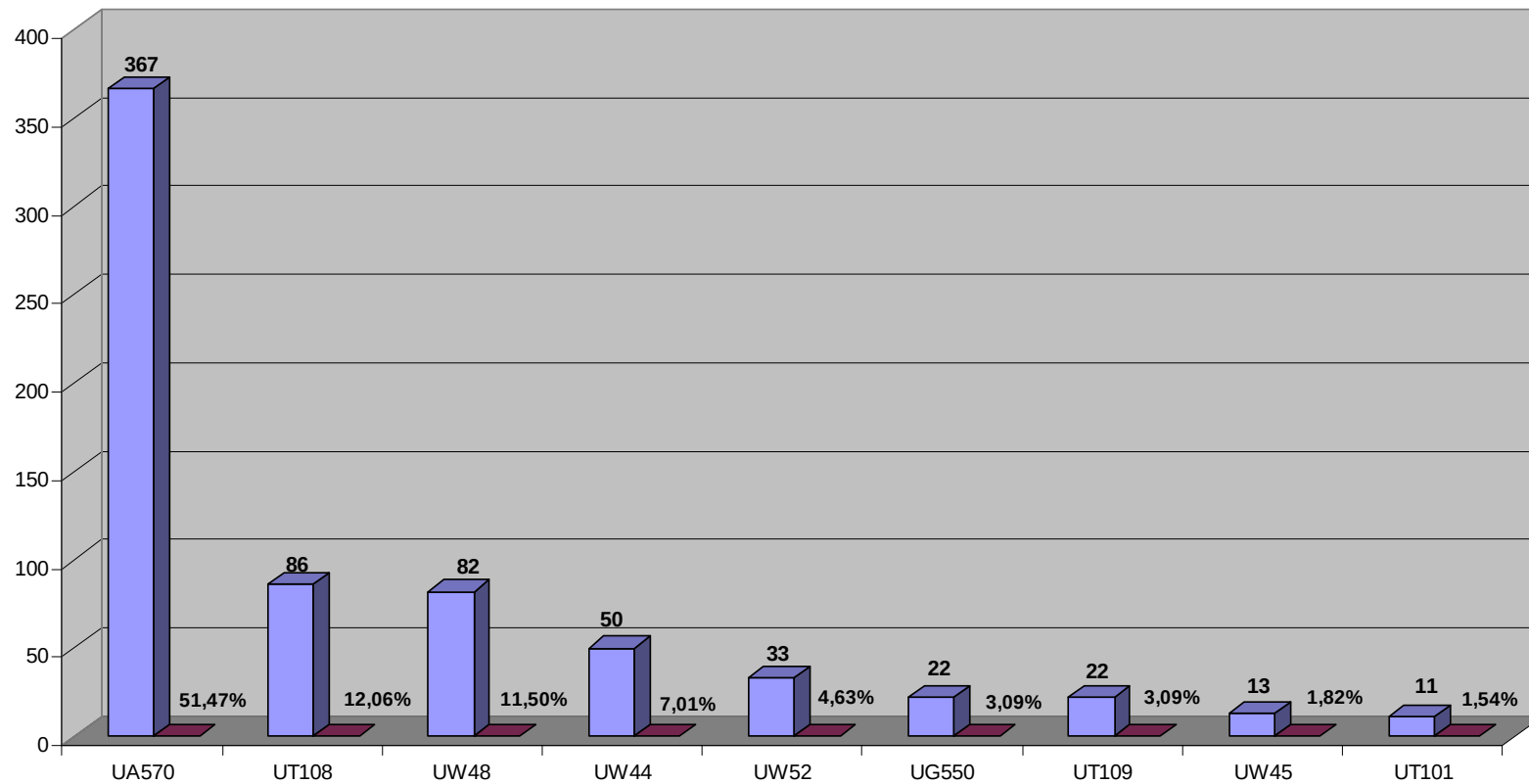
7 Standards and procedures	Start	End	Responsible party	Remarks
7.10 Submit a proposal of amendment to Doc. 7030, if necessary	SAM/IG/5	SAM/IG/6	SAM Regional Office	
7.11 Review practices and procedures to improve fuel consumption management and environmental protection	SAM/IG/1	Permanent	SAM/PBN/IG (Project RLA/06/901)	

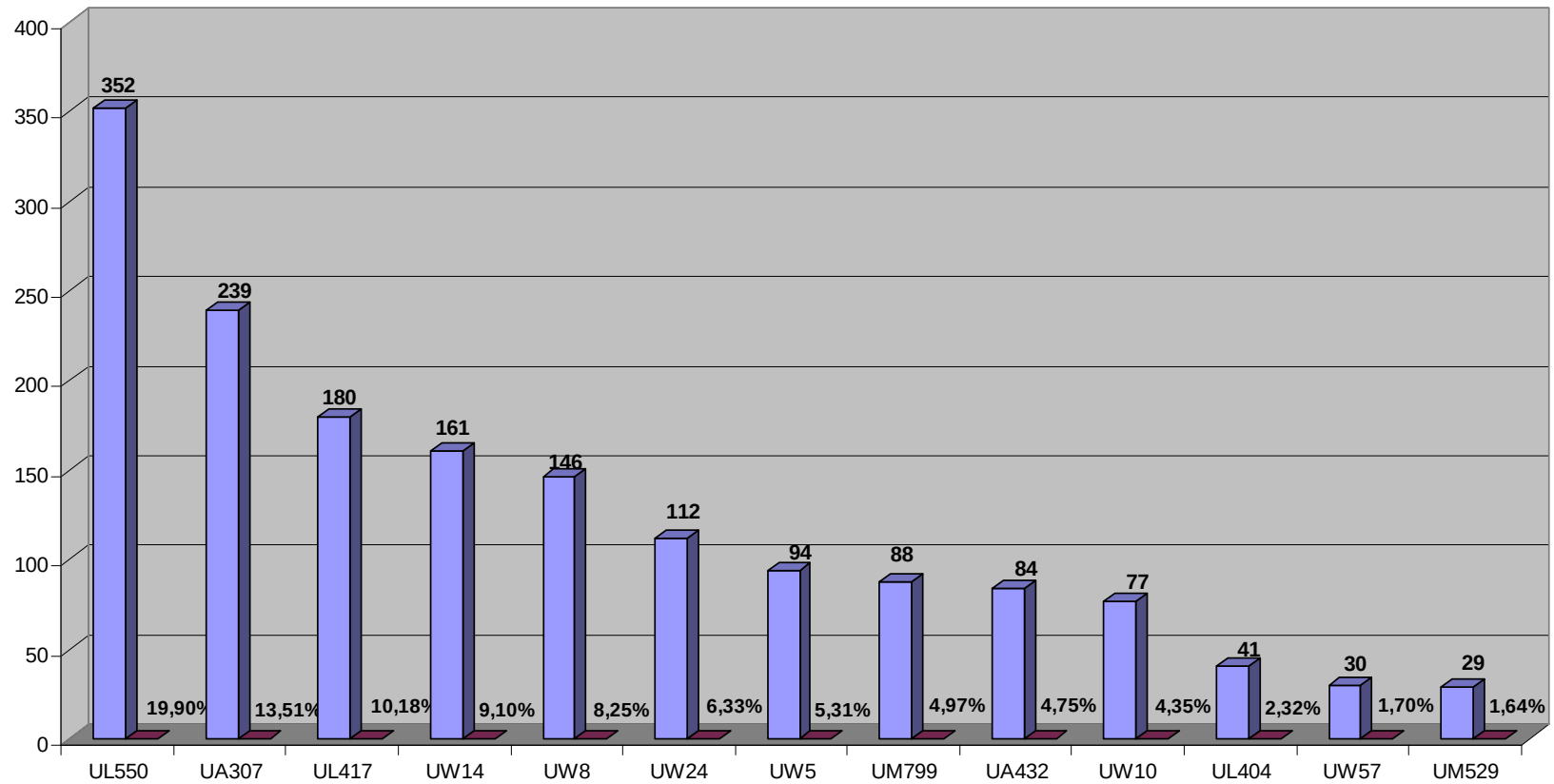
8. Training	Start	End	Responsible party	Remarks
8.1 Develop a training and documentation programme for operators (pilots, dispatchers and maintenance personnel)	SAM/IG/4	SAM/IG/5	Regional Project RLA/99/901	
8.2 Develop a training and documentation programme for air traffic controllers and AIS operators	SAM/IG/4	SAM/IG/5	SAM/PBN/IG (Project RLA/06/901)	
8.3 Develop a training programme for regulators (aviation safety inspectors)	SAM/IG/4	SAM/IG/5	States	
8.4 Conduct training programmes	SAM/IG/5	SAM/IG/6	States	
8.5 Conduct seminars for operators, explaining plans and expected operational and economic benefits	SAM/IG/1	SAM/IG/3	States	

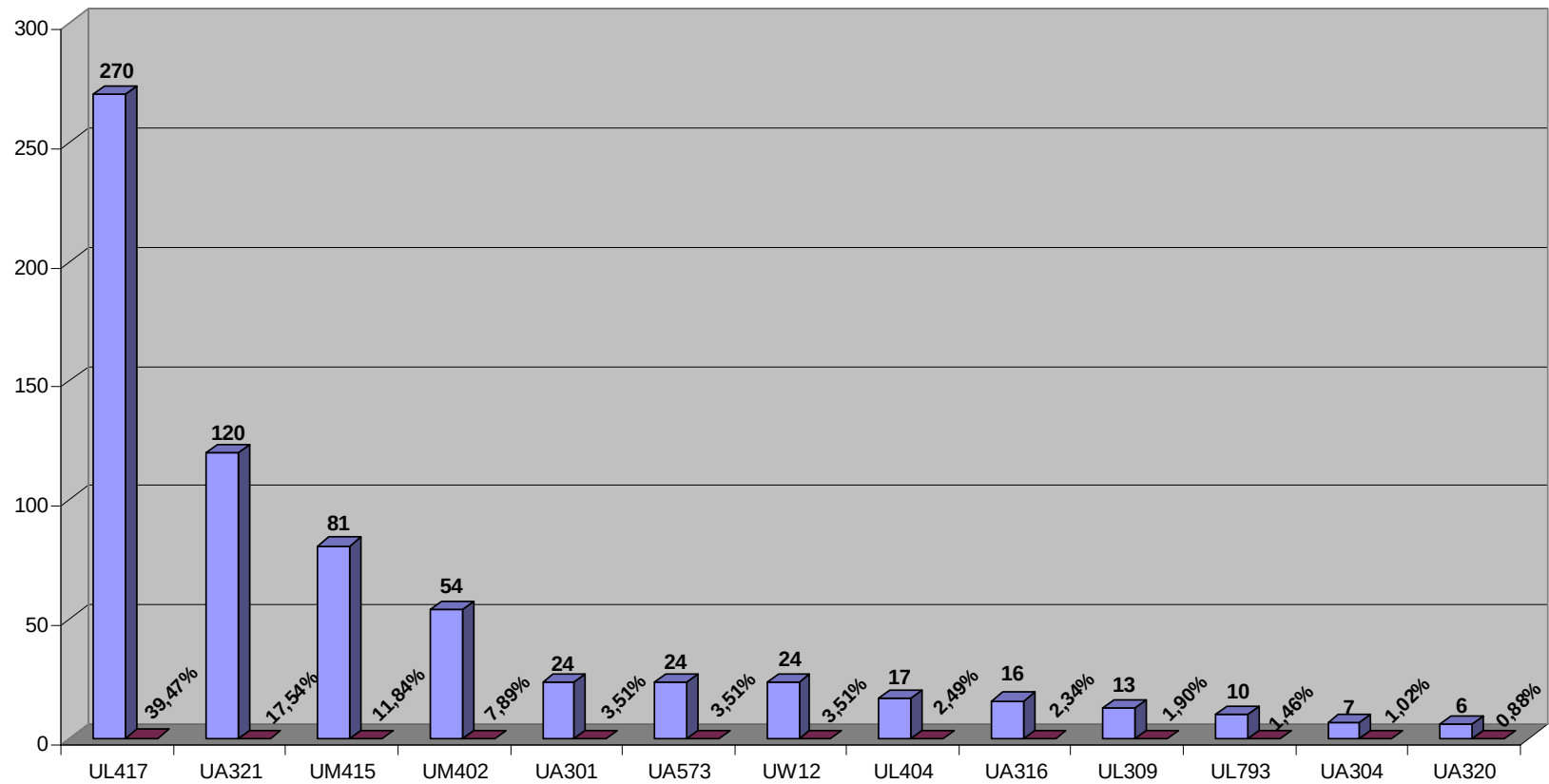
9. Implementation decision	Start	End	Responsible party	Remarks
9.1 Assess the available operational documentation (ATS, OPS/AIR)	July/2010	N/A	States	
9.2 Assess the percentage of aircraft and operators (non-exclusionary airspace)	July/2010	N/A	States	

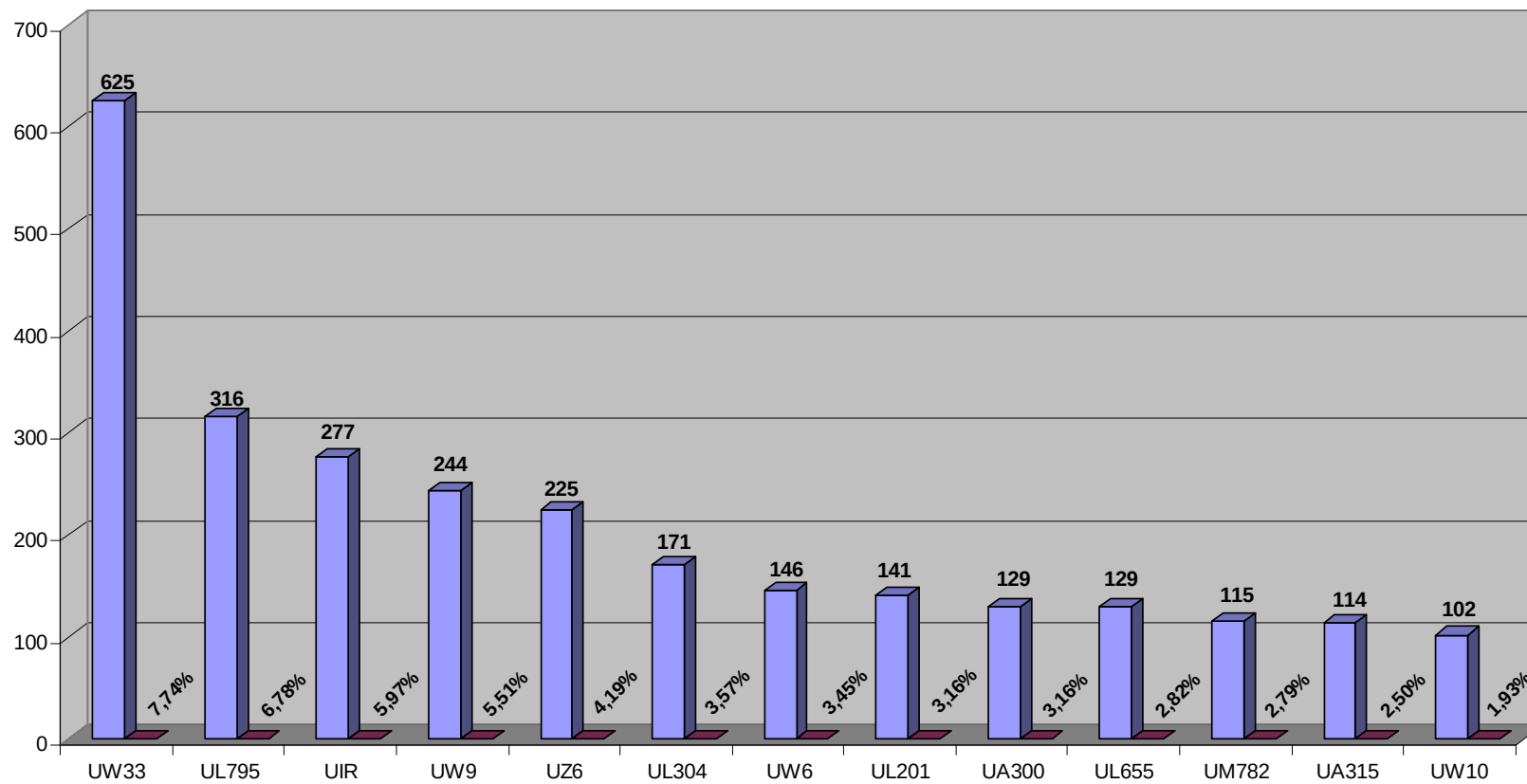
9. Implementation decision	Start	End	Responsible party	Remarks
9.3 Analyze the results of the safety assessment	July/2010	N/A	States	
9.4 Publish trigger NOTAM	Nov/2010	N/A	States	

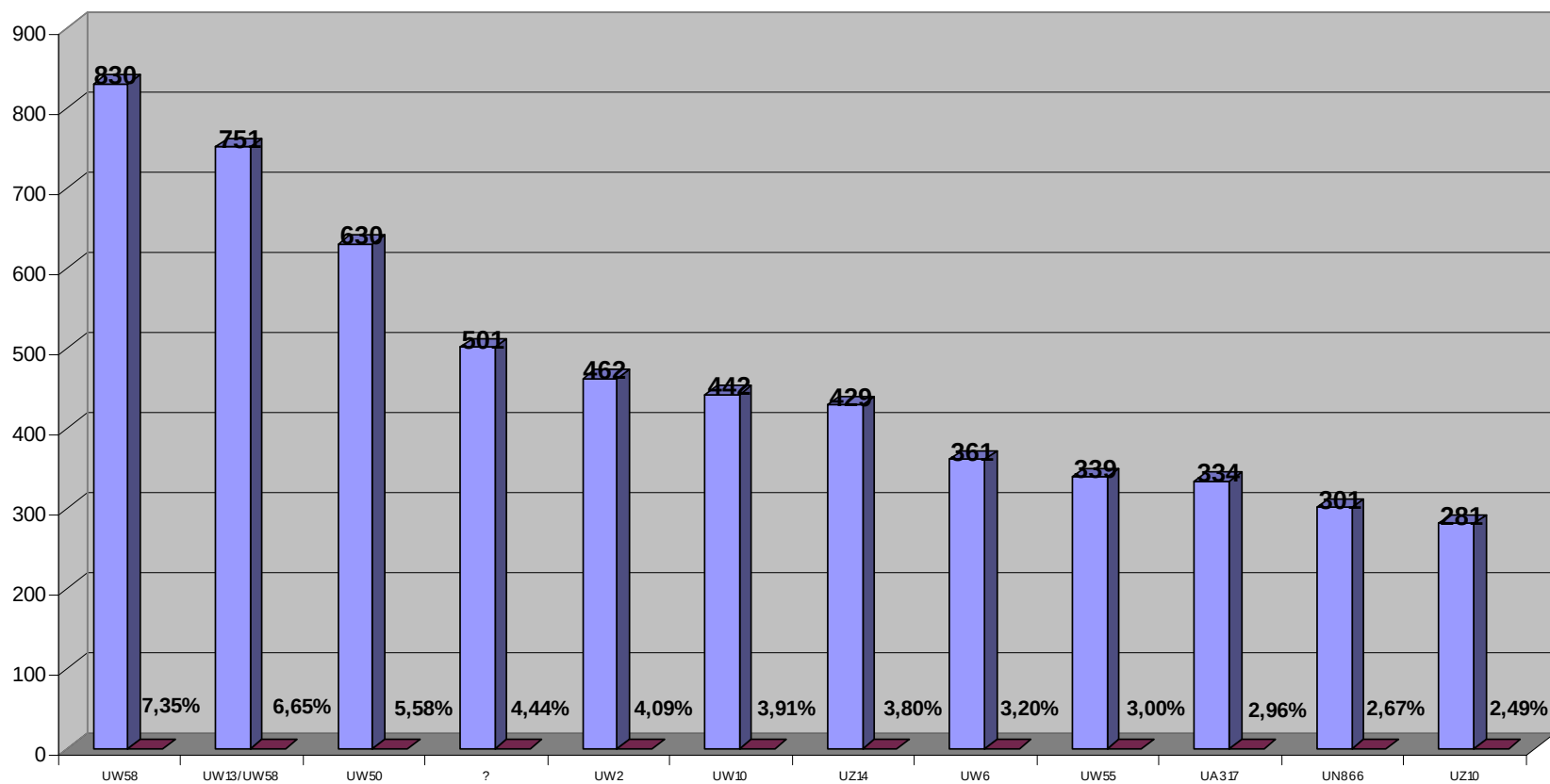
10. Performance monitoring system	Start	End	Responsible party	Remarks
10.1 Develop a post-implementation en-route operations monitoring programme	SAM/IG/4	SAM/IG/5	SAM/PBN/IG (Project RLA/06/901)	
10.2 Implement a post-implementation en-route operations monitoring programme	Nov/2010	Nov/2011	States	
Pre-operational implementation date	Nov/2010	N/A		
Definitive implementation date	Nov/2011	N/A		

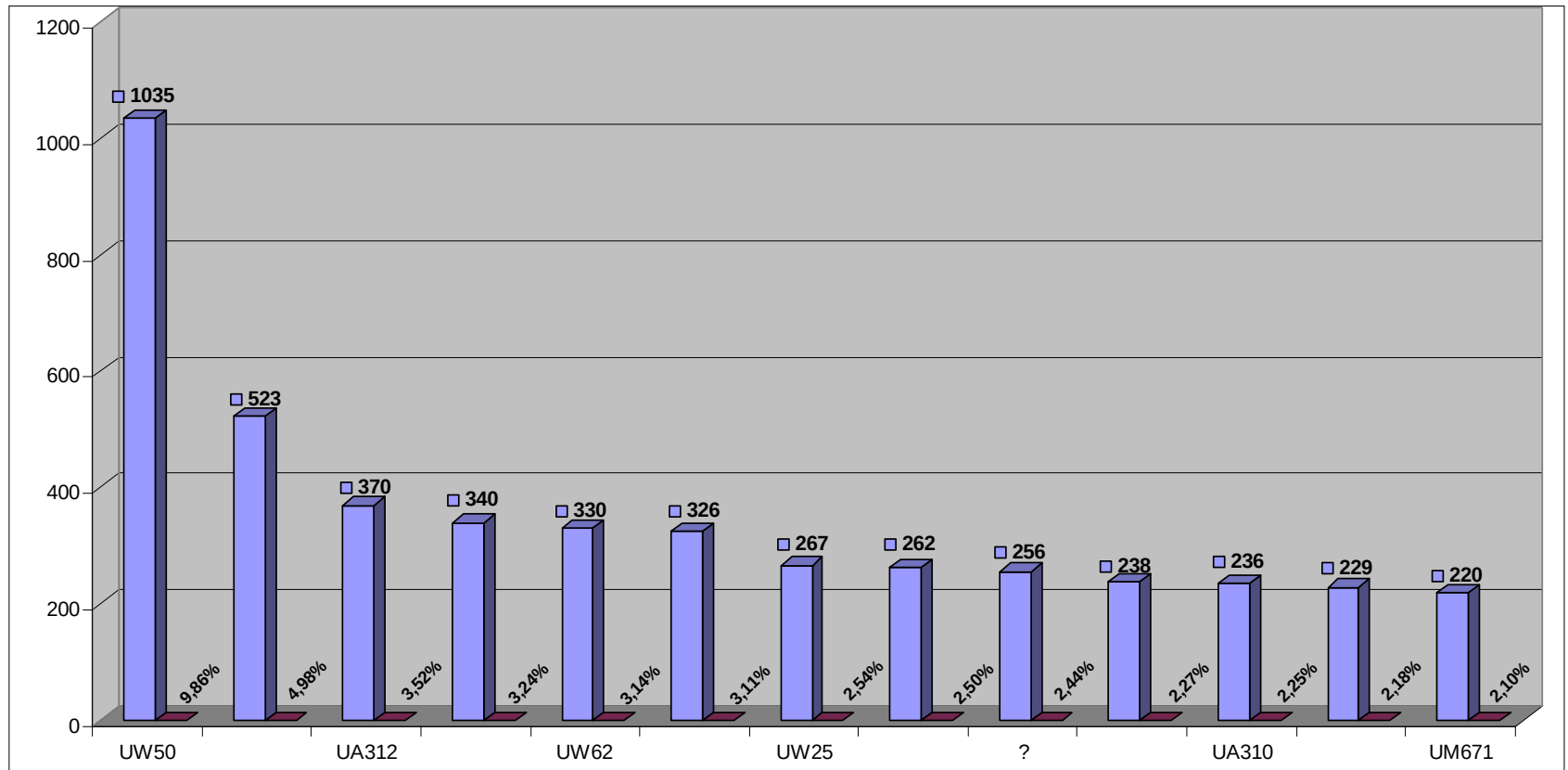
ADJUNTO 2 AL APÉNDICE B / ATTACHMENT 2 TO APPENDIX B**ATS ROUTES – SAM REGION / RUTAS ATS - REGIÓN SAM****ARGENTINA****FIR COMODORO RIVADAVIA - RUTAS ATS**
96% del tránsito de la muestra

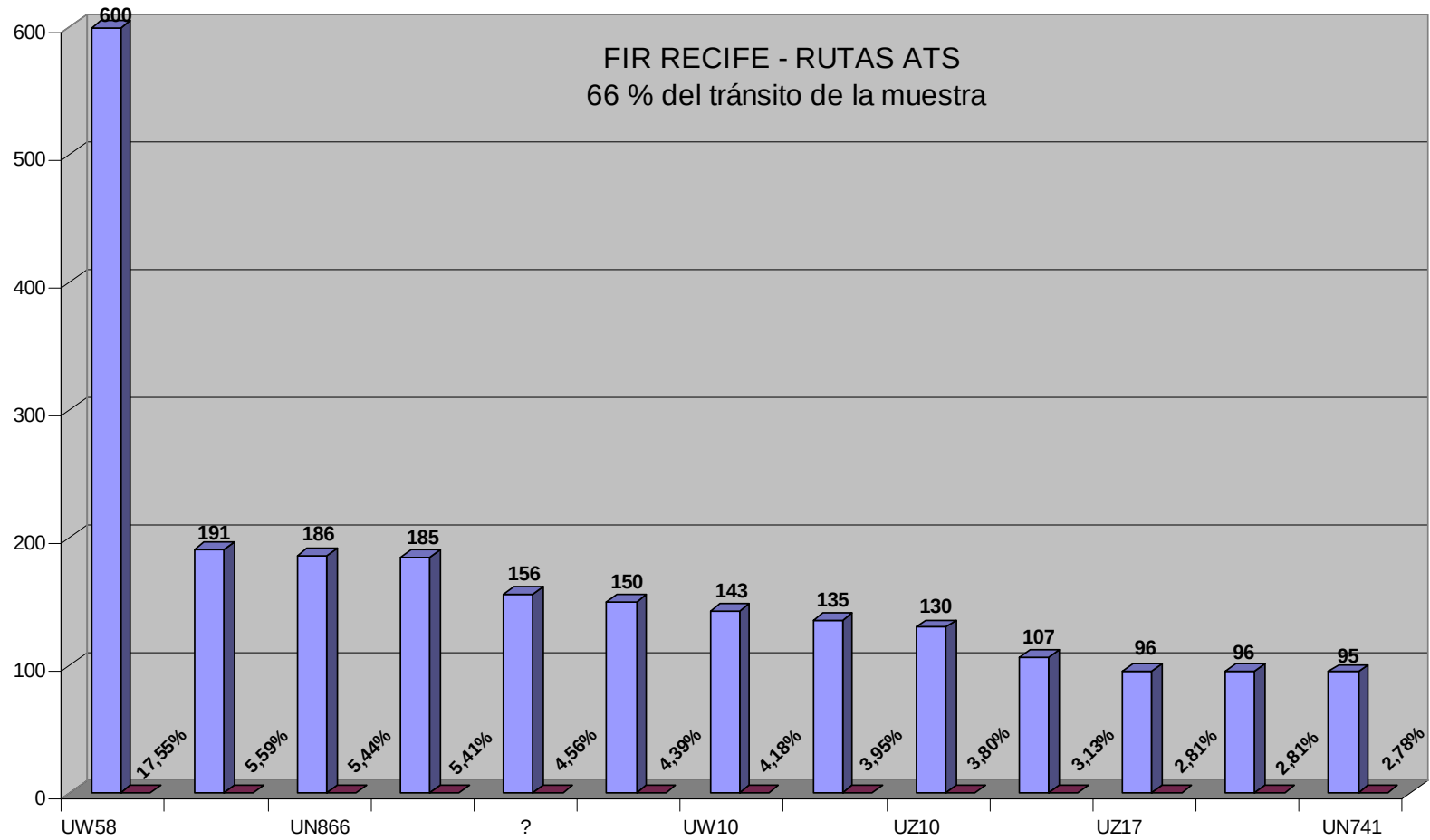
FIR CORDOBA - RUTAS ATS
92% del tránsito de la muestra

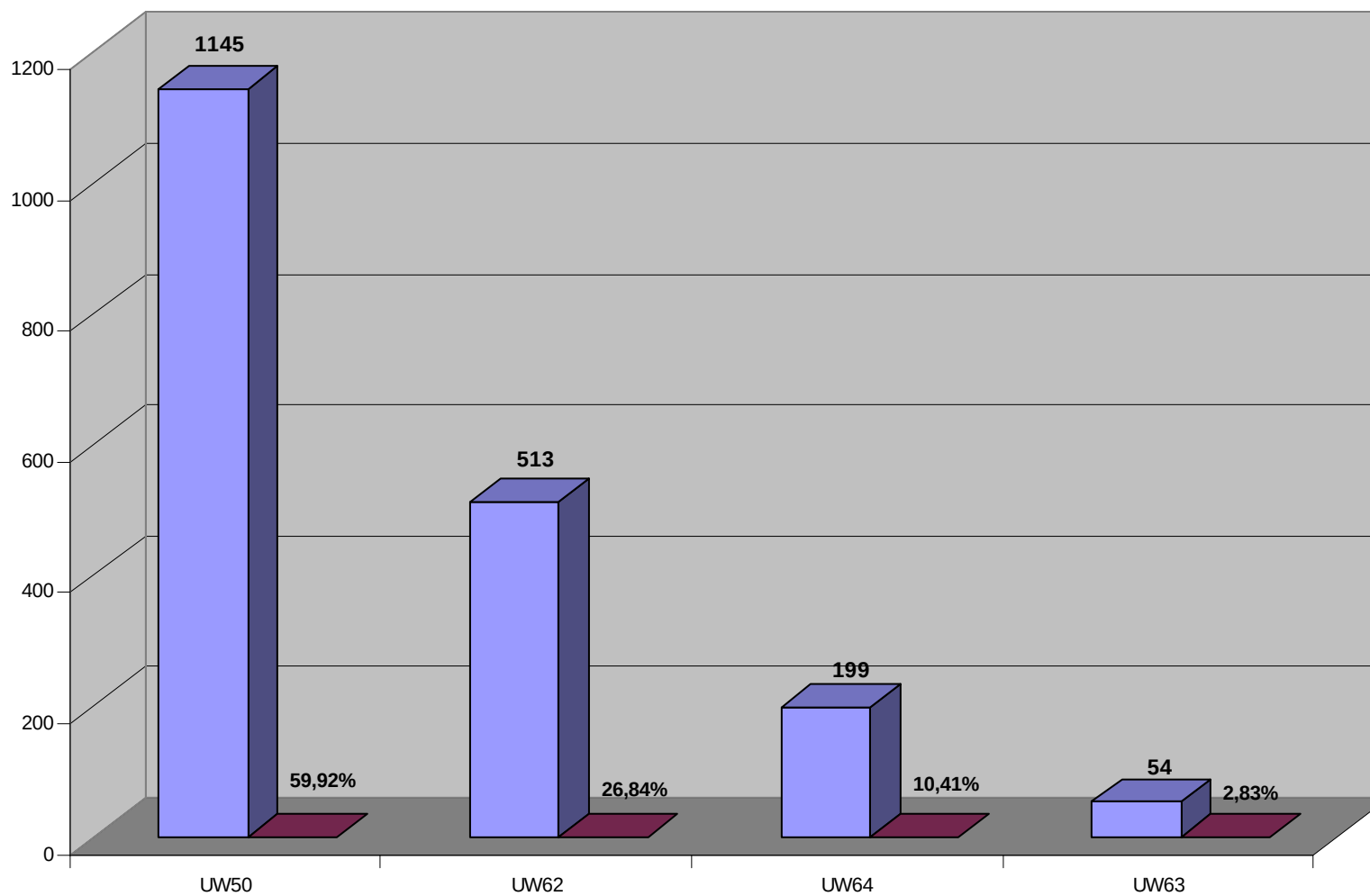
BOLIVIA**FIR LA PAZ - RUTAS ATS**
97% del tránsito de la muestra

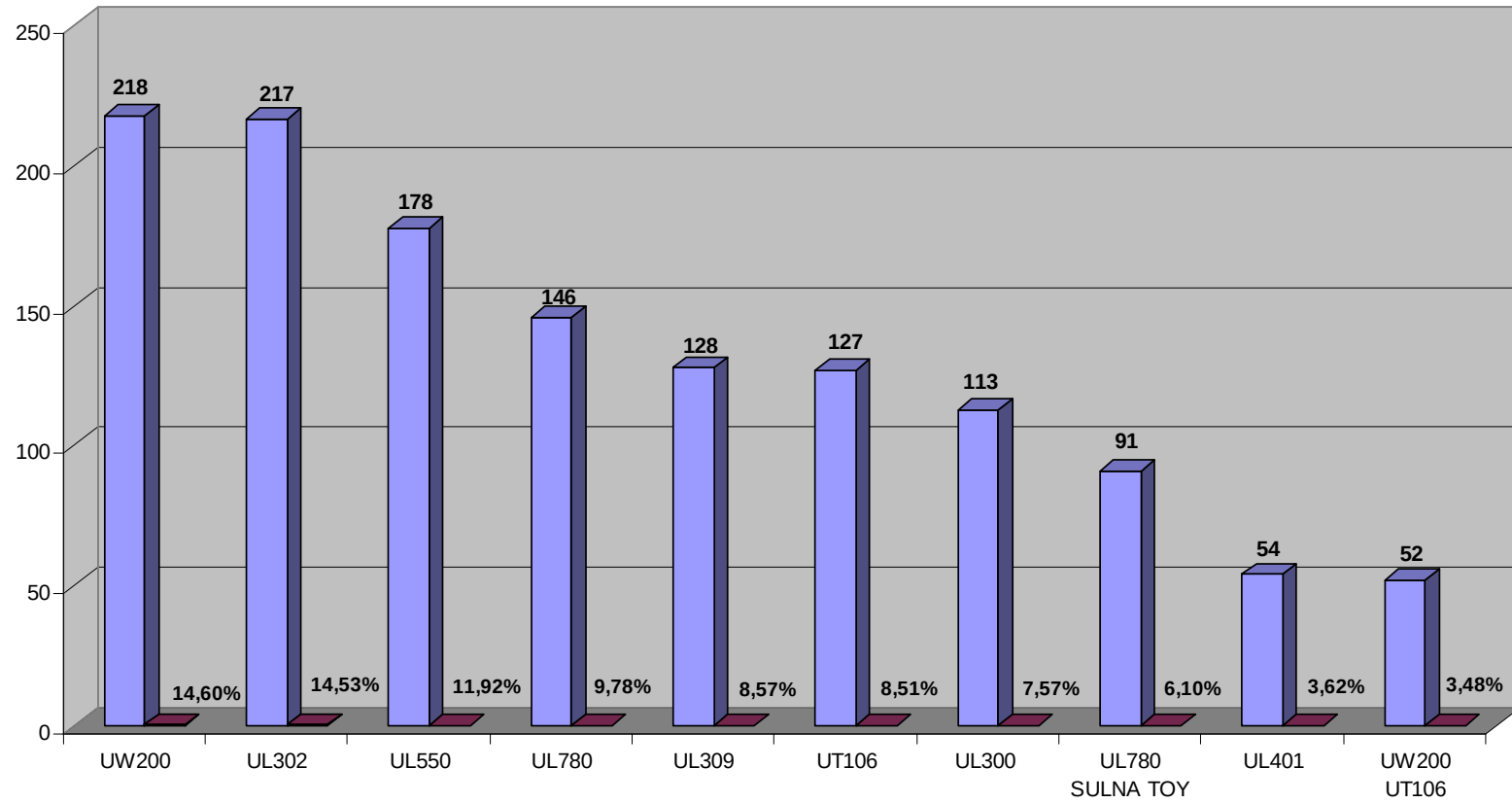
BRAZIL / BRASIL**FIR Amazónica - RUTAS ATS**
67 % del tránsito de la muestra

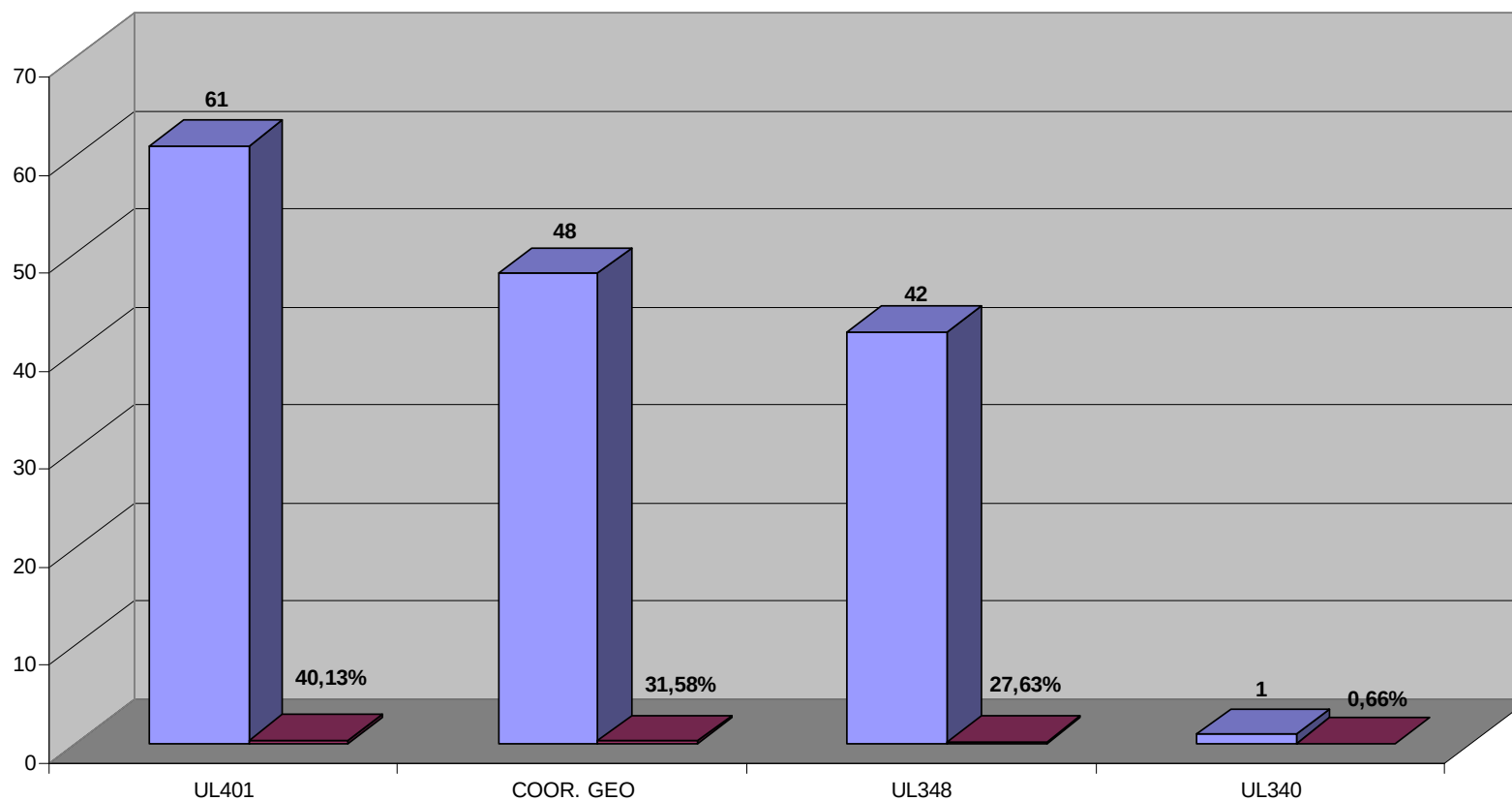
FIR BRASÍLIA - RUTAS ATS
50% del tránsito de la muestra

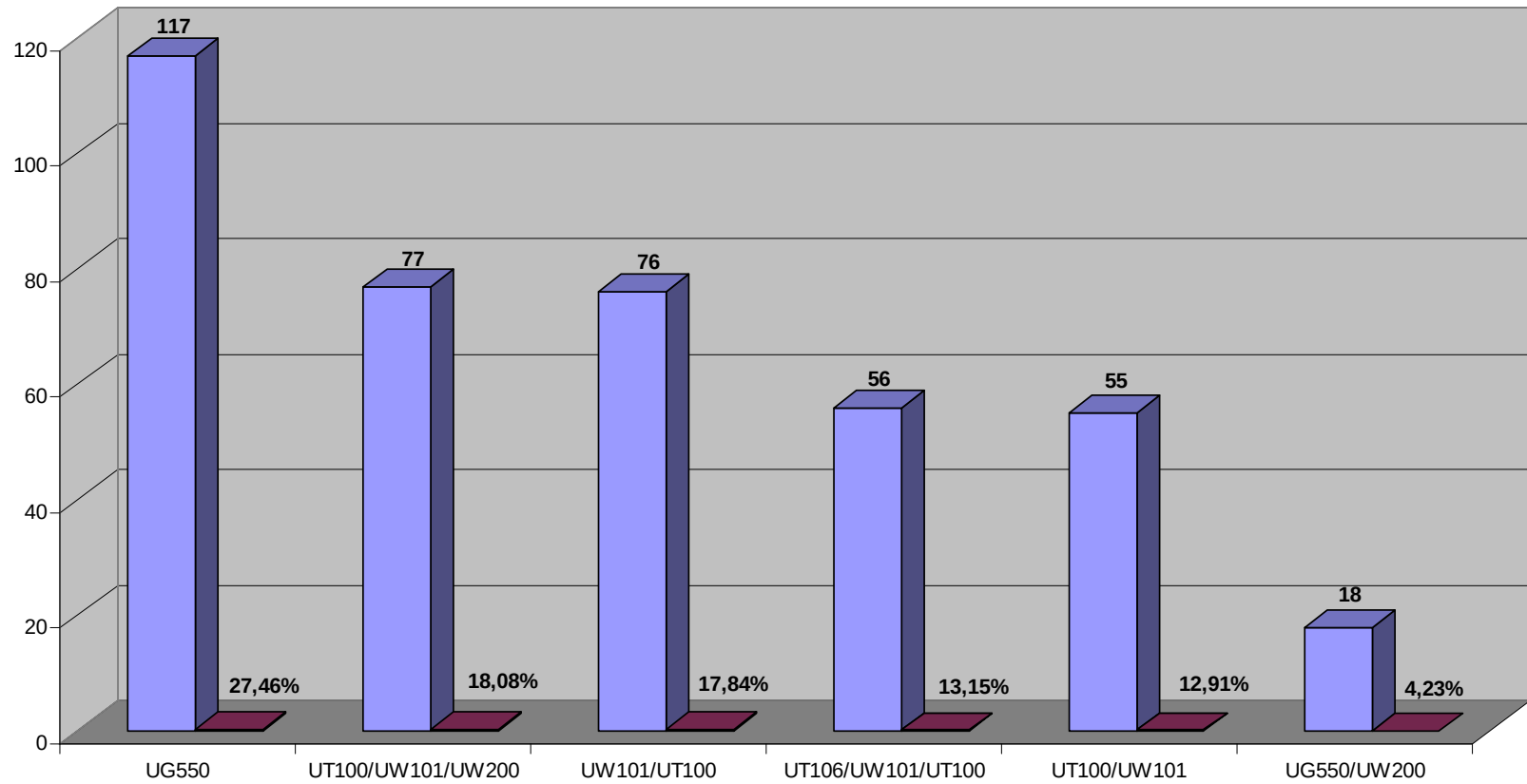
FIR CURITIBA - RUTA ATS
44% del tránsito de la muestra

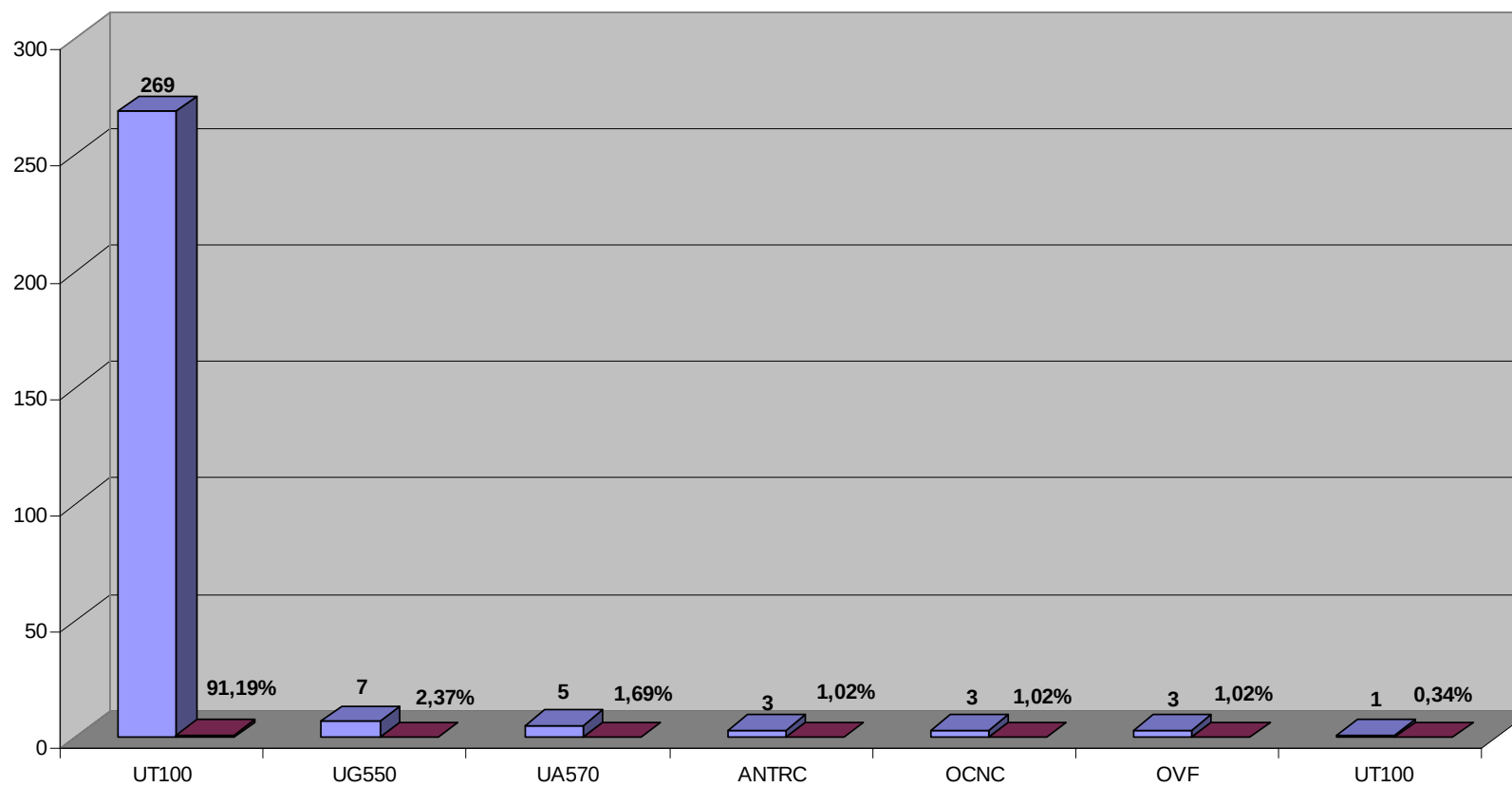


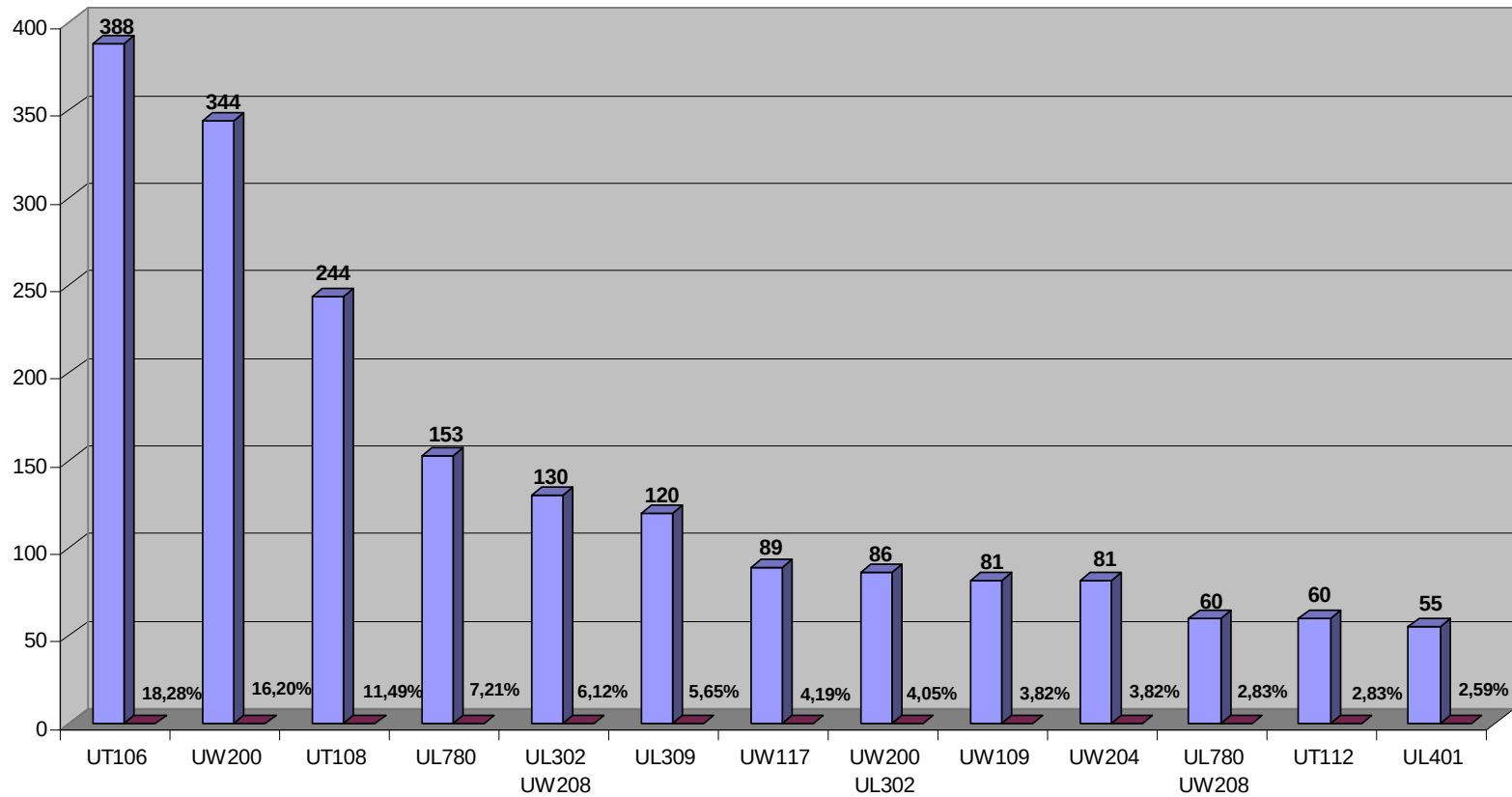
TMA SÃO PAULO - RUTAS ATS
100% del tránsito de la muestra

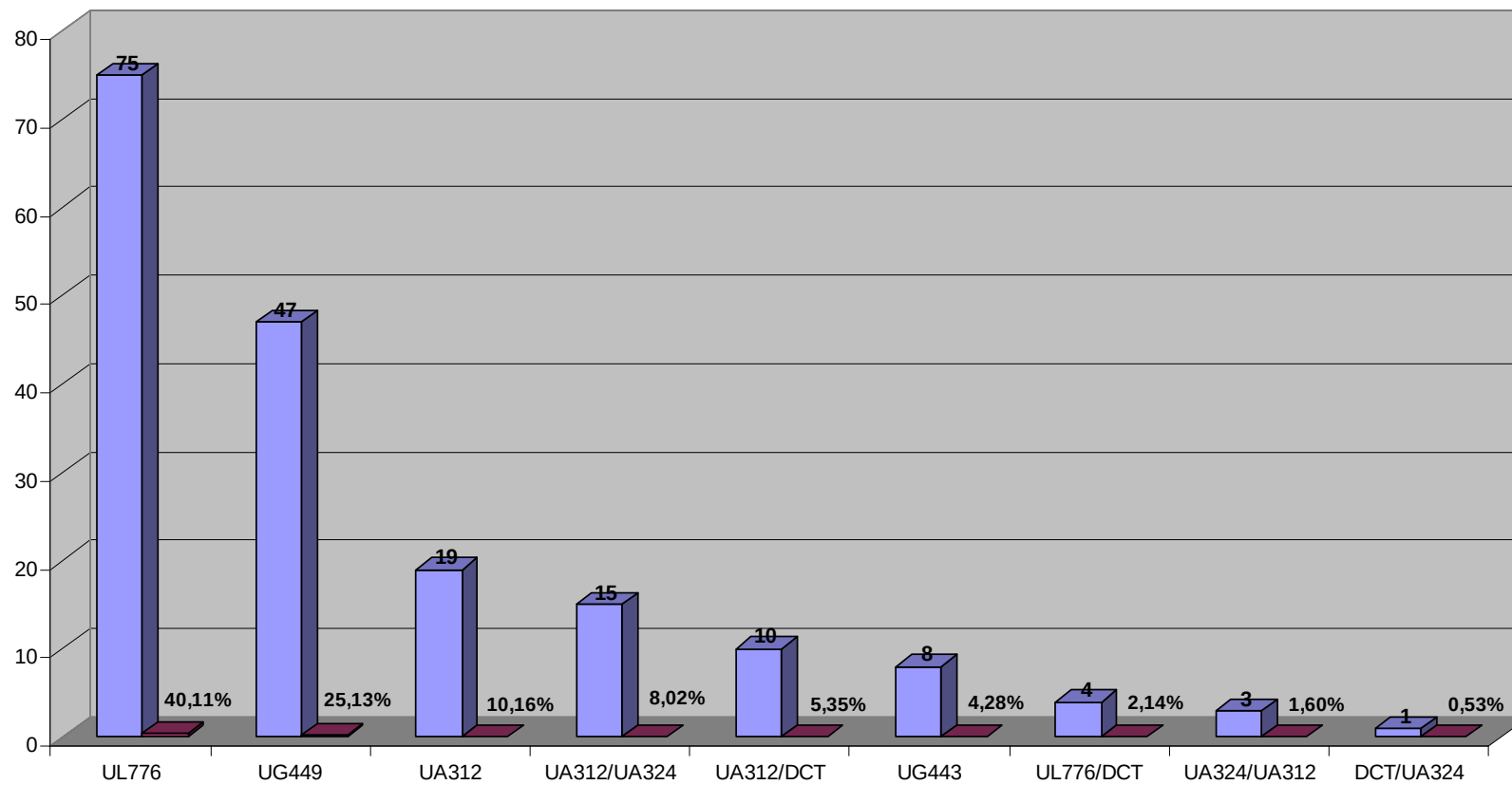
CHILE**FIR ANTOFOGASTA - RUTAS ATS**
89% del tránsito de la muestra

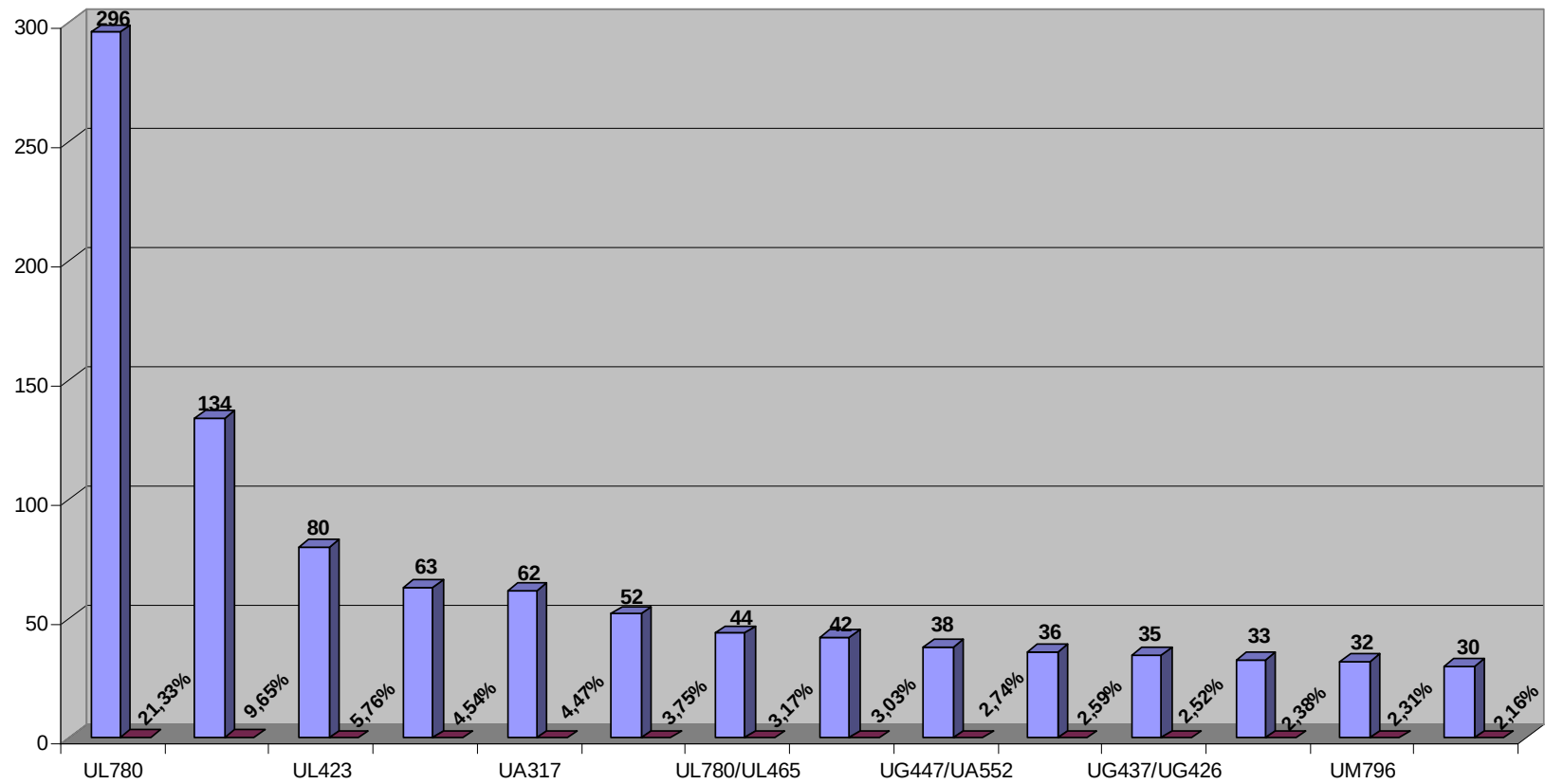
FIR PASCUA - RUTAS ATS
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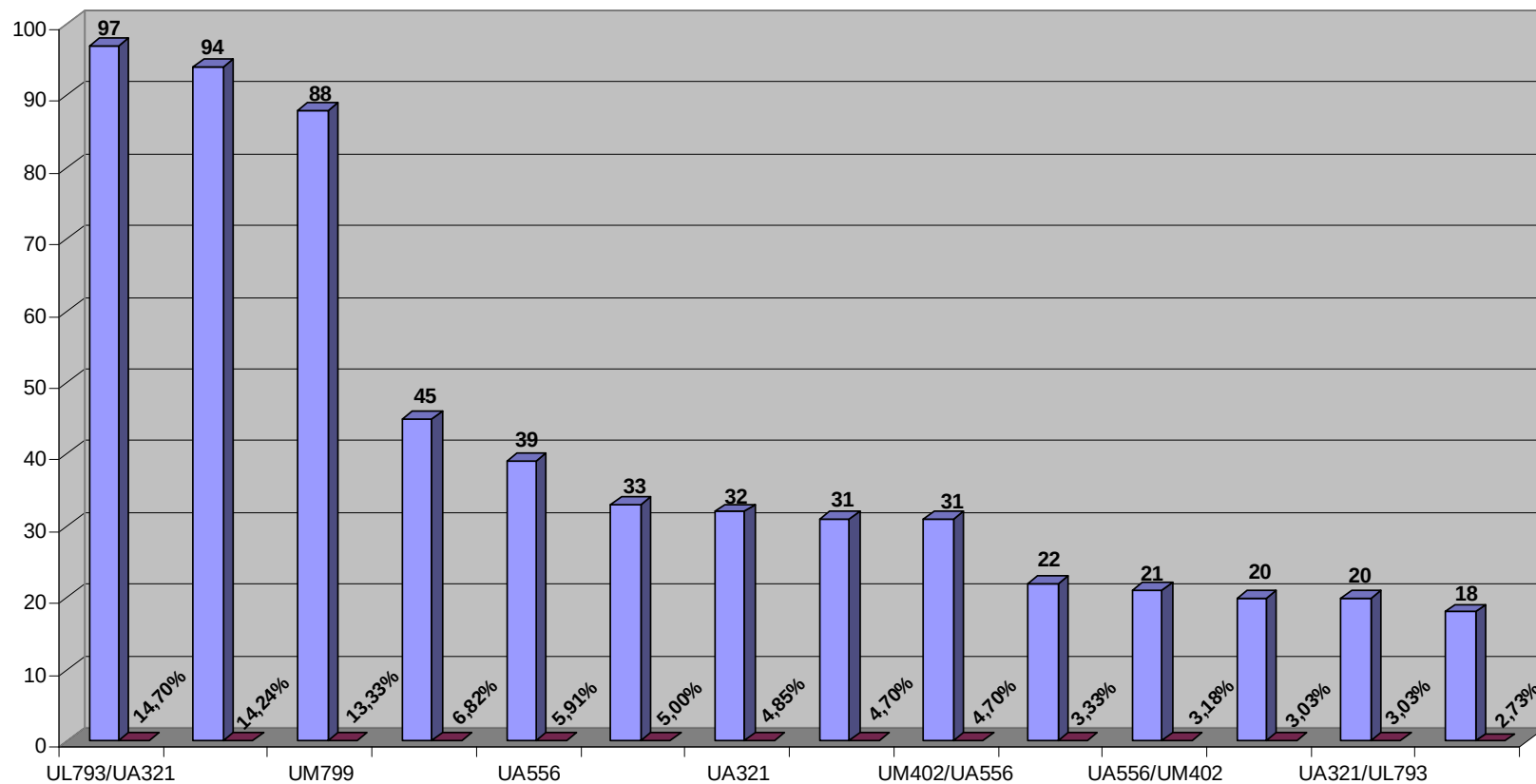
FIR PUERTO MONTT - RUTAS ATS
94% del tránsito de la muestra

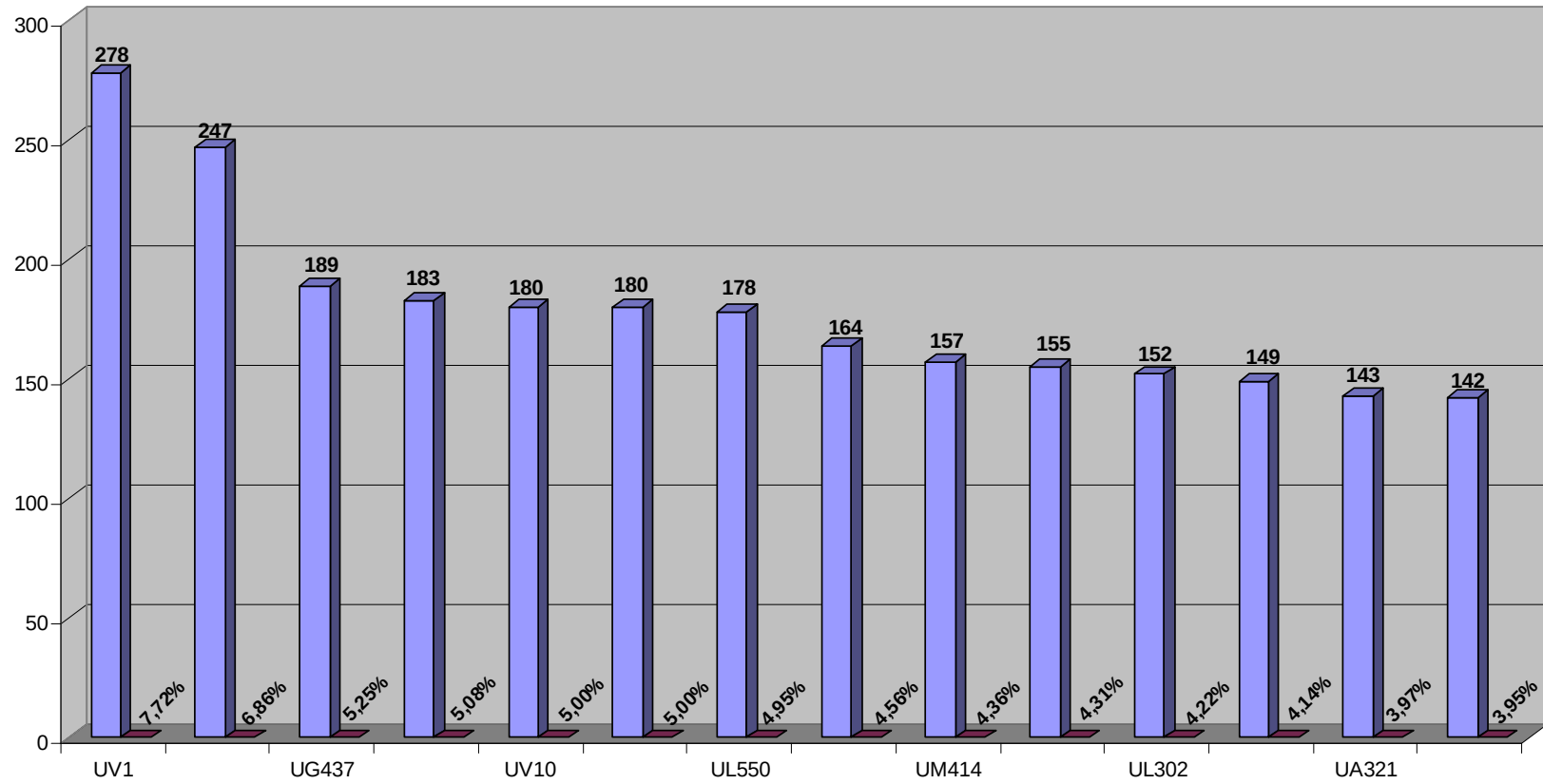
FIR PUNTA ARENAS - RUTAS ATS
98% del tránsito de la muestra

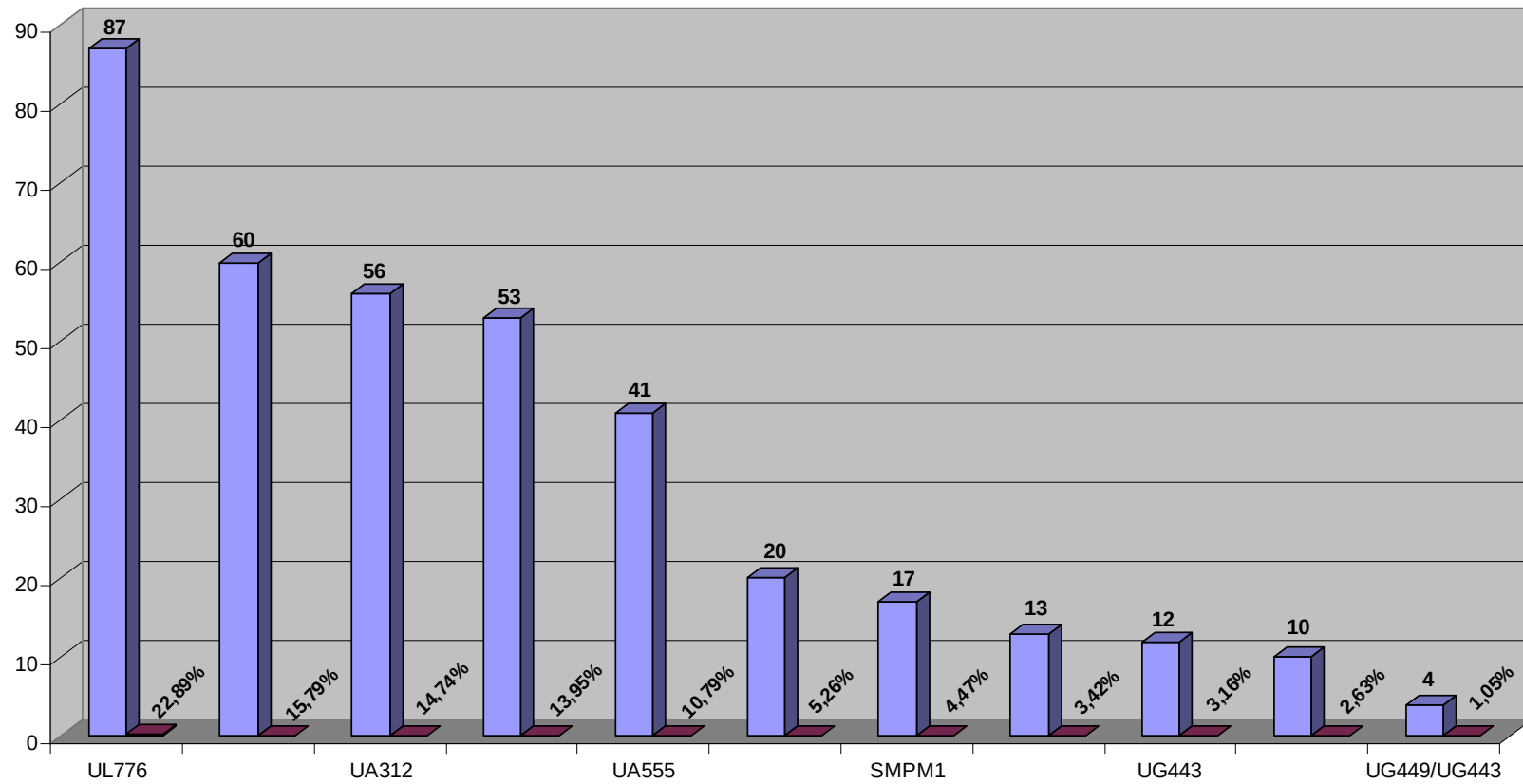
FIR SANTIAGO - RUTAS ATS
89% del tránsito de la muestra

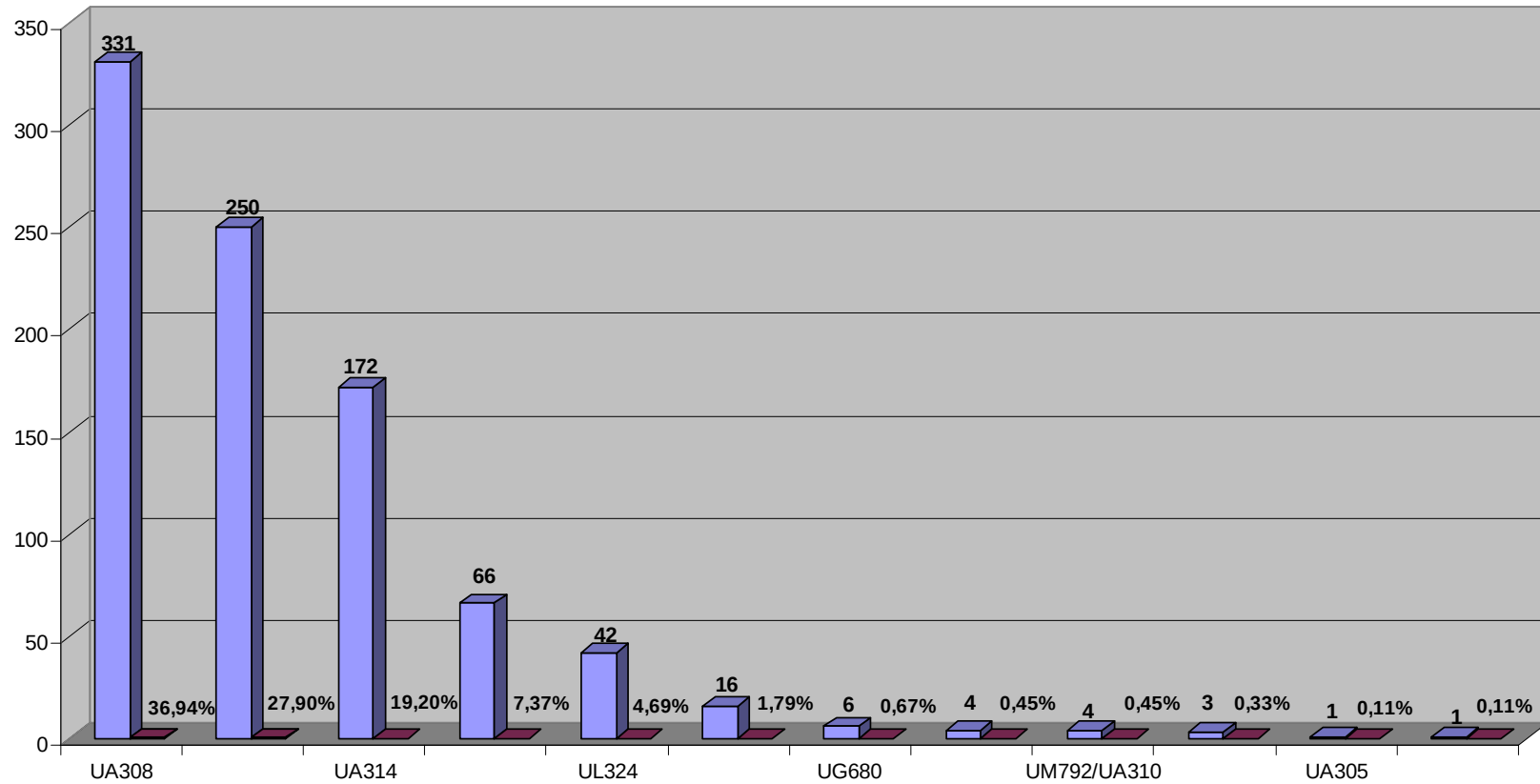
GUYANA**FIR GEORGETOWN - RUTAS ATS**
97% del tránsito de la muestra

PANAMA**FIR PANAMA - RUTAS ATS**
70% del tránsito de la muestra

PARAGUAY**FIR ASUNCIÓN - RUTAS ATS**
90% del tránsito de la muestra

PERU**FIR LIMA - RUTAS ATS**
69% del tránsito de la muestra

SURINAME**FIR PARAMARIBO - ROTAS ATS**
98% del tránsito de la muestra

URUGUAY**FIR MONTEVIDEO - RUTAS ATS
100% del tránsito de la muestra**

ADJUNTO 3 AL APENDICE B / ATTACHMENT 3 TO APPENDIX B

Región SAM Pares de Ciudades

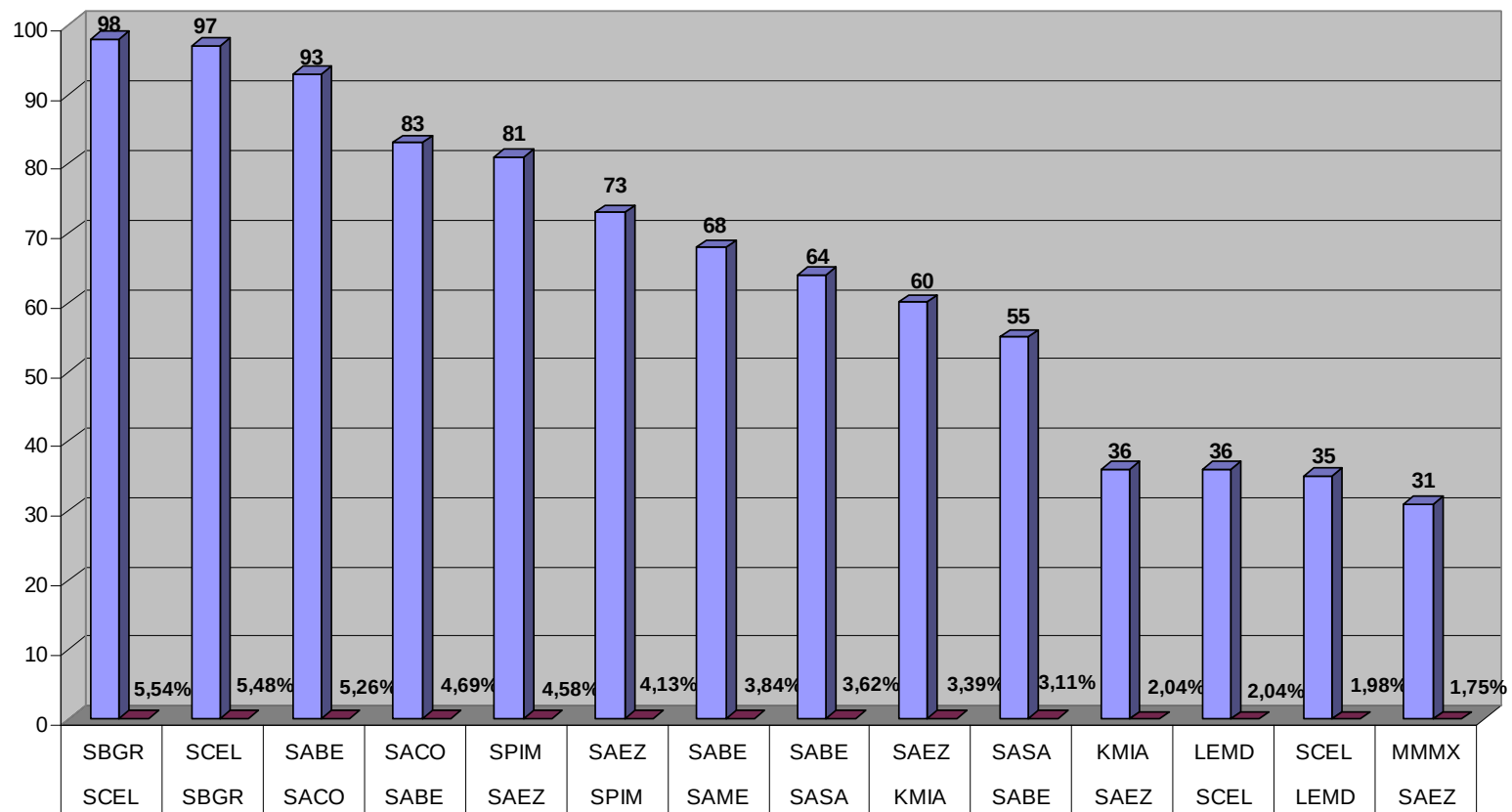
SAM Region Pairs of Cities

ARGENTINA

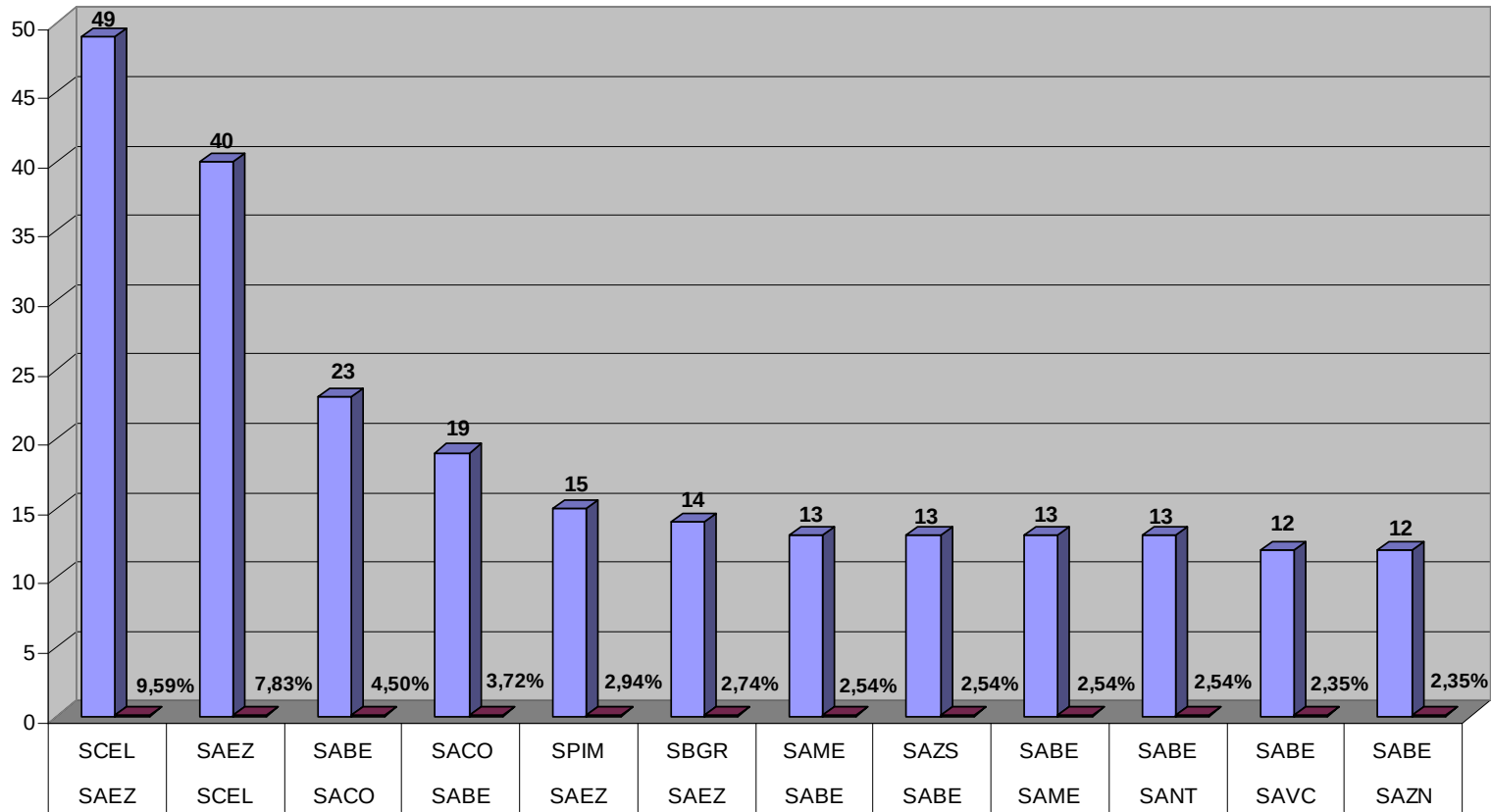
FIR COMODORO RIVADAVIA - Pares de Ciudades
65% del tránsito de la muestra



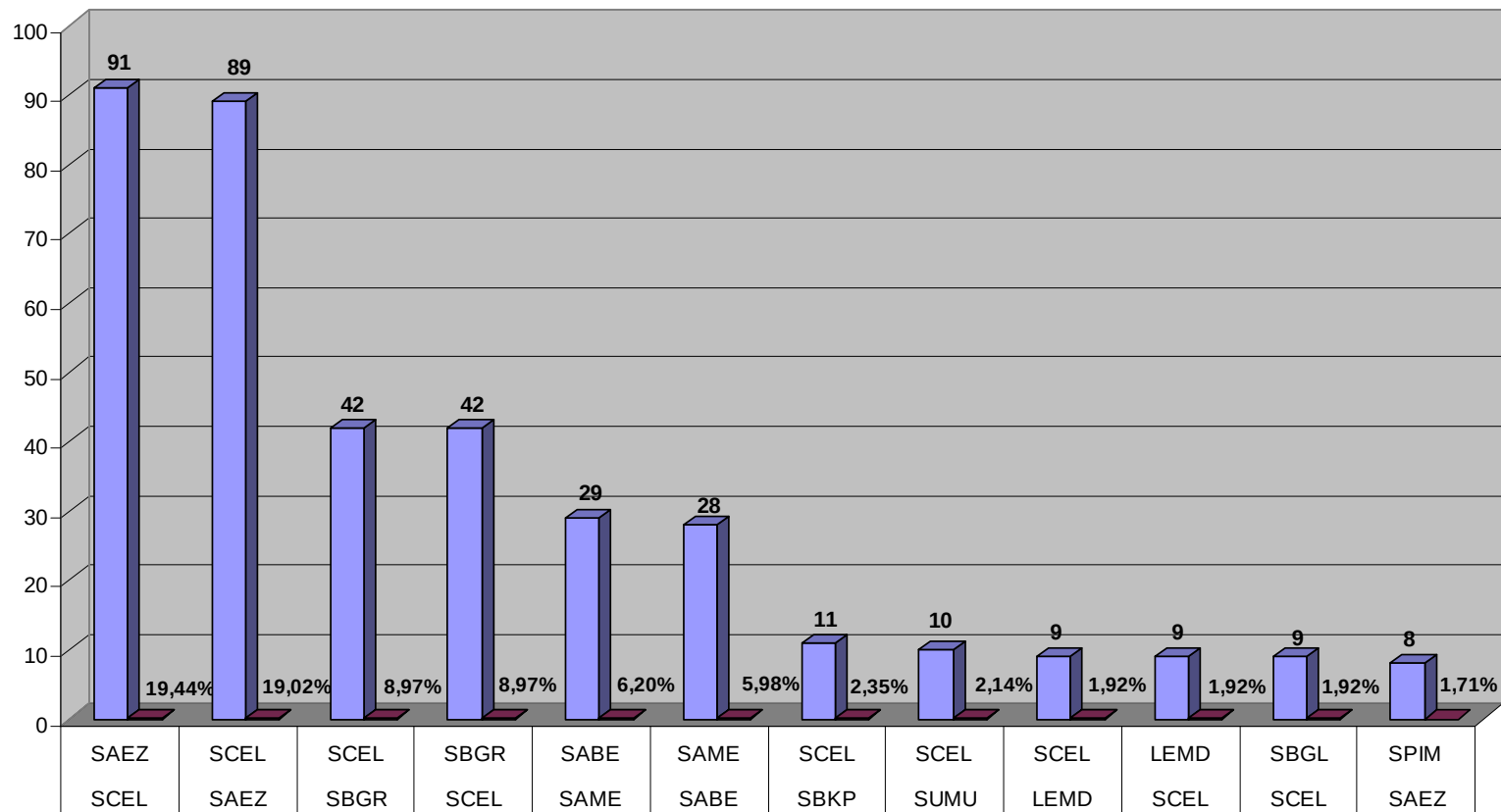
FIR CORDOBA - Pares de Ciudades
51% del tránsito de la muestra



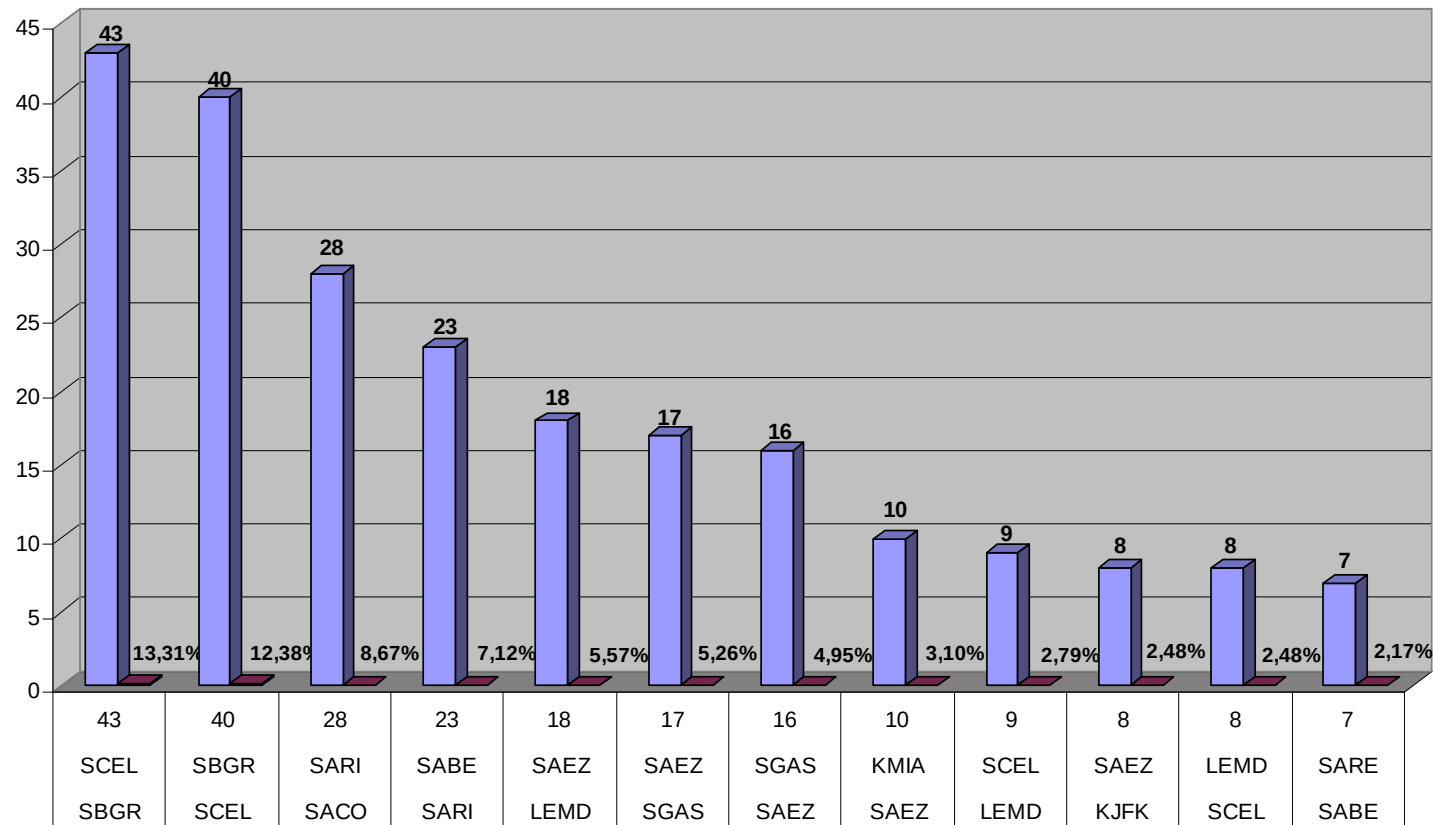
FIR EZEIZA - Pares de Ciudades
46% del tránsito de la muestra



FIR MENDOZA - Pares de Ciudades
80% del tránsito de la muestra

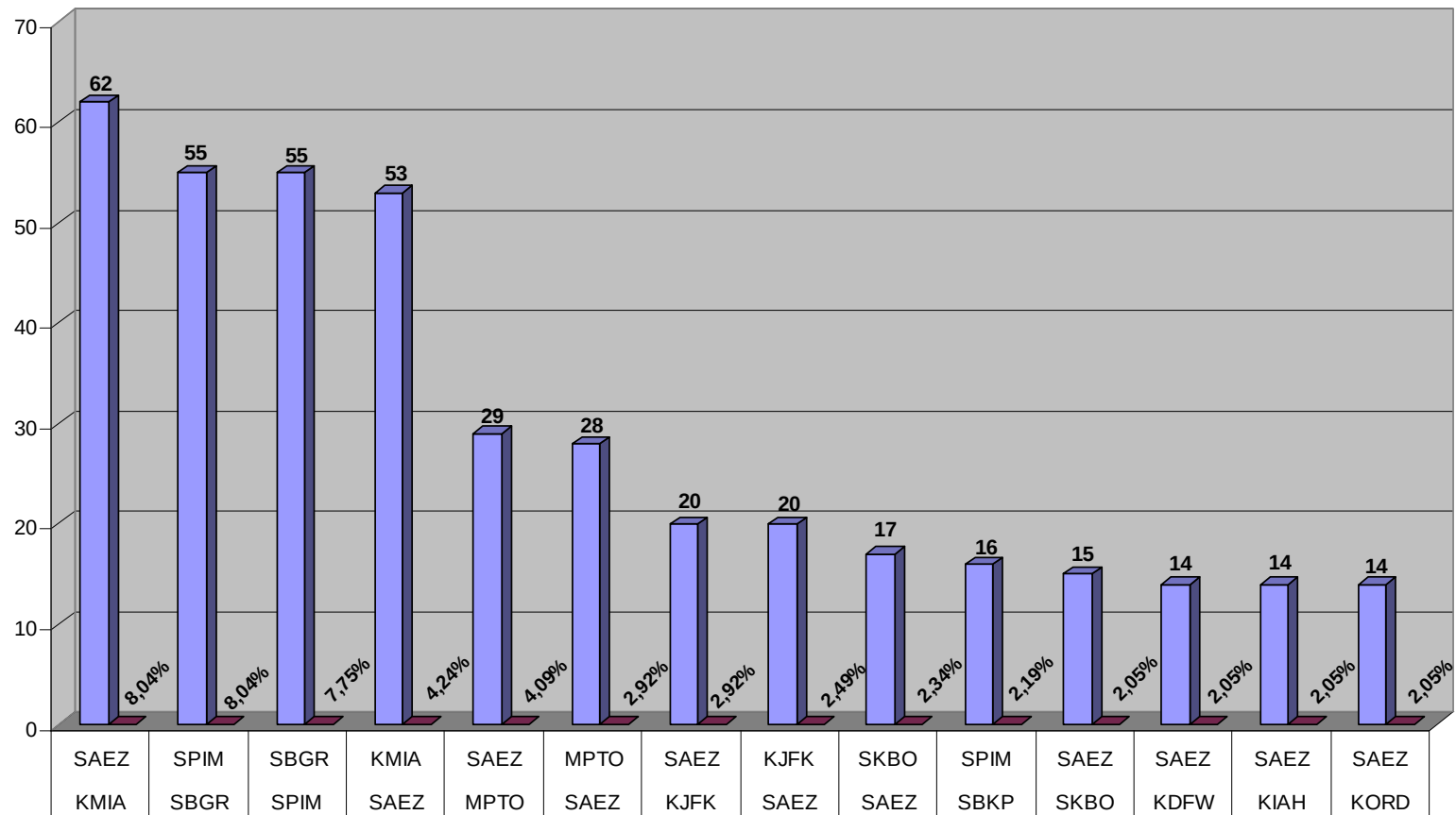


FIR RESISTENCIA - Pares de Ciudades
70% del tránsito de la muestra



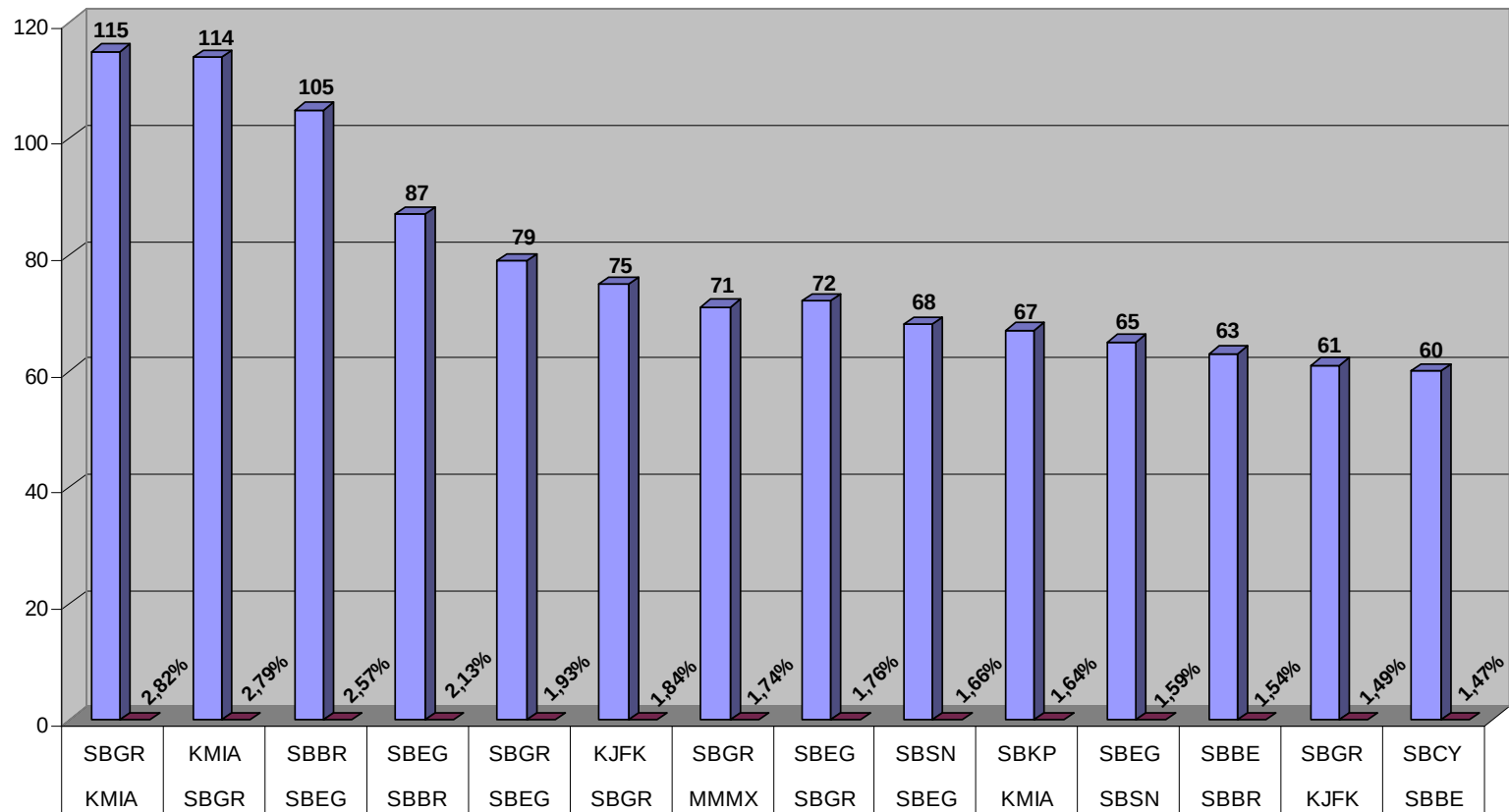
BOLIVIA

FIR LA PAZ - Pares de Ciudades
60% del tránsito de la muestra

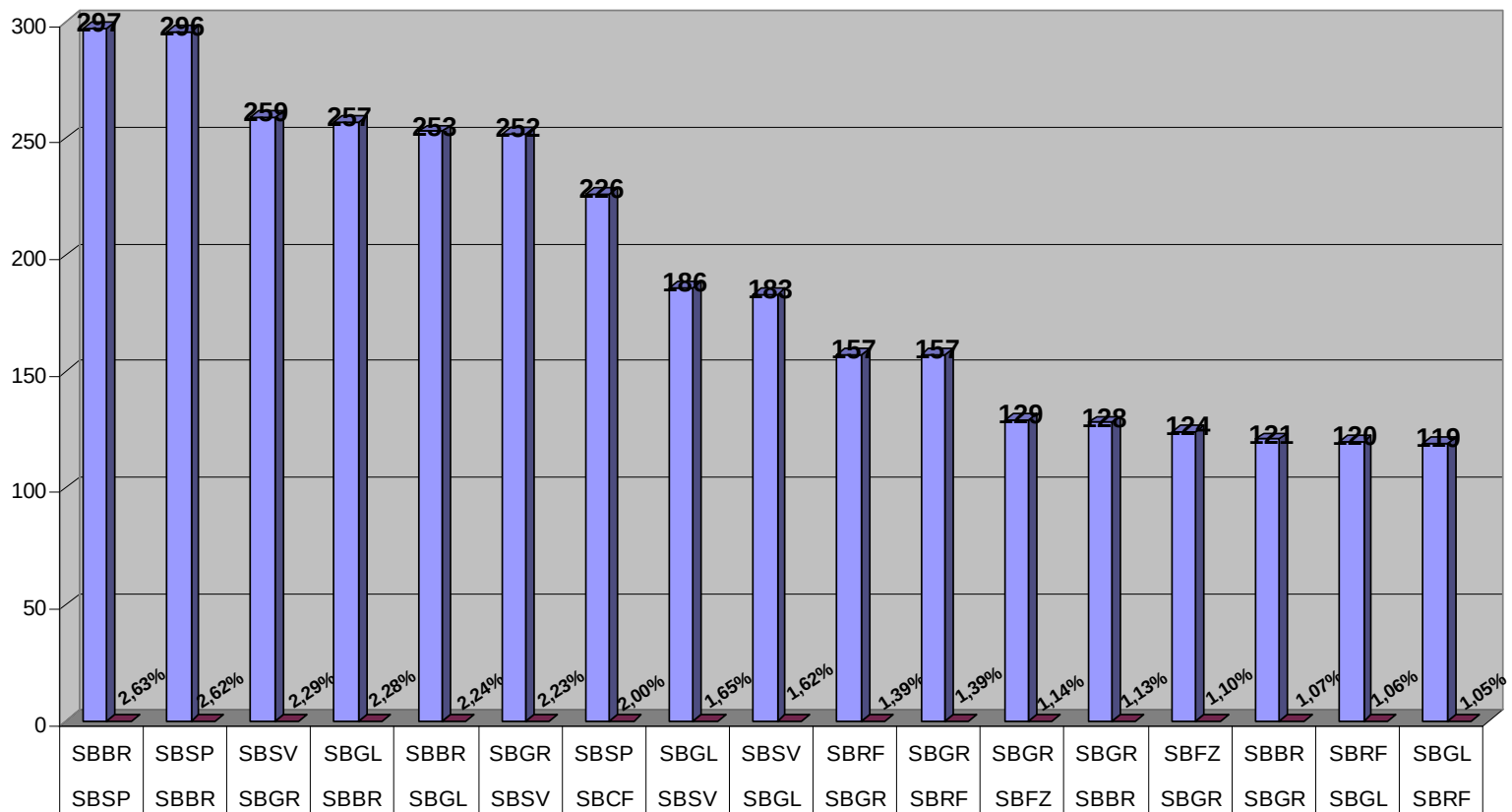


BRAZIL

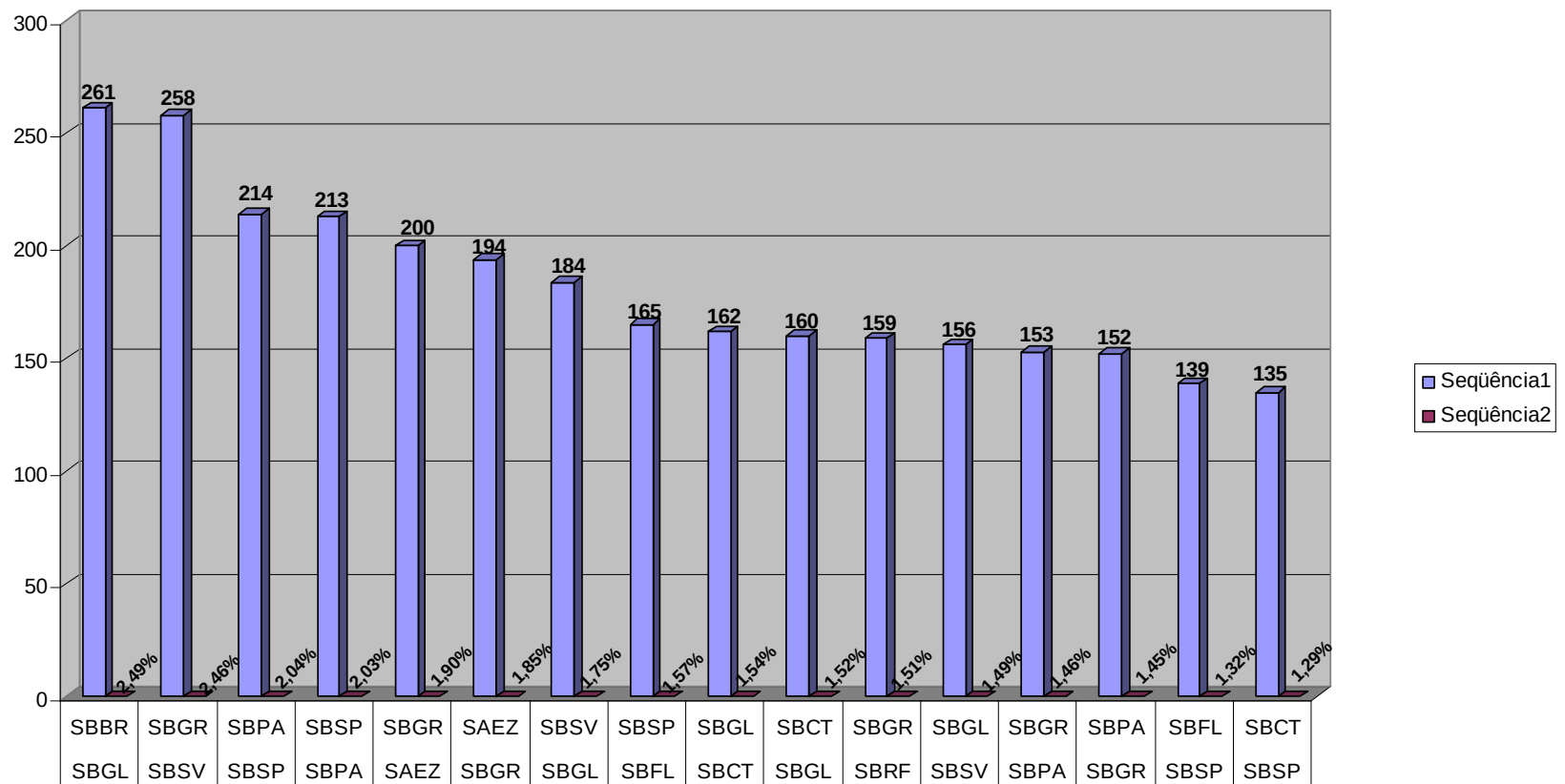
FIR AMAZONICA - Pares de Ciudades
27% del tránsito de la muestra



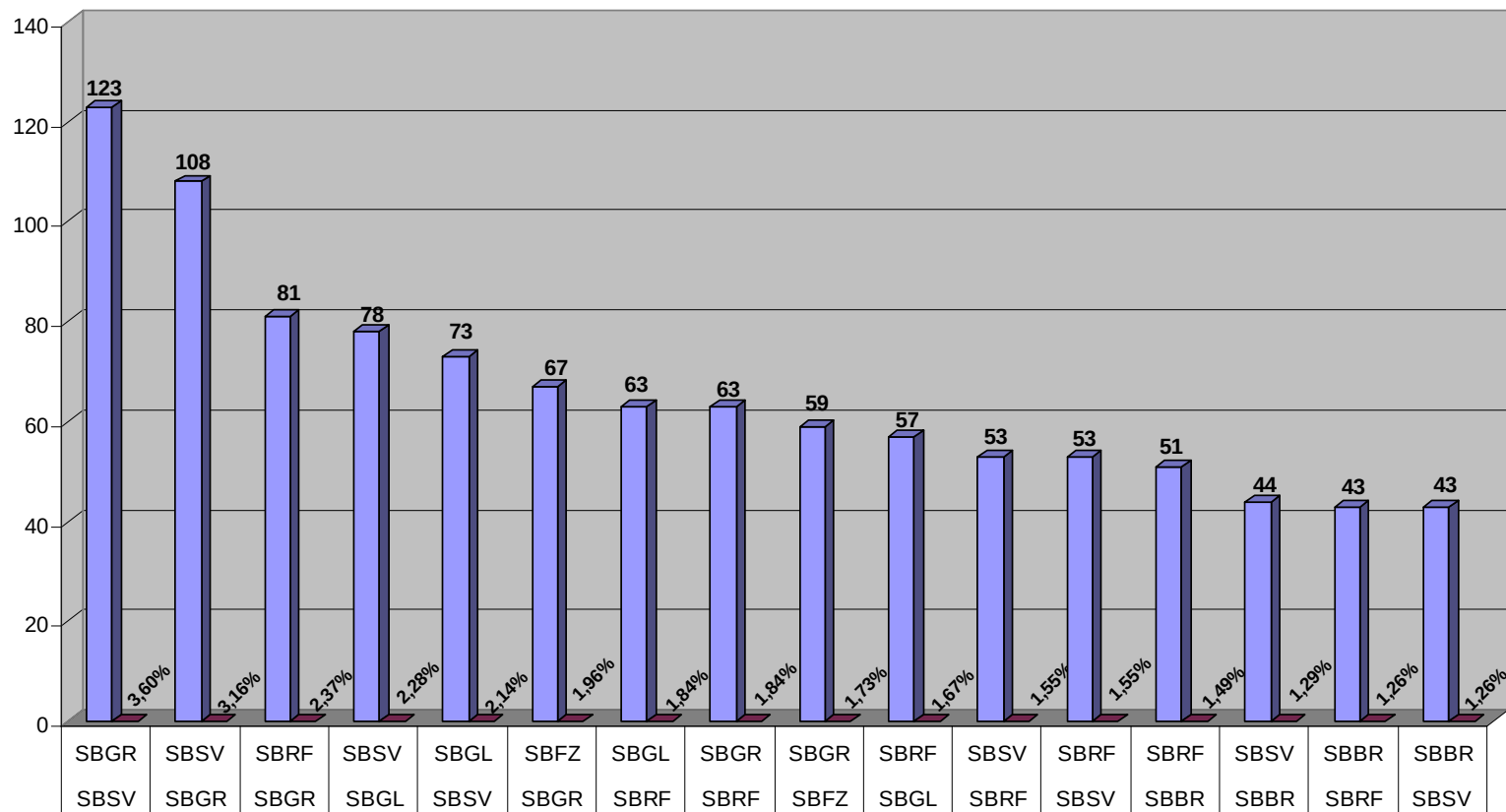
FIR BRASÍLIA - Pares de Ciudades
28% del tránsito de la muestra



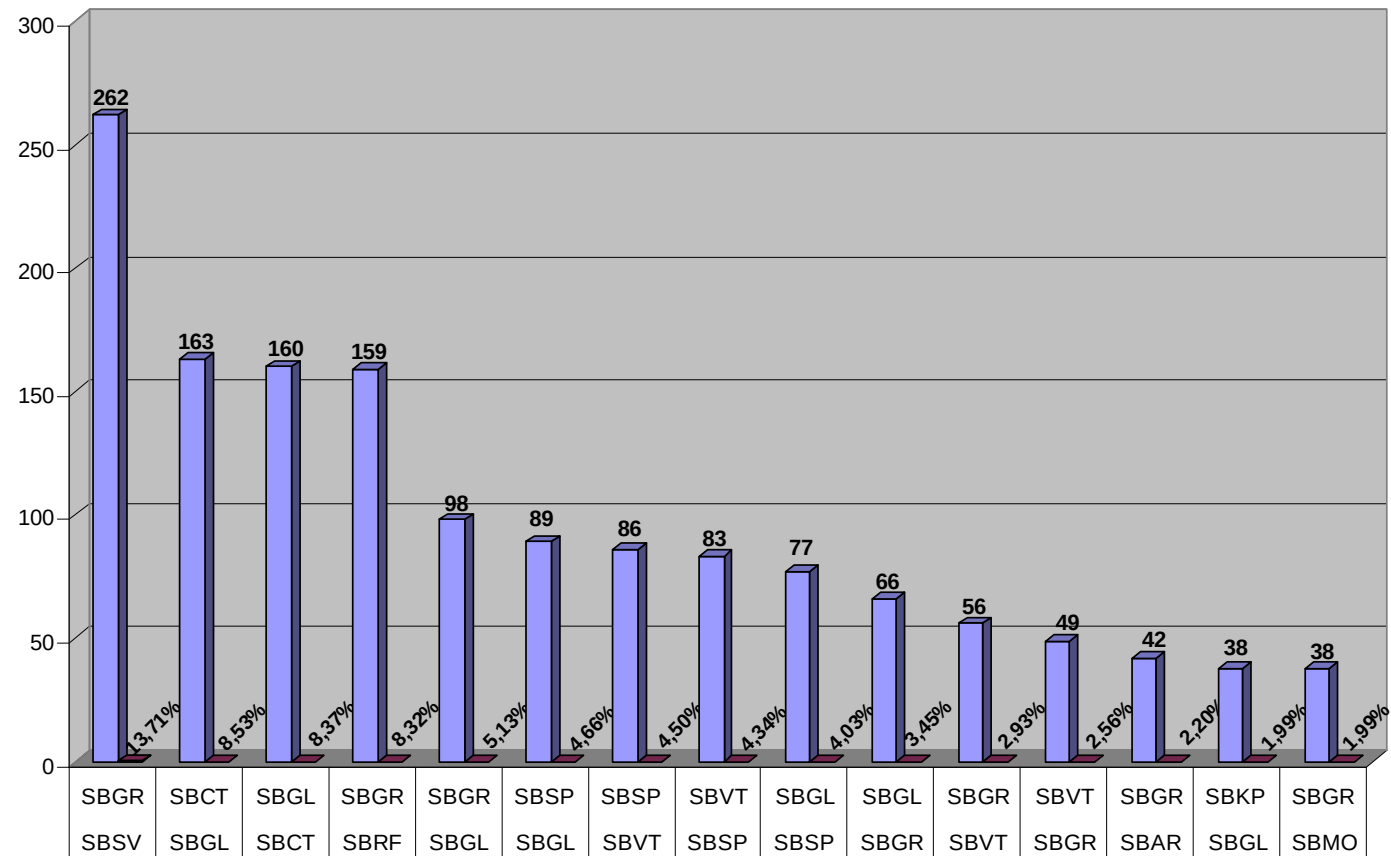
FIR CURITIBA - PARES DE CIUDADES
28% del tránsito de la muestra



FIR RECIFE - Pares de Ciudades
31% del tránsito de la muestra

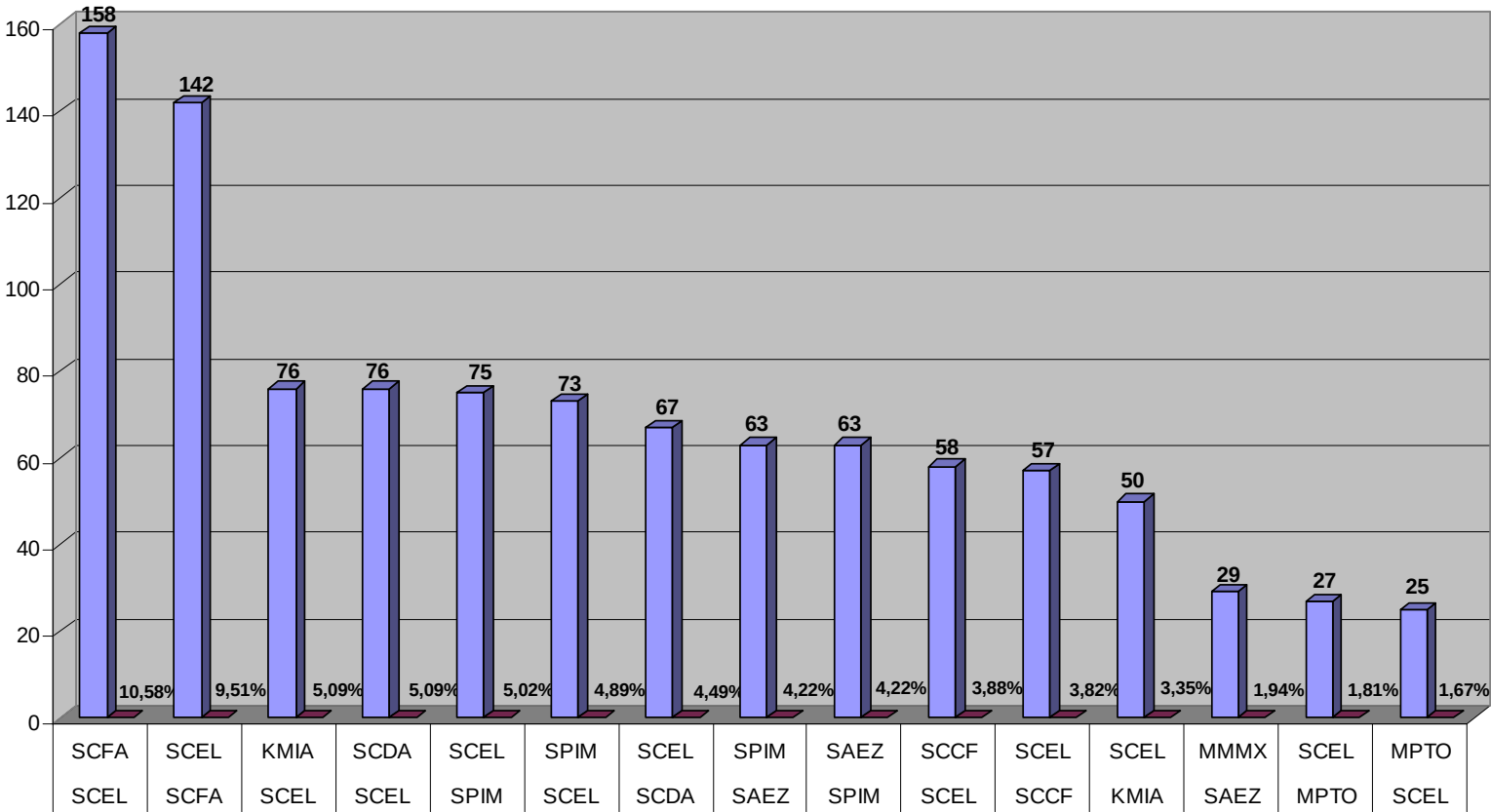


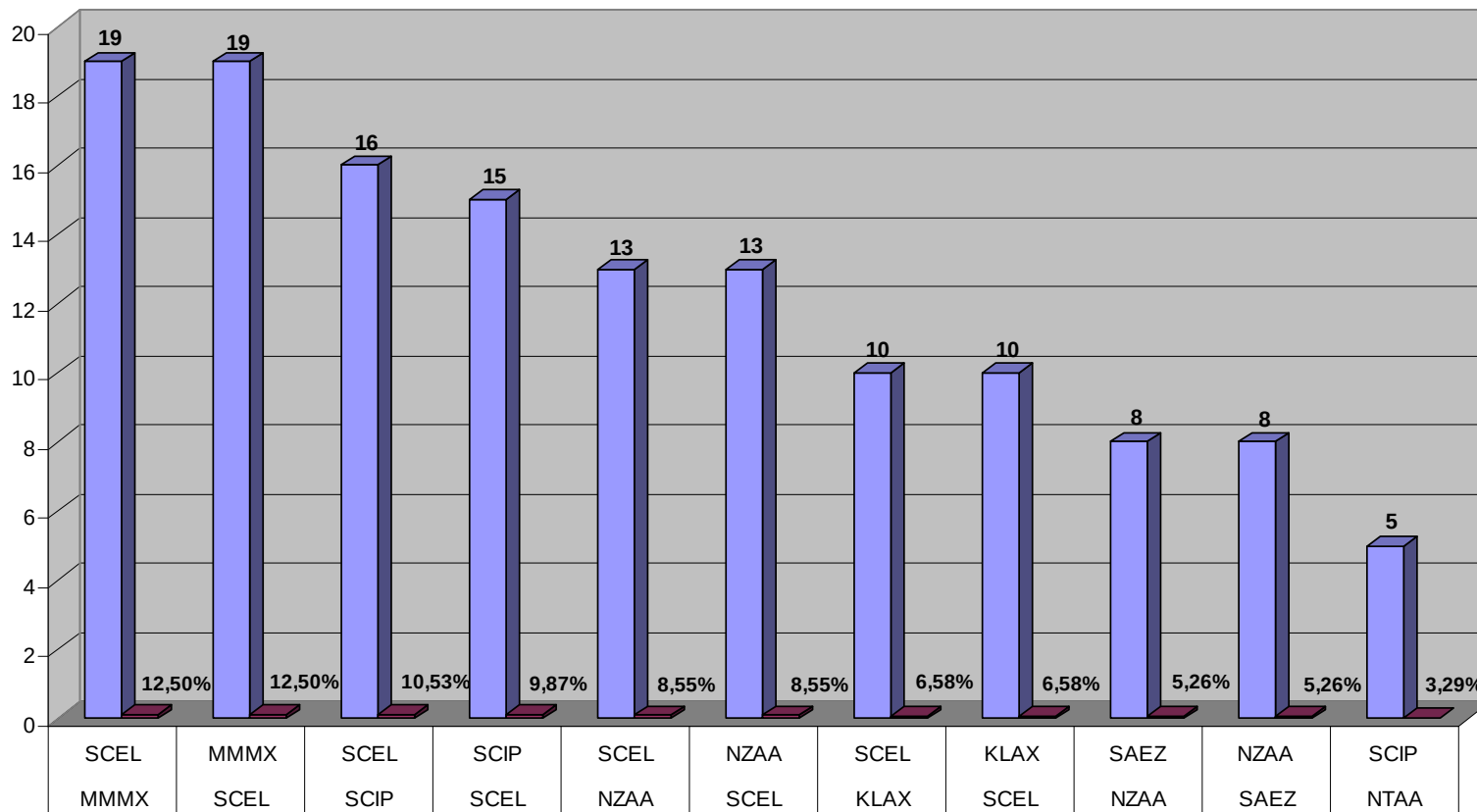
TMA SÃO PAULO - Pares de Ciudades
76% del tránsito de la muestra

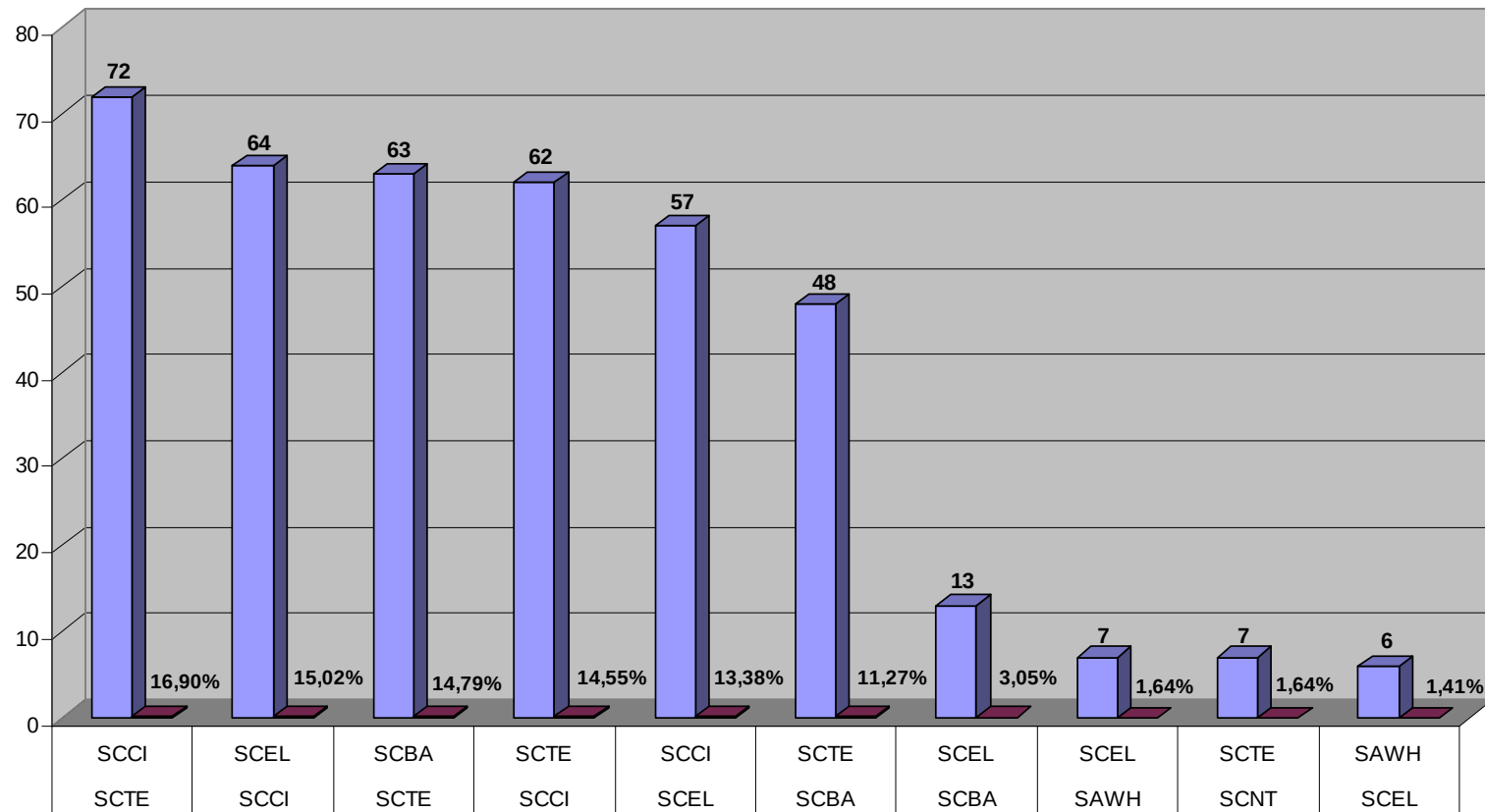


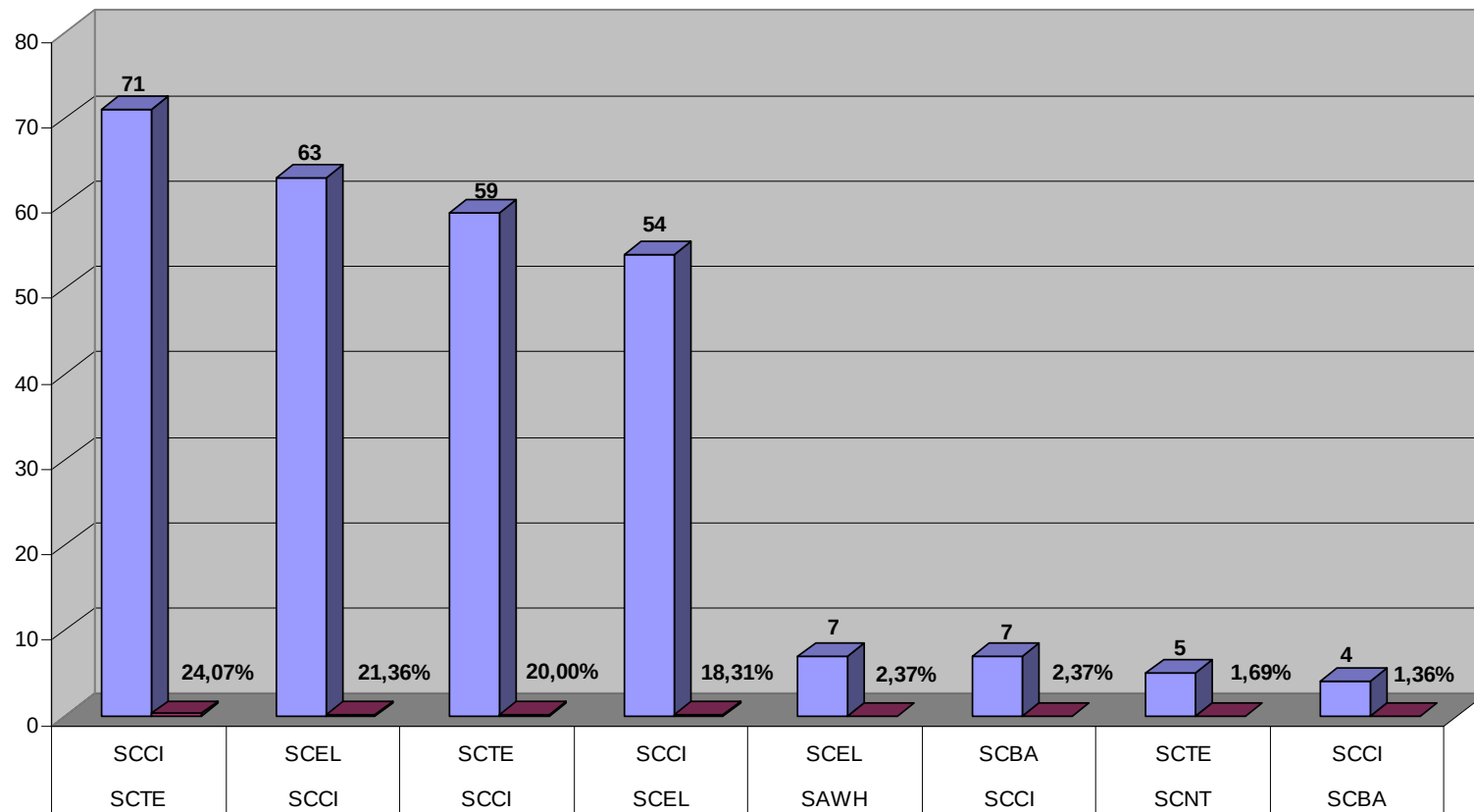
CHILE

FIR ANTOFOGASTA - Pares de Ciudades
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FIR PASCUA - PARES DE CIUDADES
89% del tránsito de la muestra

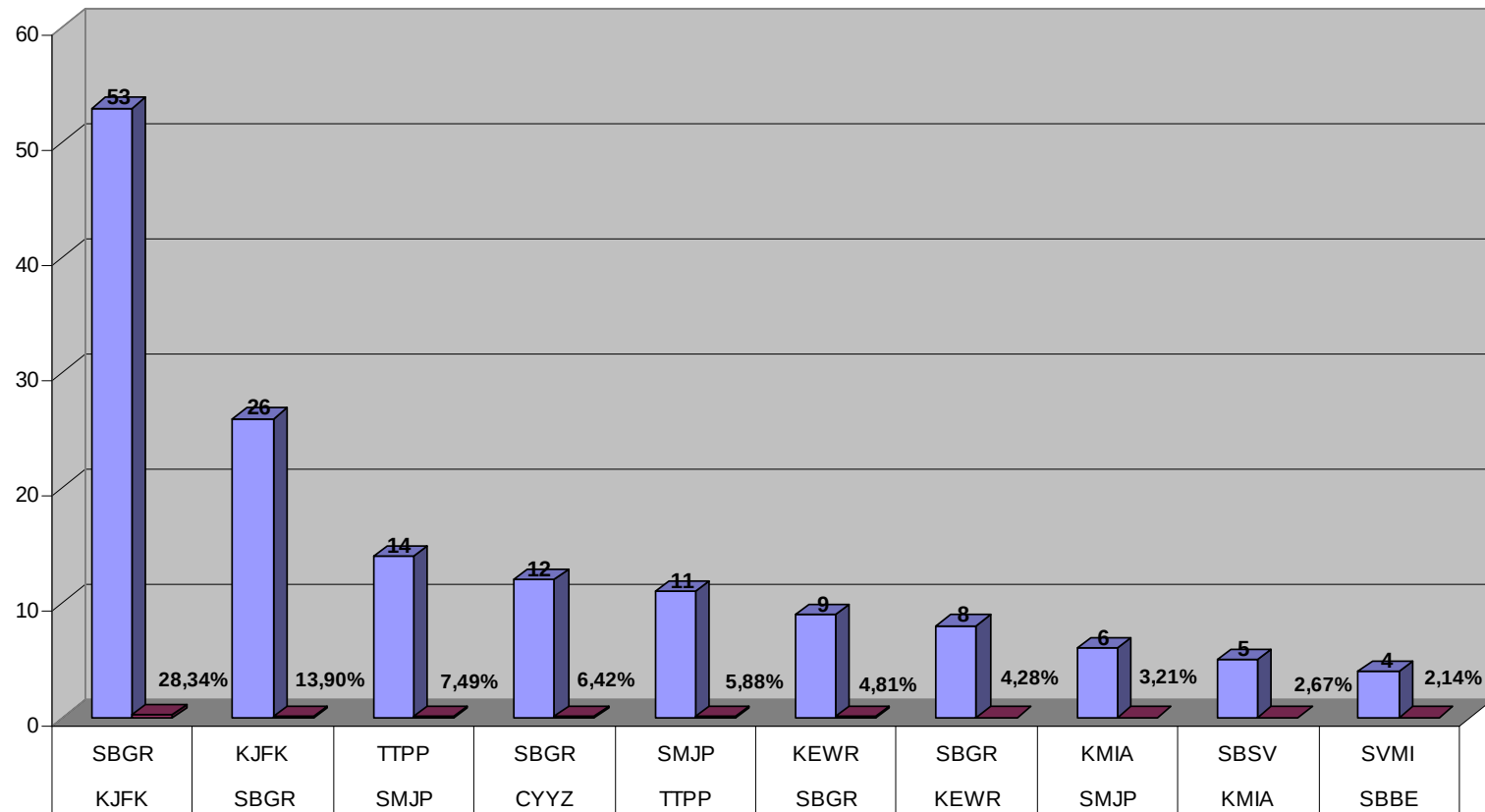
FIR PUERTO MONTT - PARES DE CIUDADES
94% del tránsito de la muestra

FIR PUNTA ARENAS - PARES DE CIUDADES
92% del tránsito de la muestra

FIR SANTIAGO - PARES DE CIUDADES
58% del tránsito de la muestra

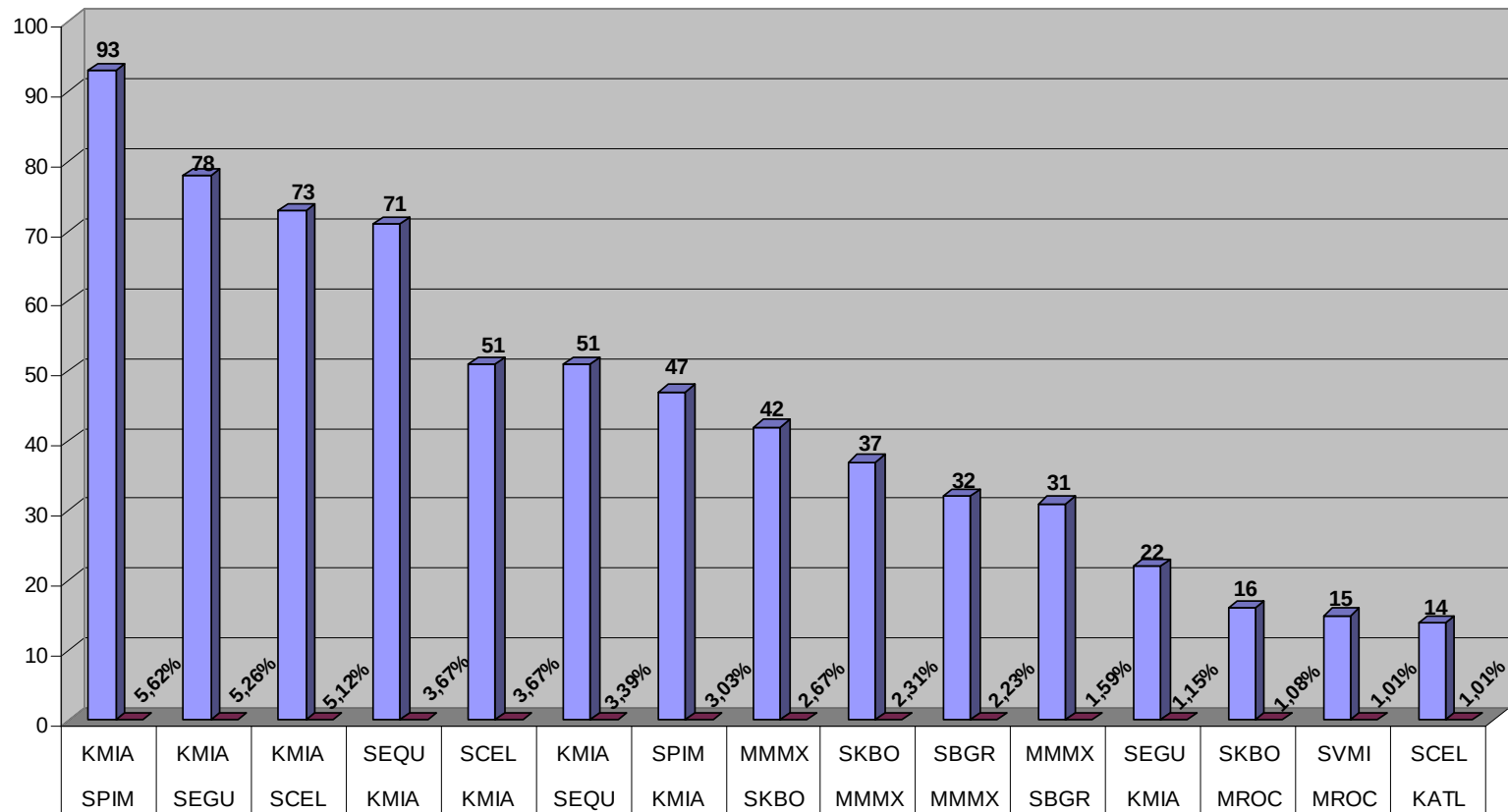


GUYANA

FIR GEORGETOWN - PARES DE CIUDADES
79% del tránsito de la muestra

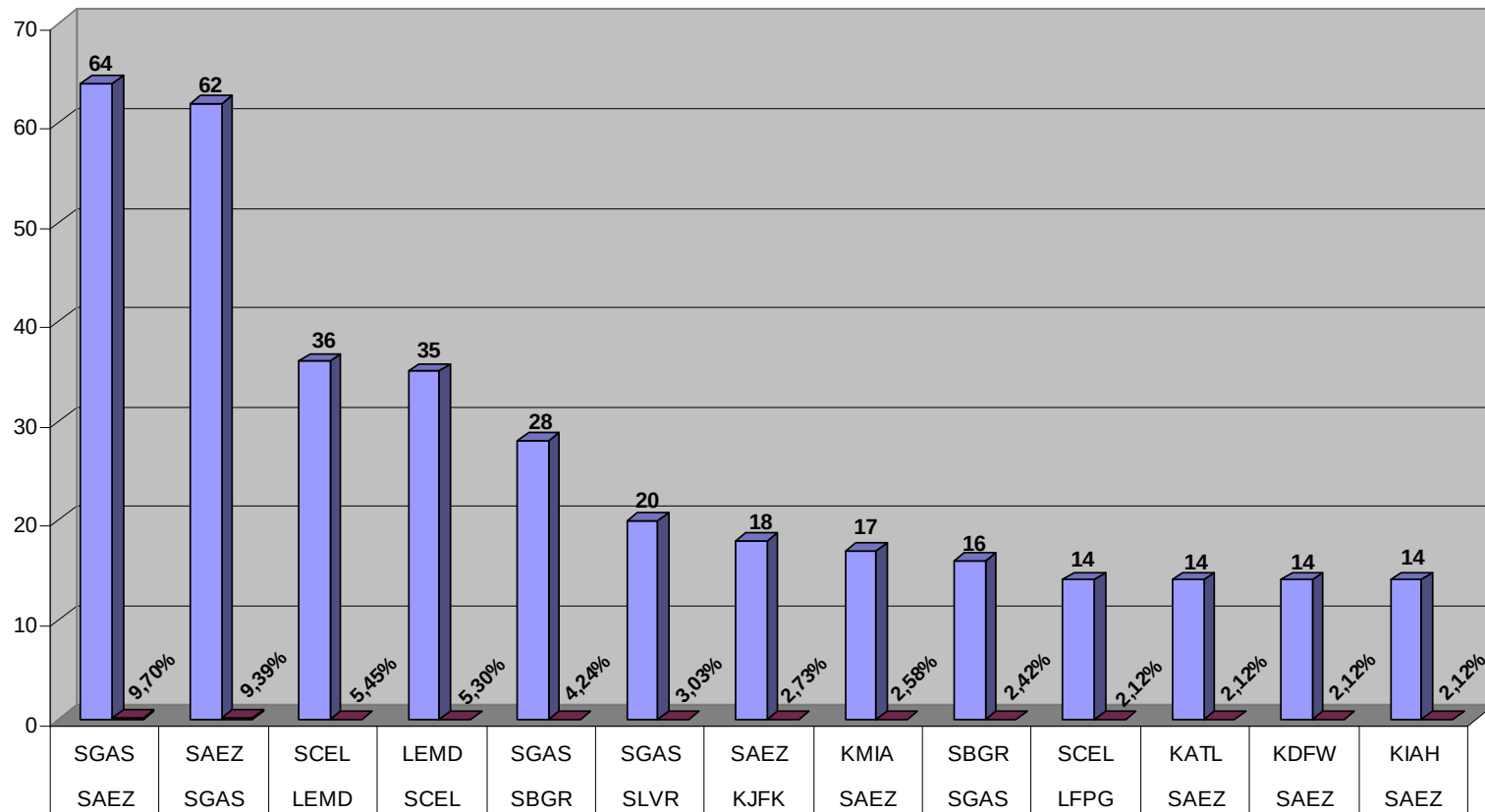
PANAMA

FIR PANAMA - PARES DE CIUDADES
48% del tránsito de la muestra



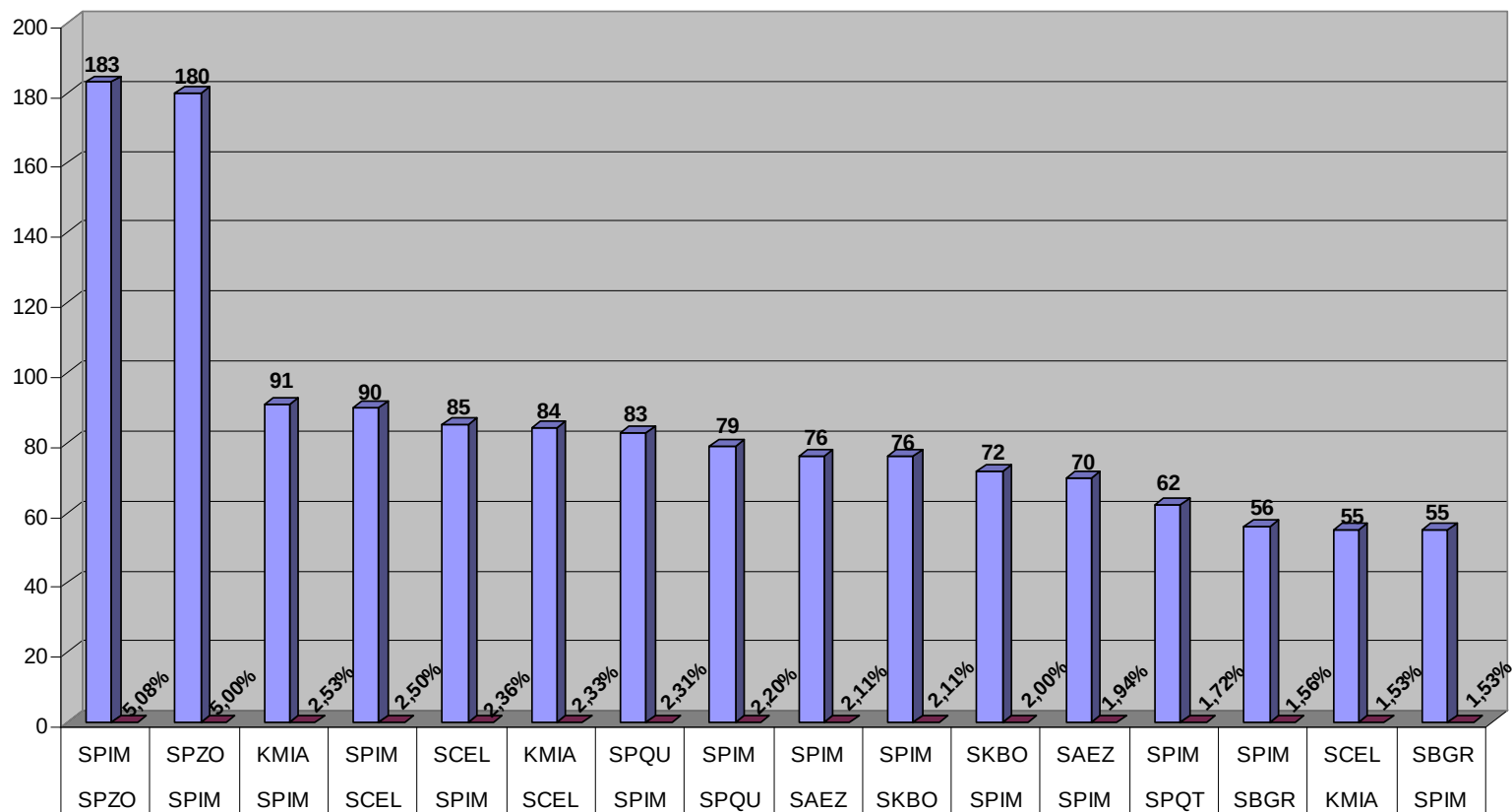
PARAGUAY

FIR ASUNCIÓN - PARES DE CIUDADES
53% del tránsito de la muestra



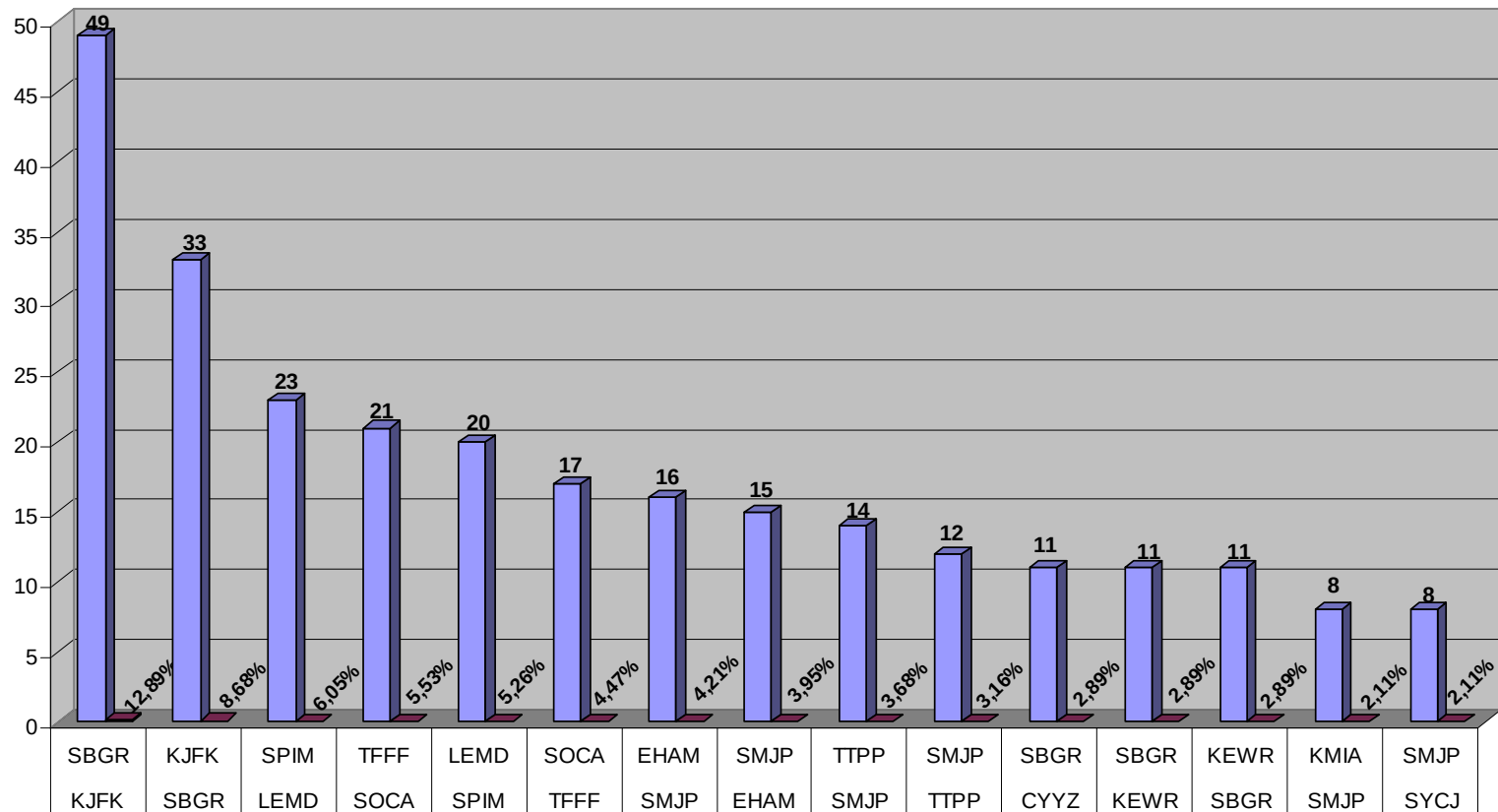
PERU

FIR LIMA - PARES DE CIUDADES
39% del tránsito de la muestra



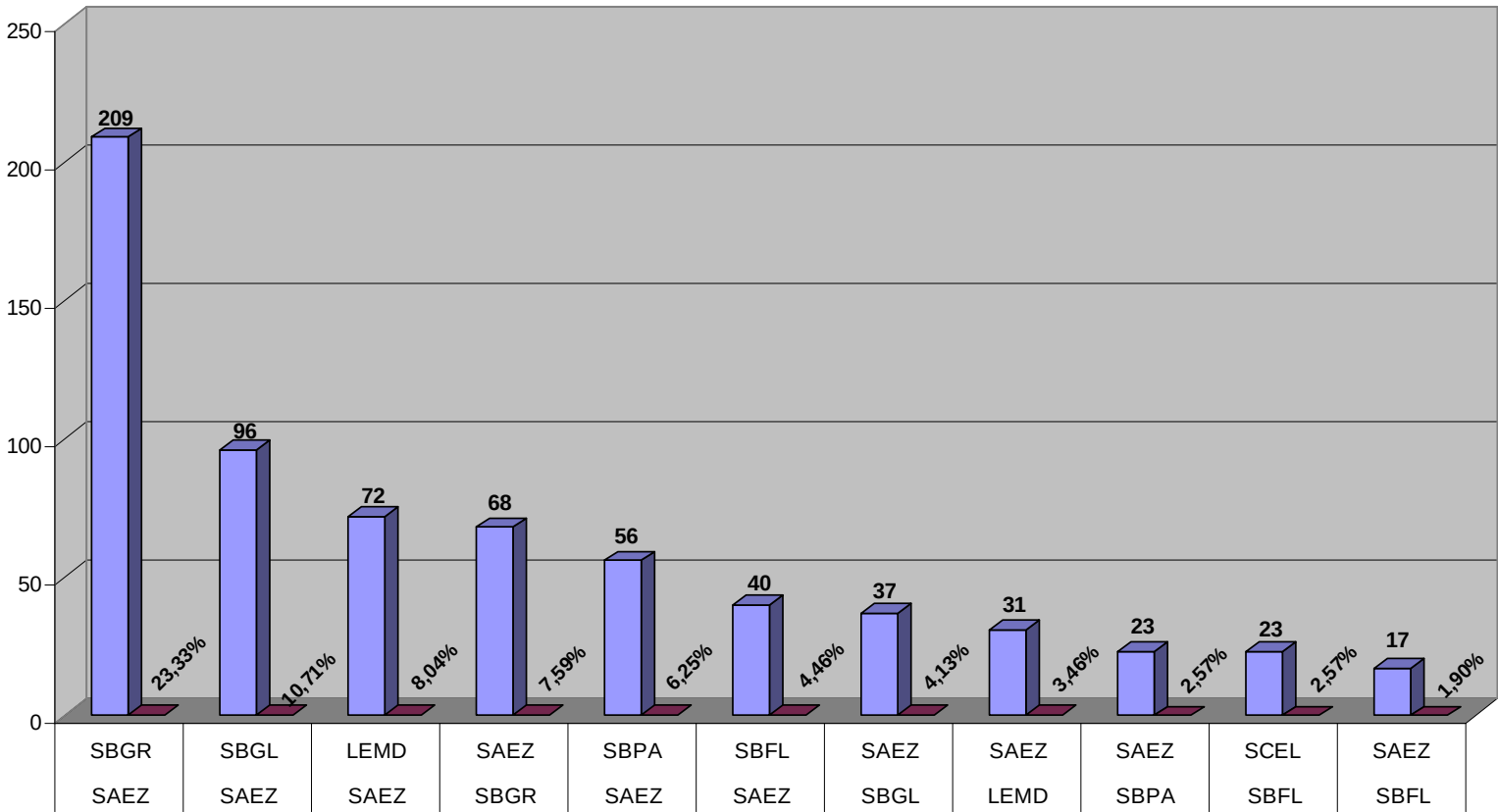
SURINAME

FIR PARAMARIBO - PARES DE CIUDADES
71% del tránsito de la muestra



URUGUAY

FIR MONTEVIDEO - PARES DE CIUDADES
75% del tránsito de la muestra



ATTACHMENT 4 TO APPENDIX B**STATUS OF GNSS REGULATIONS IN SAM STATES****ARGENTINA**

The use of GNSS was approved as a primary means of navigation in VFR and IFR flights in oceanic routes, ATS routes, TMA and non-precision approach procedures (NPA) through provision CRA N 55/07. The resolution is published in section ENR 4-2 of the AIP.

BOLIVIA

Regulatory Bulletin N° DGAC/08/2002 (Operational Use of the Global Positioning System - GPS) establishes operational criteria for the use of GNSS in the Bolivian territory as a supplementary and primary means of air navigation.

BRAZIL

IAC 3512 91/121/135, which became effective 26 April 2001, and AIC 12/99 contain guidelines for the use of GPS equipment in en-route IFR operations, TMAs and non-precision approach procedures in the Brazilian airspace. The documentation is being updated in order to meet PBN requirements. The aforementioned documents can be found at the following websites:

http://www.aisweb.aer.mil.br/aisweb_files/publicacoes/aic_a/aic_1999_a12.pdf
<http://www.anac.gov.br/biblioteca/iac/IAC3512.pdf>

CHILE

The first amendment to the third edition of DAP 0613 (Operational Use of the GPS System) was published in Resolution DGAC n 2474 of 18 October 2006, setting the operational criteria for the use of the GPS system as a primary/supplementary means of air navigation in Chilean airspace, as appropriate.

Norm DAN 0805 (Resolution N° 0709 of 19 April 2004) regulates the installation of GPS systems on board aircraft with Chilean registry.

Norm DAN 06 21 (Exempt Resolution N° 1204 of 31 May 2007) establishes the technical and operational requirements for the approval of operators that wish to apply RNAV/GNSS procedures in TMA and non-precision approaches.

The aforementioned documents may be found at:

<http://www.dgac.cl/images/IMG/pdf/otros/dap/dap0613.pdf>
<http://www.dgac.cl/images/IMG/pdf/otros/dan/DAN%2008%2005.pdf>
<http://www.dgac.cl/images/IMG/pdf/otros/dan/dan0621.zip>

COLOMBIA

AICs C06 and A01, Global Positioning System, dated 10 September 1996, set forth the operational criteria for the use of GPS as a supplementary means of air navigation in Colombian airspace. The Aeronautical Regulations of Colombia, Part 6, Air Traffic Management, Section 6.10.3, establishes RNAV (GNSS) operations through standard arrival and departure (STAR/SID) procedures and non-precision instrument procedures at the following airports: SKAS, SKUI, SKUC SKYP.

ECUADOR

Aeronautical Information Circular of 14 May 2007, which supersedes AIC 07/96 of 3 December 1996, defines the regulations for applying the GNSS system. The circular establishes the use of GNSS in RNAV navigation for instrument arrival (STAR) and departure (SID) procedures and non-precision approaches.

GUYANA

Through AIC of 25 November 2004, the use of GPS in the Georgetown FIR airspace was approved. GPS may be used for departure, approach and en-route IFR navigation.

FRENCH GUIANA

The regulations enabling the use of GNSS RNAV equipment for non-precision approaches were published in Resolution N° F-2007-01, of 26 April 2007, which superseded Resolution N° F-2005-01.

PANAMA

AIC 04/07, Operational Criteria for the Use of GNSS in Panamanian Airspace, was published on 15 March 2007. The circular was aimed at establishing the criteria for the use of GPS as a primary means of navigation in the airspace over the national territory and its jurisdictional waters, particularly the implementation of STARs and SIDs developed for the international airports of Howard and Tocumen.

PARAGUAY

Resolution 169/2000, which authorizes the use of the global positioning system (GPS) in the Republic of Paraguay, was published on 12 May 2000.

PERU

The use of GPS as a supplementary means of navigation was authorized through AIC 02/96, GPS System, dated 17/05/96.

SURINAME

On 31 March 2008, AIP supplement 01/08 on the use of GPS as a primary means of IFR navigation in the Paramaribo FIR, was published.

URUGUAY

In the airspace under the jurisdiction of the Republic of Uruguay, GPS can be used as a supplementary means of navigation for en-route operations and as a primary means of navigation in oceanic airspace. There is a NOTAM, issued for a period of 60 days, enabling the use of GPS as a primary means of navigation in continental areas.

VENEZUELA

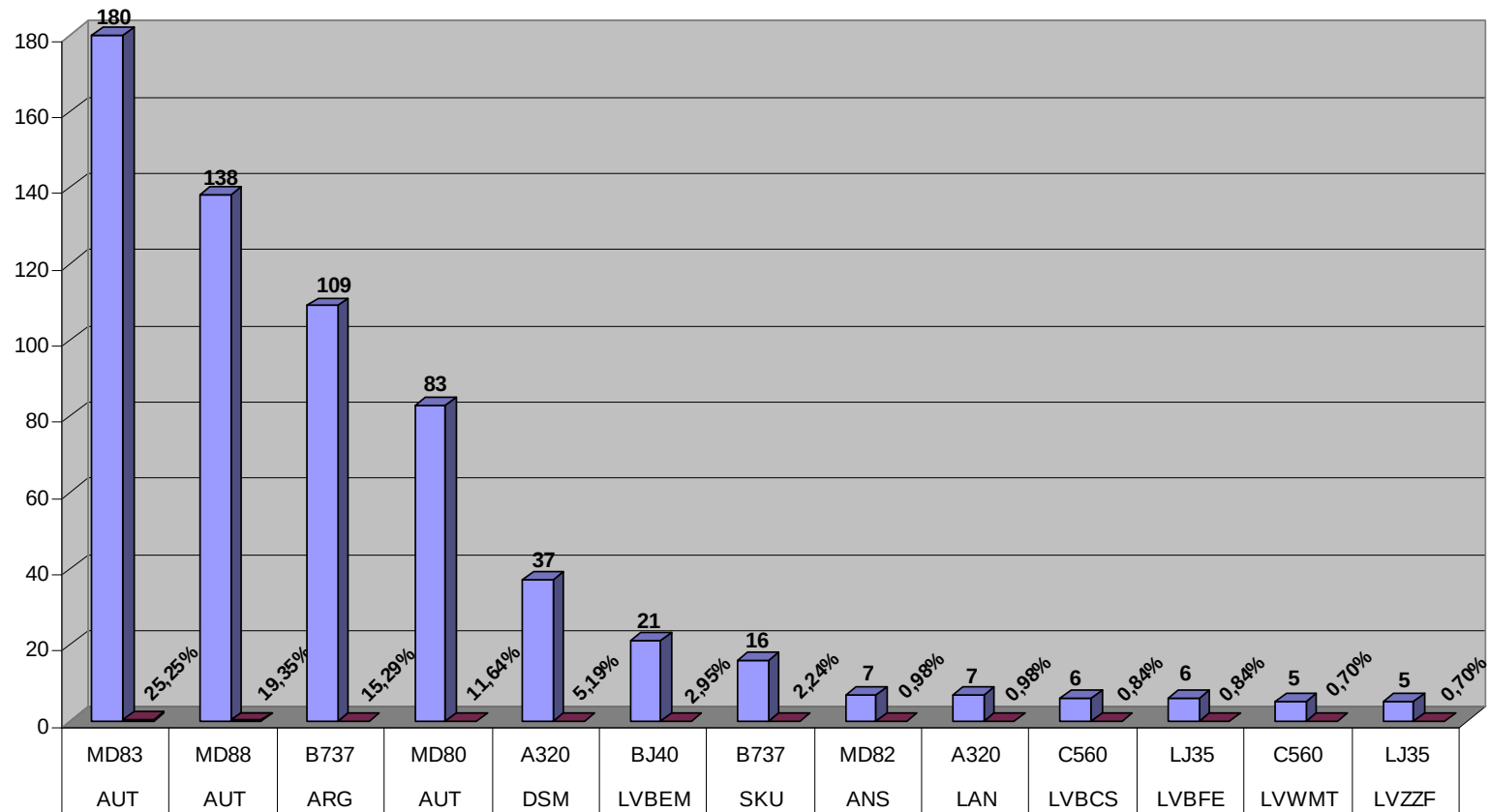
AIC A01/C01, dated 2 January 1997, defines the operational criteria for using the Global Positioning System (GPS) as a supplementary means of navigation in the upper airspace (Maiquetía FIR/UTA).

ADJUNTO 5 AL APENDICE B / ATTACHMENT 5 TO APPENDIX B

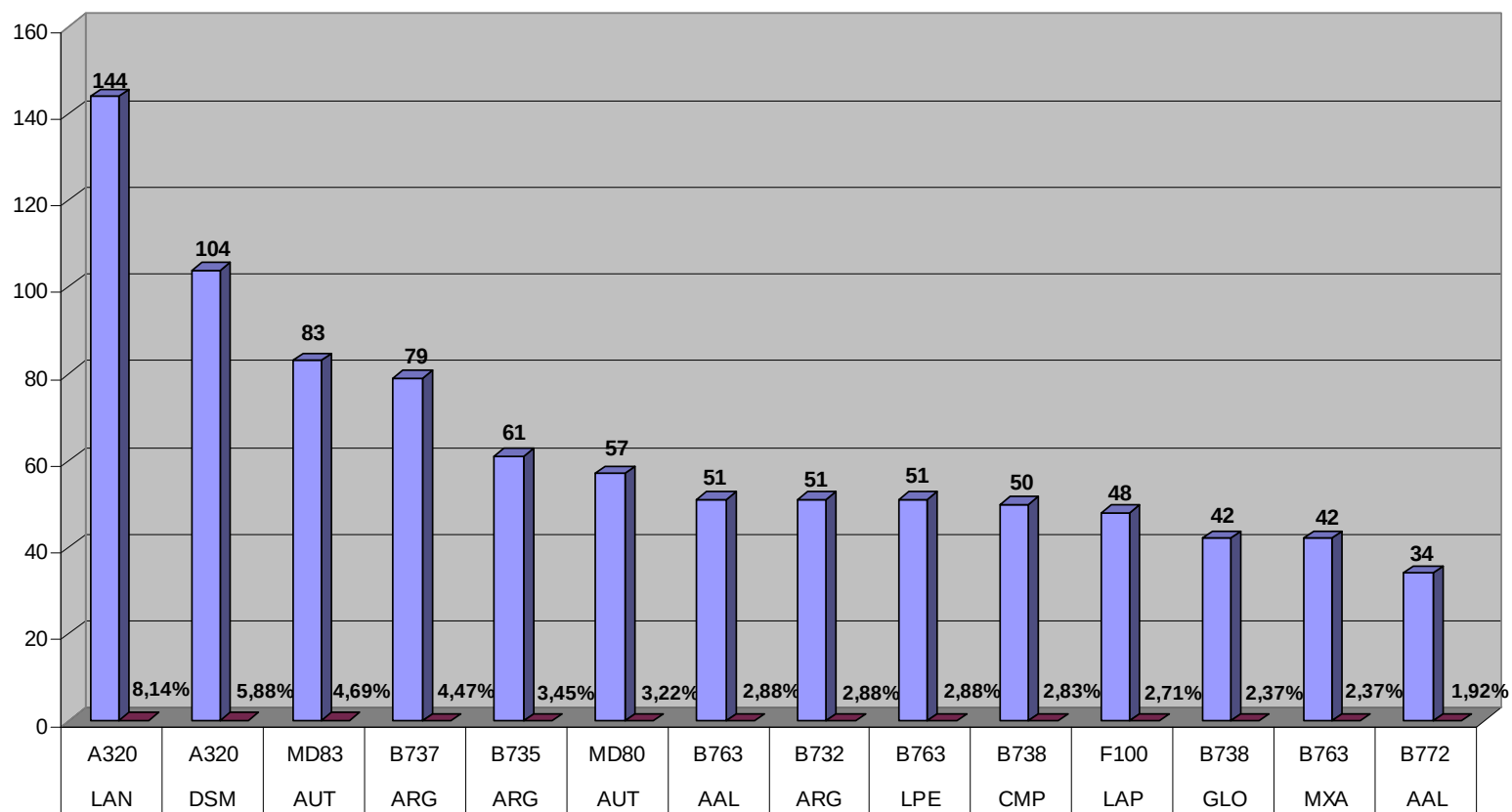
**Región SAM
Aerolínea/Tipo/**

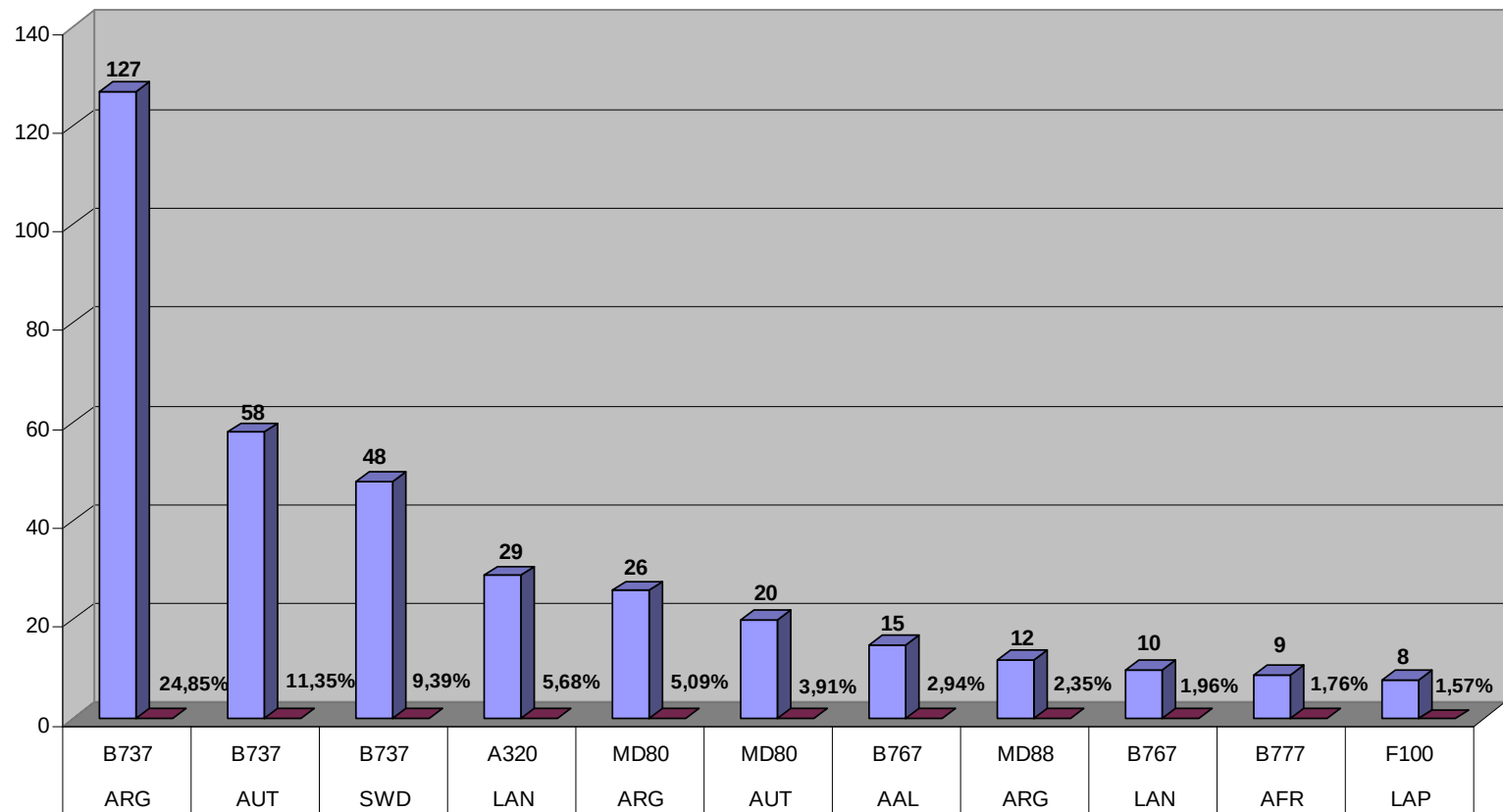
**SAM Region
Airline/Type**

ARGENTINA

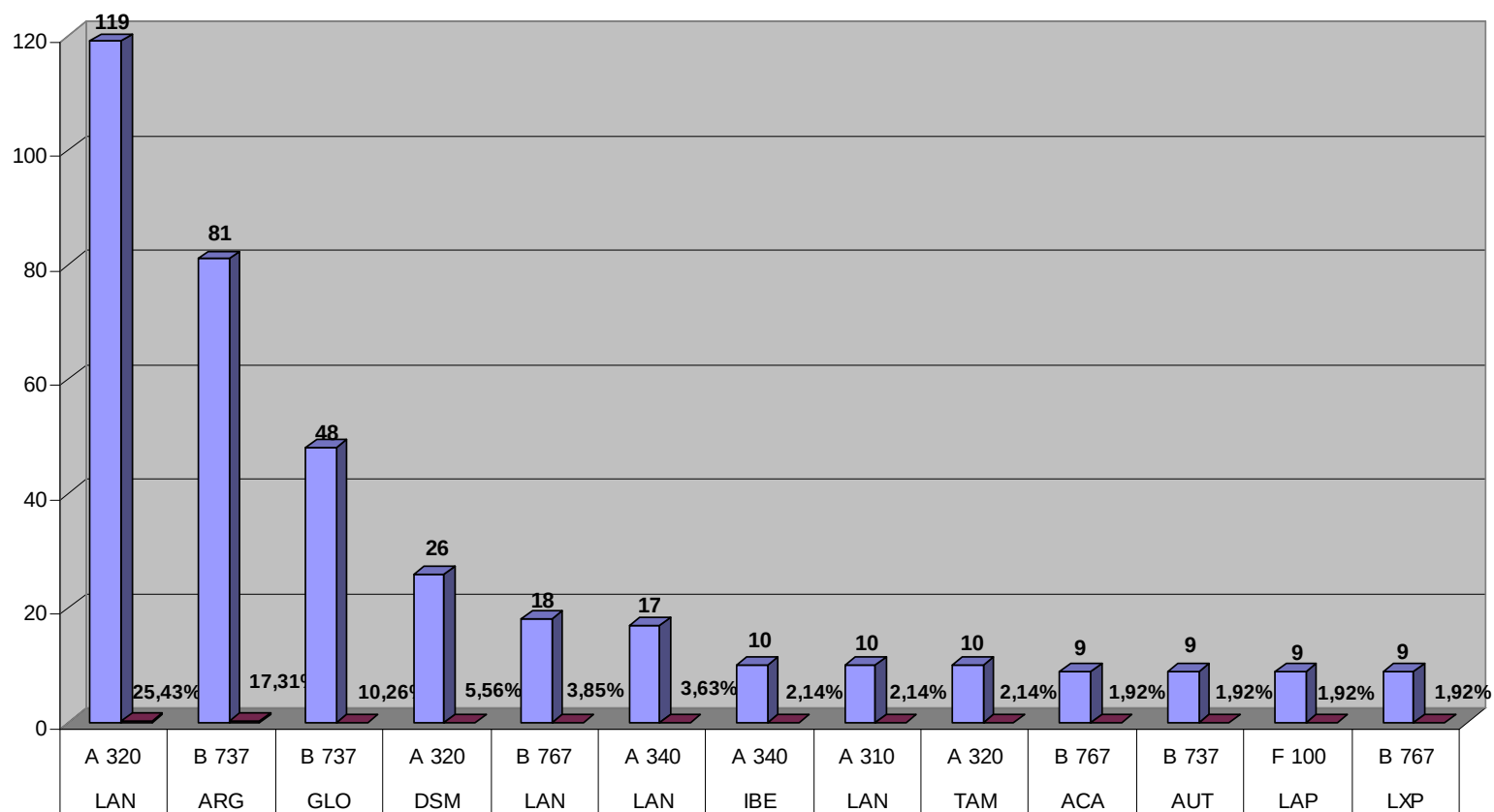
FIR COMODORO RIVADAVIA - Aerolínea/Tipo
87% del tránsito de la muestra

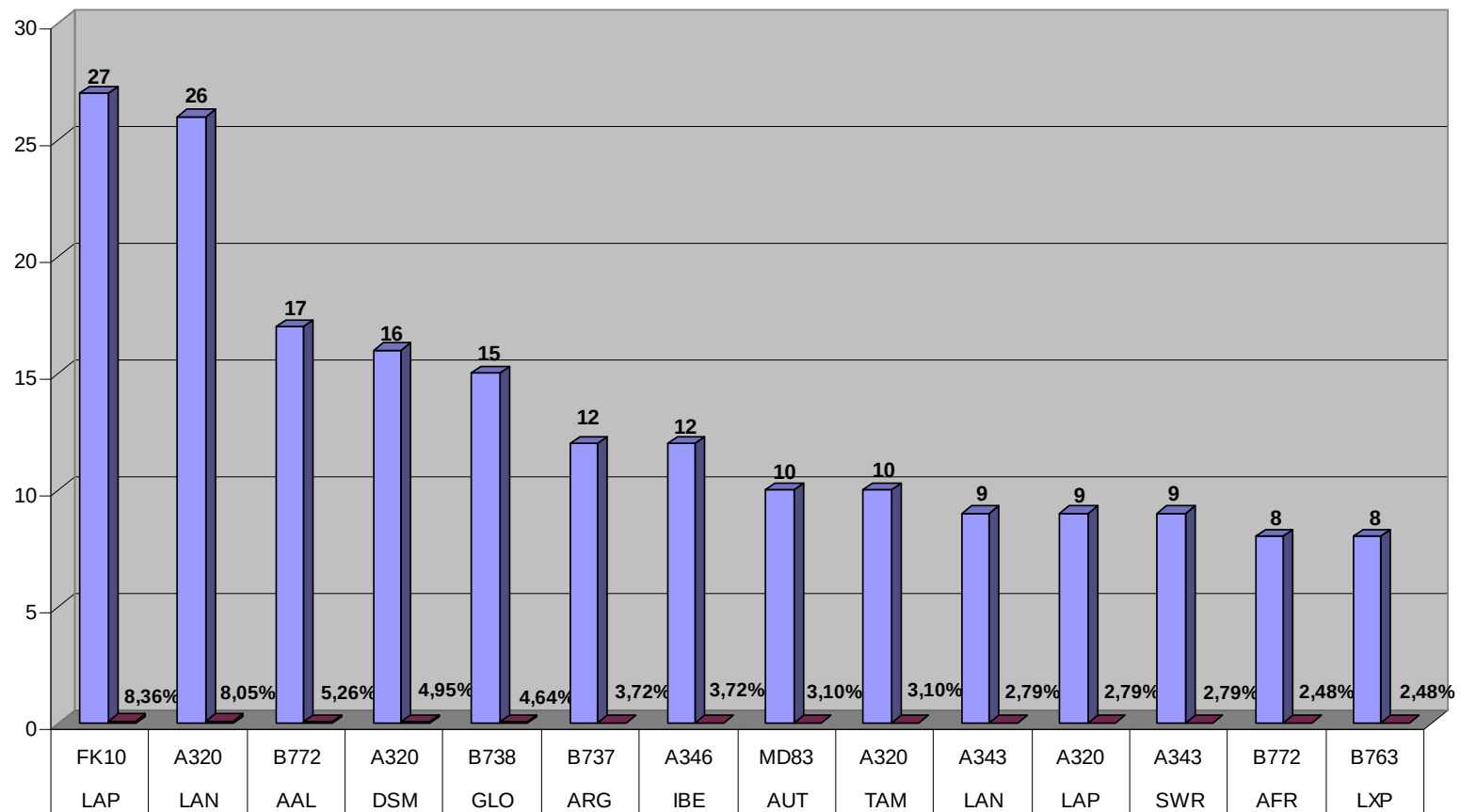
FIR CORDOBA - Aerolínea/Tipo
50% del tránsito de la muestra



FIR EZEIZA - Aerolínea/Tipo
71% del tránsito de la muestra

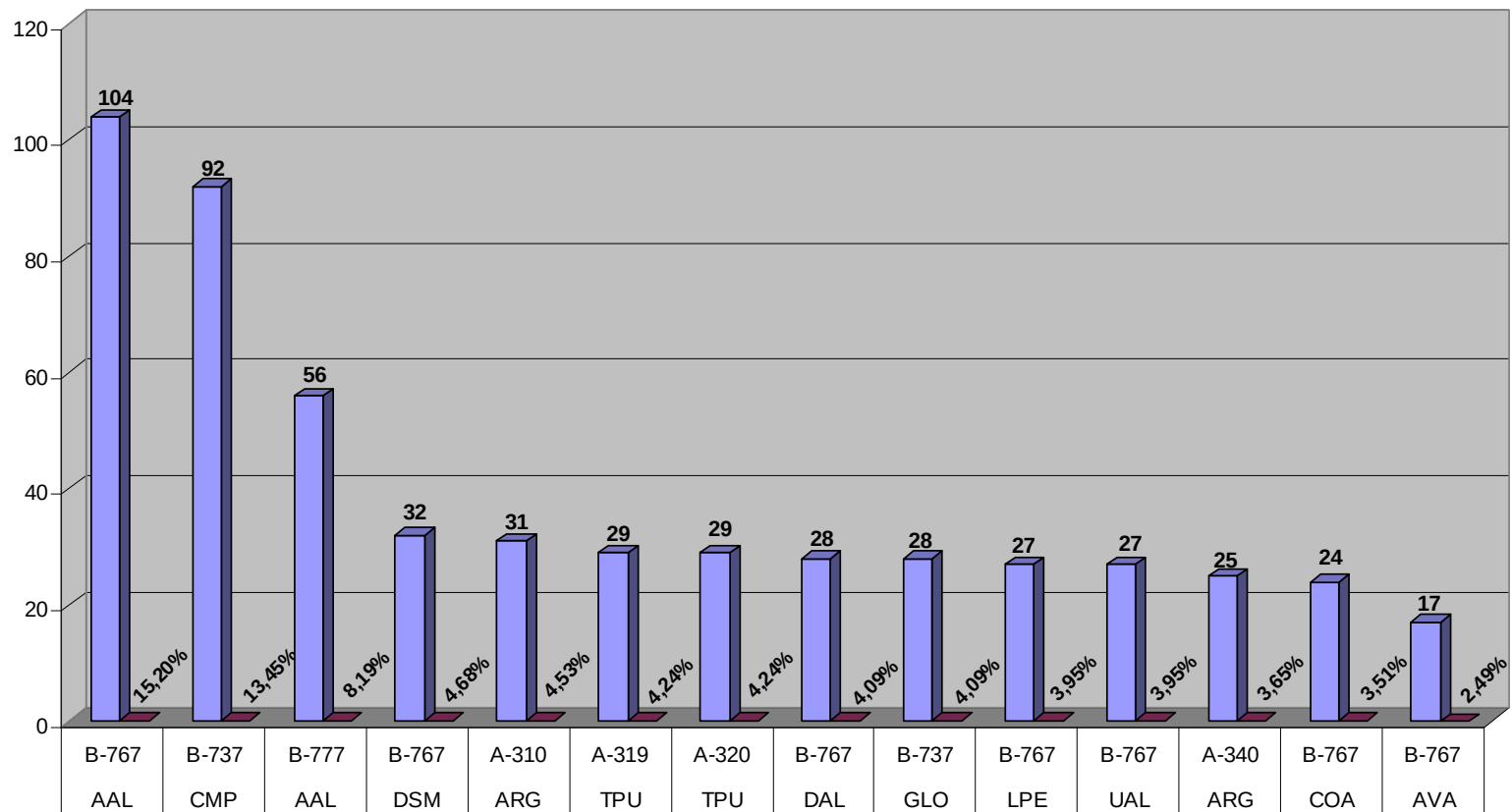
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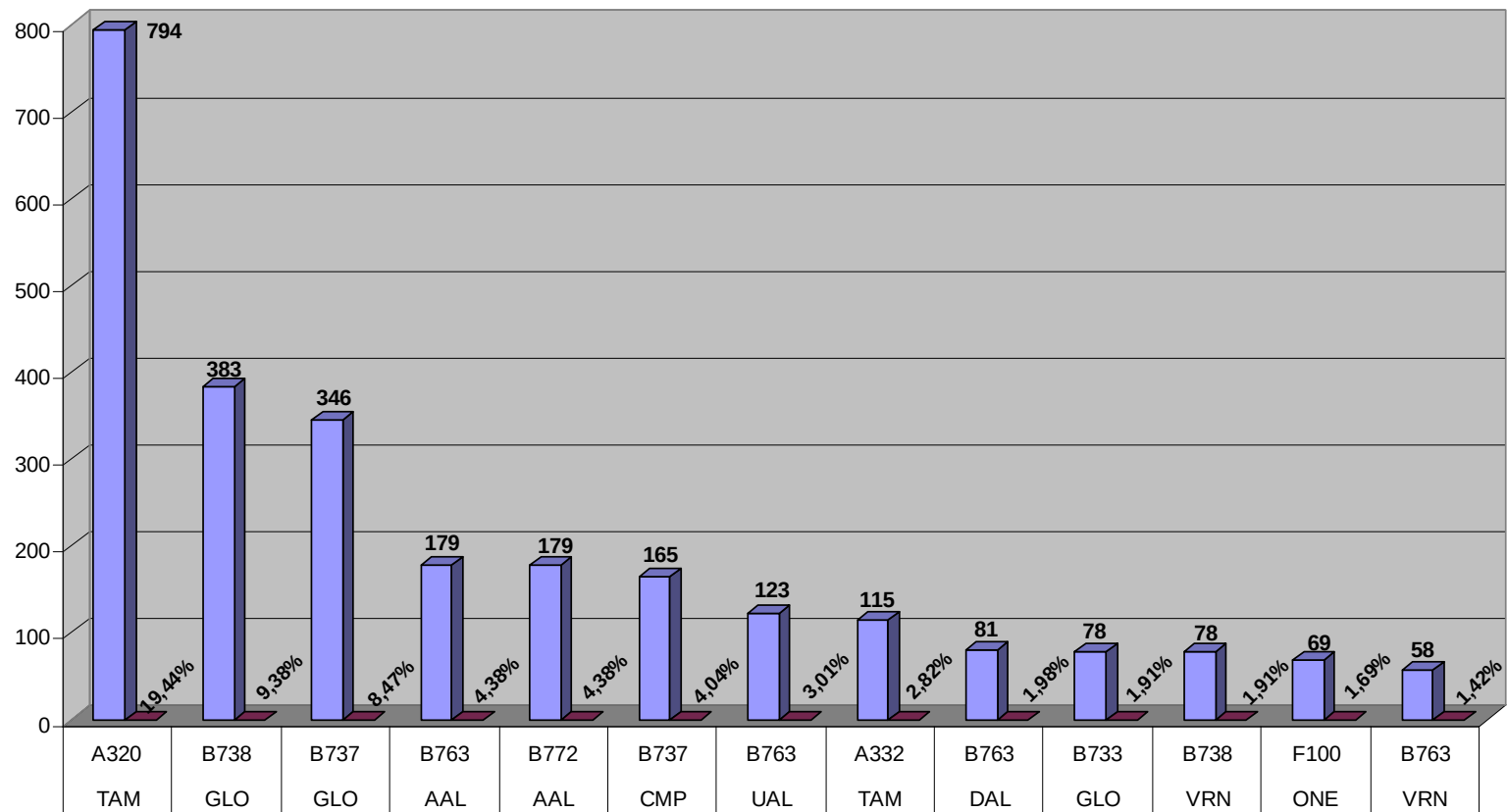
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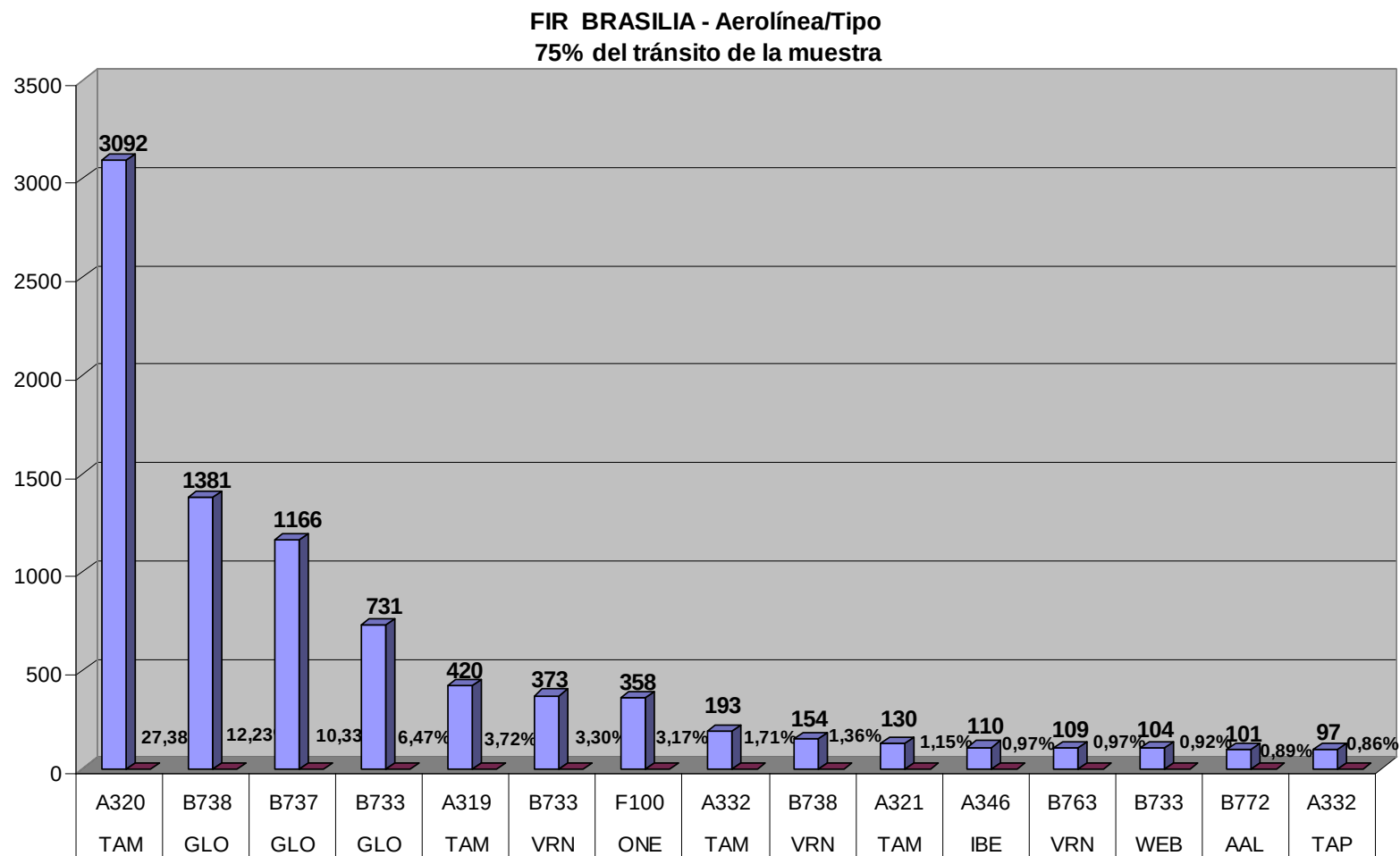
BOLIVIA

FIR LA PAZ - Aerolínea/Tipo
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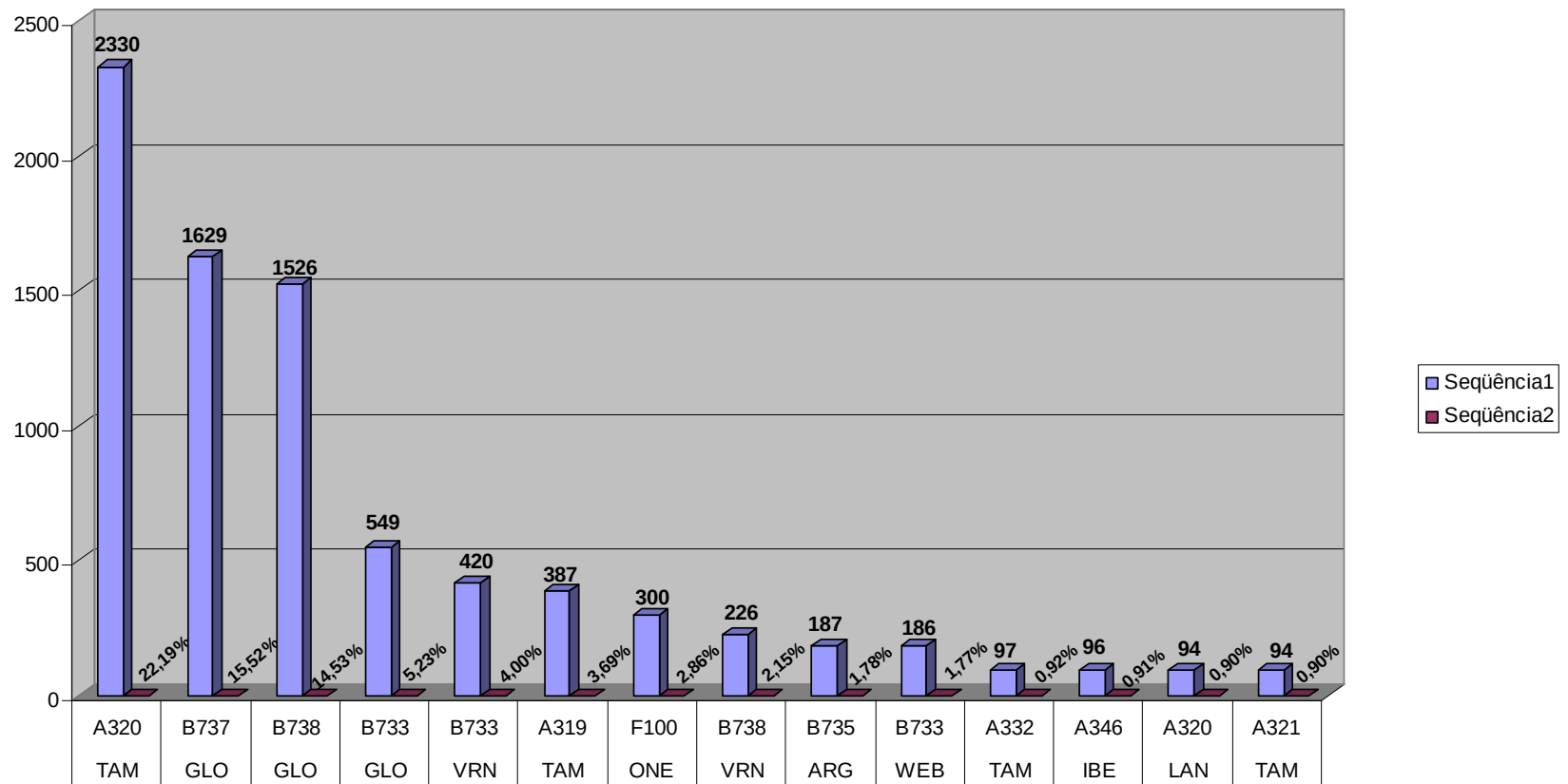


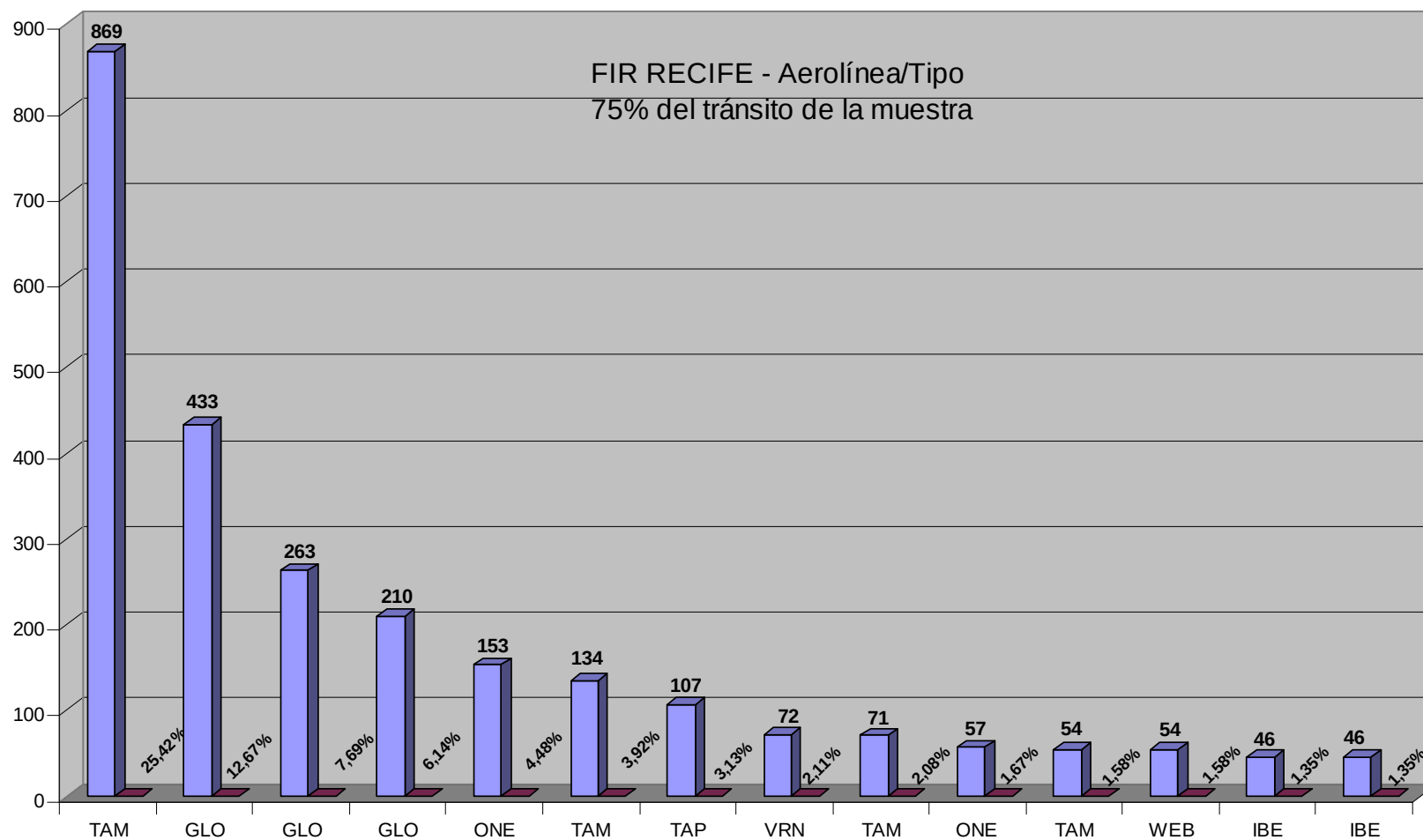
BRAZIL

**FIR AMAZONICA - Aerolínea/Tipo
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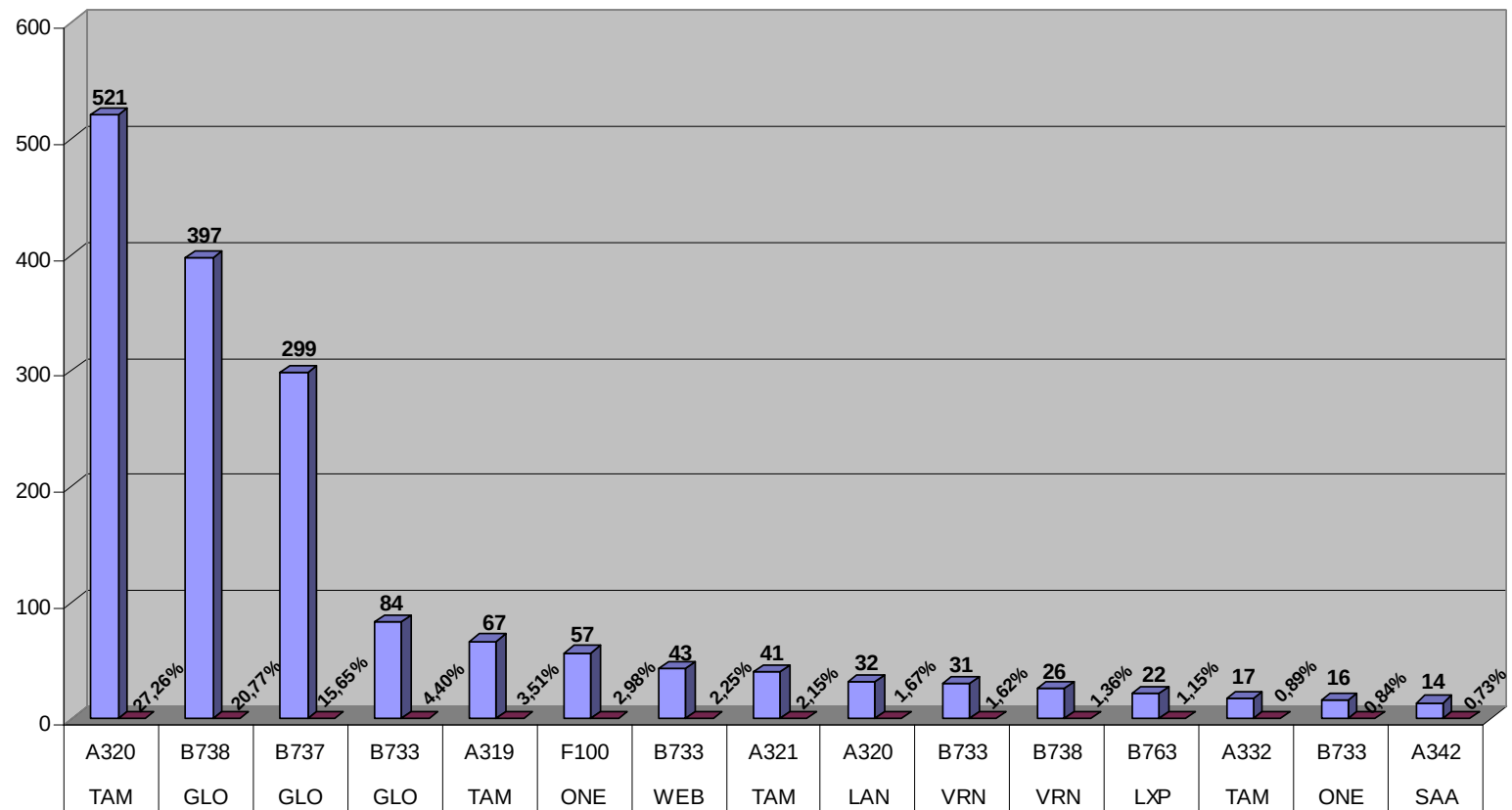


FIR CURITIBA - Aerolínea/Tipo
77% del tránsito de la muestra



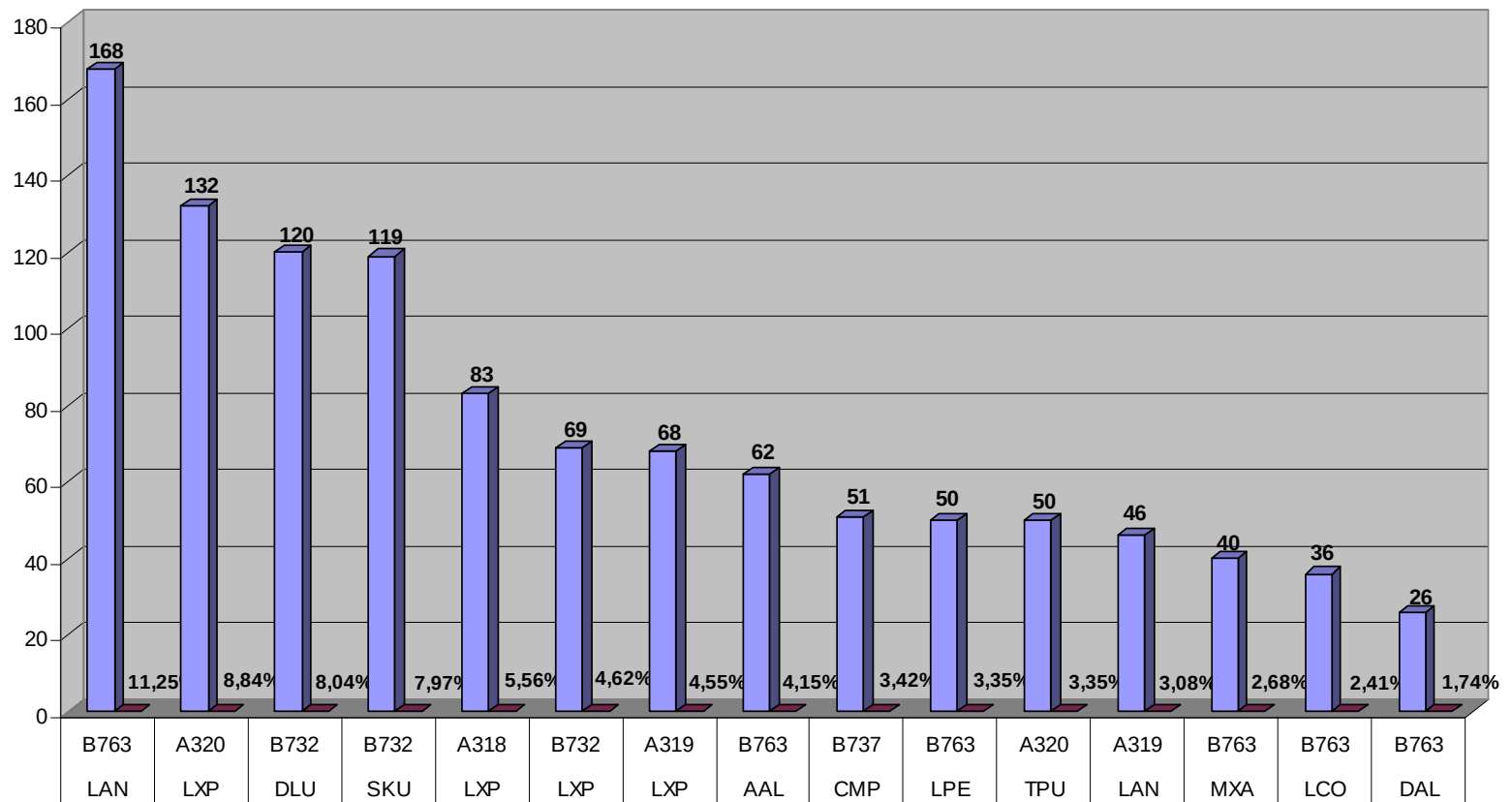


TMA SÃO PAULO - Aerolínea/Tipo
87% del tránsito de la muestra

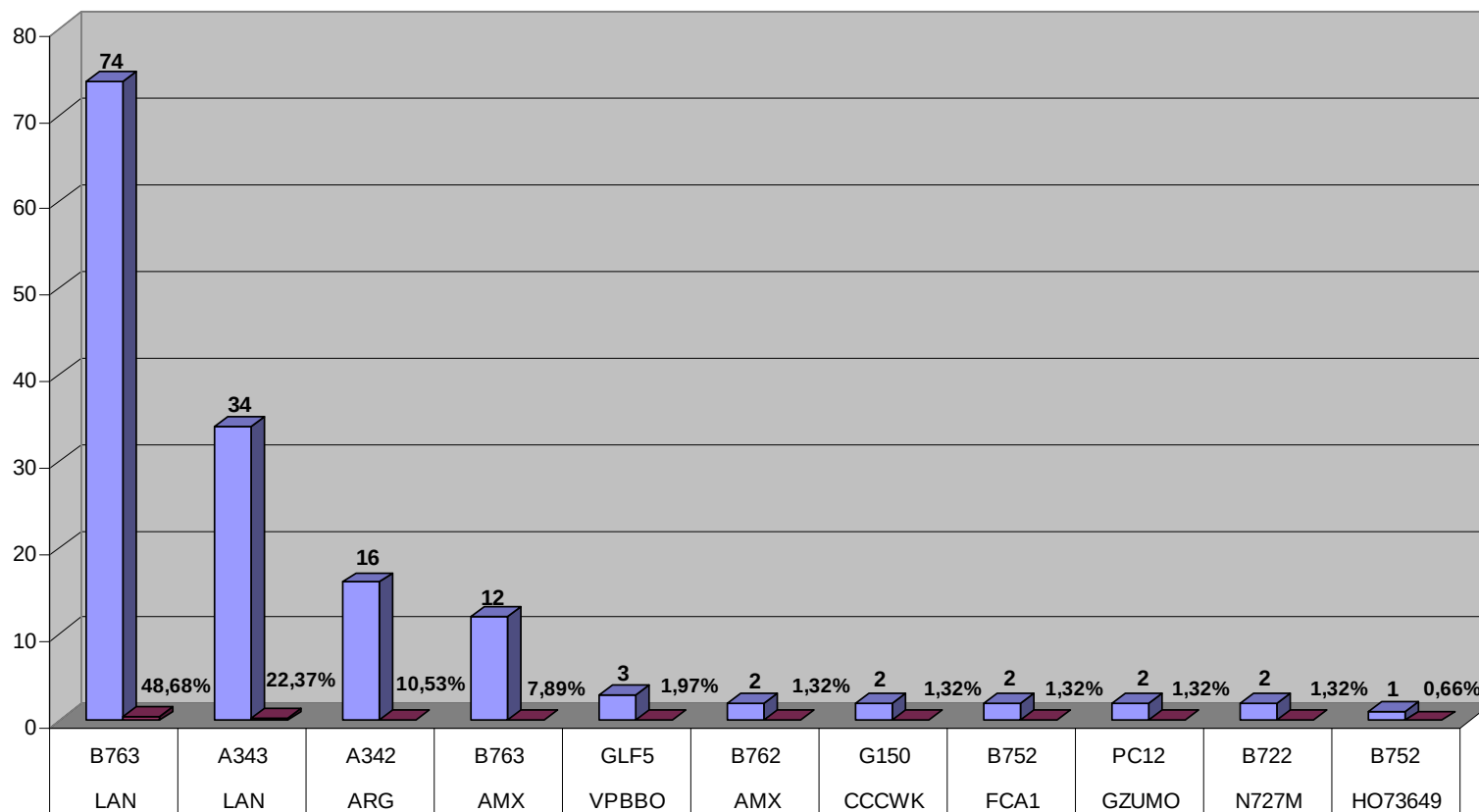


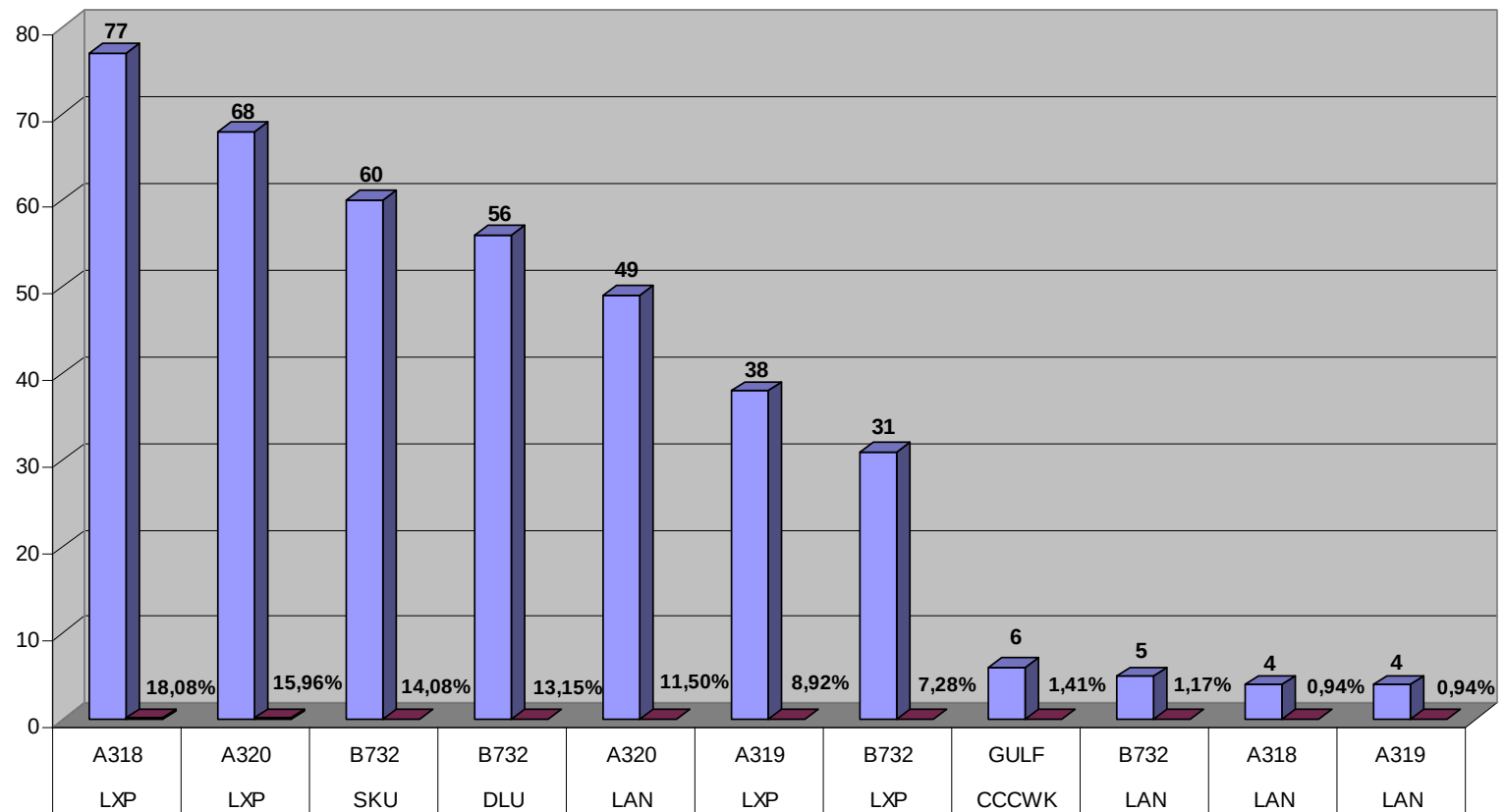
CHILE

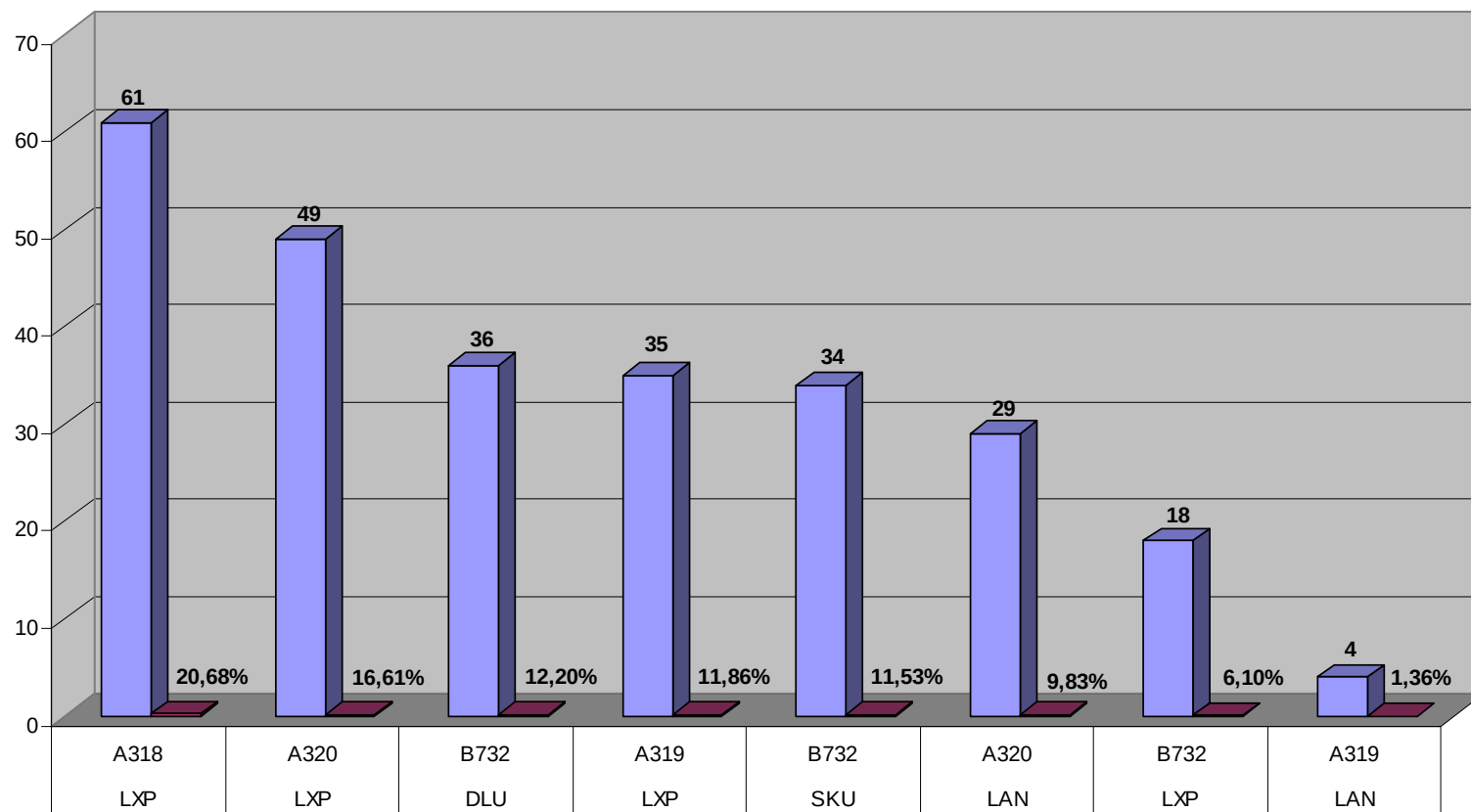
FIR ANTOFOGASTA - Aerolínea/Tipo
75% del tránsito de la muestra



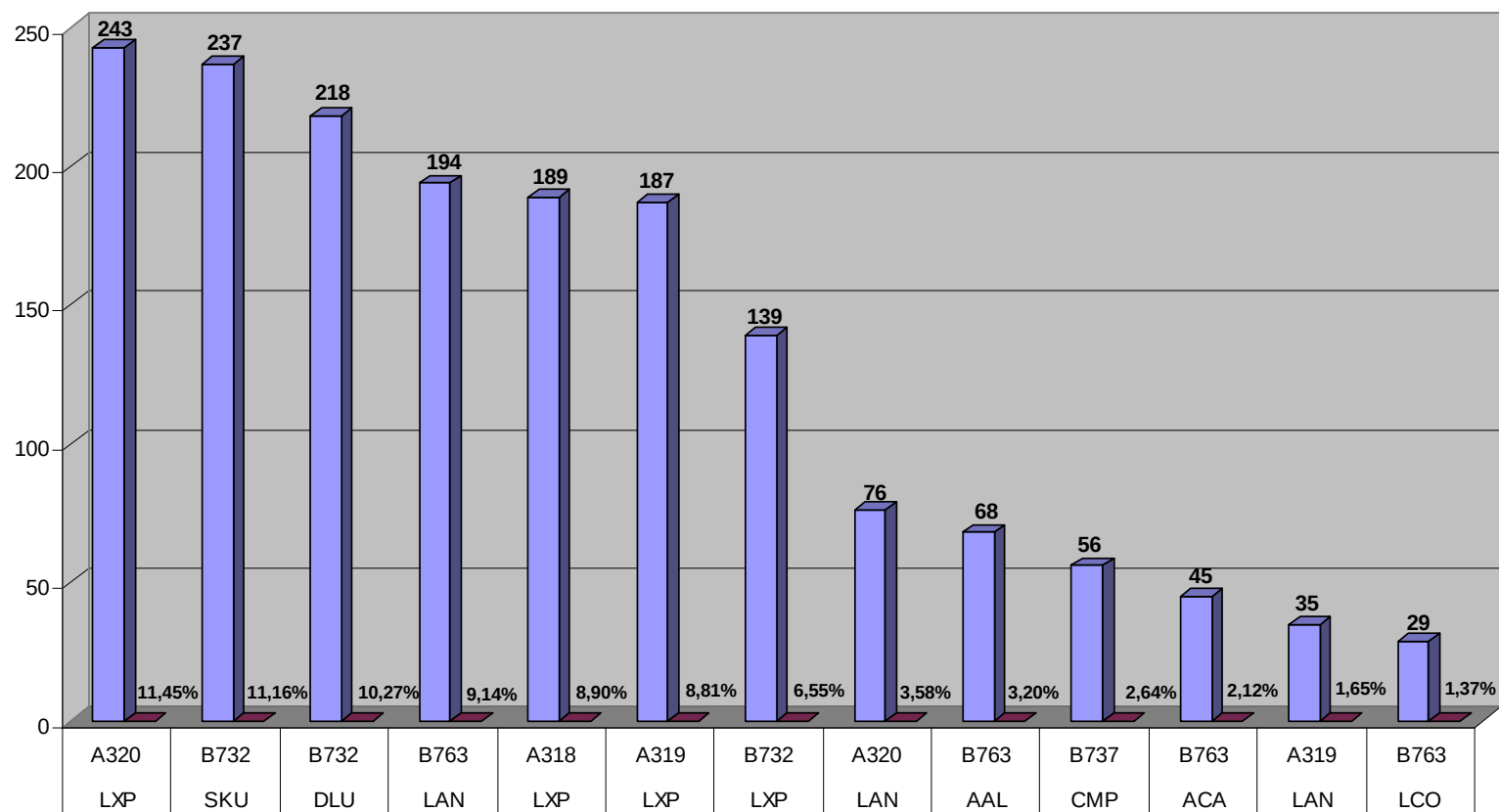
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99% del tránsito de la muestra



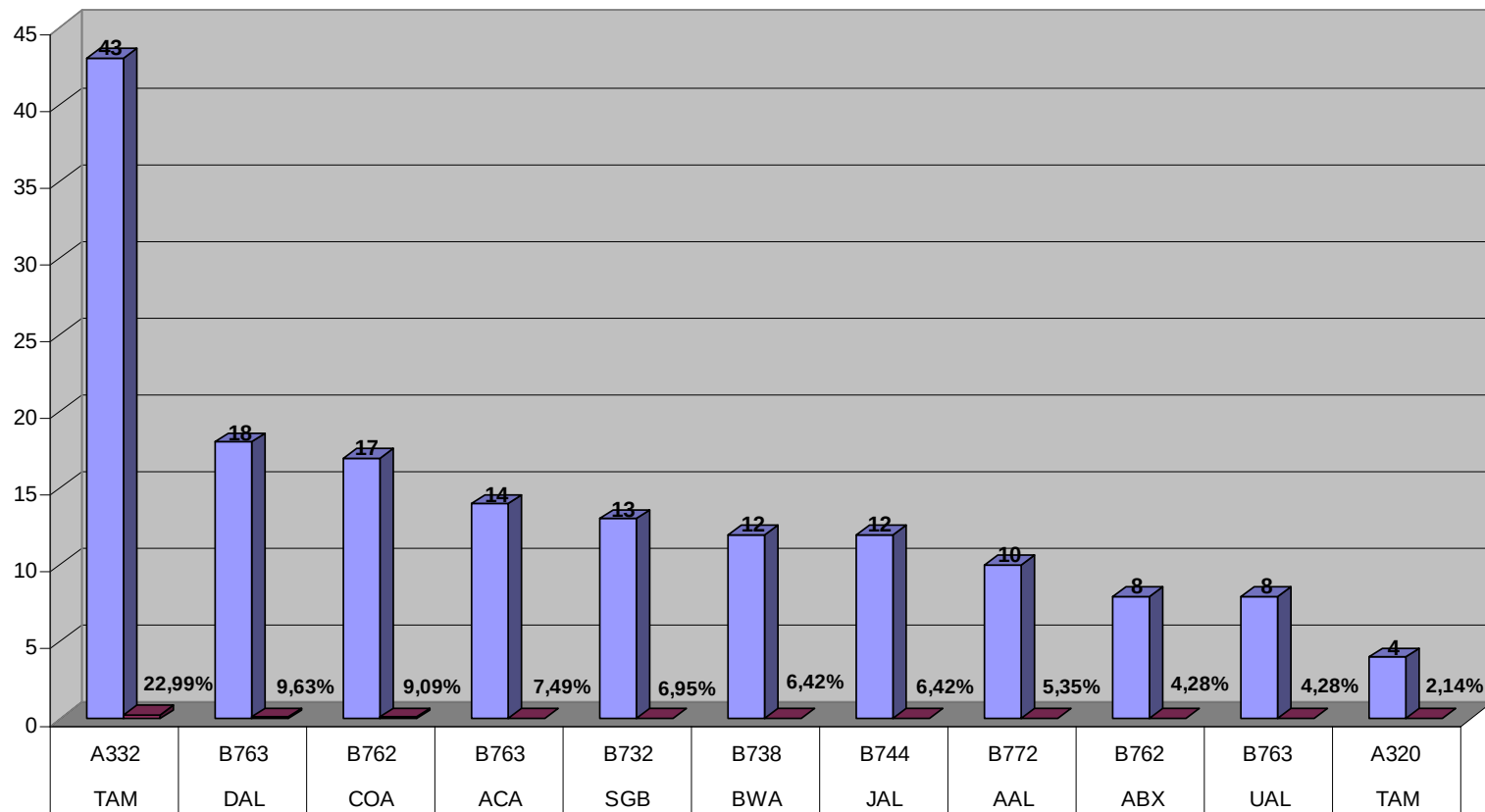
FIR PUERTO MONTT - Aerolíneas / Tipo
93% del tránsito de la muestra

FIR PUNTA ARENAS - Aerolínea / Tipo
90% del tránsito de la muestra

FIR SANTIAGO - Aerolíneas / Tipo
81% del tránsito de la muestra

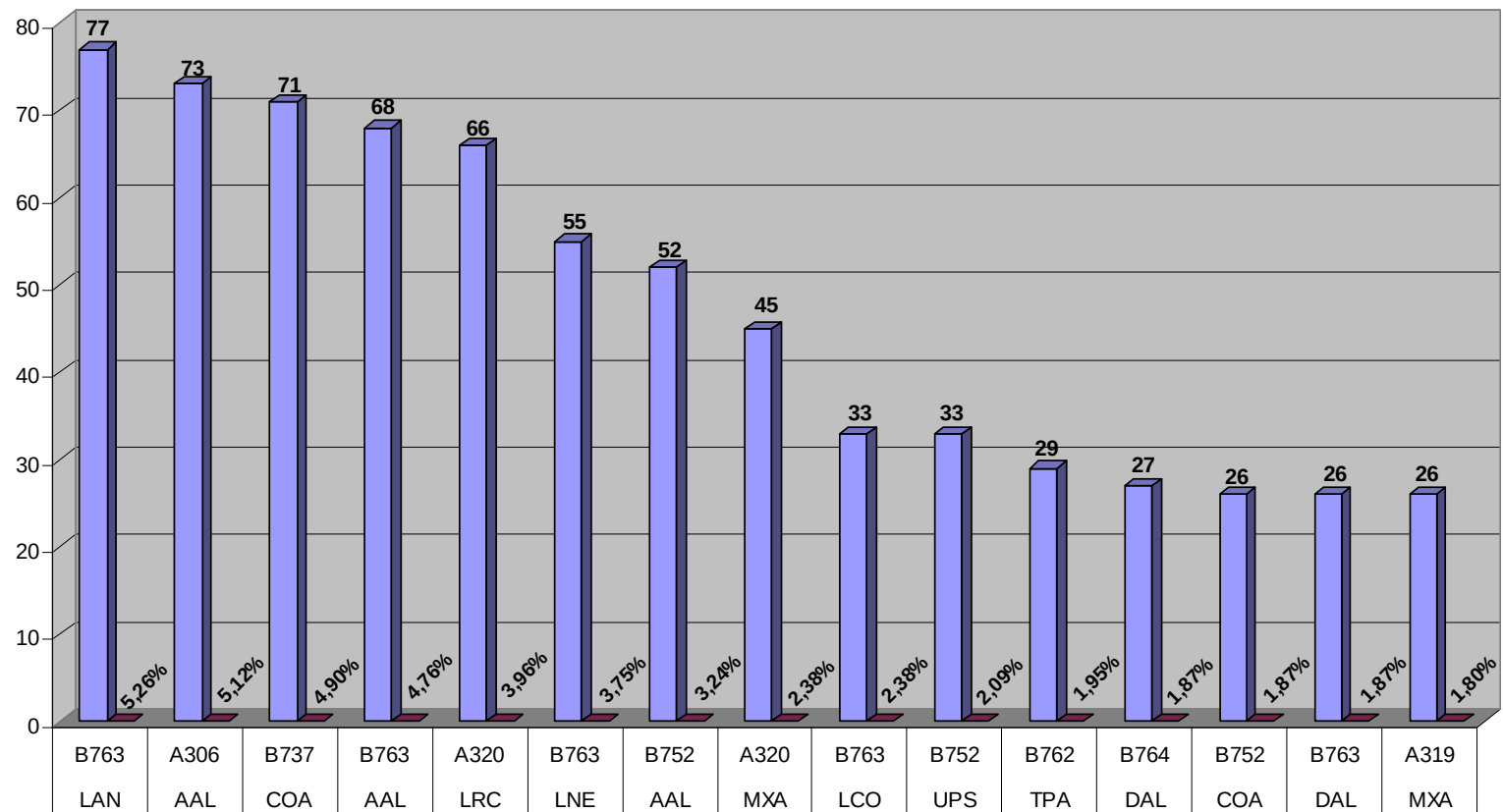


GUYANA

**FIR GEORGETOWN - Aerolínea/Tipo
85% del tránsito de la muestra**

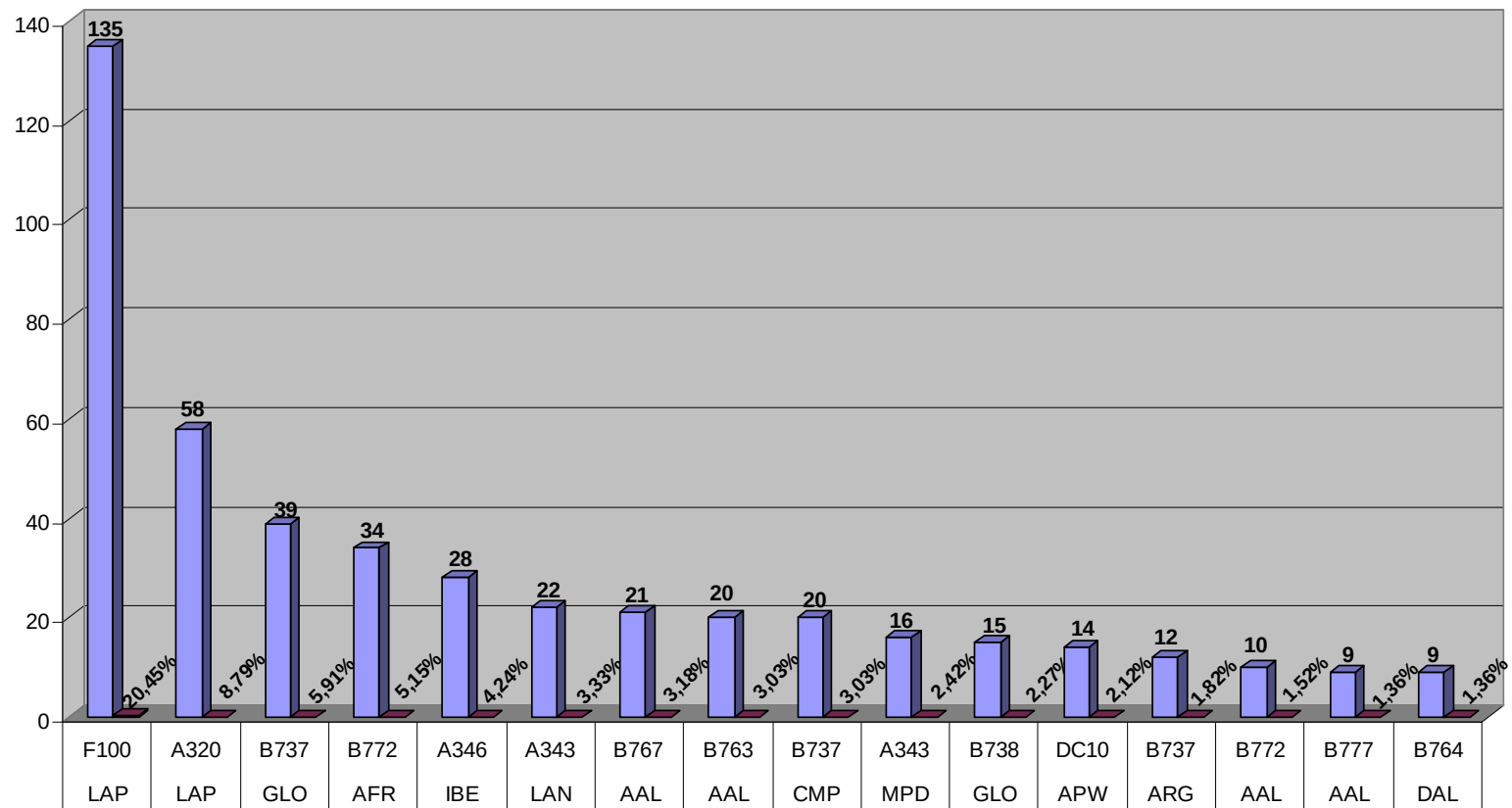
PANAMA

FIR PANAMA - Aerolínea / Tipo
51% del tránsito de la muestra



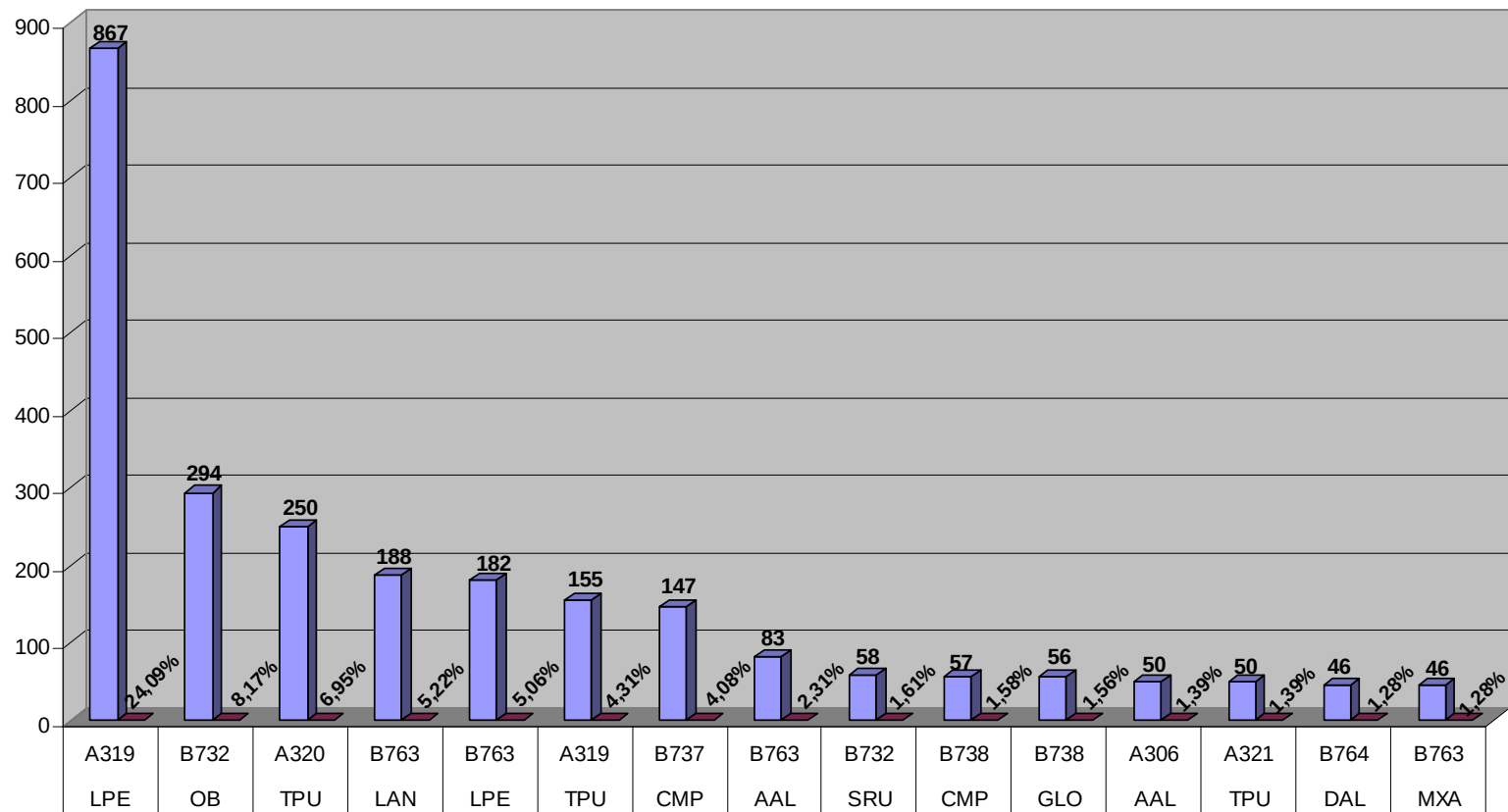
PARAGUAY

FIR ASUNCIÓN - Aerolínea / Tipo
70% del tránsito de la muestra

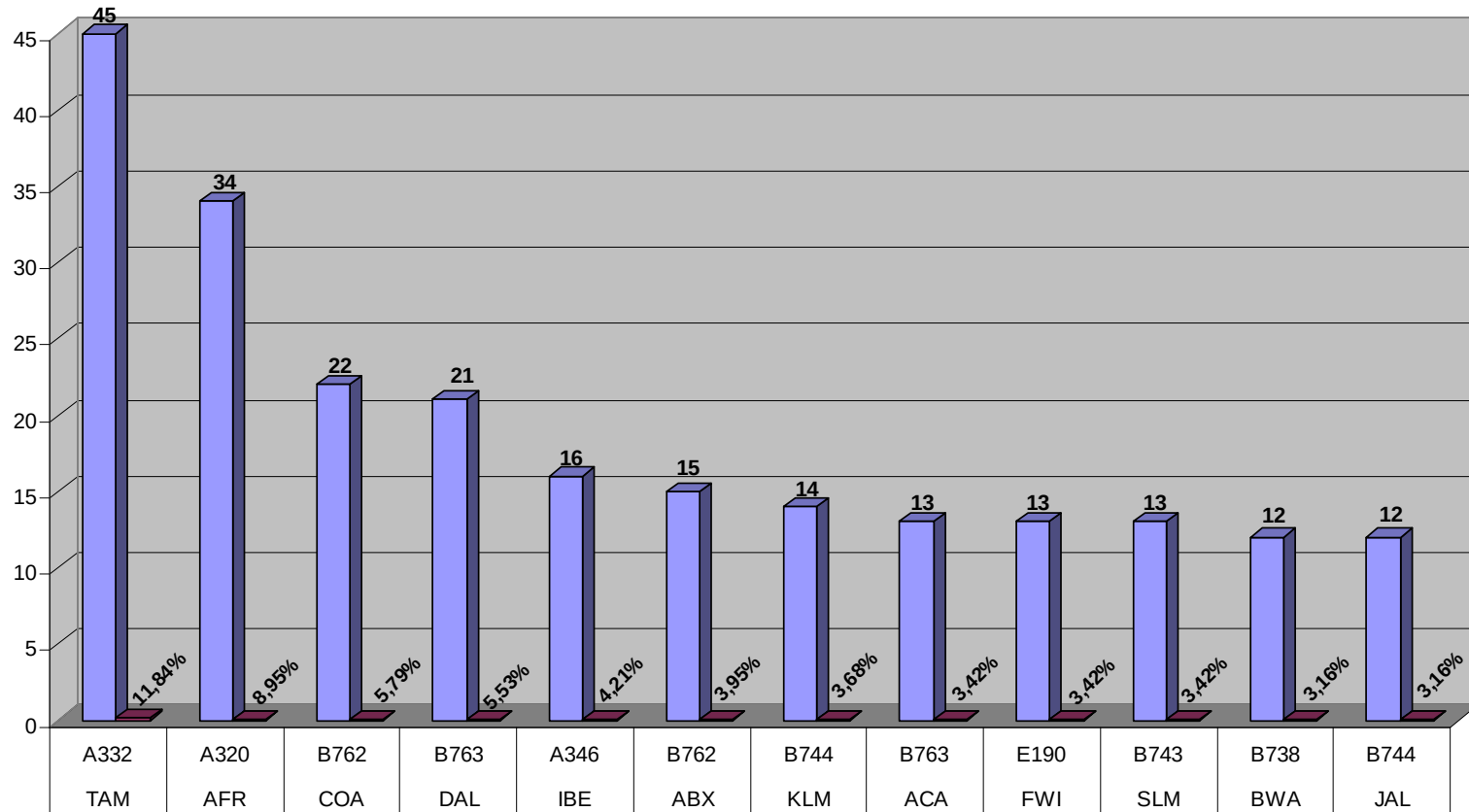


PERU

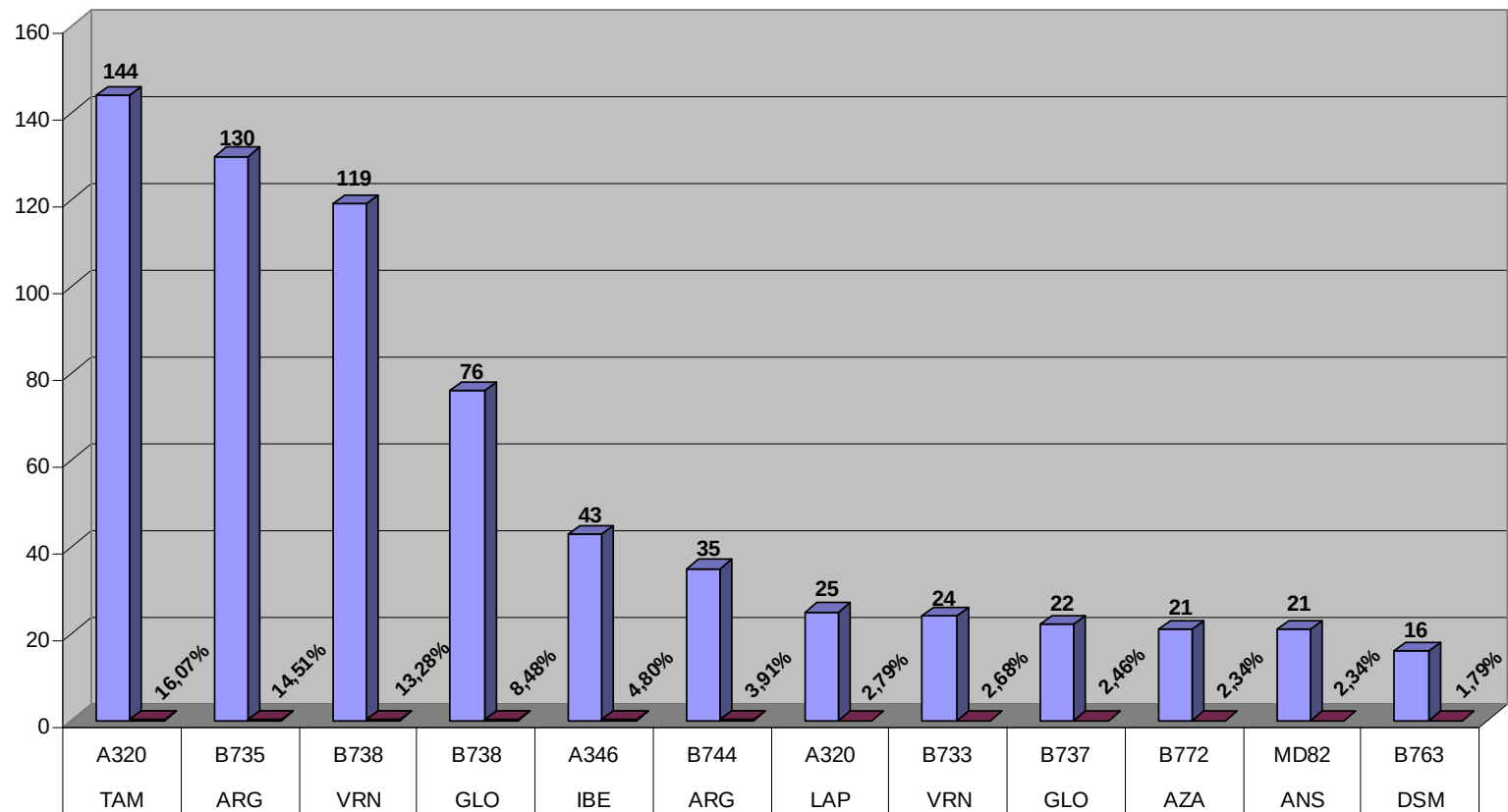
FIR LIMA - Aerolínea / Tipo
70% del tránsito de la muestra



SURINAME

**FIR PARAMARIBO - Aerolínea / Tipo
61% del tránsito de la muestra**

URUGUAY

FIR MONTEVIDEO - Aerolínea / Tipo
75% del tránsito de la muestra

APPENDIX C**INITIAL AIC MODEL FOR RNAV-5 IMPLEMENTATION**

Telephone: Fax: E-mail: Sitatex: Telex:	STATE AERONAUTICAL INFORMATION SERVICE	AIC N° DATE

1. Introduction

1.1. Continuous aviation growth makes it necessary to increase airspace capacity and points to the need for optimum use of available airspace. The improvement in operational efficiency deriving from the application of area navigation (RNAV) has resulted in the development of navigation applications in different regions and in all flight phases.

1.2. In planning navigation applications in specific routes or within a given airspace, it is necessary to define the requirements clearly and concisely. The reason for this is to ensure that the flight crew and the ATC are aware of the capacity and limitations of the navigation system (RNAV) and to guarantee that RNAV system performance is appropriate for airspace characteristics.

1.3. RNAV systems are used today in a way similar to ground-based conventional systems. An RNAV system is normally identified and its performance assessed through a combination of analyses and flight tests. The airspace concept is developed on the basis of information about RNAV equipment performance, being it necessary to determine whether different equipment models are appropriate for use in a given airspace.

1.4. In order to avoid this type of prescriptive RNAV specifications based on navigation equipment performance that result in delays in introducing new RNAV system capabilities and higher costs for appropriate maintenance and certification, ICAO developed the Performance-Based Navigation Concept (PBN).

1.5. This concept specifies the RNAV system performance requirements in terms of the accuracy, integrity, availability, continuity and functionality needed for the proposed operations in the context of the concept of a particular airspace. The PBN concept represents a shift away from systems-based navigation towards performance-based navigation. PBN application offers the following advantages:

- a) Reduces the need to maintain routes and procedures based on specific systems and, as a result, reduces the associated costs;
- b) Avoids the need to prepare operations based on specific systems for each new navigation system development, which would be prohibitively expensive;
- c) Allows for more efficient airspace use (fuel savings, noise reduction); and
- d) Facilitates operational approval of operators due to the application of a limited set of navigation specifications intended for global use.

Capacidad PBN de las Aeronaves

PBN Capacity of the Aircraft

Fecha:
Date

[illegible]

APPENDIX E

PBN IMPLEMENTATION PROJECT

TMA AND APPROACH OPERATIONS

SHORT TERM

SAM REGION

Introduction

The purpose of this document is to detail the activities of the Short-Term Performance-Based Navigation Implementation Project for TMA and Approach Operations in the South American Region, through the application of RNAV-1/RNP APCH/RNP AR. It also specifies the results that shall be obtained in each of the activities of the plan.

States shall develop their own PBN implementation projects for TMA and approach operations, based on the Model PBN Project for TMA and Approach Operations. Project RLA/06/901 will support SAM States through the development of guidance material and Project RLA/99/901 will provide support in the areas of fleet navigation capacity and aircraft and operator approval documentation.

The Short-Term Action Plan for TMA Operations is shown in **Attachment 1**, and **Attachment 2** presents the Short-Term Action Plan for Approaches.

PBN Implementation– TMA and Approach Operations - Short-Term

1. Airspace Concept

The Airspace Concept provides the scheme of operations within an airspace and is developed to meet explicit strategic objectives, such as safety improvement, increase in air traffic, environmental impact mitigation capacity, etc. The airspace concept shall include details about the practical organization of the airspace, based on user characteristics and on the CNS/ATM infrastructure that is available or to be implemented. Further details about the Airspace Concept can be found in the PBN Manual, Volume I, Chapter 2.

In the case of TMA operations, the airspace concept shall cover the implementation of SIDs and STARs that avoid arrival and departure conflicts and favour aircraft flight at optimum profiles, with the application of continuous descent approaches – CDA.

STARs must, insofar as possible, be linked to IFR approach procedures based on RNP APCH w/Baro-VNAV or, if there are clearly established operational benefits to be obtained, be based on RNP AR.

1.1. Establish and prioritize strategic objectives (safety, efficiency, the environment, etc.).

RNAV-1, RNP APCH and, in some cases, RNP AR, implementation in the SAM Region will address mainly the following Strategic Objectives:

- a) Safety – RNAV-1 application in TMAs will allow for a separation between arrival and departure paths, thus avoiding conflicts among aircraft. The use of RNP APCH with APV/Baro-VNAV and/or RNP AR will reduce the risk of collision flight into terrain (CFIT).
- b) Capacity – The use of RNAV-1 SIDs/STARs will make it possible to reduce the utilization of radar vectors and, as a result, will reduce airspace complexity and controller workload by improving the ATC capacity of the sectors and permitting a larger number of flight.
- c) Cost-effectiveness – PBN implementation will enable a larger number of aircraft to fly their optimum flight profiles, primarily through CDA use, offering users a better cost-effectiveness ratio.
- d) Efficiency – RNAV-1 application will improve operational efficiency, inasmuch as the establishment of well-defined arrival and departure points will make it possible to restructure the network of TMA incoming/outgoing routes, thereby reducing flying time. STAR–approach interaction will create the necessary conditions for establishing optimum arrival paths from the en-route to the final approach phase.

- e) Environmental Protection – Increased efficiency and fuel savings will reduce noxious gas emissions into the atmosphere. In addition, CDA application will help cut down on aircraft noise.
- f) Access and Equity – Implementation of the RNP APCH approach procedure and/or RNP AR will permit access to aerodromes under adverse weather conditions. PBN implementation shall not impede the flight of unapproved aircraft in a given airspace unless absolutely necessary because of air traffic density. It is expected that access and equity will be provided for in this way.
- g) Foreseeability – RNAV-1 navigation precision will make flight paths more foreseeable, facilitating aircraft separation and reducing the need for air traffic controller intervention in the case of possible aircraft diversions from the flight paths. STAR-approach integration will also enhance foreseeability.
- h) Global Interoperability – RNAV and RNP application, as provided for in the PBN Manual, will guarantee global interoperability through the application of standard navigation specifications, thereby avoiding the need to obtain various aircraft and operator approvals in order to fly in airspaces that use the same navigation application.
- i) ATM Community Participation – The success of PBN implementation will depend upon the effective participation of the ATM community, with a view towards guaranteeing that the operational requirements of both airspace users and service providers are met.

1.2. Collect air traffic data in order to understand air traffic flows.

Analysis of the main TMA arrival and departure flows is essential for prioritizing city pairs with a larger number of flights. The Excel spreadsheets used for the analysis of PBN en-route implementation can be obtained at the SAM Office website and used for analyzing the flows at the main TMAs in the SAM Region. It is important to note, however, that the air traffic sample used was the same as the one used for the CARSAMMA data collected between 13 and 28 January for RVSM safety assessment. This means that only flights between FL 290 and FL 410 were considered.

1.3. Analyze fleet navigation capacity.

The work to be carried out by ICAO and Project RLA/99/901, as mentioned in the PBN en-route Implementation Project, will cover PBN navigation specifications for the TMA.

There is a complete list of aircraft and avionics prepared by the FAA can be used to analyze fleet capacity for RNAV-1 and RNAV-2 specifications. This list can be found at: http://www.faa.gov/about/office_org/headquarters_offices/avs/offices/afs/afs400/afs470/media/AC90-100compliance.xls.

The appropriate GNSS-based navigation approach capacity shall be assessed for the RNP APCH specification.

For the RNP AR specification, the aircraft navigation capacity shall be assessed on the basis of clearly-established operational requirements, bearing in mind the flexibility of precision values in several approach segments that are normally between 0.3 and 0.1, as well as in accordance with the required functionalities for a specific airport, such as “radius to fix (RF) legs.”

The Excel templates used in the flow analyses for PBN en-route implementation may be obtained at the SAM Office website and used for analyzing the capacity of the fleet flying in the main SAM TMAs. Complete information is available at the SAM Office website.

1.4. Analyze the ground-based communication, navigation (VOR, DME) and surveillance infrastructure for navigation specifications, in order to comply with the Navigation Specification and the navigation reversal mode.

The ground-based communication, navigation (VOR, DME) and surveillance infrastructure is of fundamental importance for RNAV-1, both to permit the application of this navigation specification and to guarantee the navigation reversal mode in case of loss of the GPS signal. Inasmuch as this is an RNAV specification that does not require on board performance monitoring and alerting systems, ATS surveillance can mitigate the requirement for greater route spacing in order to overcome possible navigation system failures undetected by the flight crew.

The DME/DME navigation infrastructure will need to be assessed to verify whether the RNAV-1 navigation specification can be applied or whether it will be necessary to take one of the following measures:

- a) Use the inertial navigation system to cover possible gaps in DME coverage. In this case, it will be necessary to determine whether the aircraft fleet operating in the TMA is equipped with the inertial system.
- b) Assess the cost-benefit of implementing DME stations, in order to provide adequate coverage for DME/DME operations. This option will depend upon the percentage of aircraft that have DME/DME navigation alone and the State back-up policy in case of loss of the GNSS signal.
- c) Apply only GNSS to meet RNAV-1 requirements, considering the aspects cited in a) and b) above.

ATS surveillance is not required for RNP APCH approaches or RNP AR, but may be required if airspace complexity or the combined operation of approved and unapproved aircraft make it necessary.

1.5. Optimize airspace structure by implementing new SIDs and STARs and design instrument approach procedures (RNP APCH/APV Baro-VNAV or RNP AR) based on the strategic objectives of the airspace concept, considering airspace modelling, ATC simulations (in fast time and/or real time), live trials, etc.

Airspace structure will be optimized through the implementation of RNAV-1 SIDs and STARs that will provide well-defined TMA paths and arrival points, thereby avoiding air traffic conflicts and allowing users to fly their optimum flight profiles. For more complex airspaces, however, States should consider using the following tools:

- a) Airspace modelling;
- b) Fast-Time Simulation (FTS);
- c) Real-Time Simulation (RTS);
- d) live ATC trials

Use of these tools is not necessary for simple airspace changes like the implementation of a SID and/or a STAR. But for major changes in more complex airspaces, however, use of these tools can provide essential information for guaranteeing efficiency and safety. More information about these tools can be found in the PBN Manual, Volume I, part B, item 4.3.2.

The implementation of SIDs and STARs in an optimum configuration requires the spacing of TMA departure and/or arrival paths. In this respect, the State shall have trained personnel to make the necessary assessment or perform a comparative analysis, for example with other airspaces. Studies are being conducted by the Separation and Airspace Safety Panel (SASP) for the application of the aircraft separation protection areas for IFR procedures established in Doc. 8168. Approval of the proposal will facilitate appropriate TMA aircraft separation. It is important to highlight that some countries are already applying this aircraft separation methodology.

2. Prepare a performance measurement plan, including gas emissions, safety, efficiency, etc.

Performance-Based Air Traffic Management is organized based on the principle that ATM community expectations can best be met by quantifying such needs. Therefore, a series of performance objectives, goals and indicators shall be established that will make it possible to objectively justify projects for the improvement of air traffic management performance. **Attachment 6 to Appendix B** contains further details about Performance-Based ATM.

The estimated future performance of the ATM system will be of fundamental importance in guiding the planning of the improvements to be implemented. Research and development initiatives must be defined to foster the risk analysis of the following situations:

- a) the consequences of keeping the current ATM status unchanged. In this case, the ATM system would be subject to changes outside the sphere of operation of the service provider, such as: air traffic growth, changes in fleet composition, etc.; and
- b) the consequences of making changes that do not provide the expected improvement in system performance, therefore ceasing to meet the established performance goals.

The Key Performance Areas (KPA) involved in the case of simple implementations, like SIDs or STARs, are safety, efficiency and environmental protection. Safety can be measured qualitatively through a safety case. This possibility will be described more fully in the specific section on safety assessment. Efficiency and environmental protection are intrinsically related, inasmuch as an increase in efficiency normally results in a reduction in fuel consumption, thereby decreasing the amount of gas emissions released into the atmosphere. SID/STAR implementation must at least measure the expected saving in flying time and fuel consumption. It is important to stress that the implementation of a SID/STAR will not always result in a reduction in flying time, inasmuch as the purpose for its implementation could be, for example, to simplify TMA incoming and outgoing flows, thus reducing air traffic controllers and, consequently, increasing ATC capacity. In this case, a longer route could also create the necessary conditions for the use of continuous descent approach (CDA) procedures.

In more complex implementations, such as complete TMA restructuring, performance assessment will normally depend upon the use of specific tools like fast-time simulation (FTS), because a full and integrated assessment of the system will be needed that would be difficult to perform manually.

PBN implementation must consider at least the savings in flying time and fuel consumption, as well as the reduction of noxious gas emissions into the atmosphere. IATA has prepared a fuel saving calculation template that can be used to measure system performance. This template can be obtained at the SAM Office website.

3. Safety Assessment

3.1. Determine the methodology to be used for assessing airspace safety and route spacing, depending upon the navigation specification, considering airspace modelling, ATC (fast and real time) simulations, live ATC trials, etc.

The methodology for assessing airspace safety may be either quantitative or qualitative. An RSVM implementation and post-implementation safety assessment offers an example of a quantitative method. These quantitative methods are based on the Collision Risk Model (CRM) and require the use of experts in specific areas, such as statistics and mathematics. However, this safety assessment would be justified only in the case of major airspace changes, such as the complete restructuring of the most complex TMAs. Examples of collision risk models used in safety assessments can be found in DOC 9689 – Manual on the Planning Methodology for Determining Separation Minima.

A qualitative assessment based on operational judgment could be applied in the case of a SID and/or STAR implementation or of PBN application in less complex TMAs. This type of assessment must be documented through an SMS methodology-based safety case. ICAO Doc. 9859, Safety Management Manual, and Doc. CAP 760 (Guidance on the Conduct of Hazard Identification, Risk Assessment and the Production of Safety Cases) of the United Kingdom offer an example of systematic use of this methodology. The latter document can be found at: <http://www.caa.co.uk/docs/33/CAP760.PDF>.

The qualitative analysis mentioned in the previous paragraph can be used to conduct the safety assessment for the application of RNP APCH and RNP AR procedures, considering that the implementation of new approach procedures does not normally involve significant airspace changes.

3.2. Develop a data collection programme for airspace safety assessment.

In order to develop the data collection programme, the State must decide upon the safety assessment strategy, considering whether the assessment will be quantitative or qualitative. In the case of the complete restructuring of complex TMAs, the State shall collect the necessary data for the safety assessment and/or determination of the route spacing to be applied in the SAM Region.

3.3. Conduct the preliminary airspace safety assessment.

The preliminary airspace safety assessment shall be completed before the implementation date, in order to guarantee the necessary conditions for the start of the pre-operational phase, normally for a one-year period.

3.4. Prepare the final airspace safety assessment.

The final airspace safety assessment is usually performed one year after the implementation date, which will guarantee the start of the operational phase.

4. Establish a collaborative decision-making process (CDM)

The purpose of the collaborative decision-making process is to guarantee that all actors involved in the implementation process participate in the different phases of the project, thereby ensuring transparency and compliance with the interests of all users and service providers.

4.1. Coordinate planning and implementation needs with air navigation service providers, airports, regulators, users, aircraft operators and military authorities. States should guarantee the participation of the main stakeholders in PBN planning and implementation in TMAs. Representatives of the airlines, general aviation, military aviation, air navigation service providers, regulators, etc. should participate from the very beginning of the planning process.

4.2. Establish the implementation date.

The implementation date is one of the main aspects to be considered in the project, bearing in mind that it will eventually need to be adjusted to the interests of the various stakeholders.

4.3. Establish the documentation format at the State PBN website.

The Internet is an important mechanism for disseminating PBN documentation to all implementation stakeholders. The States should create an appropriate website to facilitate the dissemination of PBN activities.

4.4. Report advances in planning and implementation to the corresponding Regional Office.

States must report planning and implementation developments to the South American Regional Office in order to guarantee the necessary harmonization among SAM States and to encourage the exchange of experiences and lessons learned.

5. Automated ATC Systems

5.1. Assess PBN implementation in automated ATC systems, taking into account amendment 1 to the PANS/ATM (FPLSG).

The introduction of changes to the automated ATC system based on PBN implementation is intrinsically related to the need for the air traffic controller to differentiate between aircraft that are equipped for operations based on RNAV and RNP navigation specifications, and those that are not. That differentiation is particularly important in non-exclusionary operating environments that permit flights of aircraft both approved and not approved for a given air navigation specification. Changes in automated systems may vary in complexity, from the insertion of letters or codes in the flight progress strips and/or in the radar screen targets, to a complete change involving differentiated colours or an analysis before a flight plan is entered into the flight plan processing system, in order to guarantee that only approved aircraft can fill in an RNAV route or RNP procedure in the FPL.

Modifications in automated ATC systems must take into account amendment 1 to the PANS/ATM. This amendment, resulting from the work of the ICAO Air Navigation Commission Study Group on Flight Plans, was approved at the 177th Session of said Commission and will enter into effect on 15 November 2012. States were informed of the approval of amendment 1 to the PANS/ATM through ICAO State Letter AN 13/2.1-08/50, of 25 June 2008. The amendment can be obtained at the SAM Office website.

This amendment involves significant changes in the insertion of alphanumeric codes relating to RNAV and RNP approval that are of key importance for PBN implementation. Considering current flight plan limitations, most of these codes will be inserted in field 18. In summary, the changes concerning PBN are as follows:

- a) The name of FPL field 10 is changed to “Equipment and Capabilities”;
- b) The letter “R” in field 10 will now mean “PBN Approval”. Navigation specifications for which the aircraft and operator are approved must be inserted in FPL field 18, using the following codes:

- RNAV SPECIFICATIONS

- ✓ A1 - RNAV 10 (RNP 10)
- ✓ B1 - RNAV 5 all permitted sensors
- ✓ B2 - RNAV 5 GNSS
- ✓ B3 - RNAV 5 DME/DME
- ✓ B4 - RNAV 5 VOR/DME
- ✓ B5 - RNAV 5 INS or IRS
- ✓ B6 - RNAV 5 LORANC
- ✓ C1 - RNAV 2 all permitted sensors
- ✓ C2 - RNAV 2 GNSS
- ✓ C3 - RNAV 2 DME/DME
- ✓ C4 - RNAV 2 DME/DME/IRU
- ✓ D1 - RNAV 1 all permitted sensors
- ✓ D2 - RNAV 1 GNSS
- ✓ D3 - RNAV 1 DME/DME
- ✓ D4 - RNAV 1 DME/DME/IRU

- RNP SPECIFICATIONS

- ✓ L1 - RNP 4
- ✓ O1 - Basic RNP 1 all permitted sensors
- ✓ O2 - Basic RNP 1 GNSS
- ✓ O3 - Basic RNP 1 DME/DME
- ✓ O4 - Basic RNP 1 DME/DME/IRU
- ✓ S1 - RNP APCH
- ✓ S2 - RNP APCH with BARO-VNAV
- ✓ T1 - RNP AR APCH with RF (special authorization required)
- ✓ T2 - RNP AR APCH without RF (special authorization required)

- c) The letter “G” continues to be used in field 10 to mean “Equipped with GNSS.” The corresponding augmentations must be entered in field 18, using the NAV/ code.

5.2. Make the necessary changes in the automated ATC systems.

The introduction of changes in automated ATC systems is usually a complicated, expensive and slow process for most States. Consequently, only changes that are deemed essential for safety and efficiency must be implemented. The following main scenarios would be possible in the case of PBN implementation in the TMA:

- a) Combination of conventional SIDs/STARs and RNAV-1 – In this scenario, use of the automated ATC system would enable the controller to assign the appropriate procedure, depending upon aircraft capacity, duly in advance. The system will also foster the necessary conditions for verifying whether the aircraft is effectively approved to fly RNAV-1 SIDs/STARs. This verification could be made by comparing air traffic samples with a database of approved aircraft. If aircraft separation depends upon RNAV approval, a greater degree of ATC automation would be needed to indicate to the air traffic controller which aircraft have RNAV approval and which do not.
- b) RNAV-1 SIDs and STARs and routing of unapproved aircraft using radar vectoring – Like in the previous scenario, the air traffic controller must know the aircraft RNAV approval status in advance in order to provide radar vectoring to unequipped aircraft.
- c) Exclusionary RNAV airspaces (with or without special exceptions –State aircraft, humanitarian flights, first delivery, etc.) – In this scenario, route spacing will depend upon aircraft RNAV approval, and ATC automation will be essential to indicate aircraft approval status to the air traffic controller.

6. Aircraft and Operator Approval

6.1. Analyze aircraft and operator approval requirements (pilots, dispatchers and maintenance personnel) as established in the PBN Manual, and prepare the necessary documentation.

The PBN Manual, Volume II, Part B, Chapter 3 stipulates the general requirements for aircraft and operator approval for RNAV-1. EUROCONTROL and FAA documents on this topic are:

- a) EUROCONTROL – TGL-10 - Airworthiness and Operational Approval for Precision RNAV Operations in Designated European Airspace
- b) FAA – AC 90-100A – U.S. Terminal and En Route Area Navigation (RNAV) Operations.

The PBN Manual, Volume II, Part C, Chapter 5 contains the general requirements for aircraft and operator RNP APCH approval. EUROCONTROL and FAA documents on this topic are:

- a) EASA –AMC-20 Series – Airworthiness approval and operational criteria for RNP Approach (RNP APCH) operations (under development).
- b) FAA AC 20-138A - Airworthiness Approval of Navigation or Flight Management Systems Integrating Multiple Navigation Sensors.
- c) FAA AC 20-130A - Airworthiness Approval of Global Navigation Satellite System (GNSS) Equipment
- d) TSO C115b - Airborne Area Navigation Equipment Using Multi-Sensor Inputs

The PBN Manual, Volume II, Part C, Chapter 6 sets forth the general requirements for aircraft and operator RNP AR approval. The FAA document on this topic is:

- a) FAA AC 90-101 - Guidance for RNP Procedures with Special Aircraft and Aircrew Authorization Required

6.2. Publish national regulations for implementing RNP APCH and RNP AR for navigation specification RNAV-1.

Navigation specifications contained in the PBN Manual identify the requirements for operational and airworthiness approval for the use of RNAV or RNP applications. Provision must be made in national operational regulations for verifying compliance with these requirements, which may require specific operational approval.

Project RLA/99/901 is preparing the Latin American (LAR) Regulations, whose purpose is to harmonize the operational and airworthiness approval process in Latin America. Regional documentation provided through the LARs is expected to be available shortly. Coordination between this project and Project RLA 06/901 is fundamental for avoiding a duplication of efforts and facilitating the work of the States involved. Project RLA 99/901 could at least offer guidance material for adoption and publication by the States.

One option already in use by CAR/SAM States is to adopt documents of other States and International Organizations, as in the case of Interim Guidance 91 (RVSM) and Order 8400-12 (RNP-10).

6.3. Start the aircraft and operator approval process.

In order to meet the established implementation deadline, States must start the aircraft and operator approval process, and Project RLA 06/901 shall verify whether all States effectively initiate this process, in order to harmonize the activities of the States involved.

6.4. Establish a database of approved aircraft and operators and keep it up-to-date.

States shall establish a strategy for creating a database of aircraft and operators approved for RNP APCH and RNP AR RNAV-1 operations, similar to that created for RVSM implementation, taking into account the following objectives:

- a) When TMAs are to be completely restructured, and mainly in the case of an exclusionary airspace, it will be necessary to rely on a minimum percentage of operations approved for RNAV-1. In this connection, the creation of the database is essential for analyzing the minimum percentage.
- b) Verify whether the aircraft flying RNAV routes are effectively approved for RNAV-1, RNP APCH and RNP AR operations.

- 6.5. Verify operations using a continuous monitoring programme (aircraft and procedures).

Safety must be ensured through a continuous operational verification programme regulated by States.

7. Standards and Procedures

- 7.1. Assess the regulations for GNSS use and, where appropriate, proceed to their publication.

GNSS application is of key importance for all PBN navigation specifications, considering that some aircraft only have this equipment to meet the established performance requirements and that there are some specifications that only GNSS can meet.

The key issue is the State policy with regard to GNSS application as a means of navigation. In order for the system to be used fully, States must regulate its use as a primary means of navigation, even if this would require imposing some operational restrictions, such as, for example, requiring alternate aerodromes to provide for “conventional” approaches (VOR, NDB, ILS). Another aspect that should be considered is the need to establish a navigation reversal mode if the GNSS signal is lost, requiring the aircraft to be equipped with “conventional” air navigation systems.

States in the Region have already published some regulations for GNSS use. **Attachment 7 to Appendix B** shows the current status of these regulations in the SAM Region. Regulation of GNSS use is essential for all navigation applications.

The use of GNSS as a means of navigation is of key importance to meet RNAV-1 requirements, considering that some aircraft only have this type of RNAV equipment and that some TMAs may not have sufficient DME coverage to accommodate navigation based on this system. Consequently, SAM States should consider regulating the use of GNSS and make any changes they deem necessary.

For RNP APCH and RNP AR navigation specifications, GNSS is the only system that meets the requirements established in the PBN Manual.

- 7.2. Finalize WGS-84 implementation.

- 7.3. SID, STAR and Approach Ground Validation and Flight Inspection

A series of steps should be followed in preparing RNAV or RNP IFR procedures, starting with the generation of the data through their final publication and subsequent coding for use in the navigation database. The PBN Manual, Volume I, Part B, Appendix B contains information about the ground validation of IFR procedures. Quality control should be exercised in each design phase of the IFR procedures, in order to reach the necessary levels of precision and integrity. Doc. 8168 – PANS-OPS, Volume II, Part 1, Section 2, Chapter 4 (Quality Assurance) details the quality control procedures to be used.

Flight inspections must be made of the procedures and radio aids on which the procedures are based. Insofar as the procedure flyability is concerned, States must consider using flight simulators in order to verify whether the proposed procedures can properly serve the most critical aircraft in a given airspace/aerodrome.

7.4. Establish Navigation Database Validation Requirements and Procedures.

The integrity of navigation databases is a key safety element in a PBN environment, depending on the Navigation Specification requirements. Consequently, database integrity should meet the requirements set forth in documents DO 200A and/or EUROCAE ED 76 (Data Quality Assurance Process). The State must issue a Letter of Acceptance (LOA) documenting that the database provider meets the requirements of DO 200A and/or EUROCAE ED 76 or accept the LOAs issued by other States or International Organizations (FAA or EUROCONTROL).

7.5. Prepare the AIC model to report PBN implementation plans.

The AIC reporting PBN implementation, published approximately 2 years in advance, will give aircraft operators enough time to obtain approvals for RNP APCH and/or RNP AR RNAV-1 operations.

7.6. Publish the AIC reporting PBN implementation plans.

States must publish the AIC reporting PBN implementation plans.

7.7. Prepare an AIP Supplement model containing applicable standards and procedures, including the corresponding in-flight contingencies.

The AIP Supplement will contain specific operational standards and procedures for RNP APCH and/or RNP AR RNAV-1 implementation.

7.8. Publish an AIP Supplement containing applicable standards and procedures, including the corresponding in-flight contingencies.

7.9. Review the Procedural Handbook of the ATS units involved.

The Procedural Handbook of the ATS units gives a detailed account of their mode of operation, in an effort to harmonize the operational procedures applied by air traffic controllers. RNAV-1 implementation will require a review of these procedures, considering in particular:

- a) Aircraft separation;
- b) Contingency procedures;
- c) New SID/STAR/approach procedures;
- d) Radio aids that are essential for SID, STAR and approach procedures. For the approach, this is normally applied in cases when the missed approach is based on a ground-based radio aid.
- e) New air traffic routing models (new air flow), including the SID/STAR/approach procedures used, radar vectoring, if required, and the systematic “feeding” of TMAs.

- 7.10. Update letters of agreement between ATS units.

Letters of agreement between ATS units (between ACCs or between ACCs and APPs) shall be updated to reflect the new airspace structure implemented, if appropriate, and the procedures mentioned in the previous paragraph.

- 7.11. Review practices and procedures for improving fuel consumption management and environmental protection.

This must be an objective to be sought at all SAM/IG meetings, in accordance with the environmental policy of ICAO and of the SAM States.

8. Training

- 8.1. Prepare a training and documentation programme for operators (pilots, dispatchers and maintenance personnel).

The documentation and training leading to the operational approval of an aircraft operator is normally part of the operational certification process that guarantees the use of an Air Navigation Application. Each aircraft operator must develop a training programme to be approved by the civil aviation authority, in order to obtain approval for the use of an Air Navigation Application. The PBN Manual, Volume II, Parts B and C, contains some general training guidelines for aircraft operators that cover each Navigation Specification.

- 8.2. Develop a training and documentation programme for air traffic controllers and AIS operators.

The PBN Manual, Volume II, Parts B and C, contains some general training guidelines for air traffic controllers that cover each Navigation Specification.

- 8.3. Develop a training programme for regulators (aviation safety inspectors).

Aviation safety inspectors must receive the necessary training so as to be able to verify compliance with PBN specification norms.

- 8.4. Conduct training programmes.

States, service providers and aircraft operators must conduct the necessary training programmes within the stipulated period in order to ensure implementation by the established deadline.

- 8.5. Hold seminars for operators, indicating the plans and expected operational and economic benefits.

The main purpose for holding seminars targeting operators is to urge them to equip their aircraft within an appropriate period of time, in keeping with the established navigation specifications, showing them the objectives and benefits to be attained through said implementation.

9. Decision to Implement

At this point in the Action Plan, three basic questions must be answered:

- a) Is the aircraft operator ready for the implementation? (9.1 and 9.2)
- b) Is the air traffic service provider ready for the implementation? (9.1)
- c) Is the implementation safe? (9.3).

A specific meeting must be held to assess these three key points and reach a final implementation decision.

When a final decision has been reached, each State must publish the relevant ATS documentation, including the trigger NOTAM, seven days before the planned implementation date, in order to confirm it.

- 9.1. Assess the available operational documentation (ATS, OPS/AIR).
- 9.2. Assess the percentage of approved aircraft and operators (overall equipment involved).
- 9.3. Review the results of the safety assessment.
- 9.4. Publish the trigger NOTAM.

10. Performance Monitoring System

Following the implementation of the navigation Application, the TMA will enter the pre-operational phase for a one-year period. At the end of this period, if the assessment is positive, it will be possible to move to the operational phase. During this period, a post-implementation operations monitoring programme must be established primarily to assess safety. A performance assessment system must also be implemented, as stipulated in item 2 of the Action Plan. Both the safety and the performance assessment, as a whole, must be carried out on an ongoing basis.

- 10.1. Develop a post-implementation monitoring programme for TMA and approach operations.
- 10.2. Implement a post-implementation monitoring programme for TMA and approach operations.

ATTACHMENT 1 TO APPENDIX E

SHORT-TERM TMA PBN ACTION PLAN (RNAV-1) (GPIs 1, 4, 5, 7, 8, 10, 11, 12, 16, 21, 23)

1. Airspace concept	Start	End	Responsible party	Remarks
1.1 Establish and prioritize strategic objectives (safety, capacity, environment, etc.)			States	
1.2 Collect traffic data in order to understand traffic flows in TMA airspace			States	
1.3 Analyze the navigation capacity of the aircraft fleet in the TMA			States	
1.4 Analyze ground-based means of communication, navigation (VOR, DME) and surveillance to meet navigation specifications and navigation reversal mode			States	
1.5 Optimize airspace structure, reorganizing the network or implementing new routes based on the strategic objectives of the airspace concept, taking into account airspace modelling, ATC simulations (fast time and/or real time), live tests, etc.			States	
2. Develop a performance measurement plan	Start	End	Responsible party	Remarks
2.1 Draft a plan to measure performance, including gas emissions, safety, efficiency, etc.			States	
2.2 Implement the performance measurement plan			States	
3 Safety assessment	Start	End	Responsible party	Remarks
3.1 Determine the methodology to be used to assess airspace safety and route spacing, based on the navigation specification, taking into account airspace modelling, ATC simulations (fast time and/or real time), live tests, etc.			States	
3.2 Develop a data collection programme to assess airspace safety			States	
3.3 Prepare the preliminary airspace safety assessment			States	

3	Safety assessment	Start	End	Responsible party	Remarks
3.4	Prepare the final airspace safety assessment			States	
4	Establish a collaborative decision-making process (CDM)	Start	End	Responsible party	Remarks
4.1	Coordinate planning and implementation requirements with air navigation service providers, regulators, users, aircraft operators and military authorities			States	
4.2	Establish the implementation date			States	
4.3	Establish the documentation format in the SAM PBN website			States	
4.4	Report planning and implementation developments to the corresponding Regional Office			States	
5	ATC automated systems	Start	End	Responsible party	Remarks
5.1	Assess PBN implementation in ATC automated systems, taking into account amendment 1 to the PANS/ATM (FPLSG).			States	
5.2	Implement the necessary changes in ATC automated systems			States	

6. Aircraft and operator approval	Start	End	Responsible party	Remarks
6.1 Analyze aircraft and operator approval requirements (pilots, dispatchers and maintenance personnel), in keeping with the PBN manual, and develop the necessary documentation.			States	
6.2 Publish national regulations for the implementation of the RNAV-1 navigation specification			States	
6.3 Begin the approval of aircraft and operators			States	
6.4 Establish and keep up to date a registry of approved aircraft and operators			States	
6.5 Verify the operation of the continuous monitoring programme (aircraft and procedures)			States	

7. Standards and procedures	Start	End	Responsible party	Remarks
7.1 Assess and, if applicable, publish the regulations on the use of GNSS.			States	
7.2 Finalize WGS-84 implementation			States	
7.3 Ground validation and in-flight inspection of SIDs and/or STARs			States	
7.4 Establishment of navigation database validation requirements and procedures			States	
7.5 Develop an AIC model to report PBN implementation plans			States	
7.6 Publish the AIC reporting PBN implementation plans			States	
7.7 Develop an AIP Supplement model containing applicable standards and procedures, including the corresponding in-flight contingencies			States	
7.8 Publish the AIP Supplement containing applicable standards and procedures, including the corresponding in-flight contingencies			States	
7.9 Review the Procedural Handbook of the ATS units involved			States	
7.10 Update the letters of agreement between ATS units			States	

7. Standards and procedures	Start	End	Responsible party	Remarks
7.11 Review practices and procedures to improve fuel consumption management and environmental protection			States	
8. Training	Start	End	Responsible party	Remarks
8.1 Develop a training and documentation programme for operators (pilots, dispatchers and maintenance personnel)			States	
8.2 Develop a training and documentation programme for air traffic controllers and AIS operators			States	
8.3 Develop a training programme for regulators (aviation safety inspectors)			States	
8.4 Conduct training programmes			States	
8.5 Conduct seminars for operators, explaining plans and expected operational and economic benefits			States	
9. Implementation decision	Start	End	Responsible party	Remarks
9.1 Assess the available operational documentation (ATS, OPS/AIR)			States	
9.2 Assess the percentage of approved aircraft and operators (non-exclusionary airspace)			States	
9.3 Analyze the results of the safety assessment			States	
9.4 Publish trigger NOTAM			States	

10. Performance monitoring system	Start	End	Responsible party	Remarks
10.1 Develop a post-implementation monitoring programme for TMA operations			States	
10.2 Implement a post-implementation monitoring programme for TMA operations			States	
Pre-operational implementation date			States	
Definitive implementation date			States	

ATTACHMENT 2 TO APPENDIX D

APPROACH PBN ACTION PLAN GPIs 1, 12, 16, 21, 23

1. Airspace concept	Start	End	Notes
1.1 Establish and prioritize strategic objectives (safety, capacity, environment, etc.)			
1.2 Analyze the navigation capacity of the aircraft fleet that operates at the airport			
1.3 Analyze ground-based means of communication, navigation (VOR, DME) and surveillance to meet the navigation specifications and the navigation reversal mode			
1.4 Design instrument approach procedures (APCH/APV Baro-VNAV RNP or RNP AR) based on the strategic objective of the airspace concept, taking into account airspace modeling, ATC simulations (fast time and/or real time), live tests, etc.			
2. Develop a performance measurement plan	Start	End	Notes
2.1 Draft a plan to measure performance, including gas emissions, safety, efficiency, etc.			
2.2 Implement the performance measurement plan			
3. Safety assessment procedure	Start	End	Notes
3.1 Determine the methodology to be used to assess airspace safety, based on the navigation specification, taking into account airspace modelling, ATC simulations (fast time and/or real time), live tests, etc.			
3.2 Develop a data collection programme to assess airspace safety			
3.3 Prepare a preliminary safety assessment for the application of the procedure(s)			
3.4 Prepare a final safety assessment for the application of the procedure(s)			
4 Establish a collaborative decision-making process (CDM)	Start	End	Notes
4.1 Coordinate planning and implementation requirements with air navigation service providers, regulators, users, aircraft operators and military authorities			

4	Establish a collaborative decision-making process (CDM)	Start	End	Notes
4.2	Establish the implementation date			
4.3	Establish the format and documentation of the SAM PBN website			
4.4	Report planning and implementation progress to the SAM Regional Office			

5	ATC automated systems	Start	End	Notes
5.1	Assess PBN implementation in ATC automated systems, taking into account amendment 1 to the PANS/ATM (FPLSG).			
5.2	Implement the necessary changes in ATC automated systems			

6.	Aircraft and operator approval	Start	End	Notes
6.1	Analyze aircraft and operator approval requirements (pilots, dispatchers and maintenance personnel) in keeping with the PBN manual, and develop the necessary documentation.			
6.2	Publish national regulations for the implementation of the navigation specification			
6.3	Begin the approval of aircraft and operators			
6.4	Establish and keep up to date a registry of approved aircraft and operators			
6.5	Verify the operation of the continuous monitoring programme (aircraft and procedures)			

7.	Standards and procedures	Start	End	Notes
7.1	Assess and, if applicable, publish the regulations on the use of GNSS.			
7.2	Finalize WGS-84 implementation			
7.3	Ground validation and in-flight inspection of approach procedures			

7.4	Establish the navigation database validation requirements and procedures			
7.5	Develop an AIC model to report PBN implementation plans			
7.6	Publish the AIC reporting PBN implementation plans			
7.7	Develop an AIP Supplement model containing applicable standards and procedures, including the corresponding in-flight contingencies			
7.8	Publish the AIP Supplement containing applicable standards and procedures, including the corresponding in-flight contingencies			
7.9	Review the Procedural Handbook of the ATS units involved			
7.10	Update the letters of agreement between ATS units			
7.11	Review practices and procedures to improve fuel consumption management and environmental protection			

8. Training	Start	End	Notes
8.1 Develop a training and documentation programme for operators (pilots, dispatchers and maintenance personnel)			
8.2 Develop a training and documentation programme for air traffic controllers and AIS operators			
8.3 Develop a training programme for regulators (aviation safety inspectors)			
8.4 Conduct training programmes			
8.5 Conduct seminars for operators, explaining plans and expected operational and economic benefits			

9. Implementation decision	Start	End	Notes
9.1 Assess the available operational documentation (ATS, OPS/AIR)			
9.2 Assess the percentage of approved aircraft and operators (non-exclusionary airspace)			
9.3 Analyze the results of the safety assessment			
10. Performance monitoring system	Start	End	Notes
10.1 Develop a post-implementation approach operations monitoring programme			
10.2 Implement a post-implementation approach operations monitoring programme			
Pre-operational implementation date			
Definitive implementation date			

Agenda Item 3: Standards and procedures for performance-based navigation operations approval

Operation Approval related to RNAV 5

3.1 The Meeting took note that during the First Workshop/Meeting of SAM Implementation Group (SAM/IG/1) the regional action plan corresponding to RNAV 5 implementation for the en-route operations was examined. The Meeting was also informed that in Section 7 of this Plan related to the aircrafts and operators, the following activities were agreed to be carried out:

- a) evaluate regulations related to GNSS use, taking in consideration its application in the RNAV navigation specification;
- b) analyze aircraft and operators approval requirements (pilots, dispatchers and maintenance personnel), as showed in PBN Manual, and prepare the necessary documentation;
- c) publish the operational approval process;
- d) start aircraft and operators approval process;
- e) establish and maintain an approved aircraft and operator updated register; and
- f) check the operation according to continuous monitoring program (aircraft and procedures).

3.2 Before authorizing RNAV 5 operations, States should include in their national regulations the rules related to this navigation specification and also develop procedures accordingly for aircraft and operators approval.

3.3 At present, Project RLA/99/901 is developing Latin American Aeronautic Regulations and respective manuals for operations and airworthiness inspectors, with the purpose to establish requirements and common procedures in the region.

3.4 In this context, the Regional Cooperation System for Safety Oversight (SRVSOP) of Project RLA/99/901 was entrusted to develop an Advisory Circular (CA) and Job Aid for aircraft and operators RNAV 5 operational approval. In this regard, the Meeting took note of the contents of the Advisory Circular CA 91-002 – Aircraft and operators RNAV 5 operational approval considering that it was an appropriate guide to carry out such approvals.

3.5 Afterwards, the Meeting was informed on the Job Aid, expressing its agreement with it. In view of the above, the Meeting formulated the following conclusion:

Conclusion SAM/IG/2-5

Advisory Circular CA 91-002 and Job Aid for Aircraft and operators RNAV 5 operational approval

That States of ICAO South American Region:

- a) Use as an acceptable compliance source in aircraft and operators RNAV 5 operational approval Advisory Circular CA 91-002 and Job Aid for Aircraft and operators RNAV 5 operational approval, presented in **Appendices A and B**, respectively, to this part of the Report.
- b) Publish respective national regulations up to April 2009.

Work Programme for Advisory Circulars (CA) Development referred to PBN Operational Approvals

3.6 Considering that PBN implementation, in a short and medium term, requires of guidance material development to carry out aircraft and operators' approvals of different navigation specifications, included in PBN Roadmap, it was considered necessary to establish a work programme to simplify the development of aforementioned material.

3.7 In this regard, the Meeting took note of a proposal of a Work Programme considering it appropriate for regional requirements and approved the time scale presented in **Appendix C** this part of the Report.

APPENDIX A

ADVISORY CIRCULAR

AC : 91-002
DATE : 27/10/08
REVISION : Original
ISSUED BY : SRVSOP

SUBJECT: AIRCRAFT AND OPERATORS APPROVAL FOR RNAV 5 OPERATIONS

1. PURPOSE

This advisory circular (AC) provides acceptable means of compliance of LAR requirements in respect to aircraft and operators approval for RNAV 5 operations.

An operator may use alternative means of compliance, as far as those means are acceptable for their respective Civil Aviation Authority (CAA).

This AC also provides guidance when the stand-alone GPS is used as the primary means of navigation in RNAV 5 operations (where the stand-alone GPS equipment provides the only RNAV capability installed onboard the aircraft).

2. RELATED SECTIONS OF LATIN AMERICAN AERONAUTICAL REGULATIONS (LAR) OR EQUIVALENT REGULATIONS

LAR 91: Sections 91.880 (b) and 91.1650 or sections of equivalent regulations

LAR 121: Section 121.995 (b) or section of equivalent regulations

LAR 135: Section 135.570 (b) or section of equivalent regulations

3. RELATED DOCUMENTS

Doc 9613 Performance based navigation manual (PBN) and its related documentation

AMC 20-4 Airworthiness approval and operational criteria for the use of navigation systems in European airspace designated for Basic RNAV operations and its related documentation

AC 90-96A Approval of U.S. operators and aircraft to operate under instrument flight rules (IFR) in European airspace designated for basic area navigation (B-RNAV) and precision area navigation (P-RNAV) and its related documentation

CO 1/98 Resolution for operational approval and criteria for the use of navigation systems in European airspace designated for Basic RNAV operations

4. DEFINITIONS AND ABBREVIATIONS

4.1 Definitions

- a) **Navigation specifications.-** A set of aircraft and air crew requirements, needed to support performance based navigation operations within a defined airspace. There are two kinds of navigation specifications: RNAV and RNP. A RNAV specification does not include requirements for on-board performance monitoring and alerting. A RNP specification includes requirements for on-board performance monitoring and alerting.

- b) **Performance based navigation (PBN).**- Area navigation based on performance requirements for aircraft operating along an ATS route, on an instrument approach procedure or in a designated airspace.

Note.— Performance requirements are expressed in navigation specifications (RNAV specification, RNP specification) in terms of accuracy, integrity, continuity, availability and functionality needed for the proposed operation in the context of a particular airspace concept.

- c) **Area navigation (RNAV).**- A method of navigation which permits aircraft operation on any desired flight path within the coverage of ground or space-based navigation aids or within the limits of the capability of self-contained aids, or a combination of these.

Note.- Area navigation includes performance-based navigation as well as other operations that do not meet the definition of performance-based navigation.

- d) **RNAV operations.**- Aircraft operations using area navigation for RNAV applications. RNAV operations include the use of area navigation for operations which are not developed in accordance with the PBN manual.

- e) **Area navigation route.**- An Air traffic services (ATS) route established for the use of aircraft capable of employing area navigation.

- f) **Global positioning system (GPS).**- The United States Global navigation Satellite System (GNSS) is a satellite-based radio navigation system which utilizes precise range measurements to determine position, velocity and time in anywhere in the world. The GPS is composed by three elements: space, control, and user. The space element is formed of at least 24 satellites in 6 orbital planes. The control element consists of 5 monitor stations, 3 ground antennas, and a master control station. The user element consists of antennas and receivers that provide positioning, velocity and precise timing to the user.

- g) **RNAV System.**- Area navigation system, which permits aircraft operation on any desired flight path within the coverage of ground or space-based navigation aids or within the limits of the capability of self-contained aids, or a combination of these. A RNAV system may be included as part of the Flight Management System (FMS)

- h) **Receiver Autonomous Integrity Monitoring (RAIM).**- A technique used within a GPS receiver/processor to determine the integrity of its navigation signals using only GPS signals, or GPS signals augmented with barometrical altitude data. This determination is achieved by a consistency check among redundant pseudo-range measurements. At least one additional satellite needs to be available in respect to the number of satellites that are needed to obtain the navigation solution.

4.2 Abreviaturas

a)	CAA	Civil Aviation Authority
b)	ADF	Automatic direction finder
c)	AIRAC	Aeronautical information regulation and control
d)	AC	Advisory circular (FAA)
e)	AFM	Aircraft flight manual
f)	AMC	Acceptable means of compliance
g)	ATS	Air traffic services
h)	CA	Advisory circular (SRVSOP)
i)	CDI	Course deviation indicator

j)	CDU	Control display unit
k)	CO	Operacional Circular (Spain)
l)	DME	Distance measuring equipment
m)	DOP	Dilution of precision
n)	EASA	European Aviation Safety Agency
o)	EUROCAE	European Organization for Civil Aviation Equipment
p)	FAA	Federal Aviation Administration
q)	FDE	Fault detection and exclusion
r)	FTE	Flight technical error
s)	GNSS	Global navigation satellite system
t)	GPS	Global positioning system
u)	HSI	Heading situation indicator
v)	IFR	Instrument flight rules
w)	INS	Inertial navigation system
x)	IRS	Inertial reference system
y)	IRU	Unidad de referencia inercial
z)	LAR	Latin American Regulations
aa)	LORAN C	Long range navigation
bb)	MEL	Minimum equipment list
cc)	NDB	Non-directional beacon
dd)	ND	Navigation display
ee)	NOTAM	Notice to airmen
ff)	ICAO	Internacional Civil Aviation Organization
gg)	OM	Operations manual
hh)	PBN	Performance based navigation
ii)	PF	Pilot flying
jj)	PNF	Pilot not flying
kk)	POH	Pilot operating handbook
ll)	RAIM	Receiver autonomous integrity monitoring
mm)	RNAV	Area navigation
nn)	RTCA	Radio Technical Commission for Aeronautics
oo)	SA	Selective availability
pp)	TACAN	Tactical air navigation
qq)	TCDS	Type certificate data sheet
rr)	TLS	Target level of safety
ss)	TSO	Technical standard order
tt)	VOR	Very high frequency (VHF) omni-directional radio range

5. INTRODUCTION

5.1 In January 1998, the European Air Safety Agency (EASA) published the document related to the acceptable means of compliance (AMC 20-4) which replaced the Temporary guidance Leaflet No. 2 (TGL No. 2) issued by former JAA. This AMC contains acceptable means of compliance related to airworthiness approval and operational criteria for the use of navigation systems in European air space designated for basic area navigation operations (Basic RNAV or B-RNAV).

5.2 In the same manner, the Federal Aviation Administration (FAA) of the United States (U.S.) replaced the AC 90-96 of March 1998 by AC 90-96A issued in January 2005. This new circular provides guidance material in regards to the airworthiness and operational approval for operators of U.S. registered civil aircraft operating in European air space designated for Basic area navigation (B-RNAV) and Precision area navigation (P-RNAV).

5.3 Both current documents, AMC 20-4 and AC 90-96A, require similar operational and functional requirements.

5.4 In the context of the terminology adopted in the Performance based navigation manual (PBN manual) of the International Civil Aviation Organization (ICAO), B-RNAV requirements are termed RNAV 5.

5.5 The basis of specifications developed by EASA and FAA are supported on the capacity of RNAV equipments incorporated in the early 70s.

5.6 Since RNAV 5 operations implementation is accomplish in areas where there is no surveillance, such implementation requires an increase in route spacing to assure compliance of the Target level of safety (TLS).

5.7 RNAV 5 specification does not require an alert to the pilot in the event of excessive navigation errors, neither requires two RNAV Systems, thus, the potential for loss of RNAV capability requires the aircraft to be provided of an alternative navigation source.

5.8 The performance level selected for RNAV operations allows a wide range of RNAV systems to be approved for these operations, including INS with a two hour limit after its last alignment/position update performed on the ground, when they do not have a function for automatic radio updating of aircraft position.

5.9 Although RNAV 5 specification does not include requirements for on-board performance monitoring and alerting, it does require that the on-board equipment keeps a lateral and longitudinal navigation accuracy on route of ± 5 NM or better during 95% of the total flight time.

6. AIRCRAFT EQUIPMENT REQUIREMENTS

6.1 RNAV 5 systems allow an aircraft to navigate along any desired flight path within the coverage of ground or space-based navigation aids or within the limits of the capability of self-contained aids, or a combination of both methods.

6.2 RNAV 5 operations are based in the use of one or more RNAV equipments that automatically determine aircraft position in the horizontal plane using inputs from one or a combination of the following types of position sensors, together with the means to establish and follow a desired path:

- a) VOR/DME;
- b) DME/DME;
- c) INS o IRS;
- d) LORAN C; and

- e)
- f) GNSS.

Note.- The application of the sensors is subject to the limitations contained in Paragraph 8.4 of this AC.

7. AIRWORTHINESS AND OPERATIONAL APPROVAL

7.1 In order to a commercial air transport operator receives an RNAV 5 authorization, this must comply with two types of approval:

- a) Airworthiness approval in charge of the State of registry; and
- b) Operational approval in charge of the State of the operator.

7.2 For a general aviation operator, the State of registry will determine the aircraft meets the applicable RNAV 5 requirements and issue the operating authority (e.g., Letter of authorization – LOA).

7.3 Compliance with airworthiness requirements by themselves does not constitute the operational approval.

8. AIRWORTHINESS APPROVAL

8.1 Aircraft equipment

- a) An aircraft may be considered eligible for an RNAV 5 approval if it is equipped with one or more navigation systems approved and installed in accordance with the guide included in this document.
- b) An aircraft capacity to perform RNAV 5 operations can be demonstrated or reached in the following cases
 - 1) First case: Demonstrated capacity in the manufacturing process and declared in the Aircraft flight manual (AFM) or in the AFM supplement or in the Type certificate data sheet (TCDS) or in the Pilot operating handbook (POH).
 - 2) Second case: Capacity reached in-service:
 - i. Through an evaluation of the navigation system of the aircraft which allows to determine its eligibility.

8.2 Eligibility based on AFM or AFM supplement or TCDS or POH. To determine eligibility of the aircraft in function of AFM or AFM supplement, TCDS or POH, aircraft RNAV 5 capacity must have been demonstrated in production (aircraft in manufacturing process or new construction).

a) Aircraft RNAV 5 systems eligibility.

- 1) An aircraft may be considered eligible for RNAV 5 operations, if AFM or AFM supplement or TCDS or POH shows the appropriate instruments flight rules (IFR) navigation system installation has received airworthiness approval in accordance with this AC or AMC 20-4 or with one of the following FAA documents:
 - i. AC 90-96, AC 90-45A, AC 20-121A, AC 20-130, AC 20-138 o AC 25-15.

*Note.- An aircraft may be considered eligible for RNAV 5 operations, if AFM or AFM supplement or TCDS or POH shows the aircraft has been approved for **B-RNAV** in accordance with EASA AMC 20-4 or FAA AC 90-96A.*

- 2) Airworthiness approval guidance included in this AC provides aircraft navigation performance equivalent to EASA AMC 20-4 and FAA AC 90-96A.
- 3) Once aircraft eligibility has been established, operator approval will proceed, according to paragraph 9 of this AC.

4)

b) LAR 91 aircraft approval

- 1) LAR 91 operators should revise the AFM or AFM supplement or TCDS or POH to assure that the aircraft navigation system is eligible to perform RNAV 5 operations, according to describe on paragraph 8.2 a) 1) of this AC.
- 2) After having determined eligibility of the navigation system, LAR 91 operators will present respective documents to the AAC.
- 3) A letter of authorization (LOA) is not required when the aircraft eligibility has been determined based on the AFM or AFM supplement or TCDS or POH.
- 4) In case LAR 91 operators are not able to determine, based on the AFM or AFM supplement or TCDS or POH, whether the Aircraft system has been installed and approved according with an appropriate CA or AC or AMC, they will proceed according to paragraph 8.3. of this document.

c) LAR 121 and/or 135 aircraft approval

- 1) LAR 121 and/or 135 operators will present the following documents to AAC:
 - i. Sections of the AFM or AFM supplement or TCDS that document airworthiness approval in accordance with this AC or with mentioned documents in paragraph 8.2 a) 1) of the this document.
- 2) These operators will ensure that the aircraft navigation system will meet the functions required in paragraph 8.6 of this CA.
- 3) In case a LAR 121 and/ or 135 operator is not able to determine, based on the AFM or AFM supplement or TCDS, whether the system has been installed and approved according to an appropriate CA or AC or AMC, it will proceed in accordance with to the steps established in the following paragraph.

8.3 Eligibility not based on AFM or TCDS or AFM Supplement or POH – RNAV 5 capacity reached during service.

a) *Determination of the aircraft eligibility through evaluation of its navigation equipment.*

- 1) The operator makes a request for assessment of aircraft RNAV equipment for eligibility to the airworthiness inspection Direction or equivalent CAA entity. The operator, together with the request, will provide the following:
 - i. RNAV system make, model and part number;
 - ii. evidence that the equipment meets lateral and longitudinal navigation accuracy on route of ± 5 NM or better during 95% of the total flight time. This can be determined through the evaluation of system design. Evidence of meeting the requirements of another AC can be used for this purpose.
 - iii. proof that the system meets the required functions for RNAV 5 operations described in this CA on paragraph 8.6.
 - iv. crew operating procedures and bulletins; and
 - v. any other pertinent information required by the CAA.
- 2) in case the airworthiness inspection Direction or CAA equivalent entity is not able to determine RNAV equipment eligibility, evaluation request together with supporting documents will be forward to the aircraft certification Direction or equivalent entity from the State of registry. In any case, aircraft certification Division or equivalent will inform to airworthiness inspection Direction or CAA equivalent entity about the eligibility of the proposed equipment to perform RNAV 5 operations.

- 3) *LAR 91 Operators.*- Once the CAA has determined the aircraft equipment is eligible for RNAV 5 operations, the airworthiness inspection Direction or CAA equivalent entity will issue a letter of finding documenting that the aircraft RNAV equipment is eligible to perform those operations.
- 4) *LAR 121 or 135 operators.*- The CAA will verify aircraft RNAV system eligibility including the required functions on paragraph 8.6 of this AC.

8.4 Limitations on the design and/or use of navigation systems.- Although the following navigation systems offer RNAV capability, these present limitations for their use in RNAV 5 operations.

a) Inertial navigation systems/Inertial reference systems (INS/IRS)

- 1) Inertial systems may be used either as a stand alone inertial navigation system (INS) or as an inertial reference (IRS) acting as part of a multi-sensor RNAV system where inertial sensors provides augmentation to the basic position sensors as well as a reversionary position data source when out of cover of radio navigation sources.
- 2) INS without a function for automatic radio updating of aircraft position and approved in accordance with FAA AC 25-4, when complying with the functional criteria of paragraph 8.6 of this AC, may be used only for a maximum of two (2) hours from the last alignment/position update performed on ground. Consideration may be given to specific INS configurations (e.g. triple mix) where either equipment or aircraft manufacturer's data justifies extended use from the last position update.
- 3) INS without automatic radio updating of aircraft position, including those systems where manual selection of radio channels is performed in accordance with flight crew procedures, must be approved in accordance with FAA AC 90-45A or AC 20-130A or any other equivalent document.

b) VHF omni-directional radio range (VOR)

- 1) VOR accuracy can typically meet accuracy requirements for RNAV 5 up to 60 NM from the navigation aid and Doppler VOR up to 75 NM. Specific regions within the VOR coverage may experience larger due to propagation effect (e.g. multipath). Where such errors exist this can be accommodated by prescribing areas where the affected VOR may not be used.

c) Distance measuring equipment (DME)

- 1) DME signals are considered sufficient to meet requirements of RNAV 5 wherever the signals are received and there is no closer DME on the same channel, regardless of the published coverage volume. Where the RNAV 5 system does not take account of published "Designated operational coverage" of the DME, the RNAV system must execute data integrity checks to confirm that the correct DME signal is being received.

d) Long Range Navigation (LORAN C)

- 1) Use of Loran-C, in compliance with FAA AC 20-121A, is considered an acceptable means to comply with RNAV 5 in those areas and on routes with acceptable Loran-C coverage. Loran-C users must refer to the AFM or POH to determine if operational use of the Loran system is limited to a specified Loran-C Operational Area.

e) **Global navigation satellite system (GNSS)**

1) **Global positioning system (GPS)**

- i. The use of GPS to perform RNAV 5 operations is limited to equipment approved in accordance with the TSO-C 129(), TSO-C-145() and TSO-C-146() from FAA or ETSO-129(), ETSO-145() and ETSO-146() from EASA or equivalent documents which include the minimum systems functions specified in the present CA on Paragraph 8.6.
- ii. The integrity of GPS system must be provided by the receiver autonomous integrity monitoring (RAIM) or an equivalent means within a multi-sensor navigation system. The equipment must be approved in accordance with the AMC 20-5 or equivalent document. In addition, stand-alone GPS equipment must include the following functions according to the TSO-C 129A or ETSO-129A criteria:
 - Pseudorange step detection; and
 - Health word checking
- iii. Compliance with these two requirements can be determined the following way:
 - A statement in the AFM or POH indicating the GPS equipment meets the criteria for primary means of navigation in oceanic and remote airspace; or
 - a placard on the GPS receiver certifying it meets TSO-C 129A, TSO-C-145A and TSO-C-146A from FAA or ETSO-129A, ETSO-145A and ETSO-146A from EASA; or
 - a CAA letter of design approval for the applicable equipment. Operators should contact the avionics equipment's manufacturer to determine if the equipment complies with these requirements and ask if a letter of design approval is available. Manufacturers may obtain this letter by submitting appropriate documentation to the certifications offices of the States of aircraft design or manufacturer. Operators will keep the letter of design approval within the AFM or POH as evidence of the RNAV 5 eligibility. Any limitations included in the letter of design approval should be reflected in a letter of finding to LAR 91 operators or in the operations specifications (OpSpecs) for LAR 121 and/or 135 operators.
- iv. Traditional navigation equipment (e.g., VOR, DME and automatic direction finder (ADF)) must be installed and operative, so as to provide an alternative navigation means of navigation.
- v. Where approval for RNAV 5 requires the use of traditional navigation equipment as a back up in the event of loss of GPS, the required navigation aids as defined in the approval (e.g. VOR, DME and/or Non directional beacon (NDB)) must be installed and serviceable.

2) **Stand-alone GPS equipment**

- i. Stand-alone GPS equipment approved in accordance with guidance provided in this AC, may be used in RNAV 5 operations, subject to the limitations included in this document. Such equipment must be operated in accordance with procedures acceptable to the CAA. The flight crew must receive appropriate training for use the stand-alone GPS equipment regarding normal and contingency procedures detailed in the Paragraph 10 of this AC.

8.5 RNAV-5 system requirements

a) Accuracy

- 1) The navigation performance of aircraft approved for RNAV 5 requires a track keeping accuracy equal to or better than ± 5 NM during the 95% of the flight time. This value includes signal source error, airborne receiver error, display system error and flight technical error (FTE).
- 2) This navigation performance assumes the necessary coverage provided by satellite or ground based navigation aids is available for the intended route to be flown.

b) Availability and integrity

The minimum level of availability and integrity required for RNAV 5 systems can be met by a single installed system comprising by:

- 1) one sensor or a combination of the following sensors: VOR/DME, DME/DME, INS or IRS, LORAN C and GNSS or GPS;
- 2) RNAV computer;
- 3) control display unit (CDU); and
- 4) navigation display(s) [(e.g. navigation display (ND), horizontal situation indicator (HSI) or course indicator deviation (CDI)].

provided that the system is monitored by the flight crew and that in the event of a system failure the aircraft retains the capability to navigate relative to ground based navigation aids (e.g. VOR, DME and NDB).

8.6 Functional requirements

a) *Required Functions.*- The following system functions are the minimum required to conduct RNAV 5 operations:

- 1) Continuous indication of the aircraft position relative to track to be displayed to the pilot flying (PF) on a navigation display situated in his primary field of view;
- 2) In addition, where the minimum flight crew is two pilots, indication of the aircraft position relative to track to be displayed to the pilot not flying (PNF) on a navigation display situated in his primary field of view.
- 3) Display of distance and bearing to the active (To) waypoint;
- 4) Display of ground speed or time to active (To) waypoint;
- 5) Storage of a minimum of 4 waypoints; and
- 6) Appropriate failure indication of the RNAV system, including the sensors failure.

b) *RNAV 5 navigation displays*

- 1) Navigation data must be available for display either on a display forming part of the RNAV equipment or on a lateral deviation display (e.g. CDI, (E)HSI, or a navigation map display).
- 2) These displays must be used as primary flight instruments for the navigation of the aircraft, for maneuver anticipation and for failure/status/integrity indication. They should meet the following requirements:

- i. the displays must be visible to the pilot when looking forward along the flight path.
- ii. the lateral deviation display scaling should be compatible with any alerting and annunciation limits, where implemented.
- iii. the lateral deviation display must have a scaling and full-scale deflection suitable for the RNAV 5 operation.

9. OPERATIONAL APPROVAL

9.1 *Requirements to obtain the operational approval.*- To obtain the operational approval, the operator will comply with the following steps considering the operational procedures established in Paragraph 10 of this AC.

a) *Airworthiness approval.*- The Aircraft must have the corresponding airworthiness approvals as mentioned in Paragraph 8 of this CA.

b) *Documentation.*- The operator will present to the AAC the following documents:

- 1) The application for RNAV 5 operational approval;
- 2) Amendments to the operations manual (OM) which must include operations procedures according to what is described in Paragraph 10 of this CA, for crews and dispatchers, if applicable;
- 3) Amendments, when applicable, of maintenance manuals and programs which must have the maintenance procedures for the new equipment, as well as the training of the maintenance associated personnel;
- 4) A copy of the AFM parts, or AFM supplement or TCDS or POH, to verify the airworthiness approval for RNAV 5 for each affected aircraft;
- 5) The amendments to the Minimum Equipment List (MEL), which must identify the minimum necessary equipment to comply with RNAV 5; and
- 6) Training programs or amendments to the operator's training program for crews and flight dispatchers, if applicable, according to what is described in Paragraph 11 of this document;

c) *Training.*- Once the amendments to manuals, programs and documents have been accepted or approved, the operator will provide required training to its personnel.

d) *Validation flights.*- The AAC may perform a validation flight, if determines it is necessary in the interest of safety.

9.2 *Authorization issuance to perform RNAV 5 operations.*- Once the operator has successfully completed the operational approval process, the AAC will issue the operator, when applicable, the corresponding authorization to perform RNAV 5 operations.

a) *LAR 91 operators.*- The AAC does not require issuing a letter of authorization (LOA) to LAR 91 operators, when aircraft eligibility is based on AFM or AFM supplement or TCDS, or POH.

b) *LAR 121 and/or 135 operators.*- For LAR 121 and/or LAR 135 operators, the AAC will issue the corresponding OpSpecs, which will show RNAV 5 authorization.

10. OPERATION PROCEDURES

10.1 *Flight planning.*

- a) Before operating on a RNAV 5 route, the operator will ensure that:
 - 1) The aircraft counts on a RNAV 5 approval;
 - 2) Routes correspond to the authorization;
 - 3) The necessary equipment to operate RNAV 5 work correctly and are not degraded;
 - 4) Navigation aids based on space or ground are available;
 - 5) The crews check the contingency procedures.
- b) *Stand-alone GPS equipment.* During the planning phase the following procedures must be accomplished in regards to the stand-alone GPS equipment:
 - 1) An aircraft can depart without further action in the following cases, when:
 - i. all satellites are scheduled to be in service; or
 - ii. one satellite is scheduled to be out of service in case of GPS equipment that includes barometrical altitude.
 - 2) The availability of GPS integrity RAIM shall be confirmed for the intended flight (route and time) through the use of a prediction program either ground-based or incorporated in the on-board system, following the criteria established in Appendix 1 of the CAA, when:
 - i. any satellite is scheduled to be out of service; or
 - ii. more than one satellite is scheduled to be out of service in case of GPS equipment that includes barometric altitude.
 - 3) This prediction is required for any route and route segment RNAV 5 based upon the use of GPS.
 - 4) The specified route of flight, including trajectory to any alternative aerodrome will be defined by a series of waypoints and by the estimated time of pass over them for a speed or series of speed, which at the same time will be in function of the intensity and previous wind direction.
 - 5) Taking in consideration that during flight may occur deviations in regards to the specified ground speed, prediction must be done using different speeds within the predictable margin for them.
 - 6) Prediction program must be executed with a maximum anticipation of two hours preview to the flight departure. The operator will confirm that data about the state of the constellation and GPS ephemerides, have been updated with the latest information distributed by notice to airmen (NOTAM).
 - 7) In order to get exact prediction, the program will allow manual de-selection of satellites considered non operative, as well as selection of those back to service condition during the flight time.
 - 8) The operator will not dispatch or release a flight in case of continuous prediction loss of RAIM higher than 5 minutes to any part of the previewed route. In this event, flight can be delayed, cancelled or re-routed in which RAIM requirements may be accomplished.
- c) *ATS – ICAO flight plan.-* At the time to file the ATS flight plan, authorized aircraft operators on RNAV 5 route, will insert corresponding code on flight plan form's box 10 (equipment), as defined within ICAO Doc 7030 for these operations.

10.2 Preview flight procedures at the aircraft.- The crew will perform on the aircraft the following procedures preview to the flight:

- a) check registrations and forms to be sure that maintenance actions have been taken in order to correct defects in the equipment; and
- b) check data base validation (current AIRAC cycle), if it is installed.

10.3 *En route operations.*

- a) The crew will assure the aircraft correct functioning of its navigation system during its operation in a RNAV 5 route, confirming that:
 - 1) necessary RNAV 5 equipment have not degraded during flight;
 - 2) route corresponds to the authorization;
 - 3) aircraft navigation accuracy is pertinent for RNAV 5, assuring this through pertinent cross check; and
 - 4) others navigation aids (for example VOR, DME y ADF) must be selected in a way to permit a cross check or immediate reversion in the event of a RNAV capacity loss.

10.4 *Contingency procedures.*

- a) Flight crews must familiarize with the following general provisions:
 - 1) An aircraft must not enter or continue the operations in airspace designated as RNAV 5, according to the present ATC authorization, if because of a failure or degradation the navigation systems falls under RNAV 5 requirements, the pilot will obtain as soon as possible an amended authorization;
 - 2) According to ATC instructions, operations will continue in regards to the present ATC authorization, or when not possible, will be requested a revised authorization to return to the VOR/DME conventional navigation;
 - 3) in the event of communications failure, the flight crew must continue with the flight plan, in accordance with the published lost communication procedures; and
 - 4) in any case, the crew must follow contingency procedures established for every operation region, and obtain an ATC authorization as soon as possible.
- b) Stand-alone GPS equipment.
 - 1) The operating procedures must identify the flight crew actions required in the event of RAIM function loss or exceedance of integrity alarm limit (erroneous position). This procedures must include:
 - i. In case of loss of the RAIM detection function.- The flight crew may continue navigating with the GPS equipment. The flight crew should attempt to cross-check the aircraft position with the information provided for the ICAO conventional nav aids: VOR, DME and ADF, in order to confirm the existence of a required level of precision. In other case, the crew must revert to an alternative navigation means;
 - ii. In the event of an observed failure (including the failure of a satellite impacting the performance of the navigation systems based on GPS), the flight crew must revert to an alternative means of navigation.

- iii. In case of exceedance of the alarm limit.- The flight crew must revert to an alternative means of navigation.
- 2) *On-board equipment availability VOR, DME, TACAN or ADF.*- The operator must have installed on the aircraft the VOR, DME, TACAN or ADF on-board equipment capacity according to the applied rules of operation LAR 91, 121 and 135. This capacity must be available along the intended route of flight to assure the availability of navigation alternative means in case of a GPS/RNAV system failure.
- c) Any incidence registered in flight must be notified to the AAC in a maximum time of seventy two (72) hours, unless justified cause.

11. NAVIGATION ERROR REPORTS FOLLOW UP PROCESS

- a) The operator will establish a process to receive, analyze and do a follow up of the navigation error reports which allow determine the appropriate corrective action.
- b) Repetitive navigation error occurrences, attributed to a specific part of the navigation equipment must be analyzed in order to correct its cause.
- c) The nature and severity of the error may result in temporary withdrawn of the authorization to use the navigation equipment until the cause of the problem has been identified and rectified.

12. TRAINING PROGRAM

- a) The training program for flight crews and flight dispatchers, if correspond, must be reviewed and approved by the AAC. The operator will included at least the following modules:
 - 1) Required equipments, capacities, limitations and operation of these equipments in RNAV 5 airspace.
 - 2) The routes and airspace for which the RNAV system is approved to operate.
 - 3) The navaid limitations in respect of the operation of the RNAV system to be used for the RNAV 5 operation.
 - 4) Contingency procedures for RNAV failures.
 - 5) The Radio/Telephony Phraseology for the airspace in accordance to Doc 4444 and Doc 7030 as appropriate.
 - 6) The flight planning requirements for the RNAV operation.
 - 7) RNAV requirements as determined from chart depiction and textual description.
 - 8) RNAV 5 en route procedures;
 - 9) Methods to reduce navigation errors through dead-reckoning techniques.
 - 10) RNAV system-specific information, including:
 - i. Levels of automation, mode annunciations, changes, alerts, interactions, reversions, and degradation.
 - ii. Functional integration with other aircraft systems.
 - iii. Monitoring procedures for each phase of flight (for example, monitor PROG or LEGS page).
 - iv. Types of navigation sensors (for example, DME, IRU, GNSS) utilized by the RNAV system and associated system prioritization/weighting/logic.

- v. Turn anticipation with consideration to speed and altitude effects.
 - vi. Interpretation of electronic displays and symbols.
- 11) RNAV equipment operating procedures, as applicable, including how to perform the following actions:
- i. Verify currency of aircraft navigation data.
 - ii. Verify successful completion of RNAV system self-tests.
 - iii. Initialize RNAV system position.
 - iv. Fly direct to a waypoint.
 - v. Intercept a course/track.
 - vi. Be vectored off and rejoin a procedure.
 - vii. Determine cross-track error/deviation.
 - viii. Remove and reselect navigation sensor input.
 - ix. When required, confirm exclusion of a specific navigation aid or navigation aid type.
 - x. Perform gross navigation error check using conventional navigation aids.
- b) Training program on the GPS as a primary means of navigation.
- 1) Besides the training modules describe on the previous paragraphs, operators' training programs which use RNAV systems based on GPS as a primary navigation means will include modules described in Appendix 2.

Appendix 1

GPS integrity monitoring (RAIM) prediction program

Where a GPS integrity monitoring (RAIM) prediction program is used as a means of compliance with paragraph 5.2 (a) of this document, it should meet the following criteria:

- a) The program should provide prediction of availability of the integrity monitoring (RAIM) function of the GPS equipment, suitable for conducting RNAV 5 operations.
- b) The prediction program software should be developed in accordance with at least RTCA DO 178B/EUROCAE 12B, Level D guidelines.
- c) The program should use either a RAIM algorithm identical to that used in the airborne equipment or an algorithm based on assumptions for RAIM prediction that give a more conservative result.
- d) The program should calculate RAIM availability based on a satellite mask angle of no less than 5 degrees, except where use of lower mask angle has been demonstrated to be acceptable to the authority.
- e) The program should have the capability to manually designate GPS satellites which have been notified as being out of service for the intended flight.
- f) The program should allow the user to select:
 - 1) the intended route and declared alternates; and
 - 2) the time and duration of the intended flight.

Appendix 2

Training program on the GPS as a primary means of navigation

The training program for flight crews that use RNAV 5 systems based on the GPS as a primary means of navigation, will include a segment with the following training modules:

- a) GPS system components and operating principles.- Understanding of the GPS system and its operating principles:
 - 1) GPS system components: control segment, user segment, and space segment;
 - 2) on-board equipment requirements;
 - 3) GPS satellite signals and pseudo-random code;
 - 4) positioning principle;
 - 5) receiver clock error;
 - 6) masking function;
 - 7) performance limitations of the different types of equipment;
 - 8) WGS84 coordinate system;
- b) Navigation system performance requirements.- Define the following terms in relation to the navigation system and evaluate the degree of compliance by the GPS system of the requirements associated with the following terms:
 - 1) precision;
 - 2) integrity;
 - i. means to improve GPS integrity: RAIM and FDE
 - 3) availability;
 - 4) service continuity
- c) Authorizations and documentation.- Requirements applicable to pilots and navigation equipment for GPS operation:
 - 1) pilot training requirements;
 - 2) aircraft equipment requirements;
 - 3) AFM system certification criteria and limitations;
 - 4) GPS-related NOTAMs.
- d) GPS system errors and limitations.- Cause and magnitude of typical GPS errors:
 - 1) ephemerides;
 - 2) clock;
 - 3) receiver;
 - 4) atmospheric/ionospheric;
 - 5) multi-reflection;
 - 6) selective availability (SA);
 - 7) total typical error associated to the C/A code;
 - 8) effect of the dilution of precision (DOP) on the position;

- 9) susceptibility to interference;
 - 10) comparison of vertical and horizontal errors; and
 - 11) path-tracking precision. Collision avoidance.
- e) Human factors and GPS.- Limitations on the use of GPS equipment due to human factors. Operating procedures that offer protection against navigation errors and loss of awareness of the real situation due to the following causes:
- 1) mode errors;
 - 2) data entry errors;
 - 3) data checks and validation, including independent cross-checking procedures;
 - 4) automation-induced relaxation;
 - 5) lack of standardization of GPS equipment;
 - 6) information processing by humans and situational awareness.
- f) GPS equipment – Specific navigation procedures.- Knowledge of the appropriate operating procedures for GPS in the typical navigation tasks for each specific type of equipment in each type of aircraft that includes:
- 1) selection of the appropriate operating mode;
 - 2) review of the different types of information contained in the navigation database;
 - 3) forecast of the availability of the RAIM function;
 - 4) procedure for entering and checking the waypoints defined by the user;
 - 5) procedure for entering, retrieving and checking flight plan data;
 - 6) interpretation of the typical information shown on the GPS navigation display: LAT/LONG, distance and heading to the waypoint, CDI;
 - 7) interception and maintenance of the GPS-defined routes;
 - 8) in-flight determination of ground speed (GS), estimated time of arrival (ETA), time and distance to the waypoint;
 - 9) indication of waypoints over flight;
 - 10) use of the “DIRECT TO” function;
 - 11) use of the “NEAREST AIRPORT” function;
 - 12) use of the GPS in GPS or DME/GPS arrival procedures.
- g) Verification of GPS equipment.- For each type of equipment in each aircraft, the following operational and start-up checks must be conducted at the appropriate time:
- 1) constellation status;
 - 2) RAIM and FDE functional status;
 - 3) dilution of precision (DOP) status;
 - 4) currency of the instrument flight rules (IFR) database;
 - 5) receiver operating condition;
 - 6) CDI sensitivity;
 - 7) position indication.

8)

h) GPS messages and warnings. - For each type of equipment in each aircraft, timely action must be recognized and taken in face of GPS messages and warnings, including the following:

- 1) loss of RAIM function;
- 2) 2D/3D navigation;
- 3) dead-reckoning navigation mode;
- 4) database not updated;
- 5) loss of the database;
- 6) GPS equipment failure;
- 7) barometric data entry failure;
- 8) power failure;
- 9) prolonged parallel displacement; and
- 10) satellite failure.

Appendix 3

RNAV 5 approval process

- a) The RNAV 5 approval process is comprised of two types of approvals: the airworthiness approval and the operational approval, even though, they have different requirements, both must be considered under one process only.
- b) This process constitutes a well-arrange method, which is used by the CAA to ensure the applicants comply with the established requirements.
- c) The approval process is conformed by the following phases:
 - 1) Phase one: Pre-application
 - 2) Phase two: Formal application
 - 3) Phase three: Analysis of the documentation
 - 4) Phase four: Demonstration and inspection
 - 5) Phase five: Approval
- d) *In Phase One - Pre-application*, the CAA holds a meeting with the operator (the pre-application meeting), in which the operator will be informed about all the requirements that he needs to comply during the approval process.
- e) *In Phase Two - Formal application*, the operator submits the formal application with all applicable documents.
- f) *In Phase Three - Analysis of the documentation*, the CAA reviews the submission and evaluates the navigation equipment in order to determine the method of approval (aircraft equipment eligibility). As a result of this evaluation the CAA may accept or return the Formal Application with the documentation.
- g) *In Phase Four - Demonstration and inspection*, the operator will accomplish the training program and the validation flight if this is required by the CAA, otherwise the process will advance to the next phase.
- h) *In phase Five - Approval*, the CAA issues the RNAV 5 authorization, once the operator has completed the airworthiness and operations requirements. For LAR 121 and/or 135 operators, the AAC will issue the OpSpecs. For LAR 91, a LOA is nor required if the aircraft eligibility has been determined based on the AFM or POH or associated documentation or, for individual areas of operations.

APPENDIX B

RNAV 5 JOB AID

OPERATOR APPLICATION TO CONDUCT RNAV 5 OPERATIONS

1. Introduction

This job Aid was developed by the Regional Cooperation System for Safety Oversight (SRVSOP) to provide guidance to States, operators and inspector on the process for operators to obtain RNAV 5 authorization.

2. Purposes of this Job Aid

- 2.1 Provide RNAV 5 reference documents for operators and inspectors.
- 2.2 Provide a series of tables that show: the content of an application, related reference paragraphs, location in operator application where RNAV 5 elements are addressed and columns for the inspector to comment on, and track the status of various RNAV 5 elements.

3. Recommended inspector and operator actions

The following are suggestions on how the Job Aid can be used:

- 3.1 Inspector reviews the basic events in the RNAV 5 approval process in Part 1 with the operator in the pre-application meeting to provide an overview of approval process events.
- 3.2 Inspector reviews this Job Aid with the operator to establish the form and content of the operator application for RNAV 5 authority.
- 3.3 Operator uses the Job Aid as guide to assemble documents/exhibits for its application for RNAV 5.
- 3.4 Operator annotates Job Aid to show location of RNAV 5 program elements in the operator exhibits/documents.
- 3.5 Operator submits Job Aid and RNAV 5 operator application (exhibits/documents) to inspector
- 3.6 Inspector annotates Job Aid to show task or document “complete/satisfactory” or “open/further operator action required”.
- 3.7 Inspector informs the operator as soon as possible, when further operator action is required.
- 3.8 Operator provides inspector, when requested, with revised material.
- 3.9 The CAA issues operations specifications (OpSpecs) or Letter of Authorization (LOA) as applicable, to operator when required tasks and documents are completed.

4. Job Aid organization

Parts	Subjects	Page
Part 1	General information	4
Part 2	Operator and aircraft identification information	6
Part 3	Content of operator application for RNAV 5 authorization	7
Part 4	Operator application for RNAV 5 authority (documents to be sent to the AAC)	10
Part 5	Guide for determining RNAV 5 aircraft eligibility	13
Part 6	Basic flight crew procedures for RNAV 5 operations	16

5. **Primary source of documents, information and contacts**

For accessing to the Advisory Circular CA 91-002, enter to the ICAO/SAM Regional Office Webpage (www.lima.icao.int) under SRVSOP.

6. **Primary documents of reference**

Documents of reference	Subjects
ICAO Doc 9613	Performance based navigation manual
AMC 25-11	Electronic display system
AMC 20-5	Acceptable means of compliance for airworthiness approval and operational criteria for the use of the NAVSTAR Global positioning system (GPS)
AC 20-121A	Airworthiness approval of LORAN C for use en the U.S National Airspace System
AC 20-130()	Airworthiness approval of multi-sensor navigational system for use in the U.S. National Airspace System
AC 20-138	Airworthiness approval of NAVSTAR Global Positioning System (GPS) for use as a VFR and IFR Supplemental navigation system
AC 25-4	Inertial navigation system (INS)
AC 25-15	Approval of FMS in transport category airplanes
AC 90-45A	Approval of areas navigation systems for use in the U.S. National Airspace System
ETSO-C115b	Airborne area navigation equipment using multi sensor input
ETSO-C129A	Airborne supplemental navigation equipment using the Global positioning system (GPS)
ETSO-C145	Airborne navigation sensors using the Global positioning system (GPS) augmented by wide area augmentation system (WAAS)
ETSO-C146	Stand-alone airborne navigation equipment using the Global positioning system (GPS) augmented by the wide area augmentation system (WAAS)
TSO-C115, any version	Airborne area navigation equipment using multi-sensor inputs
TSO-C129/C129A	Airborne supplemental navigation equipment using the global positioning system (GPS)
TSO-C145A	Airborne navigation sensors using the Global positioning system (GPS) augmented by the wide area augmentation system (WAAS)
TSO-C146A	Stand-alone airborne navigation equipment using the Global positioning system (GPS) augmented by the wide area augmentation system (WAAS)
RTCA/DO-200A	Standards for processing aeronautical data
RTCA/DO-201A	Standards for aeronautical information
RTCA/DO-208	Minimum operational performance standards for airborne supplemental navigation equipment using Global positioning system (GPS)
RTCA/DO-229C	Minimum operational standards for Global positioning system/Wide area augmentation system airborne equipment
RTCA/DO-236A	Minimum aviation system performance standards: Required navigation performance for area navigation
RTCA/DO-178B	Software consideration in airborne systems and equipment certification

PART 1: GENERAL INFORMATION**Basic events in RNAV 5 authorization process**

	Operator actions	CAA actions (inspectors)
1	Establishes need to obtain authority for RNAV 5 operations.	
2	Reviews AFM, AFM Supplement or Type Certificate Data Sheet (TCDS) or others appropriate documents (e.g., Service Bulletins, Service Letters) to determine Aircraft eligibility for RNAV 5. Operator contacts airplane or avionics manufacturer, if necessary, to confirm airplane eligibility for RNAV 5.	
3	Contacts to the AAC to arrange a pre-application meeting to discuss requirements for operational approval. .	
4		During pre-application meeting, establishes: • form and content of operator application; • the date when operator application should be submitted for evaluation
5	Submits operator application to the AAC at least 60 days in advance of the planned start of RNAV 5 operations.	
6		Reviews operator application
7	Once the amendments to the manuals, programs and documents have been accepted or approved, the operator provides training to the flight crew, flight dispatchers and maintenance personnel and performs a validation flight in case of that flight is required by the AAC.	
8		Issues operational approval in the form of OpSpecs for LAR 121 and/or 135 operators (see Appendix A of LAR 119). For LAR 91 operators, is not required to issue a Letter of Authorization (LOA) for individual areas of operations and also, when the aircraft eligibility is based on the AFM, AFM supplement, TCDS or POH.

Notes related with the approval process**1. Responsible Authority.**

- a. **Commercial Air Transport - LAR 121 and/or 135 operators.-** The **State of registry** makes the determination that the Aircraft meets the applicable RNAV 5 requirements. The State of Operator issues operating authority (e.g., OpSpecs).
- b. **General aviation - LAR 91 operators.-** The **State of registry** makes determination that aircraft meets the applicable RNAV 5 requirements and issues operating authority.

2. Sections related to the Latin America Aeronautics Regulations (LAR)

- a. LAR 91 Sections 91.880 (b) y 91.1660 (Annex 6 Part II, Seventh Edition, Paragraph 2.5.2.2)
- b. LAR 121 Section 121.995 (Annex 6, Part I, Paragraph 7.2.2)
- c. LAR 135 Section 135.570 (b) (Annex 6, Part I, Paragraph 7.2.2)

3. Others related ICAO documents

- a. Annex 2 – Rules of the air
- b. Doc 4444 – Procedures for Air Navigation Services – Air Traffic Management.

PART 2: AIRCRAFT AND OPERATORS IDENTIFICATION INFORMATION

OPERATOR NAME: _____

Aircraft make, model and series	Registration number(s)	Serial number(s)	RNAV navigation systems: Number, manufacturer and model	Navigation specification requested

DATE OF PRE-APPLICATION MEETING _____

DATE APPLICATION RECEIVED: _____

DATE OPERATOR PLANS TO START RNAV 5 OPERATIONS _____

¿IS THE NOTIFICATION TIME TO CAA ADEQUATE? YES ____ NO ____

PART 3: CONTENT OF OPERATOR APPLICATION FOR RNAV 5

#	Content of operator application for RNAV 5	Reference paragraphs CA 91-002	Where found in operator exhibit/documents Note: operator should update this column to reflect the content of its application	Inspector recommendation and /or comments	Inspector Tracking: Item status and date
1	Application letter Application letter to obtain RNAV 5 authority	Paragraph 9.1 b) 1) Appendix 3, Paragraph e)	Exhibit A		
2	Airworthiness documents to determine Aircraft eligibility Airworthiness documents that establish the aircraft and the navigation system have been approved for RNAV 5 operations.	Paragraphs 8.1, 8.2 y 8.3			
3	RNAV 5 system requirements 1. One (1) RNAV system comprising of: • one or a combination of the following navigation sensors: VOR/DME, DME/DME, INS o IRS, LORAN C y GNSS o GPS; • an area navigation (RNAV) computer; • a control display unit (CDU); and • a navigation display(s) or instrument(s) (e. g., navigation display (ND), heading situation indicator (HSI) o course deviation indicator (CDI).	Paragraph 8.5 b)			
4	Availability of the conventional navigation equipment on board the aircraft when the GPS stand-alone is	Paragraph 8.4 e) 1) iv.			

[illegible]

#	Content of operator application for RNAV 5	Reference paragraphs CA 91-002	Where found in operator exhibit/documents Note: operator should update this column to reflect the content of its application	Inspector recommendation and /or comments	Inspector Tracking: Item status and date
	application, documenting RNAV 5 operational policies and procedures. 2. LAR 121 and/or 135 operators: Operations manual and check list. 3. GPS stand-alone used as a primary means of navigation: Operations manual	Paragraph 10. b)			
7	Maintenance practices - For Aircraft with established RNAV or GPS stand-alone maintenance practices, the operator shall provide document references. - For newly installed RNAV or GPS stand-alone, the operator shall provide maintenance practices for review.	Paragraph 9. b) 3)			
8	Minimum equipment list (MEL) updates, if applicable Only applicable if operator conducts operations under an MEL	Paragraph 9. b) 5)			
9	Removal of RNAV 5 operating authority Indication of the necessity to follow up action after navigation error reports, and the potential for removal of RNAV 5 operating authority.	Paragraph 12			

PART 4 – OPERATOR APPLICATION (EXHIBITS/DOCUMENTS)

Exhibit	Document title	Operator indication of inclusion	Inspector comments
A	Application letter for RNAV 5 authorization		
B	1. For aircraft manufactured RNAV 5 compliant: Airworthiness documents that show RNAV 5 approval: • AFM, AFM Supplement, TCDS o POH. 2. For in-service aircraft which eligibility can not be determined based on the AFM, AFM Supplement; TCDS o POH: • Operator letter requesting assessment of aircraft RNAV equipment.		
C	For INS or IRU only equipped aircraft: RNAV 5 time limit and area of operation. • Documentation establishing the RNAV 5 time limit and area of operations or routes for which the specific aircraft/navigation system is eligible. (Not applicable to GPS equipped aircraft).		
D	Maintenance program • For aircraft with established RNAV 5 or GPS stand-alone maintenance practices, provide list of document or program references.		
E	Minimum Equipment List (MEL) (Only for operators operating under an MEL): • MEL showing provisions for RNAV 5 equipment or GPS stand-alone.		
F	Training 1. LAR 91 operators: Methods of training: The following methods are acceptable for these operators: In-house training, LAR 142 training center or others courses of training. 2. LAR 121 or 135 operators: Training program: The LAR 121 or		

Exhibit	Document title	Operator indication of inclusion	Inspector comments
	135 operators shall provide initial and recurrent training program for flight crew, flight dispatchers and maintenance personnel. 3. GPS stand-alone: When the operator used a GPS stand-alone to conduct RNAV 5 operations, shall provide an initial and a recurrent training program for flight crew, flight dispatchers and maintenance personnel, if required.		
G	Operational policies and procedures 1. LAR 91 operators: Operations manual or sections of operator's application, documenting RNAV 5 operational policies and procedures. 2. LAR 121 and/or 135 operators: Operations manual and check list. 3. GPS stand-alone used as a primary means of navigation: Operations manual		
H	Removal of RNAV 5 operating authority Indication of the necessity to follow up action after navigation error reports, and the potential for removal of RNAV 5 operating authority.		
I	Plan for validation flight: Only if required by the CAA		

APPLICATION CONTENT TO BE SUBMITTED BY THE OPERATOR

_____ AIRCRAFT/RNAV 5 SYSTEM COMPLIANCE DOCUMENTATION

_____ OPERATIONAL POLICY/PROCEDURES

_____ MAINTENANCE MANUAL SECTIONS RELATED TO RNAV 5 SYSTEM OR GPS STAND-ALONE (if not previously reviewed)

Note 1: Exhibits/documents may be included in a binder or submitted as a stand-alone documents

PART 5 – GUIDE FOR DETERMINING AIRCRAFT ELIGIBILITY

#	Subjects	Reference paragraphs CA 91-002	Location in operator exhibits	CAA Recommendations and comments	Inspector tracking item status and date
1	RNAV system requirement	Paragraphs 5.7, 6.2, 8.1 a) y 8.5 b).			
2	Aircraft eligibility 1. For aircraft manufactured RNAV 5 compliant 2. For in-service aircraft which eligibility can not be determined based on the AFM, AFM Supplement; TCDS o POH:	Paragraphs 8.2 Paragraph 8.3 a)			
3	GPS stand-alone used as a primary means of navigation	Paragraph 8.4 e) 1) iii. (first paragraph)			
4	Multi-sensor navigation system that incorporate GPS with integrity provided by RAIM or equivalent means	Paragraph 8.4 e) 1) ii.			
5	GPS stand-alone with integrity provided by RAIM	Paragraph 10. b) 2.			
6	GPS stand-alone that include the following functions: • Pseudo range step detection; and • Health word checking	Paragraph 8.4 e) 1) ii.			
7	Availability of conventional navigation equipments when GPS stand-alone is used	Paragraph 8.4 e) 1) iv.			

#	Subjects	Reference paragraphs CA 91-002	Location in operator exhibits	CAA Recommendations and comments	Inspector tracking item status and date
8	Aircraft requirements: RNAV 5 navigation systems	Paragraph 8.4			
9	RNAV 5 system requirement • Precision • Availability and integrity	Paragraph 8.5			
10	RNAV 5 system functional requirements • Required functions • RNAV 5 navigation displays	Paragraph 8.6			
11	Navigation data base	Paragraph 10. d)			

PART 6 – BASIC PILOT PROCEDURES FOR RNAV 5 OPERATIONS

Subjects	Reference paragraphs CA 91-002	Locations in operator exhibit	CAA recommendations and/or comments	Inspector tracking: Item status and date
Operating procedures	Paragraph 10	Exhibit G		
Flight planning	Paragraph 10.1			
Verify aircraft is approved for RNAV operation	Paragraph 10.1 a) 1)			
Verify RNAV system required to meet RNAV 5 navigation specifications for the route and area are operational	Paragraph 10.1 a) 3)			
Verify that space-based or ground-based navigation aids required for RNAV 5 operations are available	Paragraph 10.1 a) 4)			
Revise i.e. contingencia procedures	Paragraph 10.1 a) 5)			
Indicate approval for RNAV 5 operations by annotating block 10 (Equipment) of the ICAO flight plan as defined within ICAO Doc 7030 for these operations	Paragraph 10. c)			
Verify the availability of GPS integrity RAIM for the intended flight (route and time), through the use of a prediction program either ground-based or provided as an equipment function or from an alternative method that is acceptable to the authority, in the following cases: • when any GPS satellites are scheduled to be out of service; or • more than one satellite is scheduled to	Paragraph 10 b)			

Subjects	Reference paragraphs CA 91-002	Locations in operator exhibit	CAA recommendations and/or comments	Inspector tracking: Item status and date
be out of service for GPS equipment that incorporate pressure altitude aiding.				
The operator shall not dispatch or release a flight in the event of predicated continuous loss of RAIM of more than 5 minutes for any part of the intended flight. In this case the flight may be delayed, cancelled or re-routed.	Paragraph 10 b) 7)			
Pre-flight procedures at the aircraft				
Review maintenance logs and forms for RNAV 5 status.	Paragraph 10.2 a)			
Verify navigation data base currency (current AIRAC cycle), if this data base is installed.	Paragraph 10.2 b)			
En route procedures				
Verify RNAV equipment required for RNAV 5 operation has not been degraded in flight	Paragraph 10.3 a) 1)			
Verify the route of flight correspond to the clearance	Paragraph 10.3 a) 2)			
Verify aircraft precision navigation is suitable for RNAV 5 operations through pertinent cross-checks.	Paragraph 10.3 a) 3)			

Subjects	Reference paragraphs CA 91-002	Locations in operator exhibit	CAA recommendations and/or comments	Inspector tracking: Item status and date
Verify others navigation aids (e. g., VOR, DME and ADF) are selected, so as to allow immediate cross-checking or reversion in the event of loss of GPS navigation capability.	Paragraph 10.3 a) 4)			
Contingency procedures	Paragraph 10.4			
The aircraft must not enter or continue operations in airspace designated as RNAV 5, in accordance with a current clearance of ATC, if due to a failure or degradation, the navigation system is downgraded under the RNAV 5 requirements, in this event, the pilot will obtain when it is possible a amended clearance.	Paragraph 10.4 a) 1)			
In accordance with ATC instructions, the operations may continue in compliance with ATC current authorization or when it is not possible, the pilot may request an amended clearance to return to conventional VOR/DME navigation.	Paragraph 10.4 a) 2)			
In all cases, the flight crew must follow the contingency procedures establish for each region and obtain an ATC clearance as soon as possible.	Paragraph 10.4 a) 3)			
Contingency procedures in the event of loss of GPS navigation capability				
The contingency procedures should identify the flight crew actions required in the event of the GPS stand-alone equipment indicating a loss of the integrity monitoring detection (RAIM) function or	Paragraph 10.4 b) 1)			

Subjects	Reference paragraphs CA 91-002	Locations in operator exhibit	CAA recommendations and/or comments	Inspector tracking: Item status and date
exceedance of integrity alarm limit (erroneous position).				
Whatever contingency registered in flight must be notify to the AAC within 72 hours, unless the delay is justify.	Paragraph 10.4 b) 3)			

Job Aid RNAV 5: 24-OCT-2008**First edition****SRVSOP Contacts**

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APPENDIX C**WORK PROGRAMME FOR THE DEVELOPMENT OF ADVISORY CIRCULARS (CA IN SPANISH) REFERRED TO PBN OPERATIONAL APPROVALS**

Navigation Specifications	CA Numbering	Title	CA to be presented in
RNP 10	CA 91-001	TBD (To be determined)	SAM/IG/3 20 to 24 April 2009
RNAV 5	CA 91-002	Aircraft and operators approval for RNAV 5 operations	SAM/IG/2 3 to 7 November 2008
RNAV 2	CA 91-003	TBD	SAM/IG/4 13 to 19 October 2009
RNAV 1	CA 91-004	TBD	SAM/IG/3 20 to 24 April 2009
RNP 4	CA 91-005	TBD	SAM/IG/5 April 2010
RNP 2	CA 91-006	TBD	SAM/IG/5 April 2010
RNP 1	CA 91-007	TBD	SAM/IG/3 20 to 24 April 2009
RNP APCH	CA 91-008	TBD	SAM/IG/3 20 to 24 April 2009
RNP AR APCH	CA 91-009	TBD	SAM/IG/3 20 to 24 April 2009

Agenda Item 4: Implementation of air traffic flow management (ATFM) in the SAM Region

4.1 The Meeting recalled that during the first Workshop/Meeting of the SAM Implementation Group (SAM/IG/1), the tasks of the **Action Plan for ATFM Implementation in Airports in the SAM Region** were defined, to be developed and presented during SAM/IG/2 Meeting. Among these tasks, the following are to be highlighted:

- a) Review experience in other Regions;
- b) Obtain and complete the information, taking note of the status in the participating States and organizations; and
- c) Obtain and complete the information, taking note of the status in the participating States and organizations regarding the electronic databases required for the evolutionary phases of the ATFM system.

4.2 With the aim of developing the above indicated tasks, an ATFM Expert was hired through RLA 06/901 Project. The result of this effort was the development of an ATFM Questionnaire to be completed by States and International Organizations. In addition to the aforementioned, a Draft ATFM Roadmap and a Draft ATFM Procedural Handbook were developed, the latter document related with the Roadmap.

ATFM Questionnaire

4.3 The Meeting took note that to date only four SAM States had replied to the ATFM Questionnaire, and was of the opinion that the administrations that had not yet done so, should complete the Questionnaire and send it electronically to the ICAO South American Regional Office by 30 November 2008. The Questionnaire is shown in **Appendix A** to this part of the Report.

4.4 Brazil and Paraguay presented the completed questionnaire to the Meeting.

4.5 Once the completed questionnaires are received, and no later than December 2008, the Regional Office will send the results of the survey to the SAM ATFM Implementation Group.

4.6 Brazil and United States offered the States of the Region the possibility of visiting their ATFM units, in order to obtain the experience and information to be used in the implementation of regional and national ATFM. In addition, with the aim of obtaining experience for the carrying out of the various tasks, the Meeting considered of great importance that, as possible, the Rapporteur of the ATFM Implementation Group visit the CGNA, Brazil, and ATCSCC, United States, facilities.

SAM ATFM Roadmap

4.7 The Meeting recalled that the ATFM Operational Concept (CONOPS ATFM) approved by GREPECAS establishes the need to harmonize ATFM planning regionally and inter-regionally. In this sense, the Meeting was of the opinion that there should be an ATFM Roadmap available to provide orientation to air navigation services providers, airspace operators and users, international organizations and others, with regard to the applications that should be implemented in the short and medium term.

4.8 The ATFM Roadmap will provide regional projects with material on ATFM implementation, as well as guidelines to States for the elaboration of their national implementation plans.

4.9 The Meeting examined the ATFM Road map, introduces some amendments, and adopted the document for its application in the South American Region, requesting the ICAO Secretariat to remit the document, for the analysis and actions deemed pertinent, to the GREPECAS ATFM Task Force. Due to the above, the Meeting formulated the following conclusion:

Conclusion SAM/IG/2-6

ATFM Roadmap

That,

- a) the ATFM Roadmap in **Appendix B** to this part of the Report be adopted, with the aim of providing orientation to the ATFM community with regard to ATFM applications to be implemented in the short and medium term in the SAM Region; and
- b) the ICAO Secretariat send the ATFM Roadmap to the GREPECAS ATFM Task Force for the analysis and actions deemed pertinent.

ATFM Manual

4.10 On the other hand, the Meeting examined the draft ATFM Manual to be applied by the SAM Region FMU/FMP, shown in **Appendix C** to this part of the Report, which contains guidelines related with ATFM implementation, such as demand and capacity, traffic management tools, traffic Management initiatives (TMI), Communications and coordination, organization and structure, system performance measurement, collaborative decision-making, common ATFM terminology whose aim is to provide orientation in ATFM management.

4.11 The document is in its initial stage, and the Meeting agreed that it would be convenient to continue with its development, task which should be included within the ATFM action plan. At the same time, the Secretariat was requested to carry out corresponding arrangements so that this task is carried out within RLA 06/901 Project Framework.

4.12 As result of the analysis to the Manual, the Meeting deemed it will be necessary to request the assistance of experts to carry out the development of the chapters pertaining to said Manual.

Methodology for the calculation of ATC sectors and runway capacities

4.13 The Meeting took note of the methodology used by Brazil for the calculation of ATC sectors capacity and of runway capacity. In addition, Argentina presented the result of the runway capacity calculation carried out in Jorge Newbery Airport. The methods used are shown in **Appendices D, E and F** to this part of the Report.

4.14 Also, the Meeting took note of the Landing Acceptance Regime (AAR) used by United States, which was considered as another methodology to calculate airport capacity.

4.15 In view of the above and as expressed by GREPECAS/15 meeting, which recognized the need to elaborate a model to determine airport capacity, as well as a method to determine the ATC capacity of the sector and provide guidance material for a harmonized application by CAR/SAM States/International Organizations, Brazil and United States agreed to carry out an analysis and development task for a standard methodology on the basis of those already available, for presentation at the next SAM/IG/3 meeting.

4.16 Finally, it was agreed that the Course on Sectors and Runway Capacity Calculation offered by Brazil during SAM/IG/1 Meeting, would be held in Rio de Janeiro, Brazil, from 23 to 27 March 2009. The Secretariat was requested to arrange for the sponsoring of RLA 06/901 Project, to permit the participation of delegates from contributing States.

Initial ATFM AIC Model

4.17 Within the tasks of the SAM ATFM Implementation Group was the assignment to develop an initial ATFM AIC Model, to be analyzed during SAM/IG/2 Meeting. In view of the afore indicated, the Rapporteur of the Group presented an AIC model, which was examined by the Meeting. After the examination made, it was agreed that SAM States publish the corresponding AIC in the AIRAC date of 7 May 2009, taking as model the AIC in **Appendix G** to this part of the Report.

ATFM tasks to be included in the ATFM action plan

4.18 The Meeting analyzed the tasks proposed in the ATFM Roadmap, and was of the opinion that the following tasks should be included in the ATFM Action Plan and, also, requested the Secretariat that these tasks be carried out within RLA/06/901 framework:

- a) Hiring of experts for the development of tasks in the ATFM Manual for the SAM Region; and
- b) Development of the Airport Capacity and Airspace Calculation Methodology for the SAM Region.

ATFM Action Plan

4.19 The Meeting examined the ATFM Action Plan, in particular, the status of execution of the tasks contained therein. Likewise, it updated the plan on the basis of proposals from the ATFM Implementation Group. The Action Plan is in **Appendix H** to this part of the Report.

Terms of Reference and Task Force for ATFM Implementation Group in SAM Region (SAM/ATFM/IG)

4.20 The Meeting revised the composition and Terms of Reference and Task Force for SAM/ATFM/IG, which are described in Appendix I to this part of the Report.

APPENDIX A

ATFM QUESTIONNAIRE

SAM/IG/1 TASK 1.2.1 ATFM QUESTIONNAIRE

The objective of this survey is to obtain information in order to learn about the current status in the participating States and Organizations with respect to:

- a) The methods for estimating airport and ATC capacity; and
- b) ATFM procedures for the following phases:
 - 1) Airport strategic
 - 2) Airport tactical
 - 3) Airspace strategic
 - 4) Airspace tactical

This information will allow the SAM Implementation Group (SAM/IG) to fulfil its planning and harmonizing objectives.

Mark with an “X” the corresponding answer. Please include your comments, if you deem pertinent. If necessary, use additional sheets. As applicable, send copies of requested electronic documents to mail@lima.icao.int

1. Does your administration currently have a method, whether basic or complex, for calculating airport capacity? If yes, please send an electronic copy of the methodology to mail@lima.icao.int

☐ YES

☐ NO

If yes, please provide any available airport capacity data for your main airports in the following table. Please note that for this table:

Total Capacity = Airport Acceptance Rate (AAR) + Airport Departure Rate (ADR).

Airport Name	Runway configuration	Airport Acceptance Rate (AAR)			Airport Departure Rate (ADR)	Total Capacity
		VFR	MVFR	IFR		

Table 1

Comments

2. Does your administration currently have a method, whether basic or complex, for calculating enroute sector capacity? If yes, please send an electronic copy of the methodology to mail@lima.icao.int

☐ YES

☐ NO

If yes, please provide any available airport capacity data for your main airports in the following table. Under the “Time Increments” column, please indicate if the sector capacity is computed by 15-minute increments, 60-minute increments, or some other increment.

ACC	Sector Name	Sector Altitudes	Sector Capacity	Time Increments

Table 2

Comments

3. Does your administration currently have procedures in place to support the following phases of ATFM?

a) Airport Strategic

☐ YES

☐ NO

b) Airport Tactical

☐ YES

☐ NO

c) Airspace Strategic

☐ YES

☐ NO

d) Airspace Tactical

☐ YES

☐ NO

Comments

SAM/IG/1 TASK 1.2.2 ATFM QUESTIONNAIRE

a) Flow management data processing and display:

1. Does your administration have a system to receive, process, and display flight plan data (FPL, RPL, etc.)?

☐ YES☐ NO

2. Does your administration have a database that includes airspace information (for example, ACC boundary coordinates, sector boundary coordinates, NAVAIDS, airways, special use airspace) and airport information (for example, runway and taxiway layout, ramp layout, parking gate information)?

☐ YES☐ NO

3. Does your administration have an electronic ATFM system that displays airborne traffic?

☐ YES☐ NO

4. Does your administration have a communication system that allows automated or manual exchange of messages to support ATFM decision making (for example, SLOT assignment messages, SLOT adjustment messages, delay reporting messages, alternate route messages)?

☐ YES☐ NO

5. Does your administration have a system to monitor the status of the air navigation infrastructure?

☐ YES☐ NO

6. Does your administration have a system to monitor and display the airport acceptance rates (AAR) at the main airports?

☐ YES☐ NO

7. Does your administration have a system to monitor and display enroute sector capacity?

☐ YES☐ NO

8. Does your administration have a system to monitor and display the mix of aircraft using the airspace or airports?

☐ YES☐ NO

b) Surveillance systems:

1. On the following table, list the type of surveillance systems in use in your administration's airspace structure.

ACC Surveillance System	TMA Surveillance System	Other Surveillance System

Table 3

c) AIS/MAP:

1. On the following lines, list the AIS and map databases that your administration has available to support ATFM.

2. Are they available in an electronic format?

☐ YES

☐ NO

3. What is the AIS database update cycle?

☐ 28-DAY UPDATE

☐ 56-DAY UPDATE

d) Meteorological information:

1. On the following lines, list the specific meteorological products and/or websites that your administration has available to support ATFM.

e) Data for historical and statistical analysis:

1. On the following lines, list the type of databases your administration maintains to support the analysis of air traffic operations and meteorological activities.

f) Communication systems and processes in support of CDM and inter-facility coordination:

1. List the types of communication systems your operational units have with:

(a) other centralized ATFM organizations

(b) other FMUs, FMPs, and/or ATS units

(c) operators and airspace users

(d) airport authorities

(e) meteorological authorities

(f) aeronautical information services

(g) the transmission of radar and ADS data to the ATFM center

APPENDIX B



ATFM

INTERNATIONAL CIVIL AVIATION ORGANIZATION

SAM ROADMAP FOR AIR TRAFFIC FLOW MANAGEMENT

(Lima, November 2008)

Version 1.1

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1.0 EXECUTIVE SUMMARY

1.1 GREPECAS determined that air traffic flow management (ATFM) implementation will help ensure optimum air traffic flow to/through specific airspace areas during periods in which the demand exceeds, or is foreseen to exceed, available capacity of the air traffic control (ATC) system. An ATFM system will help reduce ground and airborne delays and help avoid overloading the air traffic system.

1.2 In this connection, GREPECAS approved the CAR/SAM ATFM Concept of Operations (CAR/SAM ATFM CONOPS), which reflects the expected order of development events and should assist and guide the planners in the design and gradual implementation of an ATFM system.

1.3 The main stakeholders involved in ATFM include the organizations, bodies or entities which might participate, collaborate and cooperate in the planning, development, use, regulation, operation and maintenance of the ATFM System.

1.4 With regard to air traffic management, a number of airspace areas with common interests have been identified. The common interests are based on similar characteristics of traffic density, complexity and air navigation system infrastructure requirements. The identification of these airspace areas will help foster the implementation of the Global ATM Operational Concept. A description of such homogeneous and routing areas is attached to the CAR/SAM ATFM CONOPS.

1.5 As established in ICAO documents, ATFM cannot be restricted to the area of one State because of its far-reaching effects on the flow of air traffic elsewhere. ATFM should be implemented within a region, or within a defined area, as a regional ATFM centre. The main objectives of the regional ATFM centre include: assist ATC in making the maximum use of its airspace and capacity; issue flow management initiatives, as required, in order to maintain a safe, orderly and expeditious flow of air traffic; ensure that air traffic volume is compatible with declared capacities; develop a description of the principles and functions of flow management units (FMU); and establish the requirements for equipping flow management units and regional ATFM centres. The regional ATFM centre will be supported by FMUs established in each ACC within the region or defined area of application.

1.6 GREPECAS established a simple phased ATFM implementation strategy in order to ensure maximum utilization of available capacity and permit all parties concerned to obtain sufficient experience. The implementation will be initiated with the application of basic ATFM procedures at airports and then progress in an evolutionary manner to reach more complex phases, without the immediate need for a regional ATFM center. GREPECAS noted that the implementation of a regional ATFM centre would require further studies to define the operational concepts, systems requirements and institutional aspects for its implementation.

1.7 In view of the need for harmonized ATFM planning, it is considered advisable to prepare an ATFM Roadmap to provide guidance to air navigation service providers, airspace operators and users, international organisations, and others regarding the applications that should be implemented in the short term (2008 – 2010) and medium term (2010 – 2014) in the SAM Region.

1.8 The SAM ATFM Roadmap will provide material for regional projects regarding the implementation of ATFM as well as guidance for national implementation plans.

2.0 INTRODUCTION

2.1 The SAM ATFM Roadmap is being developed by the SAM States and Territories together with concerned international organizations such as COCESNA, IATA, IFALPA, and IFATCA. It is intended to assist the main stakeholders of the aviation community with planning a harmonized and coordinated transition to ATFM applications. The main stakeholders of the aviation community that benefit from this roadmap are:

- Airspace operators and users.
- Air navigation service providers.
- International organizations.

2.2 ATFM is a service designed to assist ATC with making the maximum efficient use of its airspace. This is done by balancing system demand with capacity in order to maintain a safe, orderly and expeditious flow of traffic.

2.3 In its beginning applications, ATFM need not involve complicated procedures or tools. The goal is to collaborate with system stakeholders and communicate operational information to airspace operators and ATC providers in a timely manner. In the initial application of ATFM, this can be accomplished via point-to-point telephone calls designed to exchange pertinent weather information, system constraints, and other information of operational significance. Examples include relaying information on known runway closures, volcanic activity, and reroute information. Significant benefits can be realized by applying the initial levels of ATFM service.

2.4 In more advanced applications, ATFM requires a continuous analysis and monitoring of traffic flows, regular coordination between traffic management units, and dynamic use of traffic management initiatives and programs. This involves the development, maintenance, and use of flight plan data bases, electronic flight data displays, and telephone conference systems.

2.5 Because ATFM is a collaborative process, it is ever improving, growing, and changing with a focus on meeting the operational needs of the stakeholder community. The establishment of a Collaborative Decision Making community is therefore an important key to the long-term success of ATFM.

3.0 OBJECTIVES OF THE ATFM ROADMAP

The following strategic objectives apply to the SAM ATFM Roadmap:

- a) That SAM States, Territories, and Organizations will work together to develop a seamless and harmonized ATFM system in the SAM region.
- b) To communicate with and involve all of the appropriate stakeholders during the development and implementation process.
- c) To develop the applicable regional and national documents necessary for the support of the ATFM system.
- d) To provide training to all of the appropriate stakeholders with regard to the principles and processes of ATFM in the SAM region.

4.0 **PRINCIPLES OF ATFM IMPLEMENTATION**

The implementation of ATFM in the SAM Region will be based on the following principles:

- a) Development of a Collaborative Decision Making process based on the concepts of teamwork, trust, transparency, and communication;
- b) Use of the existing system capacity on a first-come, first-served basis without compromising safety;
- c) Completion of the necessary coordination to make every possible attempt to make the best use of and to increase available capacity before resorting to the application of ATFM measures;
- d) Equitable distribution of delays among operators when taking pertinent measures to balance air traffic demand with system capacity;
- e) Application of Safety Management System processes to the ATFM services provided; and
- f) Development of a process at the local, State, and global levels to identify and correct system deficiencies to improve the capacity.

5.0 **ATFM DEVELOPMENT STRATEGY**

5.1 The initial development of ATFM in the SAM region can be characterized by the following steps.

- a) Develop and apply a common methodology to determine:
 - 1) airport capacity; and
 - 2) enroute sector capacity
- b) Identify and apply weather products that can be commonly used to assess weather impact to the system.
 - 1) METAR and TAF information
 - 2) Prognostic websites and charts
 - 3) Satellite websites and charts
 - 4) Other
- c) Identify the personnel and operational phone numbers that will serve as the point of contact for ATFM issues at each:
 - 1) ACC
 - 2) TMA
 - 3) Control Tower
 - 4) Airline Operations Center
 - 5) Weather Office
 - 6) Military Flight Operations Center
 - 7) General Aviation Operations Center
 - 8) Airport Operations Center
 - 9) Other

- d) Develop a local database to analyze the arrival and departure demand at key airports for the following time increments:
 - 1) annually
 - 2) monthly
 - 3) daily
 - 4) hourly
- e) Discuss, develop, and apply basic traffic management initiatives and procedures to balance air traffic demand with system capacity.
 - 1) Example 1: Request expanded miles-in-trail between arrivals to the same airport from adjacent sectors or ACCs.
 - 2) Example 2: Have adjacent sectors or ACCs call-for-release of departures to a constrained airport in order to fit them into the arrival flow.
 - 3) Example 3: Coordinate reroutes with adjacent ACCs for flights to a constrained airport to avoid
- f) Develop the procedures for and use point-to-point (for example, FMU-to-FMU, FMP-to-FMP, ACC-to-ACC, control tower-to-airline operator) phone calls for the initial application of traffic management initiatives.
- g) Develop the applicable procedures manuals and training materials to support this initial ATFM phase.
- h) Establish an implementation date for this phase of ATFM.
- i) Train the appropriate personnel regarding the process and procedures of this phase of ATFM implementation.
- j) Implement the processes and procedures.
- k) Evaluate the results and coordinate changes as necessary.
- l) Other.

Initial ATFM Development Steps (2008 – 2010)	
a) Develop and apply a common methodology to determine: 1) airport capacity; and 2) enroute sector capacity	March 2009
b) Identify and apply weather products that can be commonly used to assess weather impact to the system. 1) METAR and TAF information 2) Prognostic websites and charts 3) Satellite websites and charts 4) Other	March 2009

Initial ATFM Development Steps (2008 – 2010)	
c) Identify the personnel and operational phone numbers that will serve as the point of contact for ATFM issues at each: 1) ACC 2) TMA 3) Control Tower 4) Airline Operations Center 5) Weather Office 6) Military Flight Operations Center 7) General Aviation Operations Center 8) Airport Operations Center 9) Other	March 2009
d) Develop a local database to analyze the arrival and departure demand at key airports for the following time increments: 1) annually 2) monthly 3) daily 4) hourly	June 2009
e) Discuss, develop, and apply basic traffic management initiatives and procedures to balance air traffic demand with system capacity.	August 2009
f) Develop the procedures for and use point-to-point (for example, FMU-to-FMU, FMP-to-FMP, ACC-to-ACC, control tower-to-airline operator) phone calls for the initial application of traffic management initiatives.	November 2009
g) Develop the applicable procedures manuals and training materials to support this initial ATFM phase.	December 2009
h) Establish an implementation date for this phase of ATFM.	December 2009
i) Train the appropriate personnel regarding the process and procedures of this phase of ATFM implementation.	March 2010
j) Implement the processes and procedures.	June 2010
k) Evaluate the results and coordinate changes as necessary.	September 2010

5.2 The intermediate development of ATFM in the SAM region can be characterized by the following steps.

- a) Develop a SAM flight plan database with the flexibility to allow operators to input, modify, or cancel their arrival / departure flight data information.
- b) Discuss, develop, and apply more advanced traffic management initiatives and procedures to balance air traffic demand with system capacity.

- 1) Example: Establish an electronic route database to facilitate the coordination and implementation of reroutes around volcanic activity, hurricanes, severe turbulence, etc.
- c) Develop the procedures for and use of ATFM telcons among facilities in the SAM region.
- d) Update the procedures manuals and training materials to support this intermediate ATFM phase.
- e) Establish an implementation date for this phase of ATFM.
- f) Train the appropriate personnel regarding the process and procedures of this phase of ATFM implementation.
- g) Implement the processes and procedures.
- h) Evaluate the results and coordinate changes as necessary.
- i) Other.

Intermediate ATFM Development Steps (2011 – 2012)	
a) Develop a SAM flight plan database with the flexibility to allow operators to input, modify, or cancel their arrival / departure flight data information.	March 2011
b) Discuss, develop, and apply more advanced traffic management initiatives and procedures to balance air traffic demand with system capacity.	June 2011
c) Develop the procedures for and use of ATFM telcons among facilities in the SAM region.	September 2011
d) Update the procedures manuals and training materials to support this intermediate ATFM phase.	December 2011
e) Establish an implementation date for this phase of ATFM.	December 2011
f) Train the appropriate personnel regarding the process and procedures of this phase of ATFM implementation.	March 2012
g) Implement the processes and procedures.	June 2012
h) Evaluate the results and coordinate changes as necessary.	September 2012

5.3 The advanced development of ATFM in the SAM region can be characterized by the following steps.

- a) Develop a process for electronic exchange of both textual and visual flight data.
 - 1) Example: SYNCROMAX (Brazil), PROSAT (Mexico), TFMS (USA) - (previously, ETMS), an interface between these two systems, or another system yet to be defined.
- b) Develop and implement regional ATFM command centers to coordinate inter-facility traffic management initiatives, flows, etc.
- c) Update the procedures manuals and training materials to support this advanced ATFM phase.
- d) Establish an implementation date for this phase of ATFM.
- e) Train the appropriate personnel regarding the process and procedures of this phase of ATFM implementation.
- f) Implement the processes and procedures.
- g) Evaluate the results and coordinate changes as necessary.
- h) Other.

Advanced ATFM Development Steps (2014 – 2015)	
a) Develop a process for electronic exchange of both textual and visual flight data.	January 2014
b) Develop and implement regional ATFM command centers to coordinate inter-facility traffic management initiatives, flows, etc.	June 2014
c) Update the procedures manuals and training materials to support this intermediate ATFM phase.	December 2014
d) Establish an implementation date for this phase of ATFM.	December 2014
e) Train the appropriate personnel regarding the process and procedures of this phase of ATFM implementation.	March 2015
f) Implement the processes and procedures.	June 2015
g) Evaluate the results and coordinate changes as necessary.	September 2015

EXPLANATION OF TERMS

The development of this document is based on the understanding of important terms and expressions that are described below:

Stakeholders involved in ATFM -

The ATFM stakeholder community includes the organizations, bodies or entities which could participate, collaborate and cooperate in the planning, development, utilization, regulation, operation, and maintenance of ATFM system. Among them are:

Aerodrome Community - The air traffic control authorities, aerodrome authorities, commercial, military, and general aviation operators, and other parties involved in the provision and operation of the physical infrastructure needed to support the take-off, landing, and ground handling of aircraft.

Airspace Providers - Refers, in general terms, to Contracting States/Territories in their capacity as airspace owners with the legal authority to permit or deny access to their sovereign airspace. The term may also be applied to organizations of the State assigned responsibility for establishing the standards and guidelines for use of the airspace.

Airspace users - Refers to the commercial, military, and general aviation operators that utilize the sovereign airspace of States/Territories/Organizations.

ATM service providers - All of the organizations and personnel (e.g., controllers, engineers, technicians) involved in the provision of ATFM services to airspace users.

Military aviation - Refers to the personnel, aircraft, and equipment of military organizations that serve a vital role in the security of States/Territories.

International Civil Aviation Organization (ICAO) - Considered the only international organization in position to efficiently coordinate the implementation activities of global ATM.

Air Traffic Flow Management (ATFM) - A service established with the objective of contributing to a safe, orderly and expeditious flow of air traffic by ensuring that ATC capacity is utilized to the maximum extent possible and that the traffic volume is compatible with the capacities declared by the appropriate ATC authority.

Air Traffic Management (ATM) - A service which comprises airspace management, air traffic flow management, and air traffic services.

ATM Community - All the organizations, bodies or entities which might participate, collaborate and cooperate in the planning, development, use, regulation, operation and maintenance of the ATM System.

Air Traffic Management System - A system which provides ATM through the integration and cooperation of personnel, information, technology, facilities and services. It also involves the support of on-board and space-based communications, navigation and surveillance.

Air Traffic Volume - The number of aircraft within a defined airspace or aerodrome movement area in a given period of time.

Capacity (for ATFM purposes) - The maximum number of aircraft that can be accommodated in a defined airspace or aerodrome (throughput) in given period of time.

SAM ATFM Roadmap - A document offering appropriate guidance for air navigation service providers, airspace operators and users, international organizations and other appropriate ATM community members that describes the ATFM applications that will be implemented in the short, medium and long term in the SAM Region.

Regional ATFM Center - A flow management unit responsible for the provision of air traffic flow management across multiple area control centers.

Collaborative Decision Making - an operating philosophy and the associated technologies that enable traffic managers and aviation industry representatives to respond in a timely manner to constraints in the airspace system.

Demand - The number of aircraft requesting to use the ATC system in a given time period.

Efficiency - The ratio of the cost of ideal flight to the cost of procedurally constrained flight.

Flow Management Position / Flow Management Unit (FMP/FMU) - A position or working unit established in an appropriate air traffic control unit to ensure the necessary interface between the local ATFM and a centralized ATFM unit.

Homogeneous ATM area - An airspace with a common ATM interest, based on similar characteristics of traffic density, complexity, air navigation system infrastructure requirements and other specified considerations, wherein a common detailed plan will foster the implementation of ATFM.

Main Traffic Flow - The concentration of a significant volume of air traffic on the same, or similar, flight trajectories.

Routing area - An area that encompasses one or more major traffic flows, defined for the purpose of developing a detailed plan for the implementation of ATM systems and procedures.

Traffic Management Initiatives - Techniques used by traffic managers to balance air traffic demand with available capacity.

ACRONYMS

LISTA DE ACRÓNIMOS/ LIST OF ACRONYMS

ACC	Centro de control de área	Area control center
AFTN	Red de telecomunicaciones fijas aeronáuticas	Aeronautical fixed telecommunication network
AIP	Publicación de Información aeronáutica	Aeronautical Information Publication
AIS	Servicio de información aeronáutica	Aeronautical information service
ANP	Plan navegación aérea	Air navigation plan
ANS	Servicios de navegación aérea	Air navigation services
ANSP	Proveedor de servicios de navegación aérea	Air navigation service provider
AO	Operador de aeronave	Aircraft operator
APP	Oficina de control de aproximación	Approach control facility
AAR	Regimen de aceptacion del aeropuerto	Airport Acceptance Rate
ADR	Regimen de salida del aeropuerto	Airport Departure Rate
ATC	Control de tránsito aéreo	Air traffic control
ATFM	Gestión de la afluencia del tránsito aéreo	Air traffic flow management
ATM	Gestión del tránsito aéreo	Air traffic management
ATS	Servicios de tránsito aéreo	Air traffic services
CAA	Administración de aviación civil	Civil aviation authority
CAR/SAM	Regiones Caribe y Sudamérica	Caribbean and South American Regions
CATFM	Dependencia de Gestión de la afluencia del tránsito centralizada	Centralized air traffic flow management unit
C/BA	Análisis de costo/beneficios	Cost/benefit analysis
CDM	Toma de decisiones en colaboración	Collaborative Decision Making
CNS/ATM	Comunicaciones, navegación y vigilancia/gestión del tránsito aéreo	Communications, navigation, and surveillance/air traffic management
CTA	Area de control	Control Area
FDPS	Sistema de procesamiento de datos de vuelo	Flight data processing system
FIR	Región de información de vuelo	Flight information region
FMP	Puestos de gestión de afluencia	Flow management position
FMU	Dependencia de organización de la afluencia	Flow management unit
FPL	Plan de vuelo	Flight plan
GREPECAS	Grupo regional de planificación y ejecución CAR/SAM	CAR/SAM regional planning and implementation group
IATA	Asociación del Transporte Aéreo Internacional	International Air Transport Association

IFALPA	Federación Internacional de Asociaciones de Pilotos de Líneas Aéreas	International Federation of Air Line Pilots' Associations
IFATCA	Federación Internacional de Asociaciones de Controladores de Tránsito Aéreo	International Federation of Air Traffic Controllers' Associations
LOA	Carta de acuerdo	Letter of Agreement
MET	Servicios meteorológicos para la navegación aérea	Meteorological services for air navigation
NOTAM	Aviso al Personal Encargado de las Operaciones de Vuelo	Notice to Airmen
OACI/ICAO	Organización de aviación civil internacional	International civil aviation organization
PANS ATM	Procedimientos para los servicios de navegación aérea –Gestión de tránsito aéreo	Procedures for Air Navigation Services –Air traffic management
PIRG	Grupo regional de planificación y ejecución	Planning and implementation regional group
PROSAT	Pronóstico de Saturación	PROSAT
RNAV	Navegación de área/Area Navigation - RNAV Route: Ruta de navegación de área	Area navigation route
RNP	Performance de navegación requerida	Required Navigation Performance
SID	Salida Normalizada por Instrumentos	Standard Instrument Departure
STAR	Llegada Normalizada por Instrumentos	Standard Instrument Arrival
SYNCROMAX	SYNCROMAX	SYNCROMAX
TBD	A ser determinado	To be determined
TELCON	Tele-conferencia	Telephone conference
TFMS	Sistema de gestión de la afluencia del tránsito (previamente, ETMS)	Traffic Flow Management System (previously called ETMS)
TMA	Area de control terminal	Terminal management area
TMC	Coordinador de la gestión del tránsito	Traffic Management Coordinator
TMI	Iniciativa de gestión del tránsito	Traffic management initiative
TWR	Torre de control	Control Tower
WSO	Oficina del servicio meteorológico	Weather Service Office
WWW	Red mundial	World Wide Web

APPENDIX C

SAM AIR TRAFFIC FLOW MANAGEMENT MANUAL

1.0 Introduction

1.1 Definition of ATFM

ATFM is a function established with the objective of producing a safe, orderly, and expeditious flow of traffic while minimizing delays. This is accomplished through continuous analysis, coordination, and dynamic use of traffic management initiatives.

1.2 Purpose

The purpose of ATFM is to balance air traffic demand with system capacity to ensure the maximum, efficient use of the system airspace. This is accomplished by ensuring that capacity is utilized to the maximum extent possible and that air traffic volume is compatible with the capacities declared by the appropriate air traffic service providers.

1.3 Implementation

- a. Implementing of ATFM shall be established in accordance with a view to optimizing available capacity in the use of airspace and airports and enhancing air traffic flow management processes. It shall be based on transparency and efficiency, ensuring that capacity is provided in a flexible and timely manner, consistent with the recommendations of the ICAO Regional Air Navigation Plan.
- b. Implementing shall support operational decisions by air navigation service providers, airport operators and airspace users and shall cover the following areas:
 1. flight planning;
 2. use of available airspace and airport capacity during all phases of flight; and
 3. developing a single publication for route and traffic orientation.
- c. Implementing shall seek to balance the financial impact on stakeholders with expected safety improvements and the operational and technical benefits, taking into account the requirement for global interoperability;
- d. Implementing shall take into consideration the requirements of the military, law enforcement, and search and rescue communities.
- e. ATFM implementing will aim at optimizing available capacity in the use of airspace and airports and enhancing flow management processes. It shall also be based on transparency and efficiency, ensuring that capacity is provided in a flexible and timely manner.
- f. It recognizes that airspace and airports are a common resource for all categories of users that needs to be used flexibly by all of them, ensuring fairness and transparency while taking into account security and defense needs of Member States and their commitments with international organizations.

- g. Air traffic flow management should be based on principles of partnership operated in accordance with the principles laid down in the ICAO Air Navigation Plan – FASID (Doc 7754), and contain the following functions:
 - 1. Central unit for air traffic flow management;
 - 2. Flow Management Positions;
 - 3. Operators – general aviation, air carrier, military; and
 - 4. Airport Operators
- h. Military aircraft operating as general air traffic should be subject to air traffic flow management measures when operating or intending to operate within airspace to which air traffic flow management measures apply.
- i. Member States, air navigation service providers and air carriers will provide data to SYNCROMAX, PROSAT or TFMS (previously ETMS) through the appropriate networks on a voluntary basis.
- j. ATFM shall apply within the Member States' airspace and airports to:
 - 1. all flights intended to operate or operating as general air traffic and in accordance with the instrument flight rules (IFR); and
 - 2. all phases of those flights.
- k. ATFM shall apply to each of the following parties, or anyone acting on their behalf, involved in air traffic flow management activities:
 - 1. operators,
 - 2. air traffic service providers
 - 3. entities involved in airspace management
 - 4. airport operators
 - 5. the entity charged by Member States with the provision of a single central unit for flow management.

2.0 Chapter 1: Demand and Capacity

2.1 In order to balance demand and capacity, it is first necessary to determine the airport acceptance rate (AAR), airport departure rate (ADR), total airport capacity (a combination of AAR and ADR), and the sector capacity. Once these capacities are established, steps can be taken to monitor and evaluate the air traffic demand and implement measures to balance demand with declared capacity. While there are a variety of methods to compute these values, the SAM Region has agreed to develop a common methodology in a White Paper for use by the States. The White Paper will take into account the following:

- a. Determining the AAR, ADR, and Total Airport Capacity.
 - 1. Definitions:
 - (a) **Airport Acceptance Rate (AAR):** A dynamic parameter specifying the number of arriving aircraft that an airport, in conjunction with terminal airspace, ramp space, parking space, and terminal facilities can accept under specific conditions during any consecutive 60 minute period.

- (b) **Airport Departure Rate (ADR):** A dynamic parameter specifying the number of departing aircraft that an airport, in conjunction with terminal airspace, ramp space, parking space, and terminal facilities can depart under specific conditions during any consecutive 60 minute period.
- (c) **Total Airport Capacity:** A dynamic parameter specifying the *total* number of arriving and departing aircraft that an airport, in conjunction with terminal airspace, ramp space, parking space, and terminal facilities can manage under specific conditions during any consecutive 60 minute period.
- (d) **Hypothetical Runway Capacity:** The runway capacity calculated during sixty minutes, taking into account the average time of runway occupancy and the legislation concerning aircraft separation, including the specific rules and procedures adopted to the local operations.

b. Administrative considerations:

1. Identify the organization responsible for the establishment and implementation of the airport capacity and sector capacity.
2. Establish the airport capacity for the airports identified by the States, Territories, and Organizations.
3. Review and validate the associated airport capacity and sector capacity values at least once each year.

2.2 Determining AAR:

To be determined by the results of the White Paper.

2.3 Determining ADR:

To be determined by the results of the White Paper.

2.4 Determining Total Airport Capacity:

To be determined by the results of the White Paper.

2.5 Determining Sector Capacity:

To be determined by the results of the White Paper.

2.6 Monitoring demand

1. Airport
2. Sector

2.7 Evaluating demand

1. Evaluating the need for Traffic Management Initiatives

3.0 Chapter 2: Traffic Management Tools

3.1 SYNCROMAX

3.2 TFMS

4.0 Chapter 3: Traffic Management Initiatives (TMI)

4.1 Definition

4.2 Purpose

4.3 Types

1. Altitude initiatives
 - a. Capping
 - b. Tunneling
2. In-trail initiatives
 - a. Miles-in-trail
 - b. Minutes-in-trail
 - c. Call for release (enroute spacing)
3. Fix balancing
4. Airborne holding
5. Reroutes
6. Sequencing programs
 - a. Ground delay programs
 - b. Ground stops

4.4 TMI approval authority

4.5 TMI processing

NOTE: This list of traffic management initiatives is not all inclusive and will be developed more fully by a project expert.

5.0 Chapter 4: Communications and Coordination

5.1 Communicating traffic management information

1. Planning telephone conferences
2. Operational telephone conferences
3. Web pages

5.2 Operations plan

5.3 Implementing Traffic Management Initiatives

5.4 Adjusting Traffic Management Initiatives

5.5 Cancelling Traffic Management Initiatives

NOTE: This list of communication and coordination initiatives is not all inclusive and will be developed more fully by a project expert.

6.0 **Chapter 5: Organization and structure**

6.1 Line of authority

6.2 Regional Traffic Management Center

1. Mission: Monitors and manages the flow of air traffic throughout the designated airspace system in order to produce a safe, orderly, and expeditious flow of air traffic while minimizing delays.
2. Duties
 - a. Analysis
 - b. Coordination
 - c. Intra-facility
 - d. Inter-facility
 - e. Telephone conferences
 - f. CDM approach
 - g. Documentation
 - (1) Operational log

NOTE: GREPECAS recognizes that this step will require further analysis.

6.3 Flow Management Unit / Flow Management Position

1. Mission: Monitor and balance flows of air traffic within their area of responsibility.
2. Duties
 - a. Analysis
 - b. Coordination
 - c. Intra-facility
 - d. Inter-facility
 - e. Telephone conferences
 - f. CDM approach
 - g. Documentation
 - (1) Operational log

NOTE: The development of FMU/FMP will be part of the near-term focus.

7.0 **Chapter 6: System Performance Metrics**

7.1 Actual arrival and departure counts for main airports

7.2 Actual traffic counts for en route airspace

7.3 Delay information

NOTE: This list of system performance metrics is not all inclusive and will be developed more fully by a project expert. It is envisioned that the metrics structure will be developed at the local, regional, and then global levels.

8.0 Chapter 7: Collaborative Decision Making

8.1 Organization

1. Roles and responsibilities

NOTE: This will be developed more fully by a project expert.

NOTE: This section will be developed more fully by a group of project experts. It could be reviewed by at least CGNA, Colombia, Mexico, Canada, AENA, CFMU, ATCSCC. The terms and definitions must be checked and reconciled with existing ICAO documents.

9.0 Chapter 8: Common ATFM Terminology

NOTE: This section will be developed as a separate appendix so that it can be reviewed and revised on a periodic basis.

9.1 General

1. The primary goal of these guidelines is to develop terminology and phraseology for the exchange of ATFM messages between units providing ATFM services. The terminology and phraseology contained herein are intended to both reflect the current use of plain language and provide a basis for standardization and harmonization.
2. Although there are various plain language words and phrases in use today by ATFM service providers, these words and phrases can be organized into a modular and structured method of delivery to ensure communication harmonization and reduce the incidence of misunderstanding between units providing ATFM service.
3. It is not the intent of these guidelines to provide detailed information on ATFM concepts, procedures, and initiatives; however, since not all readers may be familiar with ATFM terms used in the examples, a brief description of ATFM initiatives is provided at Attachment 1. The list is not all-inclusive and does not preclude the innovation and application of other procedures that will result in improved service.
4. These guidelines include the concept of modular and structured ATFM messages and define an ATFM message's components as who, what, where, when and why. These five components are described as follows:
 - a. Who: The ATFM service unit being contacted followed by the ATFM service unit that is initiating the contact.
 - b. What: The ATFM objective to be achieved.
 - c. Where: The location of the ATFM objective to be achieved.
 - d. When: The time and/or duration of the ATFM objective to be achieved.
 - e. Why: The reason for the ATFM objective.

5. There is no module regarding “how” the ATFM restrictions should be achieved by the counterpart ATFM service provider. It is the counterpart’s responsibility how they fulfill the requested ATFM restrictions within their airspace. However, the center being asked for the ATFM restrictions may collaborate with the originating center on the type and method of ATFM measure application. It should be noted that once information is exchanged regarding an ATFM restriction, it is considered MANDATORY unless otherwise agreed.

NOTE: It is recommended that this sentence be deleted.

6. Below are the examples of possible ATFM messages:
 - FAA COMMAND CENTER, THIS IS ABCD COMMAND CENTER ... REQUIRE 100 MILES IN TRAIL REGARDLESS OF FLIGHT LEVEL ON R220, R580 AND ALL PACOTS TRACKS FOR TRAFFIC LANDING NARITA ESTIMATING FIR BOUNDARY FROM 0100 UTC UNTIL 0500 UTC DUE TO SEVERE WEATHER.
 - ABCD COMMAND CENTER, THIS IS FAA COMMAND CENTER... CAPACITY RESTRICTION: LOS ANGELES HAS STARTED FLOW RESTRICTIONS FOR ALL AIRCRAFT LANDING LOS ANGELES DUE TO EARTHQUAKE. APPROACH HAS REQUESTED GROUND STOPS FOR ARRIVALS UNTIL FURTHER NOTICE.

9.2

ATFM Message Components

1. The use of a modular and structured ATFM message provides for consistent ATFM message design and delivery. Each of the ATFM message's five components can contain plain language elements that when combined provide a complete ATFM message. The harmonization achieved lies in the delivery of an ATFM message that has all of the required components in a structured format while making allowances for different plain language elements. This is of particular benefit for ATFM service providers that use different ATFM terminology or for non-native English speaking ATFM service providers.
2. As the modular and structured ATFM message may contain several different elements of plain language, this section will examine each of the five components and detail some of the possible plain language words and phrases that are in use today.
3. **WHO:** The **who** component identifies the ATFM service unit being contacted followed by the ATFM service unit that is initiating the contact. Examples of the who component:
 - ABCD COMMAND CENTER THIS IS FAA COMMAND CENTER...
 - FAA COMMAND CENTER, THIS IS ABCD COMMAND CENTER...
4. **WHAT:** The **what** component identifies the ATFM objective to be achieved. Objectives include but are not limited to:

REQUIRE

 - (number) MILES [or MINUTES] IN TRAIL AT THE SAME FLIGHT LEVEL...
 - (number) MILES [or MINUTES] IN TRAIL REGARDLESS OF FLIGHT LEVEL...

- A RATE OF (number) AIRCRAFT PER HOUR...
- FLIGHT LEVELS (number) AND (number) NOT AVAILABLE
- ONLY FLIGHT LEVELS (number), (number) AND (number) ARE AVAILABLE
- (route/airport/airspace) NOT AVAILABLE DUE (reason) ALTERNATIVE[S] IS/ARE (routes/airports)

5. **WHERE:** The **where** component represents the location of the ATFM objective to be achieved. It is often preceded by a modifying clause, indicating what aircraft or traffic the restriction will apply to. The modifying clause and the location combination are used to construct the where component.

Examples of location:

- ...AT NIPPI...
- ...NARITA AIRPORT...
- ...ANCHORAGE APPROACH...
- ...ON A337...
- ...WESTBOUND ON PACOTS TRACK CHARLIE...
- ...EASTBOUND ON A590...
- ...INBOUND ON G344...
- ...ON PACOTS TRACK 2 LANDING SAN FRANCISCO AIRPORT...
- ...ON PACOTS TRACK ECHO BELOW FLIGHT LEVEL 350...
- ...ABOVE FLIGHT LEVEL 300...
- ...INBOUND TO TOKYO ACC...
- ...INBOUND TO OAKLAND OCEANIC SECTOR 5
- ... WEST OF MARCC

Examples of what aircraft or traffic are included:

- ...FOR ALL AIRCRAFT...
- ...FOR TRAFFIC FASTER THAN 300 KNOTS...
- ...FOR HEAVY AIRCRAFT...
- ...FOR TRAFFIC LANDING...
- ...FOR AIRCRAFT DEPARTING...
- ...FOR TRAFFIC OVERFLYING...
- ...FOR AIRCRAFT PASSING...

6. **WHEN:** The **when** component represents the time and/or duration of the ATFM objective to be achieved:

Examples of time/duration:

- ...FROM 0300 UTC UNTIL 0600 UTC...
- ...FROM NOW UNTIL 0600 UTC...
- ...FROM 2300 UTC UNTIL FURTHER NOTICE...
- ...UNTIL FURTHER NOTICE...

7. **WHY:** The **why** component represents the reason for the ATFM objective:

DUE TO/FOR...

- RUNWAY CLOSURE
- (SEVERE) WEATHER
- COMMUNICATION FAILURE
- RADAR FAILURE
- (significant event/natural disturbance such as FIRE or VOLCANIC ASH)
- STATE AIRCRAFT ACTIVITY
- MILITARY ACTIVITY
- EQUIPMENT OUTAGE
- EMERGENCY
- ATFM INITIATIVES IN (location)

9.3

ATFM Message Types

1. **Information to be shared prior to invoking the ATFM restrictions:** The information-sharing should be facilitated not only during the actual flow control but also (and more importantly) well prior to invoking the ATFM restrictions when the possibility of flow control arises. The following phrases will make clear the distinction between the ATFM messages and the information provided for situation awareness:

- POSSIBLE TRAFFIC FLOW RESTRICTIONS
- CAPACITY RELATED INFORMATION

Examples of messages sent prior to invoking ATFM restrictions follow:

- FAA COMMAND CENTER, THIS IS ABCD COMMAND CENTER...**POSSIBLE TRAFFIC FLOW RESTRICTIONS**... XYZ AIRPORT HAS CLOSED ONE RUNWAY AND STARTED SNOW REMOVAL.
- FAA COMMAND CENTER, THIS IS ABCD COMMAND CENTER...**CAPACITY RELATED INFORMATION**...XYZ AIRPORT HAS ENTERED THE STORM ZONE OF THE HURRICANE.

2. **ATFM Initiative Message:** ATFM initiatives communicate air traffic flow restrictions/objectives from one air traffic service provider to another. They follow the five component structure described earlier:

- a. Who: The ATFM service unit being contacted followed by the ATFM service unit that is initiating the contact.
- b. What: The ATFM objective to be achieved.
- c. Where: The location of the ATFM objective to be achieved.
- d. When: The time and/or duration of the ATFM objective to be achieved.
- e. Why: The reason for the ATFM objective.

Examples of ATFM initiatives follow:

- ABCD COMMAND CENTER, THIS IS FAA COMMAND CENTER ...REQUIRE 30 MINUTES IN TRAIL AT THE SAME FLIGHT LEVEL FOR ALL AIRCRAFT LANDING CHICAGO FROM 0800 UTC UNTIL FURTHER NOTICE DUE TO STATE AIRCRAFT ACTIVITIES.
 - FAA COMMAND CENTER, THIS IS ABCD COMMAND CENTER... FL350 AND BELOW NOT AVAILABLE FOR AIRCRAFT OVERFLYING XYZ DOMESTIC AIRSPACE UNTIL 0900 UTC DUE TO EMERGENCY.
3. **Coordination of aircraft exempted from ATFM initiatives:** The following phrases will be used for the coordination of aircraft which are exempt from ATFM restrictions:
- REQUEST EXEMPTION FROM ATFM
 - COORDINATION OF ATFM EXEMPTION
4. The following types of aircraft may be exempted from ATFM restrictions:
- Aircraft in a state of emergency
 - Aircraft engaged in search and rescue missions
 - Aircraft operating for humanitarian reasons
 - Aircraft carrying the head of State or distinguished visitors of State
 - Aircraft carrying a patient who needs urgent medical treatment

Examples of messages requesting ATFM exemption follow:

- ABCD COMMAND CENTER, THIS IS FAA COMMAND CENTER...**REQUEST EXEMPTION FROM ATFM**...UAL123 IS CARRYING A PATIENT WHO NEEDS URGENT MEDICAL TREATMENT.
UAL123...EXEMPTION APPROVED.
 - FAA COMMAND CENTER, THIS IS ABCD COMMAND CENTER...**COORDINATION OF ATFM EXEMPTION**... UAL501A IS OPERATING SEARCH AND RESCUE MISSIONS.
5. **Information for the next coordination:** If it is possible and appropriate, the expected time of next coordination will be forwarded with the ATFM messages:
- I WILL CALL YOU AT 0400 UTC FOR FURTHER COORDINATION
 - WE WILL CALL YOU AGAIN IN 30 MINUTES

An example of a message with information for the next coordination follows:

- ABCD COMMAND CENTER, THIS IS FAA COMMAND CENTER... REQUIRE 30 MINUTES IN TRAIL REGARDLESS OF ALTITUDE FOR ALL AIRCRAFT ON PACOTS TRACK 8 FROM 1000 UTC UNTIL FURTHER NOTICE DUE TO MILITARY ACTIVITY. I WILL CALL YOU AGAIN IN 60 MINUTES.

6. **Amendment:** The amendment of an ATFM message should be structured as the initial message and include similar elements but with additional modifiers. These modifiers may include:
 - CHANGE
 - AMEND
 - REDUCE
 - INCREASE
 - DECREASE
7. Amendment messages should also identify which message is being amended, as several restrictions could be in place at one time. Examples of ATFM amendment messages follow:
 - FAA COMMAND CENTER, THIS IS ABCD COMMAND CENTER...WE HAVE **CHANGED** THE RESTRICTION ON TRAFFIC FLYING PACOTS TRACKS CHARLIE, ECHO AND FOXTROT FOR XYZ AIRPORT. WE NOW NEED 20 MINUTES IN TRAIL AT THE SAME FLIGHT LEVEL ON PACOTS TRACKS CHARLIE, ECHO AND FOXTROT FOR TRAFFIC LANDING XYZ AIRPORT FROM NOW UNTIL 0900 UTC.
 - ABCD COMMAND CENTER, THIS IS FAA COMMAND CENTER...WE HAVE **INCREASED** THE INBOUND RATE FROM 5 AIRCRAFT PER HOUR TO 10 AIRCRAFT PER HOUR FOR TRAFFIC BEYOND OAKLAND FIR UNTIL FURTHER NOTICE.
8. **Cancellation:** The cancellation of an ATFM message should be structured the same as the initial message and include similar elements but also contain a canceling word or phrase. It is normally not necessary to state the reason for the cancellation. A canceling word or phrase may include:
 - CANCEL
 - RESUME
 - RESUME NORMAL
 - RELEASE
9. Cancellation messages should also identify which message is being cancelled, as several restrictions could be in place at one time. An example of an ATFM cancellation message follows:
 - FAA COMMAND CENTER, this is ABCD COMMAND CENTER...**CANCEL** the restriction on traffic beyond the XYZ FIR at this time. **Resume normal** traffic flow.

9.4

Description of Air Traffic Flow Management Initiatives

The following list is not all-inclusive and does not preclude the innovation and application of other procedures that will result in improved service.

<u>NAME</u>	<u>DESCRIPTION</u>
Airborne holding Recommended wording: (Inflight holding)	Planned holding of aircraft may be utilized. This is normally done when the operating environment supports holding and the weather conditions are expected to improve shortly; this ensures aircraft are available to fill the capacity at the airport.

<u>NAME</u>	<u>DESCRIPTION</u>
Altitude	Utilized to segregate different flows of traffic, or to distribute the number of aircraft requesting access to a specified geographic region. a. Capping: Term to indicate aircraft will be cleared to an altitude lower than their requested altitude until they are clear of a particular airspace. Capping may apply to the initial segment of the flight or for the entire flight. b. Tunneling: Term to indicate traffic will be descended prior to the normal descent point at the arrival airport to remain clear of an airspace situation; e.g., holding.
Fix balancing	Assigning an aircraft a fix other than that in the filed flight plan in the arrival or departure phase of flight to equitably distribute demand.
Ground delay programs (GDP)	Aircraft are held on the ground in order prior to departure to manage capacity and demand at a specific location, by assigning arrival slots. The purpose of the program is to limit airborne holding.
Ground stops (GS)	GS is a process that requires aircraft that meet specific criteria to remain on the ground. Since this is one of the most restrictive methods of traffic management, alternative initiatives should be explored and implemented if appropriate. GSs should be used:
NOTE: for ICAO, GS is Glide slope	a. In severely reduced capacity situations (below most user arrival minimums, airport/runway closed for snow removal, or aircraft accidents/incidents); b. To preclude extended periods of airborne holding; c. To preclude sector/center reaching near saturation levels or airport grid lock; d. In the event a facility is unable or partially unable to provide ATC services due to unforeseen circumstances; and e. When routings are unavailable due to severe weather or catastrophic events.
Miles-in-trail (MIT)	The number of miles required between aircraft that meet a specific criteria. The criteria may be separation, airport, fix, altitude, sector, or route specific. MIT are used to apportion traffic into manageable flows, as well as to provide space for additional traffic (merging or departing) to enter the flow of traffic.
Minutes-in-trail (MINIT)	The number of minutes required between successive aircraft. It is normally used in a non-radar environment, or when transitioning to a non-radar environment, or when additional spacing is required due to aircraft deviating around weather.
Reroutes	Reroutes are ATC routings other than the filed flight plan. They are issued to: a. Ensure aircraft operate with the “flow” of traffic. b. Remain clear of special use airspace. c. Avoid congested airspace. d. Avoid areas of known weather where aircraft are deviating or refusing to fly.
Sequencing programs	These programs are designed to achieve a specified interval between aircraft; they may be software generated or determined by ATFM personnel. Different types of programs accommodate different phases of flight. 1. Departure Sequencing Program (DSP) - Assigns a departure time to achieve a constant flow of traffic over a common point. Normally, this involves departures from multiple airports. 2. En route Sequencing Program (ESP) - Assigns a departure time that will facilitate integration in the en route stream. 3. Arrival Sequencing Program (ASP) - Assigns fix crossing times to aircraft destined to the same airport.

9.5 Table of Abbreviations

The abbreviations listed here are those used by ATCSCC and other Command Centers that are not defined in the ICAO Doc. 8400 (PANS-ABC). The shaded abbreviations are considered to be the common terms between the two centers. The asterisk shows verbatim difference in the original collocation but the abbreviation still indicates the common object.

	ATCSCC	Other Command Centers
AAR	Airport Acceptance Rate	
ACID	Aircraft Identification	
ADL	Aggregate Demand List	
ADR	Airport Departure Rate	
ADZY	Advisory	
AIM	Aeronautical Information Manual	
ALTRV	Altitude Reservation	Altitude Reservation
ANP	Air Navigation Plan	
AOA	Office of the Administrator	
AOC	Airline Operations Center	
AP	Air Patrol	
APREQ	Approval Request	Approval Request
APVL	Approval	Approval
ARINC	Aeronautical Radio Incorporated	
ARO	Airport Reservation Office	
ARTCC	Air Route Traffic Control Center	Air Route Traffic Control Center
ARU	Airspace Reservation Unit (Canada)	
ASM		Airspace Management
AT	Air Traffic	
ATCSCC	Air Traffic Control System Command Center	Air Traffic Control System Command Center
ATMC	Air Traffic Management Center	Air Traffic Management Center
ATMetC		Air Traffic Meteorological Center
ATO	Air Traffic Operations Program	
AUTODIN	Automatic Digital Network	
CARF	Central Altitude Reservation Function	
CCFMEX	Mexico Command Center	Centro de Control de Flujo de Mexico
CFMU	Central Flow Management Unit (Brussels)	Central Flow Management Unit
CCFP	Collaborative Collective Forecast Product	
CCWSU	Command Center Weather Service Unit	
CDM	Collaborative Decision Making	Collaborative Decision Making
CDR	Coded Departure Route(s)	Conditional Route
CDR	Continuous Data Recording	
CDT	Controlled Departure Time	
CFR	Code of Federal Regulations (formerly FAR)	
CGNA	Brazil Command Center	Centro De Gerenciamento Da Navegação Aérea
CIWS	Corridor Integrated Weather System	

	ATCSCC	Other Command Centers
COMSEC	Communications Security System	
CR	Collaborative Routing	
CT	Select Flights Ground Delay Program	
CTA	Controlled Time of Arrival	
CTAS-TMA	Center TRACON Automation System Traffic Management Advisor	
CVRS	Computerized Voice Reservation System	
CWA	Central Weather Advisory	
CWSU	Center Weather Service Unit	
DARC	Direct Access Radar Channel	
DCCWU	ATCSCC Weather Unit	
DOTS	Dynamic Ocean Track System	Dynamic Ocean Track System
DP	Departure Procedure	
DSP	Departure Sequencing Program	
EDCT	Expected Departure Clearance Time	Expected Departure Clearance Time
EFAS	Enroute Flight Advisory Service	
EFTO	Encrypt For Transmission Only	
EOF	Emergency Operations Facility	
EOR	Emergency Operations Room	
EPS	Engineered Performance Standards	
ESCAT	Emergency Security Control of Air Traffic	
ETE	Estimated Time Enroute	Estimated Time Enroute
ETMS	Enhanced Traffic Management System	
EUCARF	European Central Altitude Reservation Facility	
FA	General Ground Delay Program	
FAA	Federal Aviation Administration	Federal Aviation Administration
FADT	Fuel Advisory Delay Time	
FCA	Flow Constrained Area	
FDMS		Flight Data Management System
FDPS		Flight Data Processing Section
FEA	Flow Evaluation Area	
FP	Flight Plan	
FPL	Full Performance Level	
GA	General Aviation	
GAAP	General Aviation Airport Program	
GDP	Ground Delay Program	
GS	Ground Stop	
HARS	High Altitude Route System	
HDTA	High Density Traffic Airport	
IFCN	Interfacility Communication Network	

	ATCSCC	Other Command Centers
IFPFP	Individual Flight Plan From this Point	Individual Flight Plan From this Point
IFSS	International Flight Service Station	
INATS	Interruption of Air Traffic Service	
JCAB	Japan Civil Aviation Bureau	Japan Civil Aviation Bureau
LAA	Local Airport Advisory	
LADP	Local Airport Deicing Plan	
LOA	Letter of Agreement	Letter of Agreement
MAP	Monitor Alert Parameter	
MARSA	Military Assumes Responsibility for Separation of Aircraft	Military Assumes Responsibility for Separation of Aircraft
MEL	Minimum Equipment List	
MINIT	Minutes in Trail	
MIT	Miles in Trail	
MOS	Military Operations Specialist	
MTSAT	Multi-functional Transport Satellite	Multi-functional Transport Satellite
MVFR	Marginal Visual Flight Rules	
NADIN	National Airspace Data Interchange Network	
NAS	National Airspace System	
NAVAID*	Navigational Aid	Navigation Aid
NFDC	National Flight Data Center	
NMCC	National Maintenance Coordination Center	
NOAA	National Oceanic and Atmospheric Administration	
NOC	NAV CANADA National Operations Centre (Ottawa)	NAV CANADA National Operations Centre
NOM	National Operations Manager	
NOPAC	North Pacific	North Pacific
NOS	National Oceanographic Service	
NRP	National Route Program	
NTMO	National Traffic Management Officer	
NWS	National Weather Service	
OAG	Official Airline Guide	
ODP		Oceanic Air Traffic Control Data Processing System
OPSNET	Operations Network	
OTG		Oceanic Track Generator
OTR		Oceanic Transition Route
PACMARF*	Pacific Military Altitude Reservation Facility	Pacific Military Altitude Reservation Function
PACOTS	Pacific Organized Track System	Pacific Organized Track System
PMTTC	Pacific Missile Test Center	
PO	Plan of Operation	

	ATCSCC	Other Command Centers
Pref Route	Preferential Route	
PT	Planning Team	
RA	Route Advisory	
RAA	Remote Airport Advisory	
ROT	Runway Occupancy Time	
SAA	Special Activity Airspace	
SOP	Standard Operating Procedure	
STMP	Special Traffic Management Program	
SUA	Special Use Airspace	
SVRW	Severe Weather	
SWAP	Severe Weather Avoidance Program	
TEC	Tower-Enroute Control	
TELCON	Telephone Conference	
TFM	Traffic Flow Management	
TIS	Traffic Information System	
TMC	Traffic Management Coordinator	Traffic Management Coordinator
TMCIC	Traffic Management Coordinator in Charge	
TMI	Traffic Management Initiative	
TMU	Traffic Management Unit	Traffic Management Unit
TSTM	Thunderstorm	
WSO	Weather Service Office	

DOCUMENT CHANGE RECORD

The following table records the complete history of the successive versions of the present document.

Version Number	Date	Reason for Change	Pages Affected
1.0	12-05-08	Creation	All
2.0	12-09-08	General Amendment	All
3.0	07-11-08	General Amendment	All

Status: Draft

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APPENDIX D

METHODOLOGY ADOPTED BY BRAZIL TO CALCULATE THE CONTROL CAPACITY OF APP AND ACC

(Presented by CGNA- Brazilian Air Navigation Management Center)

1 Background

1.1 DECEA adopts a methodology to determine the capacity of APP and ACC sectors which makes possible to obtain a reference value for the sector's capacity. It consists in obtaining a value, calculated through a mathematical formula, whose basic data are extracted from a research carried out by a group at the ATC unity, considering a moment of heavy activity, when the controller's actions and his availability, at that moment, to control the traffic of the control sector are observed and timed. When an estimated capacity is being successfully applied to the sector at issue, that phase is not necessary.

2 Discussion

2.1 CAPACITY INVESTIGATION THROUGH MATHMATICAL FORMULA

The term ATC capacity reflects the capacity of the ATC system or of any of its subsystems, or operational positions, to provide the aircraft the services foreseen within the regular activities of these unities.

In Brazil, the capacity of ACCs is calculated by observing the capacity of their sectors which are analytically obtained, according to the methodology established in the ICA 100-30, ATC personnel planning (DECEA, 2007). In this way, the model used in Brazil can be classified as mesoscopic (where some additional detail is taking into consideration) and analytical (through mathematical formulas).

Nowadays, the calculated value can be understood as the maximum number of aircraft that can be simultaneously controlled by each operational position (ATCO), so providing the capacity carried out by the ATC unity. It is worthy to emphasize that DECEA has been working on new concepts which, in the future, will consider that value as a reference to be adjusted according to operational judgment.

According to the current model, the controller's work load is the summation of the time spent on each of the following tasks:

1. communications (transmission/reception);
2. manual activities (filling out strips) and coordination; and
3. traffic planning and distribution.

The Brazilian methodology applies the concept of the controller's "**availability factor**" (ϕ), which is defined as the percentage of time available for the ATCO to plan the aircraft separation procedures.

This availability factor is found, usually, between a minimum value of 40% of the ATCO time, for no radar control, and 60% for radar (ICA 100-30). Efforts shall be focused on increasing ϕ and the only way to achieve this goal is by applying measures which reduce the controller's engagement with the activities mentioned in 1 and 2.

This factor ϕ can present a bigger percentage when the Man / Machine Interface – MMI is enhanced.

In Brazil, the number of aircraft that can be simultaneously controlled by a controller (N), within the sector at issue, is calculated through the following formula (ICA 100-30):

$$N = \phi \cdot \delta \cdot (\eta \cdot \tau_m \cdot v_m)^{-1} \quad (1)$$

In the formula (1), the ATC capacity is inverse or direct function of some factors (ICA 100-30), as follows:

- **Factores directly proportional to the ATC capacity:**

ϕ : factor of controller availability, defined as the percentage of time available to plan the aircraft separation procedures;

δ : average distance flown by aircraft in the sector, which is function of the pathways and route or terminal established for each sector;

- **Factors inversally proportional to the ATC capacity:**

η : number of communication for each aircraft in the sector, which must be restricted to the necessary minimum for the understanding between pilot and controller. That number can be minimized by issuing a full clearance with the necessary anticipation to allow the flight planning;

τ_m : average length of time of each message. This factor can be minimized by transmitting messages in an objective way, avoiding long explanations which are detrimental as far as the understanding between pilot and controller is concerned; and

v_m : average speed of the aircraft in the sector.

Replacing δ y v_m by the average flight time spend by the aircraft crossing the sector (T), that formula can be replaced by a simpler version:

$$N = \phi \cdot T \cdot (\eta \cdot \tau_m)^{-1} \quad (2)$$

The values of the factors ϕ , T, η and τ_m are collected empirically, following the standardized procedures.

As an example, we can consider T= 12 minutes, τ_m = 9 seconds, ϕ = 60%, η = 6, which results in a number of simultaneous aircraft N = 8 per controller in the referred sector. In other words, in this sector and under these conditions, a controller would control 8 aircraft simultaneously.

Several factors are constantly influencing number N. Factors directly related, for instance, sector size or route modification. Thus, every time a significant change is notice, it is necessary an update of the determined value. Besides, it is important that the data gathering be very expressive, in order to dilute the provisional stochastic deviations and to represent trustworthy values to the ATC unity.

In ideal conditions, data research shall be conducted when there is a heavy air traffic activity, for this reason to choose the ideal season is a factor to be considered, once it has a direct influence in final results.

APPENDIX E

METHODOLOGY USED BY BRAZIL FOR THE RUNWAY CAPACITY CALCULATION

(Submitted by CGNA - Air Navigation Management Center of Brazil)

1 Introduction

1.1 The saturation of the runway operational capacity for arrivals and departures have been seen as one of the biggest problems for domestic and international airports. In order to maintain the air traffic flow near the optimal conditions, avoiding possible overflow in the system, the Brazilian Air Navigation Management Center (CGNA) applies standard procedures for runway capacity calculations. These procedures help to follow the changes in demand/capacity at the airports, to find parameters which support recommendations to the airports of interest in advance and to keep the overall operation in harmony.

According to the evolution of the air traffic at airports, the runway capacity calculation will take into account not only the runway occupancy time, but also other factors which can significantly interfere in the runway operational capacity.

1.2 To determine the capacity of a runway or a set of runways, the following factors are considered:

- a) planning factors; and
- b) factors related to the landing and takeoff operations.

1.2.1 Planning Factors

The planning factors are elements used to simplify the mathematical models, or the operational aspects, which influence the determination of the runway capacity. The most common are:

- a) Optimal conditions for aircraft sequencing and air traffic coordination;
- b) All operational teams are considered with the same capacity and same operational performance; and
- c) All radio-navigation and visual-aid are considered, technically and operationally, unrestricted, and all communication equipment (VHF/telephony) are considered operational.

1.2.2 Factors Related to the Takeoff and Landing Operations

- a) Average runway occupancy time;
- b) Aircraft Mix ;
- c) Thresholds percentage of use;
- d) Final approach segment length;
- e) Standardized minimum separation between the aircrafts for landing;
- f) Runways and taxiways configuration, and
- g) Final approach speed.

2 Analysis

The mathematical model for calculating the theoretical runway capacity used by DECEA is described in the following sections. In some of the steps, the aircraft classification is used by grade (A through E), according to the Doc 8168 (Table III-1-2).

2.1 MATHEMATICAL MODEL FOR THE THEORETICAL RUNWAY CAPACITY

STEP 1

COLLECTION OF DATA FROM THE AIRPORT:

1°) The runway occupation time at takeoff (TOPD): time taken by the aircraft during the takeoff operation or the time measured from the moment when the aircraft leaves the "hold short of" position until it flies over the opposite threshold;

2°) The runway occupation time at landing (TOPP): time spent from the point at which the aircraft crosses the threshold of the runway during the landing operation until it leaves the runway; and

3°) Flight time from the outer marker (or FAF) to the threshold of the runway (T): time taken by the aircraft during the final approach, from the moment when the aircraft crosses over the outer marker (or FAF) until it crosses the threshold of the runway or, in the absence of an outer marker, when it starts the final approach segment until it crosses the threshold of the runway. The aircraft category is considered in the time measurement process.

Obs.: The times previously described are classified by the aircraft category and are taken in the control tower of the airfield. These times will be recorded on special forms (Annexes 1 and 2, respectively). It is important to explain that during the time measurement, will be watched the "Modus Operandi" of the ATC Organs in the studied airfield.

STEP 2

AVERAGE RUNWAY OCCUPANCY TIME (MATOP)

Average runway occupancy time will be calculated for each runway threshold; due to the fact that each runway has its own configuration. This leads to different average time of runway occupancy in each threshold.

After taking the runway occupancy time, the arithmetic average of the runway occupancy time (MATOP) is calculated separately by aircraft category, as follows:

$$\text{MATOPA} = \frac{\text{TOPDA} + \text{TOPPA}}{2}$$

$$\text{MATOPB} = \frac{\text{TOPDB} + \text{TOPPB}}{2}$$

$$\text{MATOPC} = \frac{\text{TOPDC} + \text{TOPPC}}{2}$$

$$\text{MATOPD} = \frac{\text{TOPDD} + \text{TOPPD}}{2}$$

$$\text{MATOPE} = \frac{\text{TOPDE} + \text{TOPPE}}{2}$$

STEP 3

AIRCRAFT MIX (MIX)

Aircraft Mix is the fleet configuration operating at the studied airport. According to Doc 8168, the aircraft are subdivided into five categories, depending on the runway threshold crossing speed, which must be 130% of the value of the stall speed with the landing configuration (full flaps, gear down). Therefore, the aircraft are classified as follows:

- CAT "A" speed less than 90 kt
- CAT "B" Speed between 91/120kt
- CAT "C" Speed between 121/140kt
- CAT "D" speed between 141/165kt
- CAT "E" Speed between 166/210kt

The percentage by aircraft category (Mix) will be calculated from the total daily movement. To obtain this number, the data sample should be taken in the period of one week. The chosen week should contain the day selected to collect the data for calculating the runway occupation time.

The table below shows an example of aircraft mix calculation:

	MONDAY		TUESDAY		WEDNESDAY		THURSDAY		FRIDAY	
CAT	ACFT	PERC	ACFT	PERC	ACFT	PERC	ACFT	PERC	ACFT	PERC
A	32	8.42%	29	7.63%	25	6.51%	39	9.68%	25	6.31%
B	55	14.47%	57	15.00%	61	15.89%	73	18.11%	66	16.67%
C	283	74.47%	283	74.47%	286	74.48%	282	69.98%	297	75.00%
D	6	1.58%	11	2.89%	11	2.86%	8	1.99%	8	2.02%
E	4	1.05%	0	0.00%	1	0.26%	1	0.25%	0	0.00%
TOTAL	380	100%	380	100%	384	100%	403	100%	396	100%

Arithmetic mean	
CAT	Mix
A	7.71 %
B	16.03 %
C	73.68 %
D	2.27 %
E	0.31 %
TOTAL	100 %

STEP 4**WEIGHTED AVERAGE TIME OF RUNWAY OCCUPATION (TMOP)**

It is the weighted average time of the arithmetic average of the runway occupation time (MATOP) by category of aircraft, taking into account the mix of aircraft. The average time should be calculated for each threshold in the aerodrome, because the different configurations of the taxiways for each threshold in use.

$$TMOP = \frac{MIX_A \times MATOPA + MIX_B \times MATOPB + MIX_C \times MATOPC + MIX_D \times MATOPD + MIX_E \times MATOPE}{\sum MIX}$$

STEP 5**FINAL APPROACH SPEED(VA)**

It is the speed needed to go through the segment of final approach (SAF) for landing. This velocity comes from the division of the approach segment length by the flight time (T) from the outer marker (or FAF) until the runway threshold.

$$VA_A = \frac{SAF}{T_A}$$

$$VA_B = \frac{SAF}{T_B}$$

$$VA_C = \frac{SAF}{T_C}$$

$$VA_D = \frac{SAF}{T_D}$$

$$VA_E = \frac{SAF}{T_E}$$

STEP 6**AVERAGE SPEED IN THE FINAL APPROACH (VM):**

Weighted average of the final approach speeds, taking into account the mix of aircraft.

$$VM = \frac{MIX_A \times VA_A + MIX_B \times VA_B + MIX_C \times VA_C + MIX_D \times VA_D + MIX_E \times VA_E}{\sum MIX}$$

STEP 7**DETERMINATION OF SAFE SEPARATION (SS):**

The study considers the occurrence of a takeoff between two consecutive landings, but without affecting the regulatory minimum separation (SMR), which is established in rules of ICA 100-12 in the case of Brazil. With this aim, it is necessary to calculate a safe distance to be added to the regulatory minimum separation between aircrafts on approach, in order to allow the take off of an aircraft, after the landing of the first approaching aircraft, but without compromising the regulatory separation to the second approaching one.

This distance comes from the multiplication of the weighted average speed in the final and the weighted average of the runway occupation time.

$$SS = VM \times TMOP$$

STEP 8**DETERMINATION OF TOTAL SEPARATION BETWEEN TWO CONSECUTIVES LANDINGS (ST):**

By calculating the distance traveled by the second aircraft on final approach, during the time that the runway stays busy and adding the calculated distance to the regulatory minimum separation adopted, we get the necessary separation between two consecutive landings.

The total separation comes from the summation of the safe separation distance (SS) with the regulatory minimum separation, as follows:

$$ST = SMR + SS$$

There are cases where the SS can be disregarded. Usually this can happen at the airports that have two or more runways, improving the dynamism of the operation and enabling an aircraft to line up and wait on a runway during the landing of other aircraft on another runway.

STEP 9**DETERMINATION OF WEIGHTED AVERAGE TIME BETWEEN TWO CONSECUTIVES LANDINGS (TMST):**

The weighted average time used for the total separation between two consecutive landings is obtained from the total separation distance length divided by the weighted average speed of the aircraft mixing, as follows:

$$TMST = ST/VM$$

STEP 10**DETERMINATION OF THE NUMBER OF LANDING AIRCRAFT IN ONE HOUR (P):**

The possible number of landings with the proposed separation within a time interval of one hour is obtained dividing the interval of one hour by the weighted average time used for the total separation between two consecutive landings, as follows:

$$P = 1\text{Hora}(\text{sec})/\text{TMST}(\text{sec})$$

STEP 11**DETERMINATION OF THE NUMBER OF DEPARTURE IN ONE HOUR (D):**

Applying the calculated total separation it is possible to have one departure between two consecutive landings. Decreasing one aircraft of the total number of landings, we get the possible number of departure in the interval of one hour.

$$D = P-1$$

STEP 12**DETERMINATION OF THE RUNWAY CAPACITY (CP):**

The runway capacity comes from the addition of the number of landings with the number of takeoffs, as follows:

$$CP=P+D$$

STEP 13**PERCENTAGE OF RUNWAY USAGE (PU):**

The runway usage percentage is calculated from the total monthly movement, obtained from a one year data sample.

In order to achieve the required precision in the calculations, the last twelve months data of the control tower management systems are analysed to measure the usage percentage of each runway of the aerodrome.

The tables below show an example the runway usage percentage calculation:

RUNWAY	% RUNWAY OCUPATION
A	86
B	14
TOTAL	100

MES	RWY A	RWY B	MONTHLY MOVEMENT
ENE	7622	2631	10253
FEB	6364	3229	9593
MAR	9239	2409	11648

MES	RWY A	RWY B	MONTHLY MOVEMENT
ABR	9965	1184	11149
MAY	10811	896	11707
JUN	11280	291	11571
JUL	11637	620	12257
AGO	12145	263	12408
SET	11687	273	11960
OCT	9177	2184	11361
NOV	7765	2936	10701
DIC	7487	3665	11152
TOTAL	115179	20581	135760

STEP 14

CAPACITY OF A RUNWAY SET

The runway capacity of a runway set is the full sustainable capacity, in the operational point of view, considering the runway usage percentage of each runway. The runway set capacity is the weighted average of each runway capacity, considering the respective runway usage percentage, as follows:

$$CA = \frac{PU_1 \times CP_1 + PU_2 \times CP_2 + \dots + PU_N \times CP_N}{PU_1 + PU_2 + \dots + PU_N}$$

2.2 Practicable Runway Capacity

The practicable runway, or runway set, capacity can be chosen between 80% and 100% of the theoretical runway capacity.

It is recommended to use values closed to 80% of the theoretical runway capacity to reduce the possibility of delays during the operation when some external factor, like weather, operational delays of the companies, etc., interferes in the normal airdrome operation. When the practicable runway capacity value is closed to 100%, it becomes difficult to recover delays caused by external factors.

3 Action suggested

3.1 The meeting is invited to:

- a) Analyze the information presented in the Working Paper.

DEPARTURE TIME OF RUNWAY OCCUPATION

RWY: _____

Time of ending: _____

[illegible]

OBS.: In the fields below is the average time of runway occupation by aircraft category.

CAT	Average time
A	

CAT	Average time
B	

CAT	Average time
C	

CAT	Average time
D	

CAT	Average time
E	

APPENDIX B

ARRIVAL TIME OF RUNWAY OCCUPATION

Airdrome: _____

Date: _____

RWY: _____

Time of beginning:_____

Time of ending

[illegible]

OBS.: In the fields below is the average time of runway occupation by aircraft category.

CAT	Average time
A	

CAT	Average time
B	

CAT	Average time
C	

CAT	Average time
D	

CAT	Average time
E	

AIRCRAFT REGISTER		Type	Category	SPEED (KT)			wind(KT)	OBS:
				Average speed	OM	THR		

OBS.: In the fields below is the average time of runway occupation by aircraft category

CAT	Average time
A	

CAT	Average time
B	

CAT	Average time
C	

CAT	Average time
D	

CAT	Average time
E	

APPENDIX D**ABBREVIATIONS**

ARR	Arrival
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
CAT	Category
CFP	Actual Runway Capacity
CTP	Hypothetical Runway Capacity
CT	Time Counting
CGNA	Air Navigation Management Center
DEP	Departure
FAA	Federal Aviation Administration
IEPV	Brazilian Aeronautical Forms
OM	Outer Marker
FAF	Final Approach Fix
FPL	Filed Flight Plan
IMC	Instrument Meteorological Conditions
RWY	Runway
SAS	Situation Analysis System
SEP REQ	Required Separation
SGTC	Control Tower Management System
TARIS	Terminal of radar presentation with synthetic image
TG	Touch-and-Go
TOP	Runway Occupancy Time
THR	Threshold
TPH	Typical Peak Hour

APPENDIX E

DEFINITIONS

a) ACTUAL RUNWAY CAPACITY

The possible maximum number of operations during sixty minutes, taking into account the runway occupancy time. (t_{op}).

b) HYPOTHETICAL RUNWAY CAPACITY

The runway capacity calculated during sixty minutes, taking into account the average time of runway occupancy and the legislation concerning aircraft separation, including the specific rules and procedures adopted to the local operations.

c) AEROPLANE CATEGORY

Classification of aeroplanes subdivided into five groups (a, b, c, d, e), defined according to the indicated airspeed at threshold which must be equal to 130 per cent of the stall speed, with a landing configuration (full flaps, gear down).

d) AIRCRAFT MIX

Percent distribution of the aircraft fleet in operation in the analyzed airport, according to the aeroplane category.

e) PERCENTAGE BY AEROPLANE CATEGORY

Calculated index considering the total daily aircraft movement, reported in the IEPV 100-34 form (Aircraft Movement in Aerodromes) or collected from the Control Tower Management Systems. This index is equal to the percent mean of one year sample, based on weekdays (except Saturdays, Sundays and holidays).

f) PERCENTAGE OF RUNWAY UTILIZATION AT AN AERODROME

Calculated index considering the total daily aircraft movement. This index is equal to the percent mean of one year sample in order to approve the confidence on the data.

g) SATURATION

Situation on which the air traffic demand is higher than the airport capacity or than a certain control sector.

h) RUNWAY OCCUPANCY TIME FOR DEPARTING AIRCRAFT

Runway occupancy time for departing aircraft based on the moment that the aircraft leaves the holding point until the moment it crosses the opposite threshold.

i) RUNWAY OCCUPANCY TIME FOR ARRIVING AIRCRAFT

Runway occupancy time for arriving aircraft based on the moment that the aircraft crosses the threshold until the moment it vacates the runway.

j) AVERAGE RUNWAY OCCUPANCY TIME TAKING INTO ACCOUNT EACH AEROPLANE CATEGORY

Arithmetic mean, considering each aeroplane category, between the runway occupancy time for departing aircraft and the runway occupancy time for arriving aircraft.

APPENDIX F / APÉNDICE F**METODOLOGÍA PARA CÁLCULO DE CAPACIDAD DE PISTA DEL AEROPARQUE
JORGE NEWBERY***(Spanish Only)***METODOLOGÍA APLICADA DECEA - BRASIL**

En el presente Apéndice, se detallan únicamente los pasos determinados en la Metodología de cálculo de la capacidad teórica de pista teórica utilizado por el DECEA.

1° PASO**RECOLECCION DE DATOS DEL AEROPUERTO:**

Los datos fueron tomados en un período de una semana del mes de septiembre de 2008 en la TWR SABE por el equipo de la Comisión ATFM de la Dirección de Tránsito Aéreo, en una franja horaria de alta densidad de tránsito aéreo.

2° PASO**TIEMPO MEDIO DE OCUPACIÓN DE PISTA (MATOP)**

El tiempo medio de ocupación de pista será calculado por umbral de pista, una vez que cada pista tiene su configuración propia. Esto implica en tiempos distintos de ocupación de pista en cada umbral.

Después de la toma de los tiempos de ocupación de pista, el cálculo de la media aritmética de los tiempos de ocupación de pista (MATOP) es realizado, por categoría de aeronaves, entre estos tiempos.

$$\text{MATOPB} = \frac{\text{TOPDB} + \text{TOPPB}}{2}$$

$$\text{MATOPC} = \frac{\text{TOPDC} + \text{TOPPC}}{2}$$

CATEGORIA	MATOP
A	0
B	63,16666667
C	67,83333333
D	0
E	0

3° PASO**MIX DE AERONAVES (MIX):**

Mix de aeronaves, es la configuración de la flota en operación en el aeropuerto estudiado. De acuerdo al Doc 8168, las aeronaves son subdivididas en cinco categorías, según la velocidad de cruce de el umbral de la pista, que debe ser 130% del valor de la velocidad de pérdida (stall) en la configuración de aterrizaje (full flaps, gear down). De esta manera, las aeronaves son clasificadas de la siguiente forma y en las siguientes categorías:

CAT "A" Velocidad menor que 90 kt

CAT "B" Velocidad entre 91/120kt

CAT "C" Velocidad entre 121/140kt

CAT "D" Velocidad entre 141/165kt

CAT "E" Velocidad entre 166/210kt

TOMA DE DATOS DE DOS HORAS DIARIAS (14 A 16 UTC)

	LUNES 15		MARTES 16		MIÉRCOLES 17		JUEVES 18		VIERNES 19	
CATEGORIA	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%
A	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
B	55	22,54	84	31,70	81	31,89	57	22,98	74	27,51
C	189	77,46	181	68,30	173	68,11	191	77,02	195	72,49
D	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
E	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
TOTAL	244	100	265	100	254	100	248	100	269	100

MIX AERONAVES

MEDIA ARITMETICA	
CATEGORIA	%
A	0
B	27,421875
C	72,578125
D	0
E	0
TOTAL	100

4º PASO

TIEMPO MEDIO PONDERADO DE OCUPACIÓN DE PISTA (TMOP)

Es la media ponderada de la media aritmética de los tiempos de ocupación de pista (MATOP) por categoría de aeronaves, tomándose en cuenta el mix de aeronaves.

El tiempo medio debe ser calculado para cada cabecera existente en el aeródromo, en función de las diferentes configuraciones de pista de taxi para cada cabecera en uso.

$$\text{TMOP} = \frac{\text{MIX}_A \times \text{MATOPA} + \text{MIX}_B \times \text{MATOPB} + \text{MIX}_C \times \text{MATOPC} + \text{MIX}_D \times \text{MATOPD} + \text{MIX}_E \times \text{MATOPE}}{\sum \text{MIX}}$$

TMOP: 62,75 SEGUNDOS

5° PASO

VELOCIDAD DE APROXIMACIÓN FINAL (VA):

Velocidad necesaria para recorrer el tramo de aproximación final (SAF) para aterrizaje. Esta velocidad es el resultado de la división del largo del tramo de aproximación final por el tiempo de vuelo desde el marcador externo (o FAF) y hasta el umbral de la pista (T).

$$VAB = \frac{SAF}{TB}$$

$$VAC = \frac{SAF}{TC}$$

CATEGORIA		DIV CANTIDAD DE OPERACIONES	CATEGORIA	TIEMPO EN SEGUNDOS	VAA	NUDOS
A	0	0	A	0	0 NM/S	0
B	0:04:42	0:01:34	B	94	0,04042553 NM/S	145,53
C	0:43:36	0:01:59	C	119	0,03193277 NM/S	114,95
D	0	0	D	0	0 NM/S	0
E	0	0	E	0	0 NM/S	0

6° PASO

VELOCIDAD MEDIA DE APROXIMACIÓN FINAL (VM):

Media ponderada, tomándose en cuenta el mix de aeronaves, de las velocidades de aproximación final.

$$VM = \frac{MIX_A \times VAA + MIX_B \times VAB + MIX_C \times VAC + MIX_D \times VAD + MIX_E \times VAE}{\sum MIX}$$

VELOCIDAD MEDIA DE APROXIMACION FINAL (VM)	
VM= 0,034261647 NM/S	123,34 KTS(*3600)

7° PASO

DETERMINACIÓN DE LA SEPARACIÓN DE SEGURIDAD (SS):

El estudio prevé la posibilidad de que ocurra un despegue entre dos aterrizajes consecutivos, pero sin afectar la separación mínima reglamentaria (SMR), que en Brasil es establecida en la ICA 100-12, entre las aeronaves aterrizando y despegando. Con este objetivo, es necesario calcular una distancia de seguridad a ser sumada a la separación mínima reglamentaria entre las aeronaves en aproximación, de manera a posibilitar el despegue de una aeronave, en seguida del aterrizaje de la primera, pero sin comprometer la separación reglamentaria con la segunda en aproximación.

Calculándose la distancia recorrida en la aproximación final por la segunda aeronave, durante el tiempo en que la pista permaneció ocupada y sumándose la distancia calculada con la separación reglamentaria mínima adoptada, se obtiene la separación necesaria entre dos aterrizajes consecutivos. Esta distancia recorrida es el resultado entre la multiplicación de la velocidad media ponderada en la final y el tiempo medio ponderado de ocupación de pista.

$$SS = VM \times TMOP$$

DETERMINACION DE LA SEPARACION DE SEGURIDAD (SS)

$$SMR (NM) = 5$$

$$SS = 2,15 \text{ NM}$$

8º PASO

DETERMINACIÓN DE LA SEPARACIÓN TOTAL ENTRE DOS ATERRIZAJES CONSECUTIVOS (ST):

La separación total es el resultado entre el sumatorio de la separación de seguridad con la separación mínima reglamentaria. Así llegamos a:

$$ST = SMR + SS$$

$$ST = 7,15 \text{ NM}$$

9º PASO

DETERMINACIÓN DEL TIEMPO MEDIO PONDERADO ENTRE DOS ATERRIZAJES CONSECUTIVOS (TMST):

El tiempo medio ponderado empleado para recorrer la separación total entre dos aterrizajes consecutivos es obtenido dividiéndose esta distancia por la velocidad media ponderada del mix de aeronaves.

$$TMST = ST/VM$$

$$212,48 \text{ S} = 3.53 \text{ MIN}$$

10º PASO

DETERMINACIÓN DEL NÚMERO DE ATERRIZAJES EN UN INTERVALO DE UNA HORA (P):

Dividiéndose el intervalo de una hora por el tiempo medio ponderado empleado para recorrer la separación total entre dos aterrizajes consecutivos, se obtiene el número de aterrizajes posibles con la separación propuesta en el intervalo propuesto.

$$P = 1\text{Hora (seg)}/TMST(\text{seg})$$

$$P = 1 \text{ HORA (SEG) / TMST (SEG)}$$

$$P = 17$$

11° PASO

DETERMINACIÓN DEL NÚMERO DE DESPEGUES EN UN INTERVALO DE UNA HORA (D):

Aplicándose la separación total encontrada es posible intercalar un despegue entre dos aterrizajes consecutivos. Al sustraerse una aeronave del total de aterrizajes, se encuentra el número posible de despegues, en el intervalo de una hora.

$$D = P - 1$$

$$D = 16$$

12° PASO

DETERMINACIÓN DE LA CAPACIDAD TEÓRICA DE PISTA (CTP):

Las operaciones de aterrizajes y despegues son igualmente distribuidas en cualquier aeródromo, compitiendo 50% a cada una de ellas, en el período de una hora.

Para la determinación de la capacidad de pista, es suficiente sumarse el número de aterrizajes encontrados con el número de despegues. Así llegamos a:

$$CTP = P + D$$

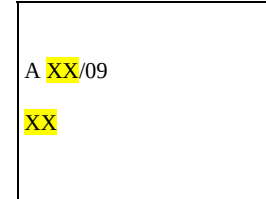
CAPACIDAD TEÓRICA DE PISTA: 33 MOVIMIENTOS POR HORA

13° PASO**PORCENTUAL DE UTILIZACIÓN DE PISTA (PU):****NO APLICABLE POR NO DISPONERSE DE LOS REGISTROS ESTADÍSTICOS****MOVIMIENTO ANUAL SABE SET 07 – SET 08 – AMBAS PISTAS 13-31**

MES	13-31
OCT 07	7403
NOV 07	7494
DIC 07	7861
ENE 08	7649
FEB 08	7388
MAR 08	7748
ABR 08	7044
MAY 08	6616
JUN 08	6685
JUL 08	6851
AGO 08	7401
SET 08	7100
TOTAL	87240

Para alcanzar una precisión adecuada en los cálculos efectuados, serán analizados los últimos doce meses de los sistemas de gestión de torre de control, pretendiendo medir el porcentual de utilización de cada pista del aeródromo.

NO APLICABLE EN ESTE CALCULO**14° PASO****DETERMINACIÓN DE LA CAPACIDAD DEL CONJUNTO DE PISTAS:****NO APLICABLE EN ESTE CALCULO**

APPENDIX G**STATE XXX**

A XX. IMPLEMENTATION OF AIR TRAFFIC FLOW MANAGEMENT (ATFM) IN THE CAR/SAM REGIONS**1. ATFM Concept**

1.1 The ATFM is a service established in order to contribute to a safe, orderly and expeditious air traffic circulation, ensuring that the maximum possible of ATC capacity is used, and that air traffic volume is compatible with capabilities declared by the ATS competent authority.

2. Concept of demand and capacity

2.1 The function of balancing demand and capacity shall consist in reducing the effects of limitations of the ATM system to a minimum. The balance between demand and capacity will enable to evaluate the air traffic flows and capacities of all the system, with a view to timely putting the necessary measures into practice. A process of collaboration shall enable the efficient management of air traffic flows through the use of the information on air traffic circulating through all the systems, the weather conditions and means available.

2.2 The balance between demand and capacity shall enable airspace users to participate in the ATM system in an optimal manner, mitigating at the same time conflicts related to the airspace and aerodrome capacity. The cooperative utilization of the instruments supporting the decisions shall ensure a more efficient use of the airspace resources, shall provide the greater possible access to these airspace resources, shall provide the greater equitable access to all users, and shall ensure that the airspace resources demand exceeds its capacity.

3. Historical summary

3.1 ICAO CNS/ATM systems received the support of the Tenth Air Navigation Conference held in 1991 at ICAO Headquarters, in Montreal, Canada. That same year, the CAR/SAM Regional Planning and Implementation Group (GREPECAS) started to work, with a view to the regional application of this new concept of air navigation services.

3.2 Further, the States, Turing the Eleventh Air Navigation Conference – (AN-Conf/11, Montreal, September 2003), supported and approved the new ICAO ATM global operational concept, which encourages the implementation of a new services management that permits the achievement of an operationally continuous regional airspace, through the application of a series of ATM functions.

3.3 According to the guidance principles established by ICAO Council with respect to the facilitation of the inter-regional harmonization, regional plans for CNS/ATM systems implementation in the Regions had to be prepared in accordance with general profiles defined in the Air Navigation Global Plan for CNS/ATM Systems. After a thorough analysis of the guidance principles of this Global Plan for CNS/ATM Systems, the CAR/SAM Planning and Implementation Group (GREPECAS) incorporated characteristics inherent to the CAR/SAM Regions, using as a basis the definitions of Homogeneous Areas and Main Traffic flows. Homogeneous areas are those airspace portions which have ATM requirements, and similar degrees of complexity, while main traffic flows are those airspaces where there is a significant amount of air traffic.

3.4 From the analysis carried out by ICAO/UNDP Regional Project RLA/98/003, it may be detached that, while in general terms in the CAR/SAM Regions environment there are no traffic congestions currently, requiring a complex flow management, it has been identified that in some airports, and airspace sectors, mainly in special periods and specific hours, where some congestions already exist, should be avoided.

3.5 In view of the above, GREPECAS/12 considered that the early implementation of ATFM shall ensure an optimal air traffic flow towards some specific areas or through them during periods in which demand exceeds or is foreseen to exceed the available capacity of the ATC system. Therefore, an ATFM system should reduce aircraft delays, both in flight and ground and avoid the system to be overloaded. ATFM system shall help the ATC to comply with the objectives and achieve a more effective use of the available capacity of the airspace and airports. ATFM should also ensure that air operations safety is not compromised in unacceptable air traffic congestion levels, and at the same time ensure that air traffic is managed effectively without the application of unnecessary flow restrictions.

3.6 During year 2005, the first meeting of the ATFM-TF was carried out, and the planning process was initiated therein, with the final goal to implement a centralized ATFM unit in the CAR/SAM Regions, and to this end, the principles, functions and requirements on which the CAR/SAM ATFM service would be based, were defined.

3.7 The ATFM/2 meeting held in year 2006 presented the document on Air Traffic Flow Management Operational Concept (CONOPS ATFM) for CAR/SAM Regions. This is oriented, such as expressed by its objective, to provide a high level description of service to be rendered in the CAR/SAM Regions within a determine time horizon. Likewise, it explains the present situation and future situation to be achieved progressively through a series of specific change stages.

3.8 The ATFM CONOPS reflects the expected order of the events that can take place, also it is intended to support and orient planners on the design and gradual development of the ATFM system to provide safety and effectiveness, as well as to guarantee an optimum air traffic flow towards determined areas or through them, during excessive demand periods or when the demand could exceed ATC system available capacity.

3.9 Since year 2008 the SAM Implementation Group coordinates the necessary tasks for the concretion of the established objective, in coordination with all States integrating the region.

4. Parties involved in ATFM – CDM Concept

4.1 The implementation and functioning future process of centralized ATFM, of FMU, and FMP in each one of the States, involves ATFM community participation, which includes ICAO, international organizations, air space users, associations, operators, air transit services providers, airport operators, military aviation and the entity entrusted by States for the provision of a unique central dependency for affluence management.

4.2 Members of ATFM community participate and cooperate in the planning, development, use, regulation, operation and maintenance of ATFM system, within the framework of the concept of Cooperation Decision Making (CDM), set by ICAO in the Operational Concept of ATM Global Air Transit Management (Doc. 9854 AN/458), Global Air Navigation Plan (Doc. 9750 AN 963), which application will allow to achieve an acceptable solution in which all participants' needs and ATM system effective operation will be considered.

5. Access to Regional ATFM Information

5.1 In GREPECAS/15 meeting, amendments to CONOPS ATFM CAR/SAM were made, which new edition (1.2 version) will be put in Lima and Mexico Regional Offices web pages (<http://www.lima.icao.int/> - <http://www.icao.int/nacc/>), same that can be looked up by ATFM Community members for the active participation of the process that involves the implementation of centralized ATFM and of FMU and FMP in each one of the CAR/SAM regions States.

APPENDIX H

Action Plan for the Implementation of ATFM at SAM Airports				
A: AIRPORT				
Task description	Start	End	Responsible party (designate individual or organisation in charge)	Remarks
1. Airport demand/capacity analysis	Sep 2008	Apr 2010		
1.1 Prepare ATFM survey	N/A	Aug 2008	Project RLA06/901 RO	Completed
1.2 Send survey to the States of the Region	Aug 2008	SAM/IG/2	RO	Completed
1.3 Analyse the methodology presented by Brazil for estimating airport capacity	June 2008	SAM/IG/2	ATFM/IG	Completed and analyzed through WP/8, WP/16.
1.4 Send response to survey	N/A	SAM/IG/2	E	The Regional Office will repeat the request to send the reply to the survey to those States that have not yet done so.
1.5 Assess survey results	N/A	December 2008	ATFM/IG	
1.6 Course offered by Brazil on Airport Capacity Estimate	Mar 2009	Mar 2009	Brazil	23 – 27 March 2009
1.7 Development of the Methodology for the Calculation of Airport and Airspace Capacity in the SAM Region	Nov 2008	Jan 2009	Brazil and USA	Result to be presented at SAM/IG/3
1.8 The States estimate the airport capacity of their major airports	Jul 2009	SAM/IG/5	E	
1.9 Identify airports where the demand sometimes exceeds capacity, including, if necessary, simulations by the States	Aug 2009	SAM/IG/5	E	
1.10 Identify operational factors affecting airport demand and capacity in order to optimise the use of existing capacity, including simulations, if necessary	May 2009	SAM/IG/5	E	

Action Plan for the Implementation of ATFM at SAM Airports				
A: AIRPORT				
Task description	Start	End	Responsible party (designate individual or organisation in charge)	Remarks
1.11 Submit the conclusions on airport capacity	N/A	SAM/IG/5	E	
2. Coordination with the ATM community	Sep 2008	Jun 2009		
2.1 Present initial AIC model	SAM/IG/2	SAM/IG/2	ATFM/IG	Completed
2.2 Publish initial AIC	SAM/IG/2	Next AIRAC date/2009 after SAM/IG/3	E	
2.3 Organise the ATFM community taking into account the CDM concept for ATFM implementation, and begin the relevant coordination		May 2009	E	
2.4 Inform the GREPECAS ATM Subgroup			N/A	
3. Infrastructure and database		Aug 2008		
3.1 Send the results of the survey developed by the hired expert to the Automation Group		Dec 2008		
3.2 Send to the Automation Group the the information obtained by the expert on the data bases used in the Brazil, United States and Eurocontrol units	Jan 2009	SM/IG/3		
3.3 Coordinate implementation activities with the Automation Group			N/A	Permanent
4. Policy, standards, and procedures			Nov 2008	
4.1 Hire expert to draft the manuals on ATFM measures for airports and FMU and FMP procedures			N/A	Task included in 4.2

Action Plan for the Implementation of ATFM at SAM Airports				
A: AIRPORT				
Task description	Start	End	Responsible party (designate individual or organisation in charge)	Remarks
4.2 Hiring of an expert for the elaboration of the ATFM Manual				Partial draft approved, which includes ATFM concepts for airspace and airports
4.3 Hiring of experts for the development of ATFM Manual chapters				
4.4 Present the model AIC Supplement			N/A	
4.5 Approve the AIC Supplement			N/A	
4.6 Publish the AIP Supplements			N/A	
5. Training	Sep 2008			
5.1 Draft ATFM training plans		SAM/IG/4		
5.2 Train the team on decision-making at airports		Jun 2009		
5.3 Hire expert to draft Manual on the Introduction to ATFM for the ATM Community		SAM/IG/3		
5.4 Present and assess the Manual for the Introduction to ATFM for the ATM Community		SAM/IG/4		
5.5 Train the members of the ATM community in the CDM and ATFM concepts		TBD		
5.6 Train the staff in ATFM measures for airports		SAM/IG/4		
5.7 Monitor the training of the ATM community		Jul 2010		
6. Final implementation decision			N/A	
6.1 Review factors affecting the implementation decision		SAM/IG/6		
6.2 Declare the pre-operational implementation in the defined area			N/A	

Action Plan for the Implementation of ATFM at SAM Airports				
A: AIRPORT				
Task description	Start	End	Responsible party (designate individual or organisation in charge)	Remarks
6.3 Declare the final operational implementation in the defined area			N/A	
7. Monitor system performance	SAM/IG/7	SAM/IG/8	CARSAMMA	
7.1 Draft the ATFM post-implementation follow-up programme at airports	SAM/IG/6	SAM/IG/7	ATFM/IG	
7.2 Implement the ATFM post-implementation follow-up programme at airports	SAM/IG/7	TBD	SAM/IG/X	
Tentative pre-operational implementation date		N/A	Oct 2010	
Tentative definitive implementation date		N/A	Dec 2010	

Note:

E	States
SAM/IG	SAM Implementation Group
ATFM/IG	ATFM Implementation Group
OR	Regional Office

Action Plan for ATFM Implementation in the SAM Region			
B- AIRSPACE			
Task description	Start	End	Responsible party (designate individual or office in charge)
1. Airspace demand and capacity analysis			
1.1 Analyse the methodology to estimate airspace capacity presented by Brazil	Jun 2008	TBD	
1.2 Prepare an airspace demand survey	TBD	TBD	
1.4 Attend the course on Airspace Capacity Estimate	TBD	TBD	
1.5 The States estimate airspace capacity at the major airports	TBD	TBD	
1.6. Identify airspace sectors where demand sometimes exceeds capacity, including simulations by the States, if necessary	TBD	TBD	
1.7 Identify operational factors affecting airspace demand and capacity in order to optimise the use of existing capacity, including simulations if necessary	TBD	TBD	
1.8 Present the conclusions on airspace capacity	TBD		
2. Coordination with the ATM community	Sep 2008	Jun 2009	
2.1 The ATM community considers the implementation of ATFM in the airspace	Sep 2008	Jun 2009	
3. Infrastructure and database	TBD	Dec 2013	
3.1 Send requirements to the Automation Group, as stipulated in Appendix B of the ATFM CONOPS	TBD	TBD	
3.2 Coordinate implementation activities with the Automation Group	N/A	Dec 2013	
4. Policy, standards, and procedures	TBD	Jun 2013	
4.1 Develop ATFM policies, taking into account the objectives and principles established in the CAR/SAM ATFM CONOPS	TBD	TBD	
5. Training	TBD	May 2013	
5.1 Train the team on airspace data collection	Jun 2009	Jun 2009	
5.2 Train the staff on strategic ATFM measures for the airspace			
5.3 Develop ATFM plans and training material	TBD	TBD	

5.4 Train the personnel involved	TBD	TBD	
6. Final implementation decision	N/A	Sep 2013	
6.1 Analyse factors affecting the implementation decision	N/A	TBD	
6.2 Declare pre-operational implementation in the area defined	N/A	TBD	
6.3 Declare definitive operational implementation in the area defined	N/A	TBD	
7. Monitor system performance	TBD	N/A	
7.1 Draft ATFM post-implementation follow-up programme	TBD	Aug 2013	
7.2 Implement ATFM post-implementation follow-up programme	Dec 2013	N/A	
Tentative pre-operational implementation date	N/A	Jul 2013	
Tentative definitive implementation date	N/A	Dec 2013	

APPENDIX I

TERMS OF REFERENCE AND WORK PROGRAMME FOR THE SAM REGION AIR TRAFFIC FLOW MANAGEMENT IMPLEMENTATION GROUP (SAM/ATFM/IG)

1. TERMS OF REFERENCE

Develop specific studies and guidance material for the implementation of a SAM Air Traffic Flow Management implementation system, according to the ICAO Strategic Objectives and Global Plan Initiatives (GPI) on this matter (GPI 1, 6 and 7).

2. WORK PROGRAMME

- a) Review existing national plans on ATFM; as well as other ATFM plans in other regions or international organizations;
- b) Review ATFM technical and operational aspects;
- c) Prepare the necessary ATFM documentation;
- d) Develop an Action Plan Model for ATFM Airport Strategic implementation and the corresponding guidelines, for the implementation of FMU or FMP.
- e) Develop an Action Plan Model for Airport Tactical ATFM implementation and the corresponding guidelines, for the incorporation of new procedures applicable in FMU and FMP.
- f) Develop an Action Plan Model for ATFM Airspace Strategic implementation and the corresponding guidelines, for the incorporation of new procedures applicable in FMU and FMP.
- g) Develop an Action Plan Model for ATFM Airspace Tactical implementation and the corresponding guidelines, for the incorporation of new procedures applicable in FMU and FMP.
- h) Develop an Action Plan Model for a SAM ATFM Centralised implementation.
- i) Follow-up of ATFM implementation in order to ensure its intra and inter-regional harmonisation, as well as among States involved.
- j) Establish training requirements with regard to ATFM.
- k) In coordination with the GREPECAS ATM/CNS Subgroup, ATM Committee, ATFM Task Force, consider the necessary activities to ensure harmonisation of ATFM standards and procedures in the CAR and SAM Regions.

3. COMPOSITION

Argentina, Brazil, Bolivia, Chile, Ecuador, Peru, Uruguay, Venezuela and IATA.

4. RAPPORTEUR

Víctor Marcelo de Virgilio (Argentina).

Assisted by

José Vagner Vital (Brazil).

Agenda Item 5: Assessment of operational requirements in order to determine the implementation of communications, navigation and surveillance (CNS) capacities improvement for en-route and terminal area operations

5.1 The Meeting analyzed the situation of implementation of conclusions formulated during SAM/IG/1 regarding to CNS improvement implementation activities.

5.2 In this regard, the Meeting was informed that all SAM Region States, except one state, have had reviewed and amended Tables CNS 2A, CNS 1Ba, CNS 1Bb and CNS 4A. Motivated by this fact, the group considered that Conclusions SAM/IG/1-2 - *Revision of FASID Table CNS 2A*, SAM/IG/1-3 - *Update of FASID Tables CNS 1Ba and 1Bb*, and SAM/IG/1-4 - *Update of FASID Tables CNS 4A*, had been implemented.

5.3 Taking in consideration the aforementioned Tables, the Meeting took note that the ICAO SAM Regional Office will start with the amendment process of the CAR/SAM Air Navigation Plan (FASID).

5.4 The Meeting reviewed the *Guideline for the Improvement of Communications, Navigation and Surveillance Systems for Satisfying Operational Requirement in the Short- and Medium-Term for En-Route and Terminal Area Operations* developed by a CNS/ATM expert hired through project RLA/06/901. This guideline presents an analysis and diagnosis of the current CNS systems' situation in the Region, identifies operational requirements for en-route operations and terminal area for a short- and medium-term, and proposes the necessary improvements in the CNS systems in order to support en-route terminal and aerodromes operations in the short- and medium-term.

5.5 The Meeting considered that this document should be reviewed by States of the Region and, in this respect, considered that the ICAO Regional Office circulate said guide to all States participating in the Meeting. Once the document is reviewed, it could be used by States as guidance material for CNS systems improvement in the short- and medium-term, in order to meet operational requirements for en-route operations and terminal area. Copy of the guide is showed in **Appendix A** to this Agenda item.

5.6 The Meeting also considered the development of a *Guideline for the Implementation of National Digital Networks in IP Protocol to Support Current and Future Aeronautical Applications*, performed by a CNS expert hired by project RLA/06/901. In this regard, the Meeting considered that the ICAO Regional Office should circulate the guide to all the States of the Region for its examination and, once reviewed, could be of reference to States when implementing IP national digital networks. Copy of the guide is presented in **Appendix B** to this Agenda Item.

5.7 The Meeting, considering the vast activities related to CNS improvement to support navigation services for en-route operations and terminal area for the short- and medium-term, determined the need to initiate CNS implementation improvement activities through the performance of two activities, the elaboration of guidance material to achieve AMHS interconnection systems and the preparation of the implementation of an ADS B trial programme in the Region. Action plans for this purpose are shown in **Appendices C** and **Appendix D** to this Agenda Item.

5.8 The Meeting took note that the Task Force for the Implementation of Communications, Navigation and Surveillance (CNS) Capacities Improvement for En-route and Terminal Area Operations and the Task Force for the Implementation of Automation Systems (ATM) and Integration of the Existing Systems in the SAM Region, jointly analyzed the agenda items.

5.9 The Meeting observed that working programme activities for the implementation of automation systems and their interconnection could be consolidated through the CNS Task Force work programme, taking into account that the systems to be implemented involve CNS aspects that are also included in the CNS Task Force's work programme.

5.10 Likewise, the Meeting considered that consolidation of both task forces would also facilitate the work in the SAM/IG meetings, considering the number of working groups existing in the SAM/IG, the tasks being carried out in a parallel way during SAM/IG meetings, and States' limited number of delegates to participate in task groups meetings. In this regard, the Meeting observed with concern the low participation of CNS personnel in SAM/IG meetings, taking into account the number of CNS activities to be analyzed in the SAM/IG meetings' agenda.

APPENDIX A

GUIDELINE FOR THE IMPROVEMENT OF COMMUNICATIONS, NAVIGATION AND SURVEILLANCE SYSTEMS FOR SATISFYING OPERATIONAL REQUIREMENT IN THE SHORT- AND MEDIUM-TERM FOR EN-ROUTE AND TERMINAL AREA OPERATIONS

Project RLA/06/901

Lima, Peru, 22 September to 3 October 2008

Final Version

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**PRELIMINARY GUIDELINE FOR THE IMPROVEMENT OF COMMUNICATIONS,
NAVIGATION AND SURVEILLANCE SYSTEMS FOR SATISFYING OPERATIONAL
REQUIREMENT IN THE SHORT- AND MEDIUM-TERM FOR EN-ROUTE AND
TERMINAL AREA OPERATIONS**

1. Objective

1.1 Within the frame of the Global Air Navigation Plan, these guidelines has been prepared as an initial document for orienting States in the implementation of the improvement of CNS systems for En-route and Terminal Area operations.

1.2 In order to achieve this objective, the following has been carried out:

1.2.1 Analysis of current CNS situation and diagnosis

1.2.2 General recommendations for action to be executed by States in the ATM operational environment

1.2.3 Identification of operational requirements for en route and terminal area in thee short- and medium-term

1.2.4 Identification of certain requirements for Aerodrome Operations from the perspective of door-to-door operations, with high density traffic or with mobile complex operations (vehicles and aircrafts) and,

1.2.5 Proposal of CNS improvements in the short- and medium-term.

2. Scope

2.1 This document is addressed to SAM States and it considers implementations at short- and medium-term, up to 2010 and in between 2011 and 2015 respectively, such as indicated in guidelines contained in the Global Air Navigation Plan within this work frame.

3. Analysis of current CNS situation and diagnosis

3.1 Communications

3.1.1 Aeronautical fixed service

3.1.1.1 *Conventional services*

3.1.1.1.1 AFTN service: circuits foreseen in CAR/SAM FASID Table CNS 1A have been totally implemented. However, and due to the average life period, maintenance of existing centres results today in a problem to be considered.

3.1.1.1.2 ATS oral service: circuits foreseen in CAR/SAM FASID Table CNS 1C have been totally implemented. Circuits are analogic and operate without inconveniences.

3.1.1.2 *Services under CNS/ATM concept*

3.1.1.2.1 AMHS service: this service has already been implemented nationwide in two States and locally in one State. Up to date other States are spreading out their systems.

3.1.1.2.2 Bi- or multilateral AMHS integration: this has not yet been started, initial arrangement exist to begin with the interconnections.

3.1.1.2.3 ATFM Units' interconnection: not implemented between States.

3.1.1.2.4 Flight plans transference

3.1.1.2.4.1 OLDI: although this service does not respond exactly to CNS/ATM concept, it is available in several States, though only one uses it operationally within the same administration environment.

3.1.1.2.4.2 AIDC: only one State has this capacity available, though not operational up to date.

3.1.1.3 *Information Transportation Network*: conventional satellite or ground means of communication is available in States without the availability of "national operative networks environments". At international level, REDDIG has the conditions to provide this support.

3.1.2 Aeronautical mobile service

3.1.2.1 *Conventional services*

3.1.2.1.1 En-route:

3.1.2.1.1.1 Continental:

3.1.2.1.1.1.1 VHF (local and remote): services have been implemented according to described in the respective CAR/SAM FASID Table CNS 2A, ensuring coverage in most of selected areas, existing inconveniences in selected low level spaces. Available equipment is conventional, and most have at least ten years of life cycle consumed.

3.1.2.1.1.1.2 HF: use only as an alternative mean. Equipment is conventional and, in general, life cycle has been exceeded at length.

3.1.2.1.1.2 Oceanic:

3.1.2.1.1.2.1 HF: this service is not available in all oceanic ACCs. Equipment is conventional and, in general, nominal life cycle has been exceeded at length.

3.1.2.1.2 In Terminal Area and Aerodromes

3.1.2.1.2.1 VHF Services: implemented according the corresponding CAR/SAM FASID Table CNS 2A. Many units do not comply with the recommendation of counting with different frequencies for App and TWR services. PDC service has been implemented below required.

3.1.2.2 *Services under CNS concept*

3.1.2.2.1 En route:

3.1.2.2.1.1 Continental

3.1.2.2.1.1.1 VDL/CPDLC: it has not been implemented yet.

3.1.2.2.1.2 Oceanic

3.1.2.2.1.2.1 HFDDL/CPDLC: it has not been implemented yet.

3.1.2.2.1.2.2 Satellite/CPDLC: service implemented in some oceanic FIR for aircrafts equipped with FANS.

3.1.2.2.2 In Terminal Area and Aerodromes

3.1.2.2.2.1.1 VDL/CPDLC: it has not been implemented yet.

3.1.2.2.2.1.2 VDL/PDC: implemented in very few airports.

3.1.3 Broadcasting service

3.1.3.1 *Conventional service*

3.1.3.1.1 ATIS: implemented according to CNS tables, in an amount below required. Conventional audio recorders and analogic VHF transmitters are used.

3.1.3.1.2 VOLMET: idem above.

3.1.3.2 *Services under CNS/ATAM concept:*

3.1.3.2.1 Digital ATIS (synthesized voice – analogic transmission): although this service does not exactly respond to the concept, there are available in some airports. The option “synthesized voice –digital data is not used.

3.1.3.2.2 D-ATIS: implemented in very few airports.

3.2 **Navigation**

3.2.1 Conventional services

3.2.1.1 *Radio navigation aids:* installed according to CAR/SAM FASID Table CNS 3.

3.2.2 Services under CNS/ATM concept

3.2.2.1 GPS: extensive use

3.3 **Surveillance**

3.3.1 Conventional services

3.3.1.1 SSR: implemented according to CAR/SAM FASID Table CNS 4A. Being these installations insufficient, the necessary coverage has not been ensured for all selected spaces. Serious problems exist in spares reposition.

3.3.1.2 Radar data exchange (State 1 radar – State 2 centre and viceversa): only exists between two States.

3.3.1.3 Inter-centre radar data exchange: only between two Sates, on ICD owner.

3.3.2 Services under CNS/ATM concept

3.3.2.1 Continental area

3.3.2.1.1 ADS-B: no services in operation are available up to date.

- 3.3.2.1.2 Multilateration: idem above.
- 3.3.2.2 Oceanic area
 - 3.3.2.2.1 ADS-C: service provided by some oceanic FIRs with FANS equipped aircrafts.
- 3.3.2.3 Exchange of inter-centre radar data:
 - 3.3.2.3.1 Asterix 62 and 63: only in one State
- 3.4 **Diagnosis**
 - 3.4.1 *Conventional services*
 - 3.4.1.1 Inexistence of national ATN makes impossible the harmonic implementation of services according to CNS/ATM concept.
 - 3.4.1.2 AFTN service is not guaranteed for long term due to increasing difficulty to obtain spare parts.
 - 3.4.1.3 Not enough Voice Communication Switching System (VCSS) in ACCs as well as in TWRs with sufficient number of services that merit the installation of this service.
 - 3.4.1.4 Not all Oceanic ACCs can render ground-air communications services through conventional HF or CPDLC rendered by a third party.
 - 3.4.1.5 Coverage of VHF communications is not guaranteed for low flight levels. Regarding technology, a big amount of VHF (and HF) obsolete equipment is available.
 - 3.4.1.6 No communications between adjacent ATFM units are available.
 - 3.4.1.7 Practically no transference of flight plans data is executed.
 - 3.4.1.8 An insufficient amount of ATIS and VOLMET has been installed.
 - 3.4.1.9 Some selected areas do not have radar coverage.
 - 3.4.1.10 Radar information exchange between States is extremely insufficient.
 - 3.4.1.11 PDC service is practically inexistent.
 - 3.4.2 *Services under CNS/ATM concept*
 - 3.4.2.1 Flight plans exchange is not carried out by OLDI or by AIDC.
 - 3.4.2.2 ADS-C service is not rendered to all oceanic FIRs.
 - 3.4.2.3 ADS-B surveillance and multilateration are practically inexistent.
 - 3.4.2.4 D-ATIS service is practically inexistent.
 - 3.4.2.5 D-VOLMET service is not available.
 - 3.4.2.6 Radar data exchange between centres is practically inexistent.

NOTE: In order to visualize the interrelation of the different Communications and Surveillance Services, the interconnection between them is being presented in “Diagram 1 - Current Situation”.

4. **ATM general recommendations**

4.1 In the SAM Region, to execute Global Plan objectives, SAM Region States should carry out, among others, the following actions:

4.1.1 Develop an airspace concept as a high level declaration in airspace planning or Master Plan, to satisfy specific strategic objectives such as Safety, Capacity, Efficiency, Environment, etc. in order to permit the application of an optimum, secure, efficient and flexible airspace structure.

4.1.2 Use in a systematic way cost-benefit analyses in the implementation of air navigation infrastructure for selection of implementation priorities.

4.1.3 Explore with adjacent States/Territories and International Organizations the possibility of joint action for the purchase of technology that will enable sharing functions and benefits.

4.1.4 Analyse the current navigation capacity of aircrafts actually available as well as cost-benefit relation regarding the use of better management systems.

4.1.5 Analyse airport and airspace management (Sectors, TMA) in terms of the equation capacity-demand-efficiency and the impact of this in traffic flow.

4.1.6 Evaluate ATM automation tools at local level and their interconnection with other systems of adjacent FIRSs for sharing of different systems data and the impact of changes to be introduced in the automated system with the corresponding cost-benefit analysis.

4.1.7 Analyse aerodrome operations surveillance tools for mobiles control (aircrafts and vehicles) and runway incursions.

4.1.8 Use tools application such as CDM (Collaborative Decision Making) for the optimum improvement of management general performance.

4.1.9 Plan and coordinate the ATS personnel training necessary for the management of the new systems and specifications.

4.1.10 Determine the methodology (Qualitative or Quantitative) to be used for evaluating TMA operational safety.

4.1.11 Elaborate a data collection programme for the evaluation of TMA operational safety.

4.1.12 Aeronautical information traditionally offered in paper should be substituted by reliable data central media for operational and strategical ATM applications, which will demand a high-quality aeronautical database.

Data link and ATM automation applications

4.2 ATS surveillance systems implementation and data link applications should consider the corresponding automation aspects, principally regarding the need of harmonizing applied systems, in order to guarantee systems inter-operability.

4.3 In the continental airspace, improved surveillance techniques application (ADS-B and/or Multilateration) will permit reducing horizontal separation minima, improve operational safety, increase capacity and improve flight efficiency in a rentable way. The use of other data link applications instead of voice Communications will provide significant advantages regarding operational safety and workload of pilots and controllers.

4.4 ADS-C and CPDLC application in oceanic airspaces will favour the necessary conditions for the use of horizontal separation minima of 30 NM and, in other oceanic airspaces of less air traffic density, it will provide reliable means for surveillance and communication, reducing workload of controllers and pilots.

4.5 Regarding ATM automation, the following documents have been elaborated up to this moment:

4.5.1 *Preliminary Document of the CAR/SAM Regions ACC Interconnection System Interface Control.*

4.5.2 *System/Subsystem Referential Specifications for Air Traffic Control Automation Systems.*

4.5.3 *CAR/SAM Plan for the Automated ACC Interconnection.*

MET data link

4.6 The access to global operational meteorological information (OPMET) on real time assists ATM in tactic decision making for aircrafts surveillance, ATFM, aircrafts dynamic en-routing and to contribute to optimization of airspace and airports.

4.7 The increment of data link use to download and upload meteorological information through Systems such as D-ATIS and D-VOLMET will facilitate the ATC task.

4.8 Other information accessed on real time, such as alerts on low level wind vertical biting and automatic systems on tail turbulence in runway, will timely contribute with OPMET automated information that will maximize runway capacity.

ATFM

4.9 To develop ATFM first phase, SAM Region States should develop a methodology to calculate airport capacity and a database in order to analyse clue airports demand, considering per hour, daily, monthly and annual movements, with special attention to high season periods particular to each place..

4.10 Likewise, this en-route and terminal area (TMA) sectors capacity-demand calculation is complementary to airport capacity-demand calculation, and both should be jointly analyzed.

4.11 These studies will determine the total capacity of the system for different periods or time bands being considered, and will provide authorities with the possibility to study measures to optimize equation capacity-demand.

4.12 Two draft documents have been elaborated: CAR/SAM ATFM Route Map that will provide for guidelines for the implementation of national plans and for regional projects, and the ATFM Manual for the CAR/SAM Regions that will be presented in the SAM/IG/2 Meeting.

En-route and TMA operations

4.13 ATM homogeneous areas and principal traffic flows are specially related to en-route airspace. However, the improvement of the capacity and efficiency of the terminal control area (TMA) and aerodromes is an important complement to achieve a homogeneous, harmonic and global ATM system.

4.14 The implementation of en-route or terminal area operations implies that States carry out, first, an assessment of the characteristics of airspace under their jurisdiction and of existing CNS infrastructure, since this is affected by different strategic objectives that determine airspace concept.

4.15 Implement new RNAV routes or eliminate conventional or RNAV routes that are no longer used could cause not only minor changes but considerable modifications in the airspace and its infrastructure, depending of the amount of affected routes. Even some existing routes could be optimize being used for contingencies or “by pass” to facilitate certain traffic conditions.

4.16 The implementation of performance/based navigation (PBN) for en-route operations will require the application of excluding airspaces, having inconsideration t hat this would offer the conditions to execute the necessary changes in airspace structure. In order to not excluding a significant amount of users, the vertical limits of airspace where this will be implemented should be deeply analysed.

5. Operational requirements

5.1 Short-term en-Route Operations (up to 2010)

5.1.1 RNAV-5 specification

5.1.1.1 This application is expected to be executed in airspaces where is possible to obtain operational benefits and that the available CNS infrastructure can support it. Each State should analyse communications, navigation (VOR, DME) and ground surveillance infrastructure to make possible the application of this navigation specification.

5.1.1.2 The use of ATS surveillance systems (Radar, ADS) can mitigate the requirement of a larger routes spacing with the purpose of overcoming eventual faults in navigation systems not detected by the flight crew since onboard systems for RNAV-5 do not require of an alert in case of occurrence of an important navigation error.

5.1.1.3 Due to the existence of airspace blocks having poor VHF communications and of airspace blocks in remote continental areas in low level traffic flows areas, direct communications between pilot and controller should be ensured in compliance with this operational requirement.

5.1.2 RNAV-5 specific requirements

5.1.2.1 *Communications:* direct communications between pilot and controller is required.

5.1.2.2 *Navigation:* alternate navigation sources are required:

5.1.2.2.1 VOR/DME

5.1.2.2.2 DME/DME

5.1.2.2.3 INS or IRS

5.1.2.2.4 GNSS

NOTE: The service supplier should carry out an assessment of navigation infrastructure, which should be adequate for proposed operations. “Gaps” in the navigation coverage can be accepted having in consideration route spacing and surfaces cleared of obstacles due to a possible error increase with lateral en route deviation while navigation phase takes place.

5.1.2.3 *Surveillance:* Do not require ATS surveillance.

NOTE: For the en-route spacing optimization, RADAR/ADS B ATS surveillance can be implemented. A cost-benefit analysis should be carried out.

5.1.3 RNP-10 specification

5.1.3.1 RNP-10 is applied in Corridor EUR-SAM, Lima Santiago Route and AORRA in South Atlantic.

5.1.4 RNP-10 specific requirements

5.1.4.1 Ground-Air communications: VHF or HF in remote areas.

NOTE: CPDLC implementation is desirable to eliminate understanding difficulties between Controller and Pilot. Aircrafts equipment should be evaluated.

5.1.4.2 Ground-ground communications:

5.1.4.2.1 Oral ATS

5.1.4.2.2 AFTN

NOTE: OLDI /AIDC system implementation is desirable since this decreases controller workload and avoids interpretation difficulties that contribute to diminish LHD.

5.1.4.3 Navigation: GNSS or INS

5.1.4.4 Surveillance: ADS-C for AORRA. The application is desirable if cost-benefit analysis can support it.

5.2 **Short-term TMA operations (up to 2010)**

5.2.1 In the first phase up to 2010, equipped and non-equipped aircrafts will be admitted in the TMA, and RNAV-1 and RNP-1 operations will be initiated after achieving an adequate rate of approved air operations.

5.2.2 RNAV-1 specifications: RNAV-1 navigations specification can be implemented in terminal areas with accuracy, continuity and adequate availability radar service, and with adequate ground navigation infrastructure, such as DME/DME and DME/DME/IRU. Pilot-Controller direct communications requirement.

5.2.3 RNAV-1 specific requirements

5.2.3.1 *Communications:* direct communication pilot-controller is required.

5.2.3.2 *Navigation:*

5.2.3.2.1 DME/DME

5.2.3.2.2 DME/DME/IRU

5.2.3.2.3 GNSS

NOTE: Radio navigation aids considered critical for this navigation specification need of a rigorous monitoring and of an on-time NOTAM issuance in case of failure of this service delivery. .

5.2.3.3 *Surveillance:*

5.2.3.3.1 Radar

5.2.3.3.2 Multilateration

5.2.3.3.3 ADS B

5.2.4 Basic RNP-1 specification: In no-radar environments or in those having inadequate ground infrastructure, basic RNP-1 application is expected in TMA selected by States, with the condition that an adequate percentage of air operations has been approved for GNSS exclusive application.

5.2.5 Basic RNP-1 specific requirements

5.2.5.1 Direct communications between pilot-controller. Improve communications in selected spaces.

5.2.5.2 Navigation: GNSS.

5.2.5.3 Surveillance: low density traffic surveillance requirement is not necessary, but desirable in high density traffic.

5.3 **RNP approaches and RNP AR**

5.3.1 The procedures based in navigation performance should be, as possible, approach procedure (APV) using Baro-VNAV to provide these systems guides in selected airports.

5.3.2 The navigation specification that includes Baro-VNAV is referred to those systems in the use of barometric altitude and RNAV information on vertical glide path.

5.3.3 RNP APCH can be implemented in most possible airports and in all international airports, and frustrated approach segment can be based on conventional aids. These procedures are RNP 0.3.

5.3.4 RNP AR APCH can be implemented in those airports where operational benefits exist due to significant obstacles. Procedures of this type have been already applied in the airports of Quito (Ecuador) and La Serena (Chile) with satisfactory results, and in trial phase in Cuzco (Peru). These are procedures that can have precision RNP 0.3 and up to RNP 0.1.

5.3.5 Specific requirements for RNP APCH and RNP AR APCH with Baro-VNAV

5.3.5.1 Communications: direct between pilot-controller.

NOTE 1: For these approaches with Baro-VNAV, altitude and temperature updated information is required in order to be supplied timely to the aircraft.

NOTE 2: ATIS D-VOLMET radio broadcasting desirable

5.3.5.2 GNSS/Baro VNAV for RNP APCH and RNP AR APCH supported navigation.

NOTA: RNP AR APCH application cannot be used in areas with interference known to GNSS signal.

5.3.5.3 Surveillance: No special requirements are needed.

5.4 **Short-term aerodrome operations**

5.4.1 Pre-departure dispatch: In selected international aerodromes, it is expected, according to Air Navigation Plan, to implement PDC (pre-departure dispatch) by voice or data.

5.4.2 Detection of mobiles and aircrafts in high density traffic aerodromes.

5.4.2.1 Up to year 2010, it is planned that the principal technology for calculation of mobiles position (aircrafts and vehicles) would be Surface Movement Radar (primary) and Multilateration systems, using transponder Mode S SSR answers and Mode S Squitter messages.

5.4.2.2 An improvement in this sense in this phase would be the application of Levels I and II of Surface movement guide and control system (A-SMGCS).

5.4.3 Surveillance:

5.4.3.1 Surface radar

5.4.3.2 Multilateration

5.4.3.3 Level I, Level II A- SMGCS

Level I: provides localization and identification of an aircraft or vehicle (Including Package I ADS-B-APT application)

Level II: provides a conflict prediction function to aircrafts and vehicles to alert controller of potential collisions or entrance on restricted or protected areas (it can be used with SMR and Multilateration).

5.5 **Medium-Term en-route operations (2011-2015)**

5.5.1 Oceanic and remote continental airspaces

5.5.1.1 In corridor EUR/SAM and in route segment Santiago de Chile/Lima RNP 4 application is expected, with utilization of ADS/CPDLC, in order to permit the use of lateral and longitudinal separation of 30 NM. Traffic increase in Corridor EUR/SAM has been very significant, and RNP 4 application can help to a better distribution of traffic and to increase the number of available routes in the Corridor.

5.5.1.2 In AORRA air traffic density is less, and it is possible that not all aircrafts are equipped with necessary equipment for RNP-4. This issue could be studied more deeply in SAT meetings.

5.5.1.3 RNP-4 specification: This is desirable especially in ADS-C/CPDLC high density traffic in order to watch lateral and longitudinal separation of 30 nautical miles and communications via data link.

5.5.1.4 RNP-2 specification: in this phase this application is expected in selected continental airspaces, with GNSS exclusive application. A back-up system of GNSS will be necessary as well as the development of contingency procedures in case of GNSS failure. RNP-2 application will facilitate performance based navigation in aircrafts operating in airspaces without ATS surveillance service. With the exclusive application of GNSS more information on GNSS signal will be necessary. However, further development of operational requirements should be expected for the RNP 2.

5.6 **Medium-Term TMA operations (2011-2015)**

5.6.1 Approach and routes -SIDs & STARs-

5.6.1.1 The application of RNAV1 and RNP 1 specifications established for the short-term will be extended according to ground complementary infrastructure and to aircrafts navigation capacity.

5.6.1.2 RNAV1 and RNP 1 will be mandatory for aircrafts operating in high density traffic TMAs. However, some procedures are already being applied in certain excluding airports of the SAM Region.

5.6.1.3 In this phase, the extension of application of RNP 0.3 and RNP AR to selected airports is expected. Likewise, it is expected to start with the application of GLS procedure, which will make better transition period between TMA and approach phases, using basically GNSS for the two phases.

5.6.1.4 These procedures will permit achieving strategic objective of accessibility in airports with bad weather conditions when conventional procedures do not support lower minimas.

5.6.1.5 *Planned NAV improvement:* GLS system (GBAS Landing System)

5.6.1.6 RNP 2 specification: This specification is being developed by ICAO RNPSORSG Panel.

5.7. **Medium-term aerodrome operations**

5.7.1 In aerodromes selected due to complexity and traffic density

5.7.1.1 *Improvement:* Surface Movement Guide and Control System (A-SMGCS Levels III and IV)).

Level III: Provides defined specific functions in airport following contributions of pilots and drivers of mobiles and introduces automated en-routing function optimized by graphical maps containing details of taxiways, obstacles runways and mobiles position for crew and drivers. It also provides dynamic maps with updated runway conditions (in use, interdicted, etc.) and automatic display of signalling on ground (stop bar, centerline, etc.) according to the route used by the controller. (Includes ADS-B Package I, ATSA SURF application.)

Level IV: Contains the functions described for Level III plus control function, which is complemented by a conflict resolution function in the aircraft or vehicle cabin.

5.7.1.2 *Surveillance:* A-SMGSC and, in Level IV, Traffic Information Service (TIS-B) could be required for a complete airport situational photography, only in those airports having very high complexity and traffic.

6. **Improvements to be introduced in Communications, Navigation and Surveillance (CNS/ATM concept)**

6.1 **In the short-term**

6.1.1 Transportation networks:

6.1.1.1 In order to make possible a harmonized implementation of all the new services, the Aeronautical Telecommunications Network should be the **first communications component to be implemented**, over which the different applications contained in CNS/ATM concept will be set up, being AMHS the first. **Table 1** presents a diagram where it can be seen how the transportation network overlaps with, at least, the communications and surveillance services.

6.1.1.2 With this purpose, the Regional Office has developed and Orientation Guide in order to assist States to start this national effort as soon as possible.

6.1.2 Communications

6.1.2.1 *AMHS:*

6.1.2.1.1 No improvement should be done in AFTN centres, all efforts should be addressed to the early implementation of AMHS in total territory of each State.

6.1.2.1.2 Those States that have available this service should make the necessary arrangements to connect their MTA between them, using the REDDIG for this purpose.

6.1.2.2 *VCSS:* those States that do not have available the Voice Communication Switching System (VCSS) in ACCs and TWR and have an important amount of services to deliver should make their best effort to implement this system.

6.1.2.3 *OLDI:* States that have available Automated Processing Centres with OLDI facility

6.1.2.3.1 Should use this service between their national centres, and

6.1.2.3.2 Make bilateral arrangements that are necessary for its implementation between States.

6.1.2.4 *AIDC:* those States that do not have Automated Processing Centres should make the necessary provisions to have available, at least, OLDI facilities and, if possible, AIDC..

6.1.2.5 *CPDLC:* States with Oceanic FIR should make their best efforts to render CPDLC service to aircrafts equipped with FANS. If this service is not available, at least HF conventional communications should be guaranteed.

6.1.2.6 *ATIS:* States should make efforts to deliver these services in all international airports.

6.1.2.7 *VOLMET:* States should make their best efforts to render these services in all FIRs.

6.1.2.8 *VHF Coverage:* coverage of continental communications in VHF should be ensured.

6.1.3 Navigation:

6.1.3.1 States should ensure an adequate DME/DME navigation infrastructure in ground.

6.1.4 Surveillance:

6.1.4.1 *Radar coverage in selected airspaces:* States should make efforts to ensure radar coverage in their corresponding selected spaces.

6.1.4.2 *ADS-C*: States with Oceanic FIR should make their best efforts in order to facilitate ADS-C service to aircrafts equipped with FANS.

6.1.4.3 *ADS-B / multilateration*: Those States that could not comply with what is indicated in paragraph 6.1.4.1 (radar coverage), should make efforts to substitute it with ADS-B or multilateration coverage.

6.1.4.4 *Radar information exchange*: States should make the necessary bilateral arrangements to share radar data between adjacent ACCs, under modality allowed by technology installed in respective centres.

6.2 **In the medium-term**

6.2.1 Transportation networks: The Regional Office will coordinate with the ACP (Aeronautic Telecommunications Panel) the Regional IP addressing diagram and will make the necessary arrangements to establish the same diagram in the whole Region.

6.2.2 Communications

6.2.2.1 *AMHS*:

6.2.2.1.1 It is expected that in this period AFTN within the Region have practically disappeared and that all States have AMHS available.

6.2.2.1.2 Bi- and multilateral integrations between each State AMHS should be continued.

6.2.2.1.3 The Regional Office will coordinate the necessary tasks for interregional connectivity (CARSAM – EURSAM – NANSAM, etc.), while that all individual efforts of each State in this respect will be welcomed.

6.2.2.2 *AIDC*: States should make efforts to have Automated Centres in all their ACCs. If this are already available, and the count with OLDI facilities, they should also have AIDC. If Automated Centres are not available, States should get them directly with AIDC capacity.

6.2.2.3 *CPDLC*:

6.2.2.3.1 *Oceanic Area*: States should render CPDLC services in corresponding ACC, through HF DL or third party services.

6.2.2.3.2 *Continental Area*: those States that have decided to renew existing VHF equipment should make the necessary efforts to replace them by equipment having VDL capacity. However, this hypothetical situation should not be interpreted as a requirement, since administrations are invited to initiate pre-operational trials at any time.

6.2.2.4 *DATIS and DVOLMET*: States should start rendering DATIS and DVOLMET services, replacing similar conventional services or implementing the service where it is not available.

6.2.3 Navigation:

6.2.3.1 *Augmentation*: GBAS.

6.2.4 Surveillance:

6.2.4.1 *ADS-C*: all States having responsibility over an Oceanic FIR should facilitate ADS-C service to FANS-equipped aircrafts.

6.2.4.2 *Radar coverage /ADS-B / multilateration*: States should ensure that all the corresponding selected areas render an efficient radar and/or ADS-B/multilateration coverage.

6.2.4.3 *Radar information exchange*: States should make necessary efforts and bilateral arrangements to share radar data between adjacent Automated Centres, in Asterix 62 and 63 categories.

6.2.4.4 *Surface movement guide and control system* (A-SMGCS Levels III and IV) and Traffic Information Service (TIS-B) in Level IV, only in those airports of very high complexity and traffic.

NOTE: In Diagram 2 “Medium-Term Improvements” a future interrelation between different services under CNS/ATM concept is presented. In this diagram, affected services are marked in dark grey, and, in dashed line, which of the interrelation links have been modified.

[illegible]

Diagram 1 – Current Situation

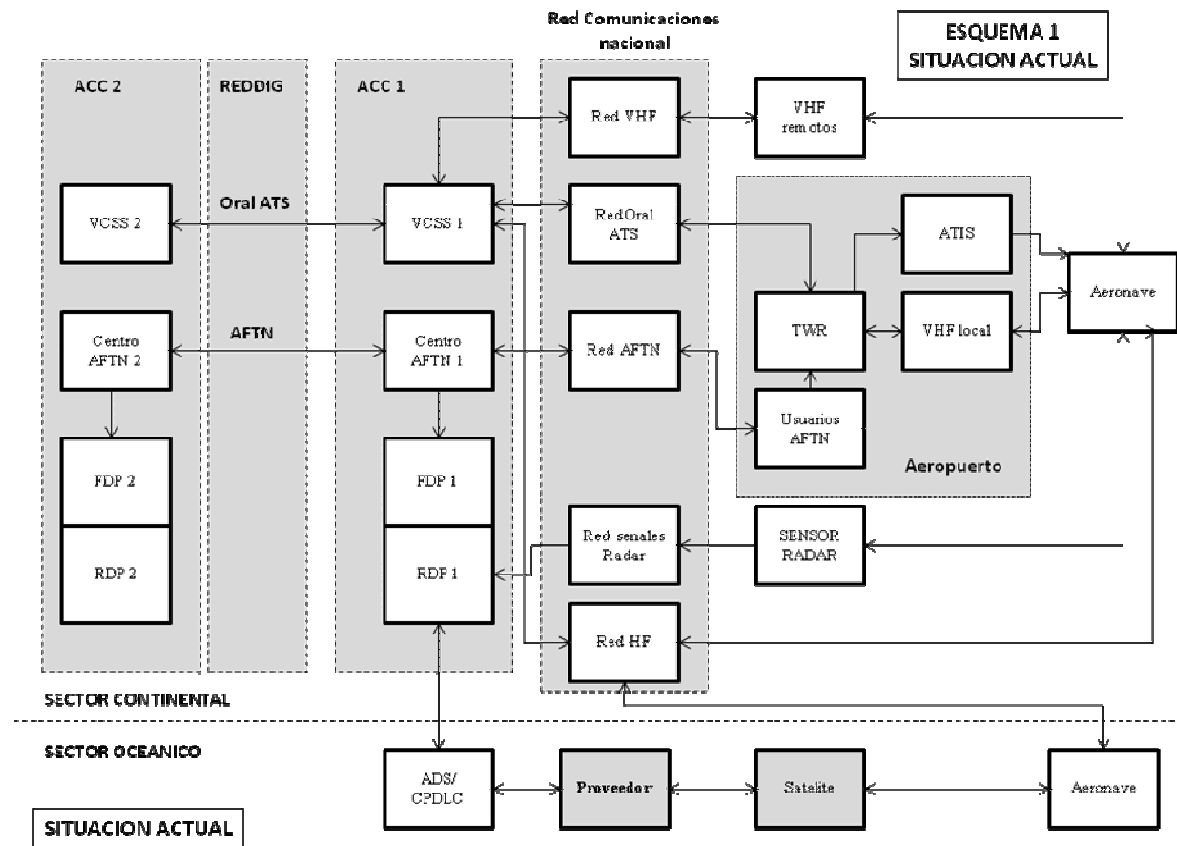
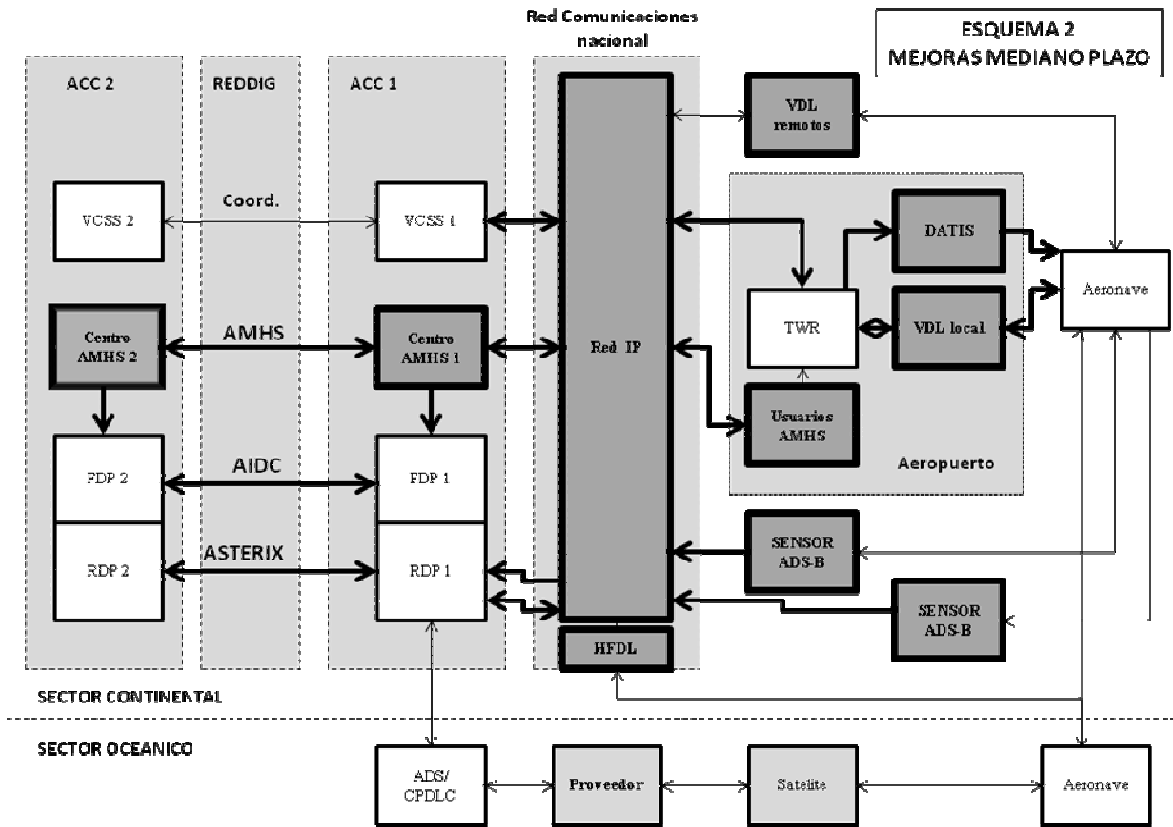


Diagram 2 – Medium-Term Improvements



APPENDIX B

**GUIA DE ORIENTACION PARA LA IMPLEMENTACION DE REDES NACIONALES
DIGITALES EN PROTOCOLO IP PARA APOYAR ACTUALES Y FUTURAS
APLICACIONES AERONAUTICAS**

(Spanish Only)



ORGANIZACIÓN DE AVIACION CIVIL INTERNACIONAL

PROYECTO RLA/06/901

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1. Antecedentes

1.1 Cuando el panel SICAS fue originalmente encargado del desarrollo de los SARP para la Red de Telecomunicaciones Aeronáuticas (ATN), el panel fue requerido para basar la ATN en los protocolos abiertos que fueren el “estándar industrial”, lo que dio lugar a la elección de los protocolos de la ISO, Open Systems Interconnection (OSI).

1.2 En aquel momento, el uso de este protocolo fue asignado por mandato por muchos Estados contratantes de ICAO. Antes de 1997, el panel y su sucesor, el ATNP, habían trabajado con éxito y se validaron los SARP para la ATN. Desde entonces, los usos de los servicios de tráfico aéreo (ATS) basados en estos SARP, se han movido hacia el despliegue y ahora se están utilizando operacionalmente en algunas áreas.

1.3 Sin embargo, aunque los protocolos de la ISO fueron apoyados fuertemente por los Estados contratantes, fuera de los servicios de comunicaciones aeronáuticos, los de la industria fueron convertidos usando un más viejo sistema de estándares que se conocen colectivamente como “TCP/IP” (más correctamente la Suite de Protocolos de Internet (IPS)). Éstos ahora son los estándares de hecho para las comunicaciones abiertas, y los productos basados en protocolos del IPS están extensamente disponibles y a un bajo costo.

1.4 En el ambiente de tierra, un ahorro en costes extremadamente significativo puede ser hecho introduciendo los productos basados en los protocolos IPS para la ayuda de ICAO, tales como el servicio de la manipulación de mensajes del ATS (ATSMHS), y otros en apoyo de comunicaciones aeroterrestres. Los Estados contratantes de ICAO han comenzado el despliegue del IPS en tales áreas.

1.5 En el ambiente aeroterrestre, hay interés en el uso del IPS. Sin embargo, esto es un ambiente muy diverso a la tierra. Hay trabajos específicos a hacer con respecto a la movilidad y la seguridad, que tienen que ser consideradas cuidadosamente. Mientras que hay un deseo de hacer uso de los estándares industriales en el ambiente aeroterrestre, esto se reconoce como más complejo, y su implementación durará por consiguiente más tiempo en comparación con el ambiente de tierra.

1.6 En consideración de las consideraciones antedichas, el Consejo de Navegación Aérea dirigió al grupo de trabajo I del ACP (Panel de Comunicaciones Aeronáuticas) a estudiar el uso del TCP/IP en el establecimiento de una red aeronáutica y la fabricación de las recomendaciones para el trabajo futuro en esta área.

1.7 El grupo de trabajo I del ACP progresó la tarea con la siguiente metodología:

1.7.1 Un examen de los Estados contratantes del ACP fue emprendido para determinar el grado que el IPS estaba siendo utilizado para las comunicaciones aeronáuticas en cada estado, y en qué contexto.

1.7.2 La consideración fue dada a los requisitos de comunicaciones aeronáuticas en áreas tales como funcionamiento, seguridad, movilidad, etc.

1.7.3 La consideración separada fue dada a la tierra-tierra y los ambientes aeroterrestres, y la capacidad de los productos “disponibles” existentes del IPS para cumplir estos requisitos.

1.7.4 Una conclusión entonces fue desarrollada, en la conveniencia del IPS para cumplir requisitos aeronáuticos de comunicaciones, y un programa de trabajo futuro propuesto fue formulado para facilitar el uso del IPS en el área seleccionada de comunicaciones aeronáuticas.

1.8 *La conclusión del informe del ACP es que el uso del IPS para apoyar la comunicación aeronáutica en el ambiente de tierra se justifica completamente.*

2. **Consideraciones generales contribuyentes a la toma de decisiones**

2.1 Business

2.1.1 La decisión para ejecutar el IPS debe ser una decisión económica así como una decisión técnica. Debe ser observado que mientras que los protocolos establecidos existentes del IPS están libres de restricciones de la patente y disponibles sin carga, esto puede no ser verdad de los protocolos futuros.

2.1.2 Hay una población grande de vendedores y de proveedores de servicios para los servicios del equipo y del establecimiento de una red del IPS. Esto ha creado un ambiente competitivo que debe permitir a Estados contratantes de ICAO obtener la tasación favorable cuando está comparado al equipo y a los servicios en red.

2.2 Soporte industrial

2.2.1 Hay una gran cantidad de compañías que proporcionan el equipamiento en red y servicios basados en IPS, mientras que el establecimiento de una red de la OSI gradualmente disminuye su capacidad de soporte. Además, los estándares del IPS son mantenidos por el Internet Engineering Task Force (IETF) con la ayuda activa de la industria.

2.2.2 El número de nodos desplegados para el IPS está en los diez millones, mientras que las redes WAN basadas en OSI no se despliegan en esta escala, y los se han desplegado se están substituyendo por el IPS.

2.3 Políticas de seguridad a considerar

2.3.1 El establecimiento de una red IPS aumenta la necesidad de la seguridad eficaz; esto es debido a la misma franqueza del IPS. La oscuridad de los protocolos de ISO/OSI debido al hecho de que no estén desplegados extensamente en redes, proporciona una cantidad determinada de protección.

2.3.2 Los ataques contra redes del IPS se publican bien, y los piratas informáticos gastan mucha energía hacia la concepción de nuevas formas de ataque. El coste de un sistema capaz de infligir daño importante en una red puede estar tan solo en una computadora barata que apoye el IPS.

2.3.3 Esto significa que los sistemas del ATS usando el IPS, sin mecanismos de seguridad eficaces, serían vulnerables a las varias formas de violación de seguridad. Por lo tanto se recomienda que los servicios de seguridad existentes subyacentes del análisis ATN de la vulnerabilidad estén puestos al día para reflejar el uso del IPS.

2.3.4 Hay numerosos mecanismos de seguridad que se pueden utilizar en una red IPS. Los sistemas actuales pueden utilizar el protocolo de la seguridad del IP (IPSec) para asegurar seguridad de la capa de red y/o el protocolo de SSL/TLS para asegurar seguridad de la capa de transporte del IPS. IPSec puede proporcionar servicios de encriptación y/o de autenticación.

2.3.5 Por otra parte, la Administración Aeronáutica de cada Estado deberá observar su incumbencia interna en las Políticas de Seguridad de la Información dictadas por sus propios gobiernos.

2.3.6 Es recomendable la lectura de la Norma “Information Technologies – Security techniques – Codes of practice for information security management “ISO-IEC 17799, del año 2005, publicado por la ISO (International Standardization Organization) y la IEC (International Electrotechnical Commission). La última versión, BS ISO IEC 17799: 2005 reemplaza a las versiones más viejas de los estándares BS 7799 e ISO 17799. Está basada en el British Standard 7799. Aunque la norma ISO 17799 no es de cumplimiento obligatorio, *proporciona una base sólida para un programa de seguridad de la información.*

2.3.7 Asimismo, deberá contemplarse lo estipulado en ICAO – DOC 9705 – SubVolumen VIII – SEC (ATN Security Services). 3ra. Edición (2002) y los Checklist de auditoria de seguridad (Information Security Management BS 7799.2:2005 Audit Check List for SANS).

2.4. Implantación

2.4.1 Puesto que el IPS es el estándar mundial de facto del establecimiento de una red, con muchos años de despliegue detrás de él, hay una población grande de ingenieros experimentados en establecimiento de redes, disponibles para apoyar la puesta en práctica. Esta base de conocimiento puede apoyar el despliegue de una ATN basada en IPS.

2.5 Capacitación

2.5.1 No obstante lo antedicho, es imprescindible iniciar rápidamente un esquema de capacitación y/o certificación en redes IPS, que permita al Estado contar con el mínimo numero de personas que puedan contribuir a instalar, habilitar, gestionar y mantener la red IPS en forma satisfactoria.

3. **Consideraciones específicas de diseño y despliegue**

3.1 Elecciones básicas para el diseño preliminar de la red nacional

3.1.1 La recomendación básica que debiera atender cada Estado es que la red IPS *debe ser exclusivamente privada.*

3.1.2 Cada estado podrá seleccionar el *proveedor* de los *elementos IPS* que estime conveniente; sin embargo, deberá considerar que esa elección debe ser prácticamente definitiva, ya que no es recomendable de ninguna manera disponer de equipamiento con idéntico fin, pero de diferentes marcas, ya que este hecho obligara a *multiplicar* innecesariamente:

3.1.2.1 La capacitación.

3.1.2.2 Los repuestos.

3.1.2.3 Los recursos humanos.

3.1.2.4 La gestión remota.

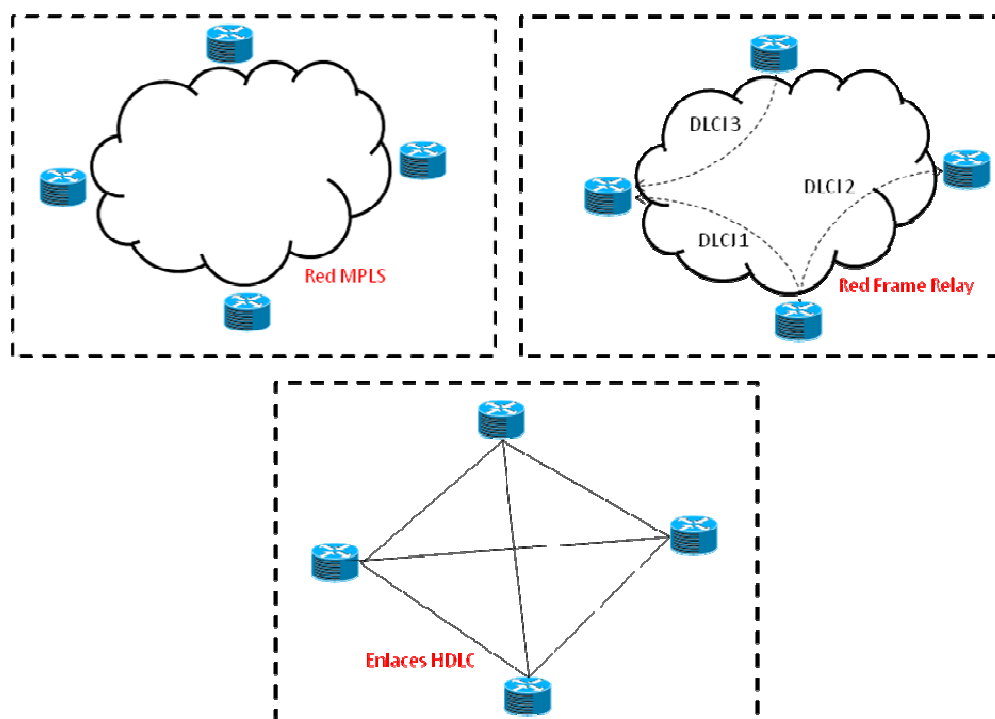
3.1.3 Asimismo, es una decisión de cada Estado (basada en sus políticas técnicas y económicas) elegir si la red IPS deberá ser:

3.1.3.1 Soportada por *redes terrestres o satelitales* (o bien un mix de ambas).

3.1.3.2 Basada en una red de enlaces *propios o arrendados* a las PTTs (*).

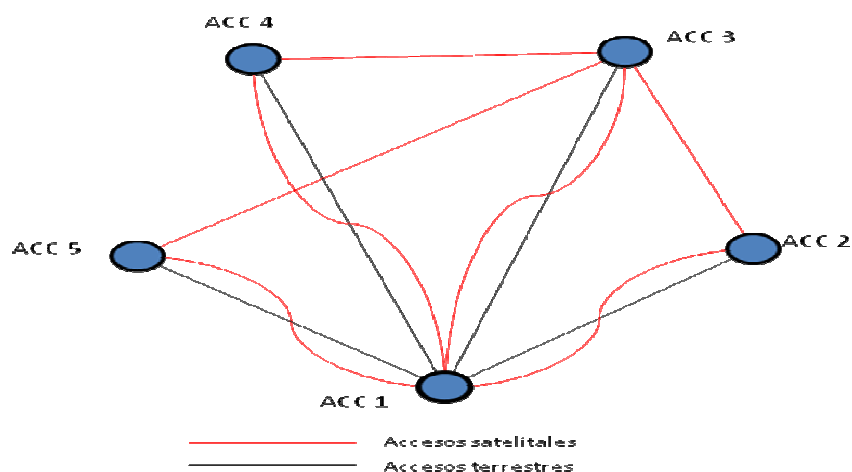
3.1.3.3 Transportada sobre líneas dedicadas o conexiones conmutadas. Las conexiones conmutadas, a su vez, pueden ser de circuitos conmutados o de paquetes/celdas conmutadas (*).

FIGURA 1: MPLS, Frame Relay y HDLC



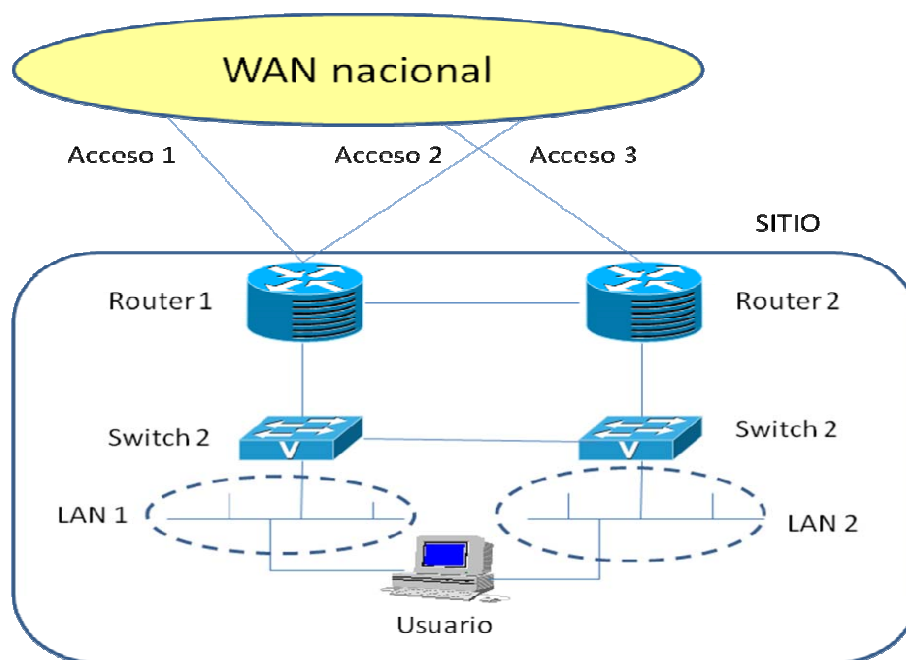
3.1.3.4 Si se utiliza punto a punto, *accesos* a la WAN (red de área ampliada) *simples* o *duplicados* en cada uno de los sitios donde llega, Ver Figura 2 (*).

FIGURA 2: EJEMPLO DE RED IP, HDLC, ACCESOS REDUNDANTES



3.1.3.5 Con *elementos de networking simples o duplicados (Ver Figura 3).*

Figura 3: Elementos de networking redundados



(*): Estos asuntos se tratan extensamente en el Apéndice 1.

En el *Apéndice 1 “Conceptos de networking”* se pormenorizan los distintos aspectos contribuyentes al diseño y configuración de una red, así como todo lo relativo a los elementos de segmentación de datos que la constituyen (*routers y switches*).

En el *Apéndice 2 “Descripción de un router”*, se detallan todos los aspectos constructivos, funcionales y técnicos de un router.

En el *Apéndice 3 “Protocolos de enrutamiento”* se detallan aspectos relativos al enrutamiento.

NOTA: en todos los Apéndices se hace referencia extensiva a elementos Cisco, sin que con ello se pretenda influir en la elección de cada Estado en los elementos a ser instalados.

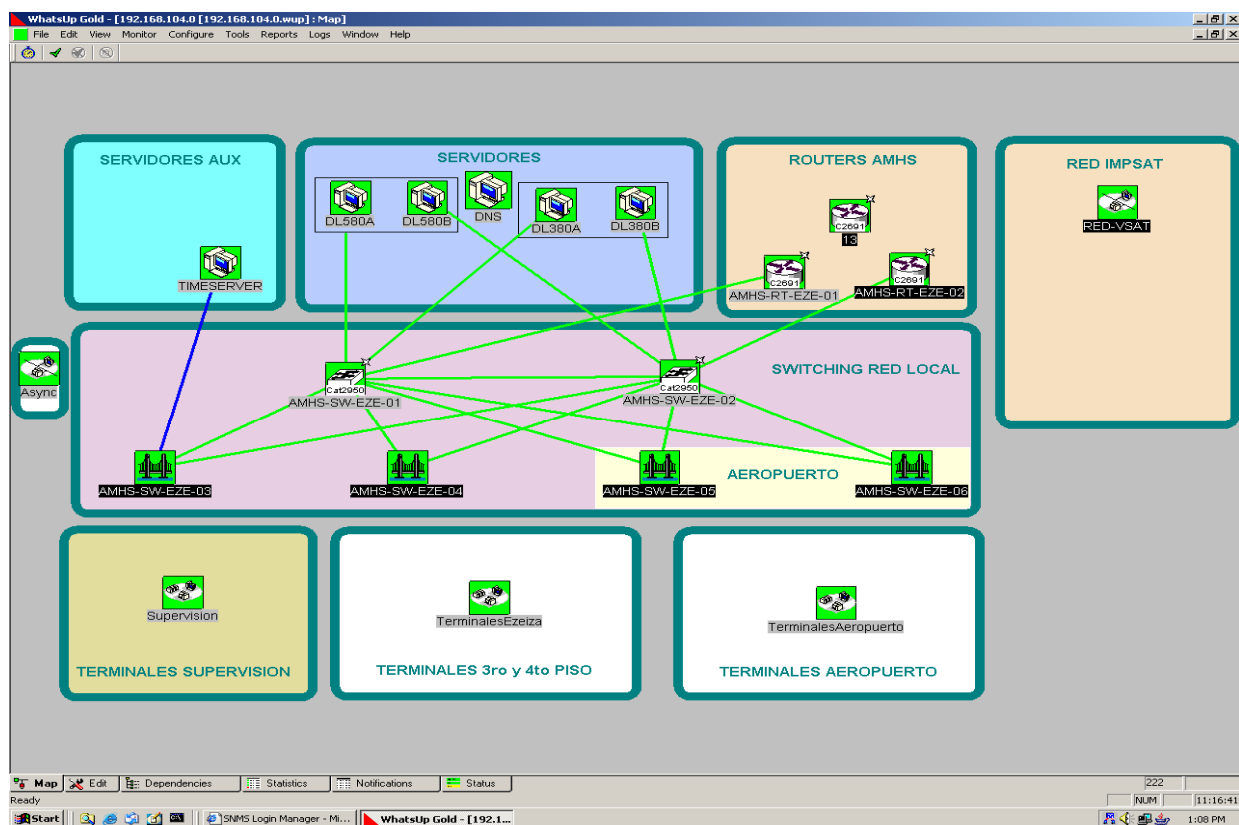
3.2 Gestión remota de la red

3.2.1 La red deberá ser instalada de forma de tal de permitir la visualización y gestión remota de *todos y cada uno de sus componentes*.

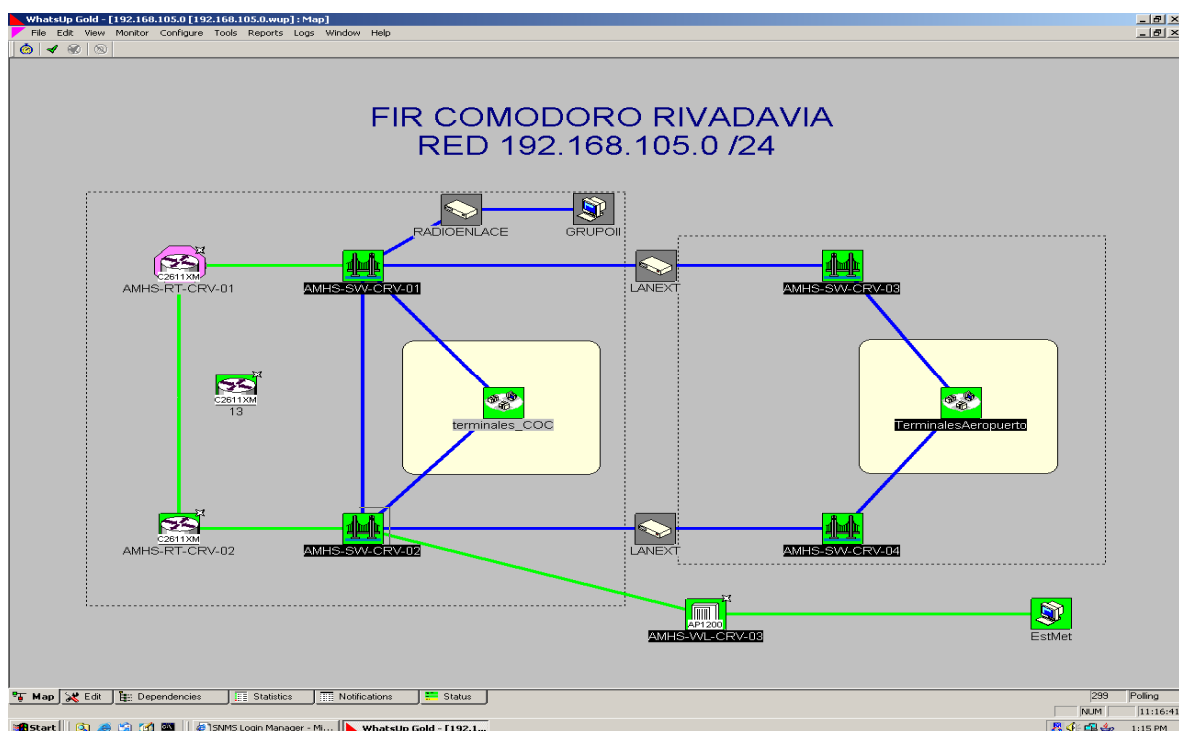
En el *Apéndice 4 “Paquete de gestión de dispositivos”* se exponen los elementos de gestión disponibles y su inserción en el funcionamiento de la red IPS.

3.2.2 En las figuras siguientes se exponen ejemplos de visualización de los elementos de red correspondientes a:

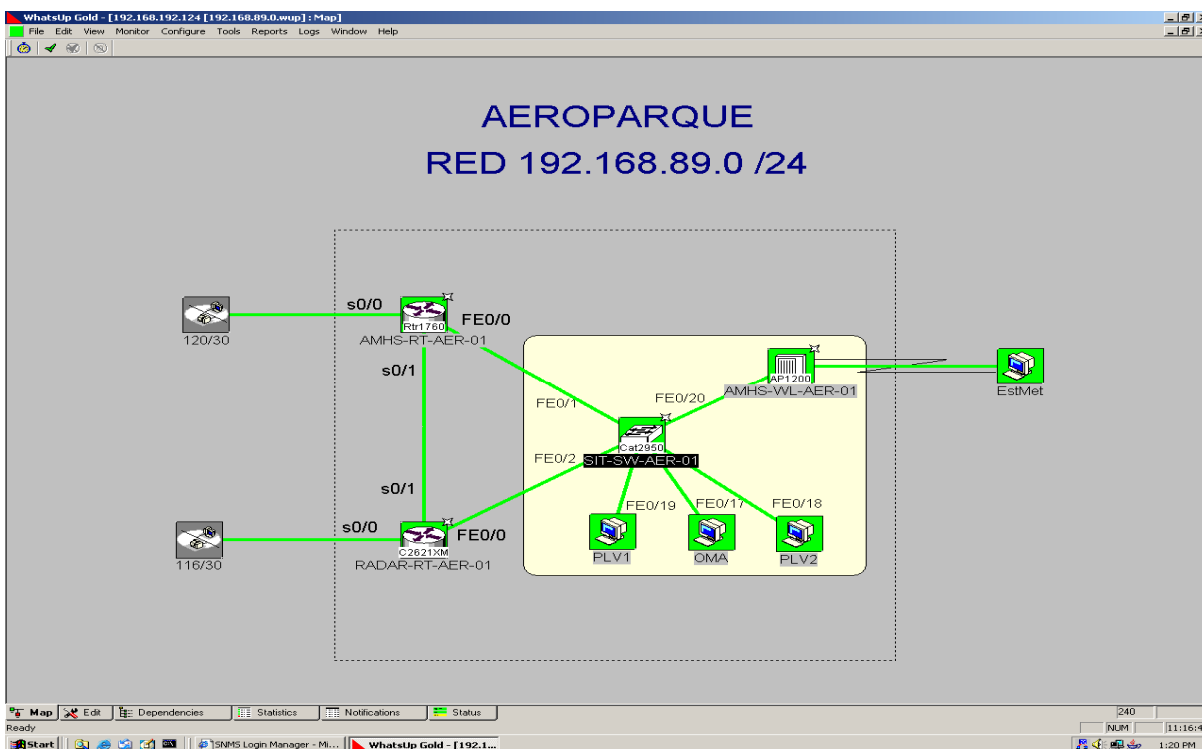
3.2.2.1 La sede central de un servicio AMHS



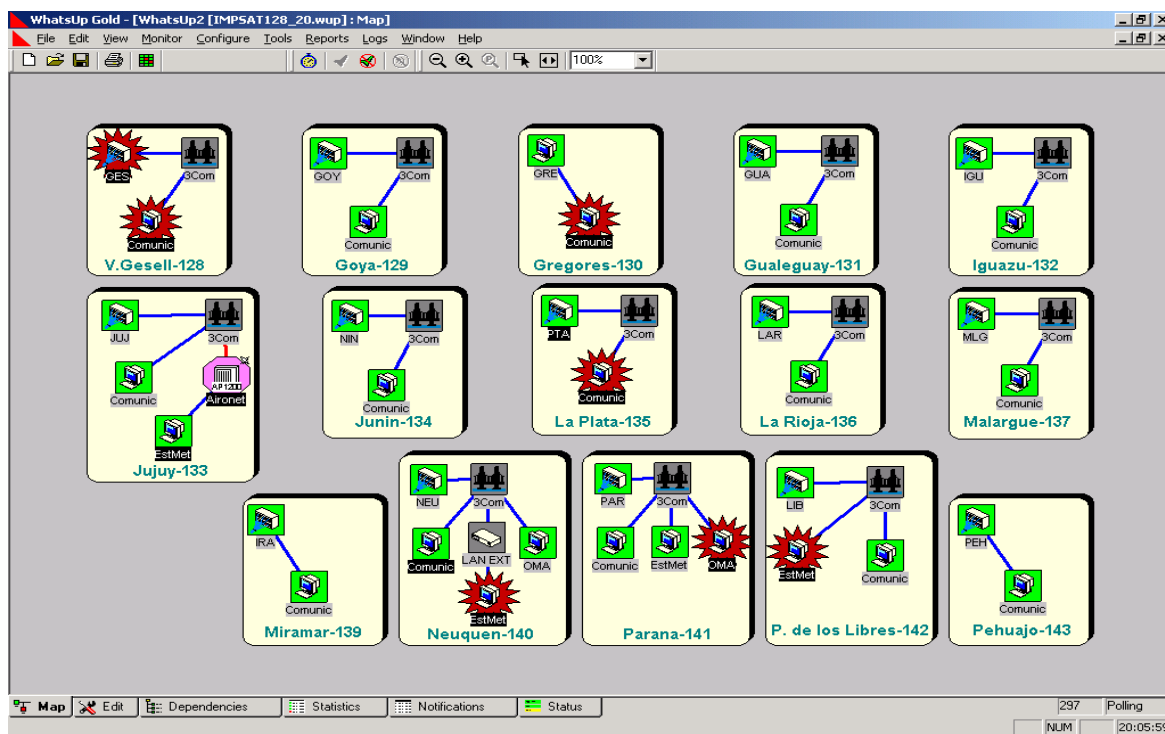
3.2.2.2 Un ACC, bajo la concepción de “inexistencia de punto común de falla”.



3.2.2.3 Un aeropuerto de gran movimiento



3.2.2.4 Un grupo de pequeños aeropuertos



3.3. Plan de direccionamiento

3.3.1 Cada Estado podrá utilizar las direcciones y el esquema de direccionamiento que prefiera, pero es recomendable:

3.3.1.1 Que las direcciones de red sean asignadas en bloques continuos.

3.3.1.2 Que la distribución de bloques de direcciones se realice en forma jerárquica, de forma tal de permitir la escalabilidad de ruteo.

3.3.1.3 Que sea posible poder configurar subredes, para poder aprovechar así al máximo cada red asignada.

3.3.2 Las únicas direcciones asignadas y conocidas por el resto de los Estados serán las de las interfaces de los equipos de comunicaciones utilizados en las fronteras de interconexión entre las redes internas y externas a cada Estado.

3.3.3. De esta forma cada estado deberá garantizar el ruteo a través de su red hacia la/s dirección/es internas de los servidores de aplicación que utilice contra otros Estados.

3.3.4 La Oficina Regional se encargara de determinar cual de las opciones de *ruteo regional* será la seleccionada finalmente, como asimismo coordinara y asignara las direcciones y modalidad que se establezca, en virtud de los arreglos institucionales correspondientes (Grupo de Tareas ATN, Comité CNS, Grepecas, ACP, etc.)

3.4 Transferencia de servicios

3.4.1 A fin de no perturbar el normal desarrollo de las operaciones aéreas, es recomendable que los servicios se muden a la red IPS de a uno por vez, y paulatinamente. Tal como fue largamente establecido, el *AMHS* **debe** ser primer servicio a ser montado sobre la ATN basada en IPS.

3.4.2 Una vez completado el despliegue de este servicio en particular, cada Estado podrá elegir entre:

3.4.2.1 Continuar con otros servicios de datos (señales radar, aplicaciones AIS y/o MET, AIDC, OLDI, etc.).

3.4.2.2. Iniciar la transferencia de servicios operacionales de voz (comunicaciones ATS directas o conmutadas).

3.4.2.3 Un mix entre las dos opciones mencionadas.

3.4.3 *Señales radar*: si estas son generadas en forma IP nativa, se montaran directamente, según el direccionamiento correspondiente. Si son generadas en forma serial sincrónica, ya sea esta V.35 o V.24, deberá ingresárselas a la red en forma “multicast”, a fin de ser recibidas en los destinos necesarios.

3.4.4 *AIDC*: esta aplicación deberá ser “montada” encima de la aplicación AMHS, por lo que su transporte por la red IP es inmediato.

3.4.5 *OLDI*: para los Estados que dispongan del servicio OLDI X.25 en lugar del AIDC, es recomendable efectuar los arreglos de software necesarios para que el mismo sea transportable vía IP en lugar de X.25.

3.5.6 *Comunicaciones orales ATS (ACC – TWR o entre ACCs del mismo estado)*: es recomendable iniciar las pruebas pre operacionales duplicando circuitos convencionales con aeropuertos de gran densidad de trafico, a fin de detectar / corregir los inconvenientes que pudieren surgir. Una vez finalizada esta etapa, se deberán desafectar los convencionales y ampliar el uso hacia el resto de la red.

3.4.7 *Comunicaciones orales ATS (entre ACCs de distintos estados)*: vía REDDIG, una vez efectuados los arreglos bi o multilaterales necesarios.

3.4.8 *ADS –B*: cuando se disponga de este servicio.

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PROTOCOLO IP (RFC791-RFC760)

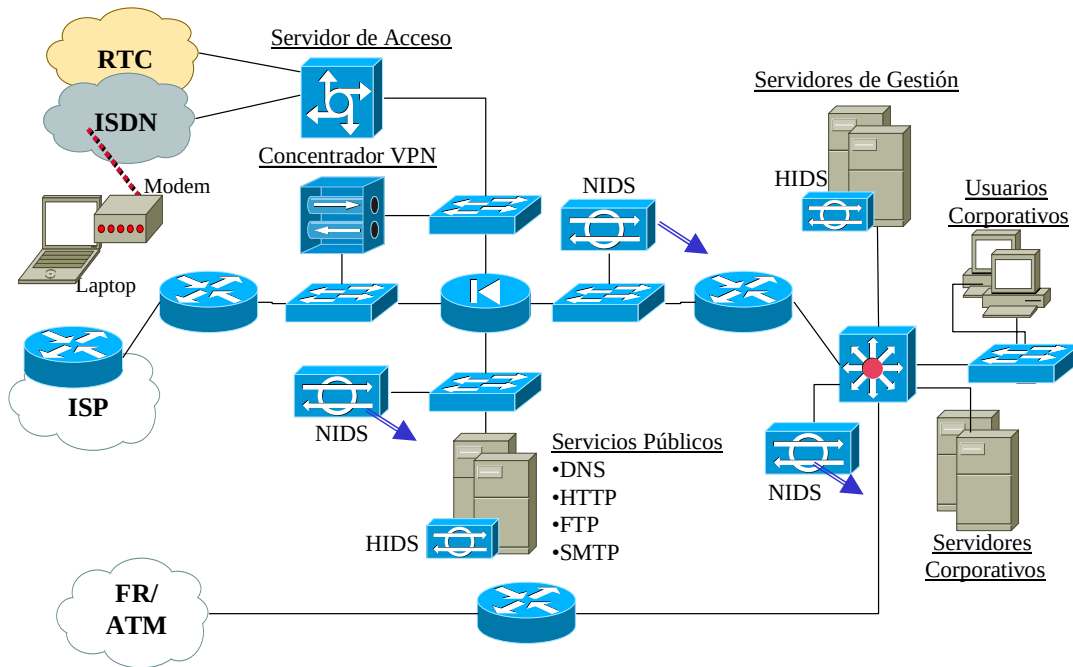
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1. NETWORKING

1.1 El término networking (ó también internetworking) se aplica a la industria, productos y a las actividades relacionadas con la interconexión, diseño y administración de las redes individuales, de manera que pasan a funcionar y comportarse como una única gran red.



1.2 En la figura se muestra el diagrama de una red corporativa de mediano porte. En ella se muestran los dispositivos de uso frecuente en las redes. De manera general, los objetivos de diseño de una red son:

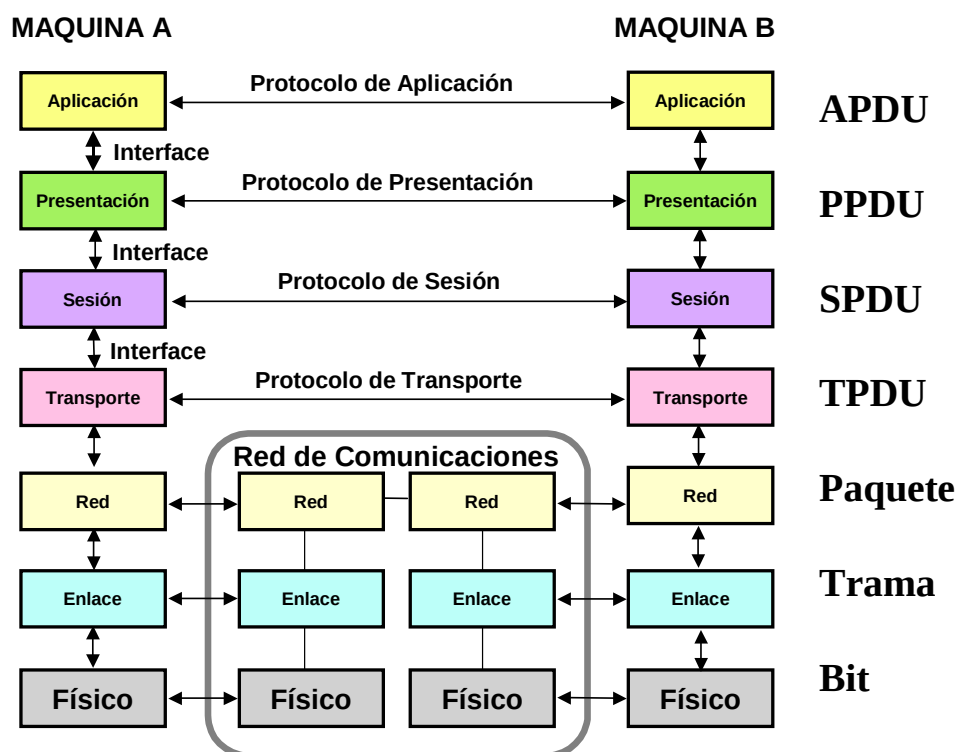
- 1.2.1 Funcionalidad
- 1.2.2 Performance
- 1.2.3 Seguridad
- 1.2.4 Gestión
- 1.2.5 Escalabilidad
- 1.2.6 Compatibilidad

Modelos de referencia

1.3 Los modelos de referencia proveen la ventaja de dividir la complejidad de las operaciones de la red en un conjunto manejable de niveles o capas. El diseño de protocolos en base a los modelos de referencia posibilita la introducción de cambios en una capa, sin que las otras se vean afectadas. Es un instrumento eficaz para analizar todo tipo de redes.

Modelo de referencia OSI

1.4 El modelo de referencia OSI es un marco de trabajo desarrollado por la ISO para promover la estandarización de los protocolos utilizados en la interconexión de sistemas heterogéneos (abiertos).



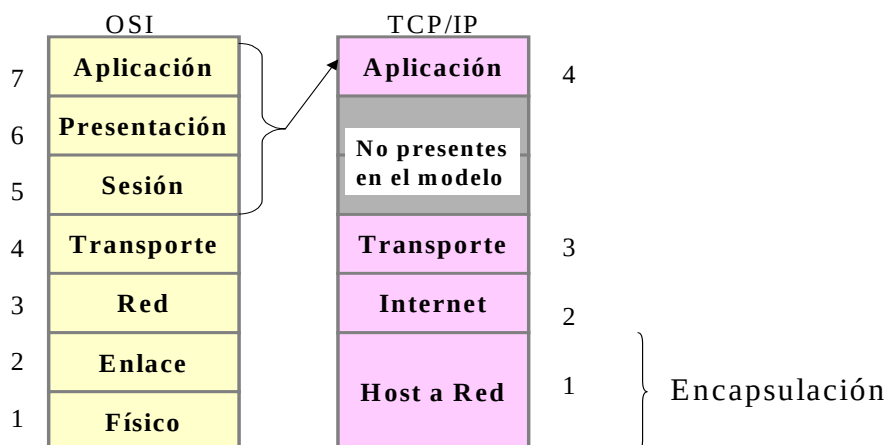
CAPA OSI	DESCRIPCIÓN FUNCIONAL	EJEMPLOS
7.- APLICACIÓN	Semántica. Interface con las aplicaciones/usuarios.	Telnet, HTTP, FTP, www, NFS, SMTP, SNMP, X.400
6.- PRESENTACIÓN	Formato de los datos. Sintaxis. Procesamientos especiales (encriptación).	JPEG, ASCII, EBCDIC, TIFF, GIF, PICT, encryption, MPEG, MIDI
5.- SESIÓN	Flujo ordenado de los datos entre las partes intervinientes (transacciones).	RPC, SQL, NFS, nombres NetBios, AppleTalk ASP, DECnet SCP
4.- TRANSPORTE	Calidad de servicio. División entre red y capas sup. Mux.	TCP, UDP, SPX
3.- RED	Direccionamiento lógico. Enrutamiento.	IP, IPX, APPLE TALK, ICMP
2.- ENLACE DE DATOS	Acceso al medio. Enlace entre estaciones vecinas. Manejo de Errores.	IEEE 802.3/802.2, HDLC, Frame Relay, PPP, FDDI, ATM, IEEE 802.5/802.2
1.- FÍSICA	Señales físicas. Conectores. Temporización.	EIA/TIA-232, V.35, EIA/TIA-449, V.24, RJ-45, Ethernet, 802.3, 802.5, FDDI, NRZI, NRZ, B8ZS ¹

¹ Atención: frecuentemente estas especificaciones se complementan (ej: RJ-45 es solamente el conector).

Modelo de referencia TCP/IP

1.5 En el modelo TCP/IP no existen las capas de presentación y sesión. Directamente sobre la capa de transporte se encuentra la capa de aplicación, la cual contiene todos los protocolos de alto nivel.

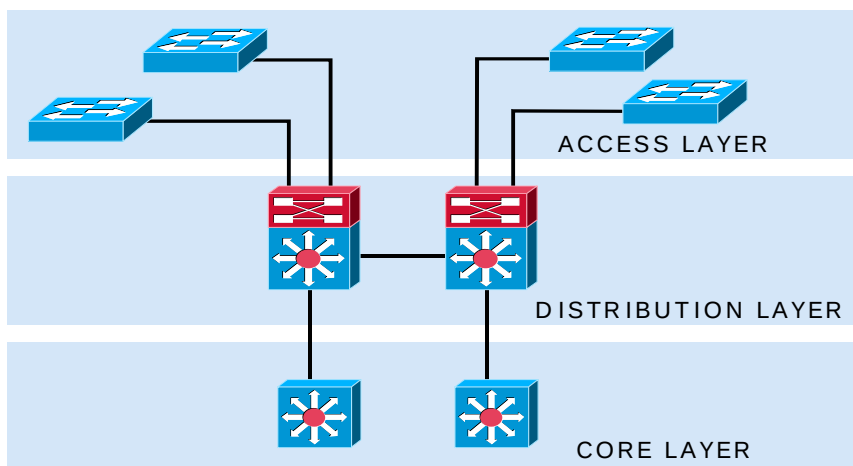
1.6 Un gran vacío (y por ende gran flexibilidad) existe por debajo de la capa internet en el modelo TCP/IP, dado que no define ningún protocolo (solamente menciona que el host debe conectarse a la red utilizando algún protocolo para enviar los paquetes).



1.7 Siempre que se hable del modelo de capas (a menos que se indique lo contrario), se utilizará el modelo de referencia OSI. Así, todo el mundo sabe que IP es un protocolo de capa 3 (nótese que en el modelo TCP/IP corresponde a la capa 2).

Modelo jerárquico CISCO

1.8 Con las mismas ventajas de la modelización en capas de OSI, y otras orientadas a las implementaciones prácticas de redes Campus, CISCO posee su propio diseño jerárquico - facilidad de operación y administración, mejor comprensión, escalabilidad, implementación de políticas, eficacia del direccionamiento y resolución de problemas-.



1.9 En el siguiente cuadro se resumen las características de cada una de las capas del modelo jerárquico:

CAPA CISCO	DESCRIPCIÓN
CORE	Transporte de alta velocidad, elevada confiabilidad, redundancia y baja latencia. Conexiones entre sitios. Switches de alta velocidad. No comprimir, filtrar, encriptar u otras cargas de procesamiento.
DISTRIBUTION	Listas de acceso, listas de distribución, sumarización de rutas, enrutamiento de VLANs, políticas de seguridad, filtros, agregación, encriptación, compresión y calidad de servicio. Routers de alta velocidad y switches de capa 3.
ACCESS	Servicios de acceso remoto, acceso local shared y switched, filtrado de direcciones MAC y segmentación. Agregación de VPN's. Switches de acceso.

Bases numéricas

1.10 El estudio de las direcciones físicas y lógicas exige el repaso de las bases y conversiones numéricas. En el siguiente diagrama se muestra el principio de formación de los números en diferentes bases.

b^n	b^7	b^6	b^5	b^4	b^3	b^2	b^1	b^0	base
...	10^7	10^6	10^5	10000	1000	100	10	1	$b=10$
...	128	64	32	16	8	4	2	1	$b=2$
...	8^7	8^6	32768	4096	512	64	8	1	$b=8$
...	16^7	16^6	16^5	65536	4096	256	16	1	$b=16$

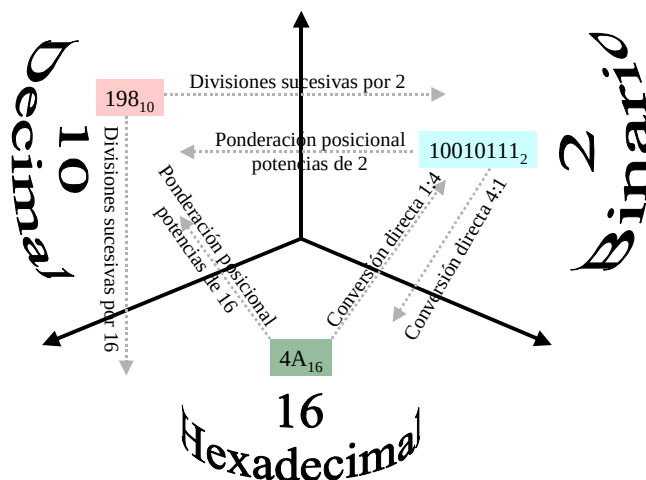
Base decimal: 0 1 2 3 4 5 6 7 8 9

Base binaria: 0 1

Base octal: 0 1 2 3 4 5 6 7

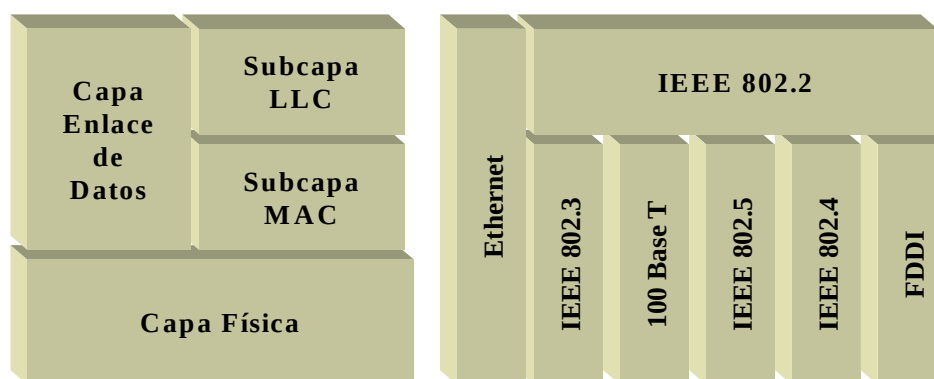
Base hexadecimal: 0 1 2 3 4 5 6 7 8 9 A B C D E F

1.11 Las claves para las conversiones entre diferentes bases está representada por:



2. PROTOCOLOS DE LAN

2.1 Los protocolos de LAN funcionan en las dos capas más bajas del modelo de referencia OSI.



2.2 El IEEE (Institute of Electrical and Electronic Engineers) diferencia la capa de enlace en dos subcapas: MAC (Media Access Control) y LLC (Logical Link Control). La subcapa MAC permite e instrumenta el acceso al medio, tal como el método de contención o token passing, mientras que la subcapa LLC se encarga del framing, control de flujo, control de errores y direccionamiento de subcapa MAC.

Métodos de acceso al medio

2.3 Los protocolos de LAN, típicamente usan uno de dos métodos para acceder al medio físico de la red: CSMA/CD (Carrier Sense Multiple Access/Collision Detect) y Token-passing. En el esquema CSMA/CD los dispositivos de la red contienden por el uso del medio físico. Por ello se denomina acceso por contención. Los ejemplos más característicos de redes LAN que utilizan CSMA/CD son Ethernet/IEEE 802.3, incluyendo 100BaseT.

2.4 En el esquema de acceso al medio Token-Passing, los dispositivos de la red acceden al medio físico en base a la posesión de una ficha (token). Los ejemplos más característicos son Token Ring/IEEE 802.5 y FDDI (Fiber Distributed Data Interface).

Nombre	Subcapa MAC	Subcapa LLC	Comentarios
Ethernet_II (DIX)	Ethernet	No existe diferenciación	Especificación propietaria de Digital, Intel y Xerox.
IEEE Ethernet	IEEE 802.3	IEEE 802.2	Conocida como Ethernet 802.3
Token-Ring	IEEE 802.5	IEEE 802.2	Originario de IBM
FDDI	ANSI X3T9.5	IEEE 802.2	Sin comentarios

Métodos de transmisión

2.5 Las transmisiones en las LAN corresponden a tres clasificaciones: *unicast*, *multicast* y *broadcast*. En los cuales una trama se envía a uno o más nodos.

2.5.1 En la transmisión *unicast* un único paquete es enviado desde un origen a un destino.

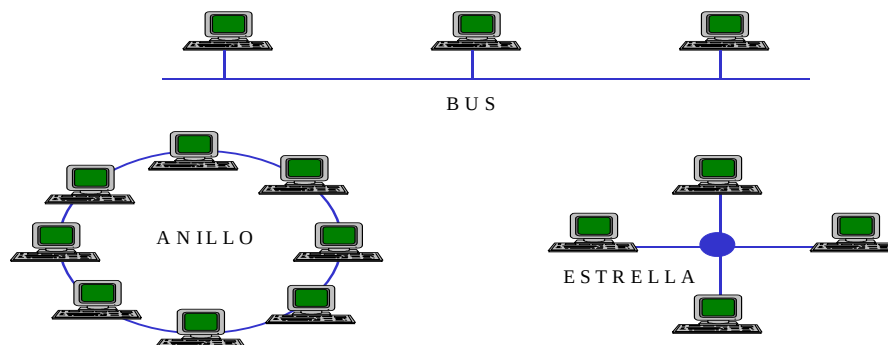
2.5.2 En *multicast*, un único paquete generado por un nodo origen, es copiado y enviado a un subconjunto especificado de nodos de la red.

2.5.3 La transmisión *broadcast* consiste en un único paquete copiado y enviado a todos los nodos de la red. El nodo origen genera un único paquete utilizando la dirección broadcast.

Topologías de LAN

2.6 Las topologías de LAN definen la forma en la que se organizan los dispositivos dentro de la red.

2.7 Existen tres topologías comunes: **bus**, **ring (anillo)** y **star (estrella)**.



2.8 Aunque estas topologías son arquitecturas lógicas, los dispositivos reales no necesitan estar físicamente organizados de acuerdo con estas configuraciones. Las topologías lógicas bus y ring, por ejemplo, suelen organizarse físicamente como una estrella (mediante un hub).

2.9 Las implementaciones más utilizadas de Ethernet (incluyendo Fast Ethernet, GigaEthernet y 10 GE) emplean una *topología de bus*, aún cuando aparentemente la topología física que se implementa a través de hubs y switches se presenta como estrella.

3. TECNOLOGÍAS ETHERNET

3.1 Ethernet ha sobrevivido, en su batalla inicial, como una tecnología de medio físico esencial a causa de su tremenda flexibilidad y relativa simplicidad de implementación y comprensión. Hoy, sin duda, es la tecnología de red LAN cómodamente dominante.

3.2 El término Ethernet se aplica a la familia de implementaciones LAN, las cuales incluyen:

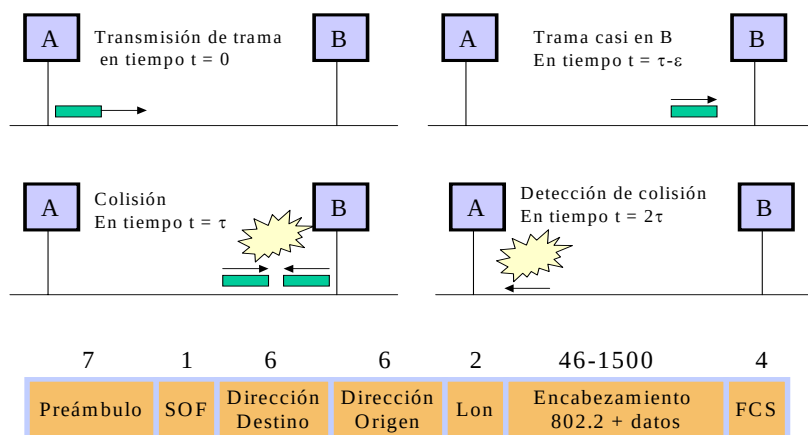
Estándar	Subcapa MAC	Segmento Max (metros)	Tipo de Cable	#Pares
10Base5	802.3	500	50 ohm thick	-
10Base2	802.3	185	50 ohm thin	-
10BaseT	802.3	100	UTP 3-4-5	2

Estándar	Subcapa MAC	Segmento Max (metros)	Tipo de Cable	#Pares
10BaseFL	802.3	2000	FO	1
100BaseFL	802.3u	100	UTP 5	2
100BaseFL	802.3u	100	UTP 3	4
100BaseFL	802.3u	100	UTP 3-4-5	2
100BaseFL	802.3u	400/2000	FO multimodo	1
100BaseFL	802.3u	10000	FO monomodo	1
1000BaseSx	802.3z	220-550	FO multimodo	1
1000BaseLx	802.3z	3000	FO	1
1000BaseCx	802.3z	25	STP	2
1000BaseT	802.3ab	100	UTP 5	2
10GBaseE ²	802.3ae	40000	FO monomodo	1

Ethernet e IEEE 802.3

3.3 Ethernet es una especificación de LAN en banda base inventada por Xerox Corp., para operar a 10 Mbps, utilizando CSMA/CD, sobre cable coaxil. El diseño fue creado para servir en redes con requerimientos esporádicos de altas cargas de tráfico. La especificación IEEE 802.3 fue desarrollada en base a Ethernet. IEEE 802.3 provee una gran variedad de opciones de cableados (por ejemplo 10Base5: en la cual 10 es la velocidad en Mbps., Base el método de señalización banda base, y 5 el tipo de medio físico coaxil).

3.4 En el ambiente broadcast de Ethernet, todas las estaciones “ven” todos las tramas que se transmiten sobre la red. Cada estación debe examinar las tramas para determinar si les han sido destinadas, en cuyo caso dichas tramas son pasadas hacia la capa superior.



² Existen otros estándares para FO mono y multimodo.

3.5 Cualquier estación sobre una LAN CSMA/CD puede acceder al medio físico en cualquier momento pero, antes de enviar datos, las estaciones verifican (“escuchan”) si no existen transmisiones en el medio. Si el medio está inactivo, puede iniciar la transmisión de sus datos.

3.6 Ocurre una colisión si dos o más estaciones comienzan la transmisión al mismo tiempo, en cuya situación ambas transmisiones resultarán dañadas y será menester retransmitir después de cumplido un cierto tiempo de back-off impuesto por un algoritmo que ejecutan las estaciones.

3.7 Los campos de la trama IEEE 802.3 son:

3.7.1 *Preámbulo*: Patrón alternante de unos y ceros para indicar a las estaciones la presencia de una trama.

3.7.2 *SOF* (Comienzo de trama): byte de delimitación para sincronizar la recepción de la trama.

3.7.3 *Direcciones de Destino y Origen*: Los tres primeros bytes de la dirección están especificados por el IEEE identificando al fabricante. Los últimos tres bytes los configura el fabricante. La dirección de origen es siempre unicast (un nodo), pero la dirección de destino puede ser unicast, multicast (grupo) o broadcast (todos los nodos).

3.7.4 *Longitud*: El número de bytes de datos que siguen a este campo.

3.7.5 *Datos*: Si los datos en el frame son insuficientes para llenar el campo a su mínimo valor de 64 bytes, se insertan bytes de padding para asegurar por lo menos una longitud de 64 bytes.

3.7.6 *FCS* (Frame Check Sequence): Es un valor CRC de 4 bytes para implementar el control de errores.

100-Mbps Ethernet (IEEE 802.3u)

3.8 Esta tecnología de LAN de alta velocidad ofrece una actualización importante en el ancho de banda disponible. 100BaseT es la especificación de la implementación 100 Mbps Ethernet sobre UTP y STP.

3.9 La subcapa MAC es compatible con IEEE 802.3, de manera que se mantiene el formato, tamaño y mecanismos de detección de errores, a la vez que soporta todas las aplicaciones y software de red de las redes 802.3.

3.10 100BaseT soporta ambas velocidades 10 y 100 Mbps, pero el diámetro máximo de la red queda reducido aproximadamente 10 veces respecto a 10BaseT (de 2000 a 205 metros), debido a la necesidad de detectar las colisiones dentro del tiempo necesario para transmitir un frame de longitud mínima de 64 bytes, aunque las estaciones se encuentren en los extremos de la red.

1 Gigabit Ethernet

3.11 1 GE es una extensión del estándar IEEE 802.3, la cual ofrece 1 Gbit/s de ancho de banda, manteniendo la compatibilidad con los dispositivos de red Ethernet y Fast Ethernet.

3.12 1GE provee un nuevo modo operativo full-dúplex para conexiones switch-to-switch y switch-to-station. Sin embargo, utiliza el mismo formato y tamaño de trama, y objetos de gestión de las redes IEEE 802.3.

3.13 Esta red ha sido diseñada para operar sobre fibra óptica, pero podrá ser implementada sobre UTP 5 y cable coaxil. El Grupo de Trabajo IEEE 802.3 formó a la Fuerza de Tareas 802.3z Gigabit Ethernet para desarrollar los estándares. El objetivo fue permitir operaciones full y half dúplex a 1 Gbps., de conformidad con el formato de frame tradicional y el método CSMA/CD de acceso al medio. También se prevé compatibilidad retroactiva con 10BaseT y 100BaseT.

3.14 Además el estándar especifica el soporte de enlaces de fibra multimodo con una longitud máxima de 500 metros, enlaces de fibra monomodo de hasta 2 Km, y enlaces de cobre de 25 metros como mínimo.

10 Gigabit Ethernet

3.15 La especificación de Ethernet a 10 Gigabit (10GE) es significativamente diferente en varios aspectos, a los primeros estándares Ethernet, principalmente en que solamente provee soporte para fibra óptica y opera en modo full-duplex. Lo cual significa que los protocolos de detección de colisiones no son necesarios.

3.16 Pero a pesar de escalar a 10 Gigabits por segundo, Ethernet conserva el formato de la trama y las capacidades actuales, de forma tal que no torna obsoletas a las inversiones en infraestructura de redes. 10GE es interoperable con otras tecnologías de networking, tales como SDH, haciéndose posible el tránsito de tramas Ethernet sobre trayectos SDH con muy alta eficiencia.

3.17 La expansión de Ethernet para su uso en redes de área metropolitana impulsa aún más el avance que la tecnología había experimentado con las redes a 1 Gbps., haciendo posible las conexiones Ethernet de extremo-a-extremo. Ethernet a 1 Gigabit ya ha sido desarrollada como tecnología de backbone para las redes metropolitanas con fibra oscura. Con las interfaces 10GE, transceptores ópticos y fibra monomodo, los proveedores de servicios podrán construir enlaces con un alcance mayor a los 40 Km.

4. DISPOSITIVOS DE LAN

4.1 Los dispositivos de red más utilizados son:

Repeaters

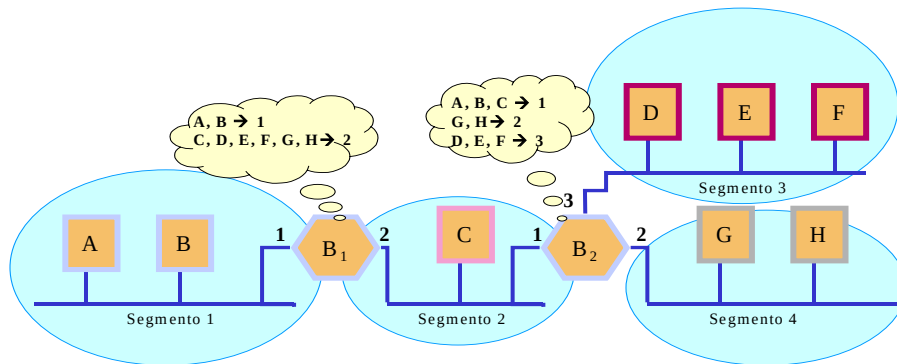
4.2 Un repetidor es un dispositivo de capa física utilizado para interconectar los segmentos de una red extendida. El repeater esencialmente se comporta posibilitando que varios segmentos de cable sean tratados como uno solo. Reciben señales de un segmento de red, las amplifican, re temporizan y las retransmiten hacia los demás segmentos. Estas acciones previenen el deterioro de las señales causadas por la longitud del cable y la cantidad de los dispositivos conectados.

Hubs

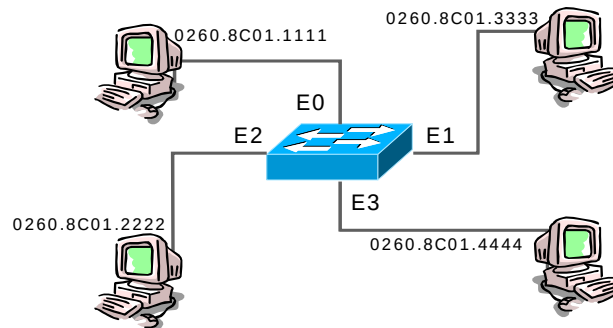
4.3 Un Hub es un dispositivo de capa física que conecta múltiples estaciones de usuario a través de un cable dedicado. Las conexiones eléctricas se establecen en el interior del Hub. Los Hubs crean una red física estrella, al mismo tiempo que mantienen la configuración lógica en bus o ring de la LAN. Podría decirse que el Hub funciona como un repeater multipuerto.

Bridges y Switches

4.4 Los bridges y switches³ son dispositivos que funcionan principalmente en la capa 2 del Modelo de Referencia OSI. (Dispositivos de capa de enlace de datos). Varios tipos de operaciones de bridging han tenido lugar en los escenarios de internetworking. Los bridges transparentes han sido principalmente aplicados en los entornos Ethernet, mientras que los bridges source-route se utilizaron en las redes Token Ring. Los bridges de capa MAC, están diseñados para operar entre redes homogéneas, mientras que otros pueden traducir diferentes protocolos de capa de enlace (por ejemplo IEEE 802.3 e IEEE 802.5).



4.5 Actualmente la tecnología de conmutación (switching) ha emergido como sucesor evolucionario en las soluciones de red. Superior performance, throughput, mayor densidad de puertos, menor costo por port y mayor flexibilidad son las características que contribuyeron al éxito de los switches para reemplazar a los bridges y complementar a los routers.



4.6 Los switches son significativamente más rápidos que los bridges porque la conmutación se implementa en hardware (existen switches store&forward, cut-through y fragment-free). Pueden interconectar redes Ethernet a 10, 100 y 1000 Mbps.

Full-Dúplex

4.7 El comportamiento en Half-Dúplex es requerido cuando las estaciones utilizan un hub Ethernet 10BaseT, el cual recrea un equivalente eléctrico del bus y las reglas CSMA/CD permanecen en efecto. Si la topología permite colisiones, entonces CSMA/CD debe ser utilizado para reaccionar a las mismas.

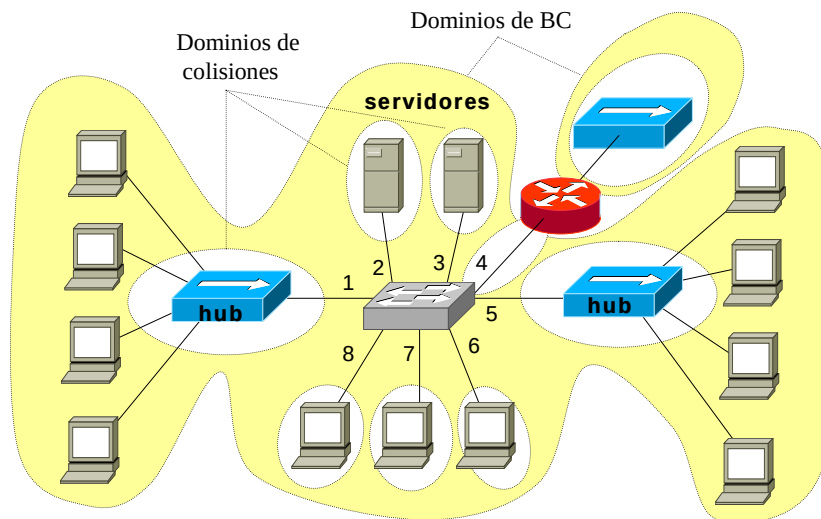
³ Aclaración: existen switches ATM, LAN switches, y varios tipos de switches de WAN.

4.8 La operación Full-Dúplex no es posible con un hub 10BaseT compartido, pero si es posible cuando se quita la posibilidad de que existan colisiones (como en un switch). Esto da origen a las redes switcheadas.

Colisiones y Broadcasts

4.9 Los diferentes dispositivos delimitan los dominios de colisiones y de broadcast.

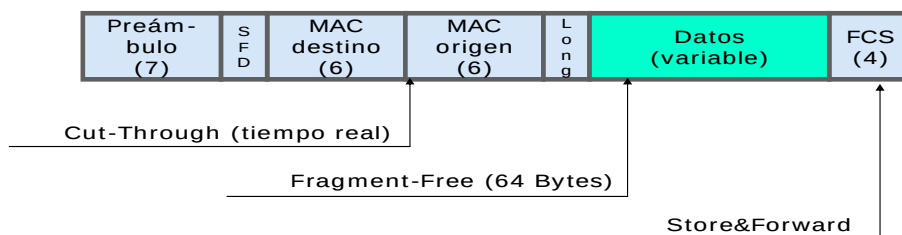
4.10 El **dominio de colisiones** está conformado por todas las placas de red que reciben una transmisión originada en ese dominio (en un hub son todas las interfaces conectadas a sus puertos). Ello provoca que mientras existan señales en el medio de transmisión, todas las otras estaciones deban postergar su chance de transmitir.



4.11 El **dominio de broadcast** está conformado por todas las interfaces de red que reciben una transmisión broadcast (bc) o multicast (mc) originada en el dominio (un bc trasciende a los hubs, bridges y switches, pero no a un router). En la figura se muestran los dominios de colisiones y de broadcast de una red formada por múltiples dispositivos.

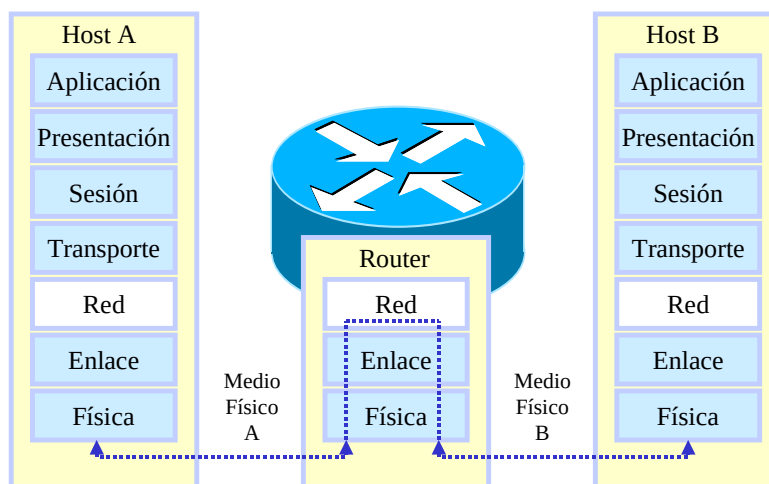
Tipos de operación

4.12 Entre las ventajas de los switches se encuentra la capacidad de operar en diferentes modos con relación al momento de transmisión de las tramas recibidas. **Store & Forward** es el modo tradicional más lento, en el cual el switch aguarda a recibir el frame completo, para chequear que todos los requisitos de forma están correctos antes de retransmitirlo. El modo **Cut-Through** es el más rápido, ya que una vez determinada la dirección de destino, el frame comienza a transmitirse inmediatamente por el puerto de salida, aunque sin posibilidad de chequear si la unidad reúne los requisitos de longitud, chequeo de errores, etc. Finalmente, el modo Fragment-Free, es un modo intermedio, en el cual el switch aguarda recibir el número mínimo de bits para asegurar que el mismo no constituye un “runt” (frame anormalmente corto, producto de una colisión o error de transmisión).



Routers

4.13 Una de las formas más usuales de interconectar LAN's y subredes en la actualidad es a través del uso de routers. Los routers se instalan en los puntos límites entre dos subredes físicas y/o lógicas. El routing es un método más sofisticado que el bridging para implementar el internetworking. En teoría, un router (o un conmutador de capa de red) puede oficiar de traductor entre una subred con un protocolo de capa física P1, un protocolo de capa de enlace de datos DL1, y un protocolo de capa de red N1, y otra subred con protocolo de capa física P2, un protocolo de capa de enlace de datos DL2, y un protocolo de capa de red N2. En general, un router se utiliza para interconectar redes que utilizan la misma capa de red, pero diferentes protocolos de capa de enlace.



4.14 Los routers permiten interconectar LAN's a través de WAN's, utilizando los servicios tradicionales (Líneas punto a punto, Frame Relay y ATM), y los nuevos servicios de redes IP/MPLS. Algunos routers operan directamente sobre SDH, y también pueden interconectar LAN's diferentes, tales como Token Ring, y Ethernet.

4.15 La utilización de los routers permite el establecimiento de redes diferentes, tanto física como lógicamente, cada una con su propio espacio de direcciones. Los métodos de enrutamiento se vuelven crecientemente sofisticados, a medida que las topologías crecen en tamaño y complejidad. Los protocolos de capa de red más comunes son IP, IPX, y AppleTalk, aunque la tendencia general está a favor de IP.

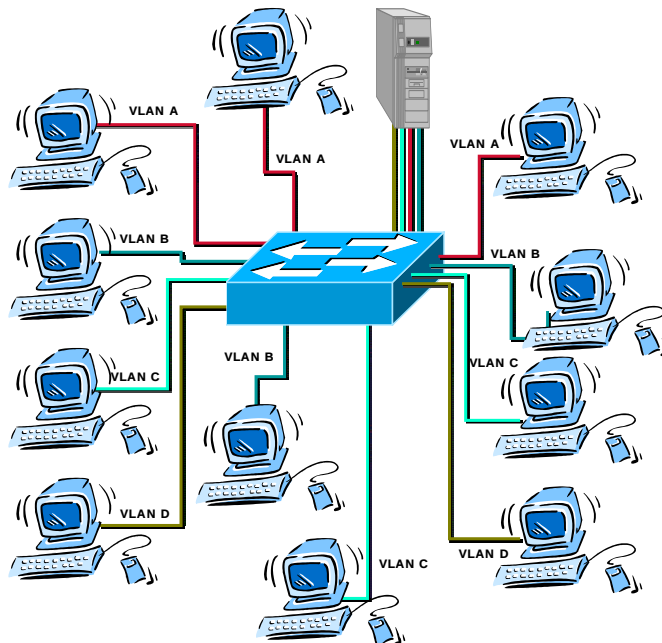
5. VLANs

5.1 Los switches segmentan el dominio de colisiones al máximo (solamente un dispositivo conectado en cada puerto, con la posibilidad de deshabilitar el control de colisiones y transmisión full dúplex). Sin embargo la performance de toda la red es vulnerable al exceso de cierto tipo de tráfico porque los switches propagan los bc y mc hacia todos sus puertos.

5.2 Una forma de limitar el alcance del tráfico mc y bc es a través de la configuración de VLANs (redes LAN virtuales). El soporte de VLAN's permite aislar redes dentro de un mismo switch (también puede extenderse a varios switches), impidiendo que los dispositivos conectados a puertos de VLANs diferentes puedan comunicarse (excepto que se integren a través de un router). El diseño de VLANs está basado en consideraciones de seguridad, performance, administración, etc.

5.3 La figura muestra un switch con soporte de VLANs en el que se han configurado 4 VLANs: A, B, C y D.

5.4 En este ejemplo, cada puerto del switch constituye un dominio de colisiones (en realidad no existirán colisiones, y su detección puede ser desactivada tanto en los dispositivos como en los puertos del switch). La diferencia substancial respecto al esquema del switch sin VLANs es que ahora cada VLAN constituye un dominio de broadcast (es decir que un bc o mc transmitido en la VLAN 2, por ejemplo, no será trasladado a las otras 3 VLANs).



5.5 Todas las terminales conectadas a los puertos pertenecientes a una misma VLAN podrán comunicarse, pero no podrán hacerlo con aquellas conectadas a VLANs diferentes.

5.6 Para posibilitar que todas las terminales puedan acceder al servidor, existen dos posibilidades:

5.6.1 Utilizar cuatro puertos del switch, cada uno perteneciente a una VLAN y conectarlos a 4 interfaces Ethernet instaladas en el servidor.

5.6.2 Utilizar una única interface con soporte de un protocolo de trunking (también soportado por el switch) para conectarla al puerto del switch que transporte el tráfico de todas las VLANs.

5.7 En ambos casos, si se habilita la función de routing en el servidor, también será posible que las terminales ubicadas en VLANs diferentes puedan comunicarse entre ellas.

6. REDES Y DISPOSITIVOS WAN

CARACTERÍSTICAS WAN

6.1 Las características más importantes de las WAN son:

6.1.1 Área geográfica extendida: la red opera más allá del campo geográfico local de una LAN y –generalmente- utiliza los servicios de un carrier para interconectar dispositivos sobre áreas globales.

6.1.2 Las WAN utilizan conexiones –interfaces- en serie de diversos tipos y velocidades para acceder al ancho de banda.

6.1.3 Proporcionan conectividad tanto full-time como part-time.

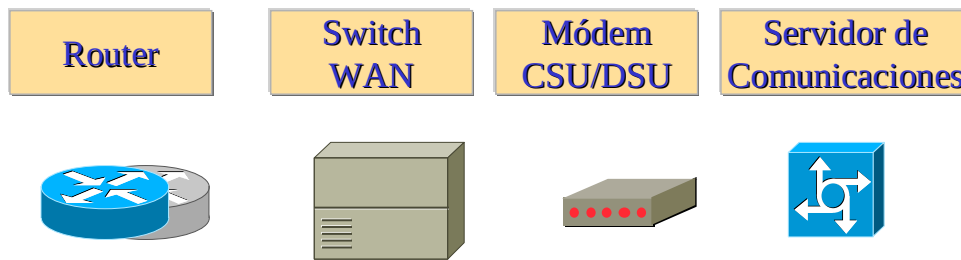
6.1.4 Por definición, una WAN conecta dispositivos separados por áreas amplias. Los dispositivos WAN incluyen:

6.1.4.1 *Routers* que ofrecen múltiples servicios incluyendo internetworking y puertos de interface para WAN.

6.1.4.2 *Switches* que se conectan al ancho de banda WAN para voz, datos y comunicación por video.

6.1.4.3 *Módems* que sirven de interface para servicios de grado de voz. Incluyen unidades de servicio de canal/unidades de servicio de datos (CSU/DSU) que sirven de interface para los servicios T1/E1; adaptadores de terminal/terminación de red (TA/NT), que sirven de interface para los servicios de red digital de servicios integrados (ISDN).

6.1.4.4 *Servidores de comunicaciones* que concentran la comunicación por conexión telefónica para el acceso de usuarios.



6.2 En las redes WAN se utiliza el método de la división en capas OSI para la encapsulación, al igual que las LAN.

TECNOLOGÍAS WAN

6.3 Las especificaciones de capa física de los protocolos WAN describen cómo proporcionar conexiones eléctricas, mecánicas, operativas y funcionales para los servicios de networking de área amplia. Estos servicios, generalmente, se obtienen de proveedores de servicio WAN (carriers).

6.4 Las especificaciones de *enlace de datos* de los protocolos WAN describen cómo se transportan los frames (o tramas) por una única ruta de datos establecida entre sistemas comunicantes. Incluyen protocolos designados para operar a través de servicios dedicados *punto-a-punto*, *multipunto*, y conmutados multiacceso tales como *Frame Relay*.

6.5 Los estándares WAN son definidos y administrados por una cantidad de autoridades reconocidas incluyendo a las siguientes organizaciones:

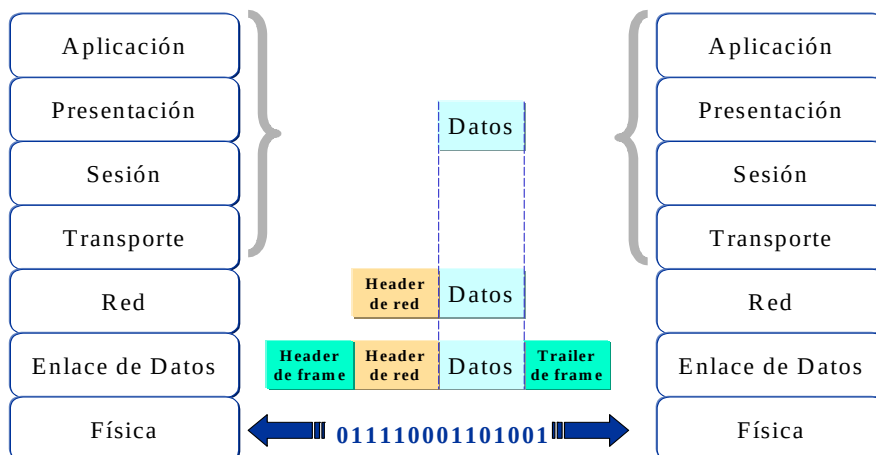
6.5.1 Unión Internacional de las Telecomunicaciones sector de Normalizaciones (ITU-T), ex Comité de Consultoría Internacional para Telefonía y Telegrafía (CCITT)

6.5.2 Organización Internacional para la Normalización (ISO)

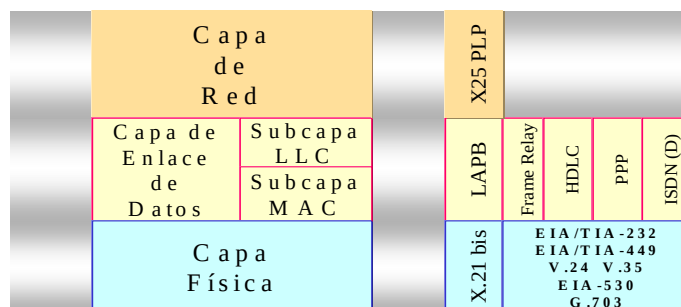
6.5.3 Internet Engineering Task Force (IETF)

6.5.4 Asociación de Industrias Electrónicas (EIA)

6.6 Los estándares y especificaciones de WAN describen tanto los métodos de entrega de la capa física como los requerimientos de la capa de enlace de datos incluyendo el direccionamiento y la encapsulación del flujo de datos. En la figura se muestran las unidades de datos genéricas de los protocolos de las capas inferiores.

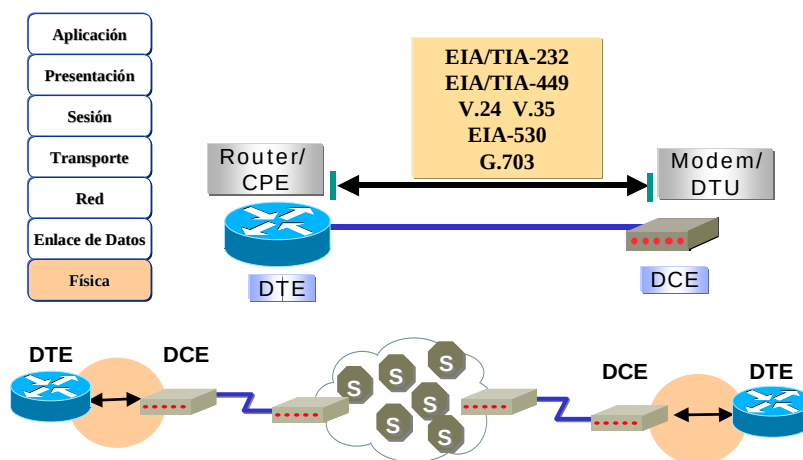


6.7 En la figura siguiente se muestra la pila de protocolos utilizados por las redes WAN.



Capa física

6.8 La capa física WAN describe la interface entre el equipo terminal de datos (DTE) y el equipo de comunicación de datos (DCE). Generalmente, el DCE es el proveedor de servicio, y el DTE el dispositivo conectado. Bajo este modelo, los servicios ofrecidos al DTE se disponen a través de un módem o unidad de servicio de canal/unidad de servicio de datos (CSU/DSU).



6.9 Los siguientes estándares de la capa física especifican estas interfaces:

6.9.1 EIA/TIA-232

6.9.2 EIA/TIA-449

6.9.3 V.24

6.9.4 V.35

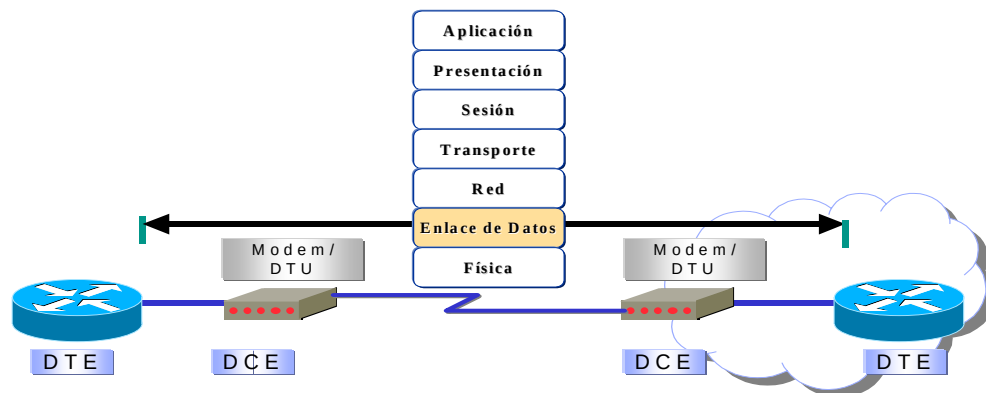
6.9.5 X.21

6.9.6 G.703

6.9.7 EIA-530

Capa de enlace de datos

6.10 A continuación se indican los protocolos de encapsulación de enlace de datos más comunes, asociados con las líneas síncronas en serie.



6.10.1 **Control de enlace de datos de alto nivel (HDLC)** - Un estándar ISO. HDLC podría no ser compatible entre diferentes fabricantes a causa de la forma en que cada fabricante haya decidido implementarlo. HDLC soporta tanto configuraciones punto a punto como multipunto.

6.10.2 **Frame Relay** - Utilizando un entramado simplificado sin mecanismos de control de error a través de facilidades digitales de alta calidad, Frame Relay puede transmitir datos muy rápidamente, en comparación con estos otros protocolos WAN.

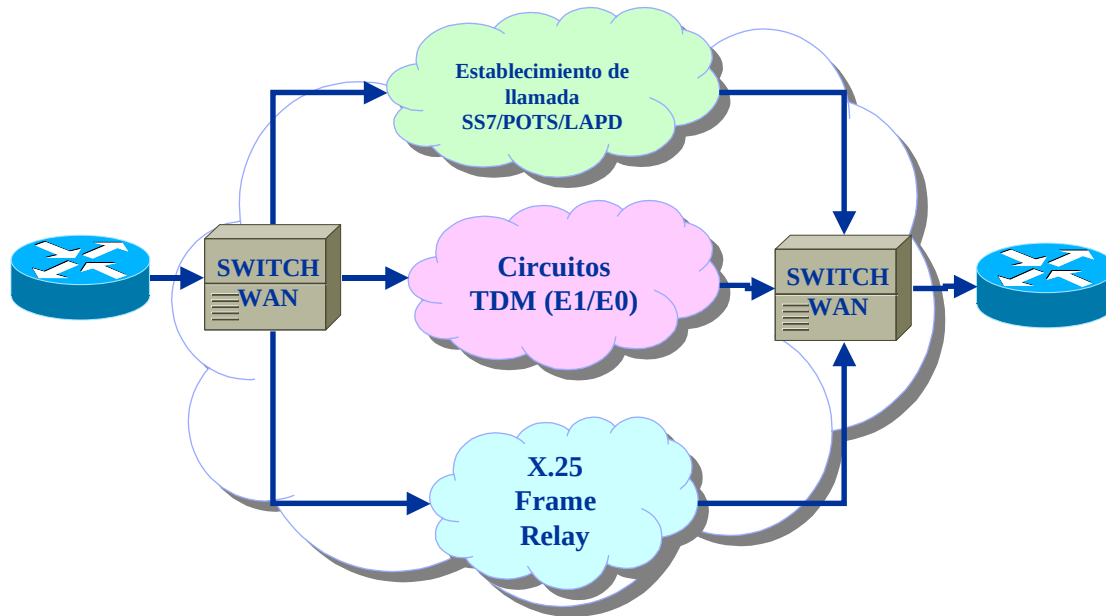
6.10.3 **Protocolo punto-a-punto (PPP)** - Descrito por RFC 1661, dos estándares desarrollados por la IETF. PPP contiene un campo de protocolo para identificar el protocolo de la capa de red.

6.10.4 **Red digital de servicios integrados (ISDN)** - Un conjunto de servicios digitales que transmite voz y datos a través de líneas telefónicas existentes.

7. SERVICIOS WAN

CLASIFICACIÓN DE LOS SERVICIOS

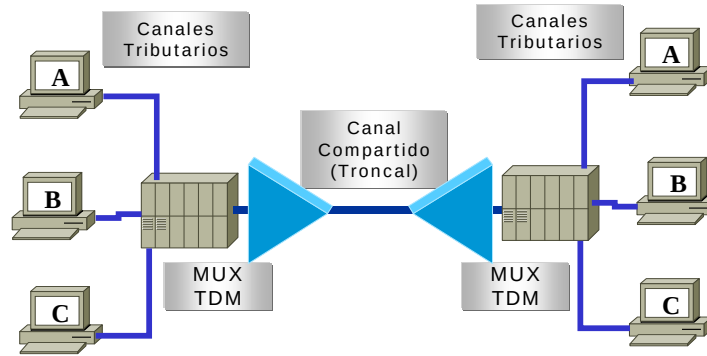
7.1 Como ha quedado expresado, una de las diferencias importantes de las WAN respecto de las LAN consiste en que para las primeras se debe contratar a un proveedor (carrier) para utilizar los recursos de transporte de la red.



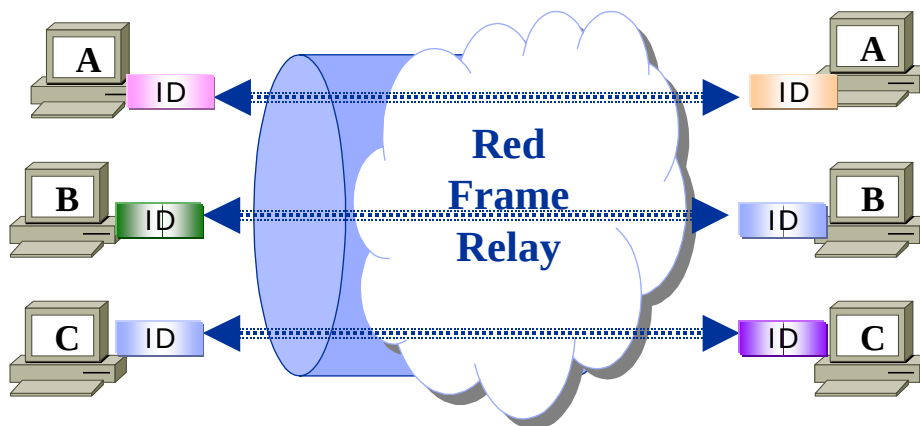
7.2 El servicio telefónico básico es el servicio WAN más comúnmente utilizado. El servicio telefónico y el servicio de datos se conectan desde el punto de presencia (POP) del edificio a la oficina central (CO) del proveedor WAN. Puede establecerse una clasificación preliminar de la “nube WAN”, la cual organiza a los servicios de proveedores WAN en tres tipos principales:

7.2.1 **Servicio de establecimiento de llamada** – Establece y libera las llamadas entre los usuarios telefónicos. El establecimiento de llamada más comúnmente utilizado es señalización por canal común número 7 (SS7). Utiliza mensajes y señales de control telefónico entre los puntos de transferencia a lo largo del camino hacia el destino llamado.

7.2.2 **Multiplexación por división de tiempo (TDM)**—Información proveniente de muchas fuentes posee una ubicación de ancho de banda en un único medio. La conmutación de circuitos utiliza la señalización para determinar la ruta de la llamada, que es una ruta dedicada entre el emisor y el receptor. Con la multiplexación del tráfico en divisiones de tiempo fijas, TDM evita facilidades congestionadas y retrasos variables. El servicio telefónico básico y la red digital de servicios integrados (ISDN) utilizan circuitos TDM.

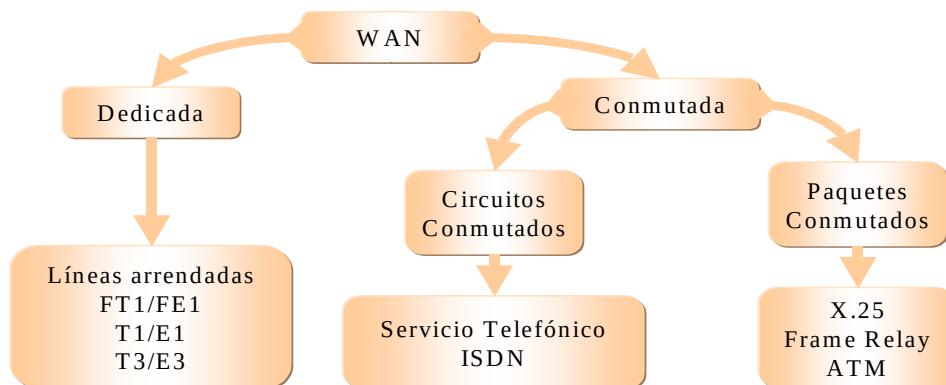


7.2.3 **Servicios de Conmutación de Paquetes** (tal como X.25 o Frame Relay). La información contenida en paquetes o frames comparte ancho de banda no dedicado con otros frames WAN del suscriptor. La conmutación de paquetes X.25 utiliza enrutamiento de capa 3 con el direccionamiento de emisor y receptor contenidos en el paquete. X.25 puede utilizar circuitos virtuales conmutados (SVCs), con algún retraso inicial para el establecimiento de la llamada, o circuitos virtuales permanentes (PVCs), que evitan los retrasos para el establecimiento de la llamada. Frame Relay utiliza identificadores de capa 2 y circuitos virtuales permanentes (PVCs).



TECNOLOGÍAS

7.3 Existen dos tipos de opciones generales para el networking de área amplia: líneas dedicadas o conexiones conmutadas. Las conexiones conmutadas, a su vez, pueden ser de circuitos conmutados o de paquetes/celdas conmutadas.



7.4 Los enlaces de una red de área amplia pueden ordenarse al proveedor WAN a diversas velocidades que se enuncian en capacidad de bits por segundo (bps). Esta capacidad en bps determinará cuán rápidamente pueden transmitirse los datos a través del enlace.

7.5 El ancho de banda WAN se provee en nuestro medio, Europa y Japón en base a las jerarquías digitales PDH y SDH. El término E1, es el primer nivel de multiplexación de la jerarquía PDH, y se refiere a una señal de 2,048 Mbps.

7.6 Una jerarquía similar se ha desarrollado en los Estados Unidos, donde cada formato se denomina señal digital (DS). El término T1 suele utilizarse coloquialmente para referirse a la señal DS1. El término T3 suele utilizarse para referirse a la señal DS3.

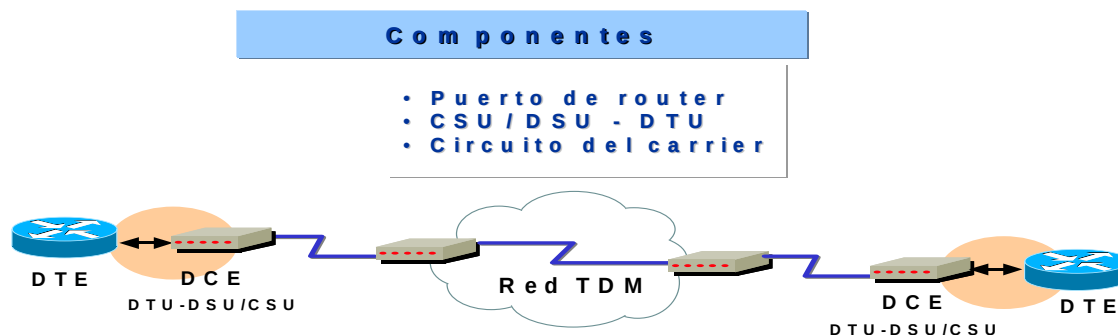
Servicio de líneas dedicadas

7.7 Las líneas dedicadas -o líneas arrendadas- proporcionan un servicio full-time. Las velocidades de transmisión pueden ascender hasta una velocidad E3 (34,364 Mbps), o mayor, pero comúnmente son E1 (2,048 Mbps) o E1 Fraccional (incrementos de 64 kbps o n64Kbps).

7.8 Las líneas dedicadas se utilizan generalmente para transportar datos, voz y video. En el diseño de la red de datos, las líneas arrendadas proporcionan generalmente conectividad principal entre sitios o campus importantes, y conectividad de LAN a LAN.

7.9 Cuando se efectúan conexiones de líneas arrendadas, se requiere un puerto de router para cada conexión, además de una CSU/DSU y el circuito existente del proveedor de servicio.

7.10 El costo de las soluciones de líneas dedicadas puede volverse significativo cuando se lo emplea para conectar muchos sitios, lo cual es especialmente cierto si lo que se desea es emplear una red mallada completa. La conectividad dedicada, full-time, es proporcionada por enlaces en serie punto a punto.



7.11 Las conexiones se efectúan utilizando los puertos seriales sincrónicos del router con un uso típico del ancho de banda de hasta 2 Mbps (E1) disponible a través del uso de una unidad de servicio de canal/unidad de servicio de datos (CSU/DSU). La utilización de diferentes métodos de encapsulación en la capa de enlace de datos proporciona **flexibilidad y fiabilidad** para el tráfico de los usuarios.

7.12 Las líneas arrendadas de este tipo son ideales para ambientes de alto volumen con un patrón de tráfico de velocidad constante. *El uso del ancho de banda disponible es una preocupación puesto que el costo de la línea se paga aún cuando la conexión esté inactiva.*

Servicio de circuitos conmutados

7.13 Las conexiones de circuitos conmutados de un sitio a otro se establecen a la demanda, solamente cuando es necesaria una comunicación y son generalmente de bajo ancho de banda. Las conexiones del servicio telefónico básico se limitan generalmente a 33,6 Kbps. sin compresión, e ISDN a 64 ó 128 Kbps.

7.14 Las conexiones por circuitos conmutados se utilizan principalmente para conectar usuarios remotos y móviles a LANs corporativas. También se destacan como líneas de respaldo para circuitos primarios de mayor velocidad, tales como Frame Relay y líneas dedicadas.

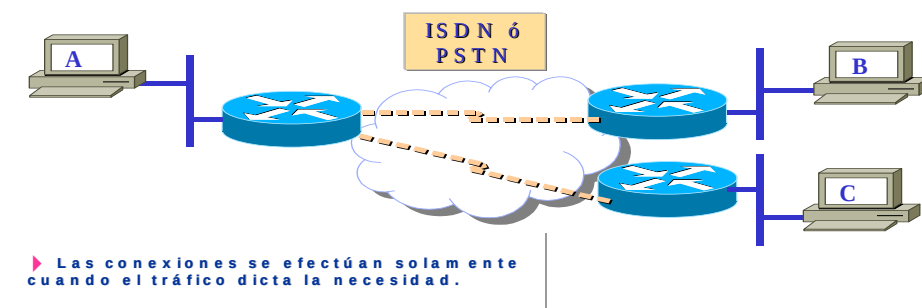
Enrutamiento por llamada bajo demanda

7.15 El enrutamiento por llamada telefónica bajo demanda (DDR) significa que la conexión se efectúa sólo cuando un tipo de tráfico específico inicia la llamada, o cuando es necesario un enlace de respaldo. Estas llamadas de circuitos conmutados, generalmente, tienen lugar sobre redes ISDN.

7.16 DDR es un sustituto ideal para las líneas arrendadas cuando no se requiere la disponibilidad full-time del circuito, como en los siguientes casos:

7.16.1 Cuando los patrones de tráfico son de bajo volumen o periódicos. Las llamadas tienen lugar y las conexiones se establecen sólo cuando el router detecta tráfico marcado como "interesante". Debe evitarse que los broadcasts periódicos, tales como las actualizaciones de protocolo de enrutamiento, disparen llamadas.

7.16.2 Cuando es necesaria una conexión de respaldo para redundancia o carga compartida. El DDR puede utilizarse para proporcionar carga compartida y/o interface de respaldo. Por ejemplo, se pueden tener varias líneas en serie, pero sólo se desea utilizar la línea secundaria cuando la primaria se encuentre muy ocupada, de modo de compartir la carga. Cuando las líneas WAN se utilizan para aplicaciones críticas, pueden configurarse líneas DDR secundarias –de habilitación automática- como backup, en caso de que las líneas principales queden fuera de servicio.



ISDN

7.17 ISDN fue desarrollada por las compañías telefónicas con la intención de crear una red totalmente digital.

Generalidades

7.18 ISDN incluye a los siguientes dispositivos:

7.18.1 **Equipo terminal 1 (TE1)** — Designa a un dispositivo que es compatible con la red ISDN. Un TE1 se conecta a una terminación de red de tipo 1 ó 2 (NT1/NT2).

7.18.2 **Equipo terminal 2 (TE2)** — Designa a un dispositivo que no es compatible con ISDN y requiere un adaptador de terminal (TA).

7.18.3 **Adaptador de terminal (TA)** — Convierte las señales eléctricas estándar a la forma utilizada por ISDN de modo tal que los dispositivos no ISDN puedan conectarse a la red ISDN.

7.18.4 **Terminación de red de tipo 1 (NT1)** — Conecta el cableado del suscriptor ISDN de 4 alambres a la facilidad de bucle local convencional de 2 alambres.

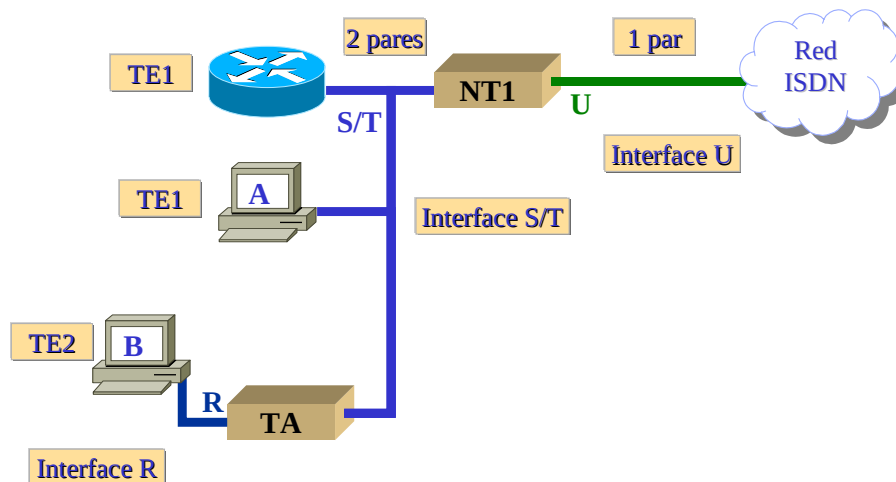
7.18.5 **Terminación de red de tipo 2 (NT2)** — Dirige el tráfico hacia y desde diferentes dispositivos de suscriptor y la NT1. La NT2 es un dispositivo inteligente que efectúa la conmutación y la concentración (por ejemplo una PBX).

7.19 Los puntos de referencia separan a los grupos funcionales de ISDN, y definen los límites de las siguientes interfaces:

7.19.1 La interface S/T define el límite funcional entre un TE1 y el NT. La S/T se utiliza también para definir la interface TA a NT.

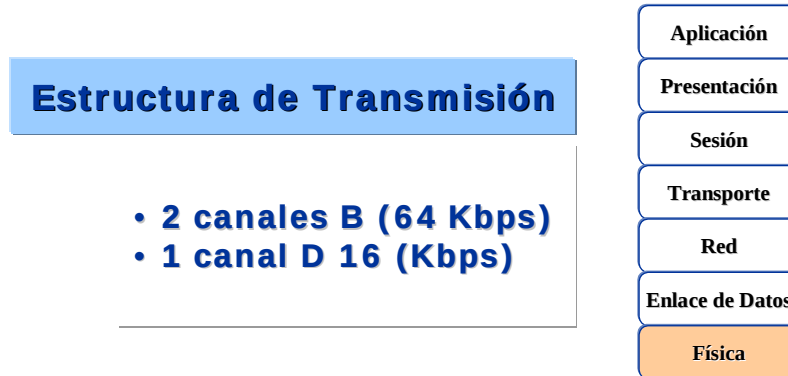
7.19.2 La interface R define a la interface entre un TE2 y el TA.

7.19.3 La interface U define a la interface de 2 alambres entre la NT y la "nube" ISDN.

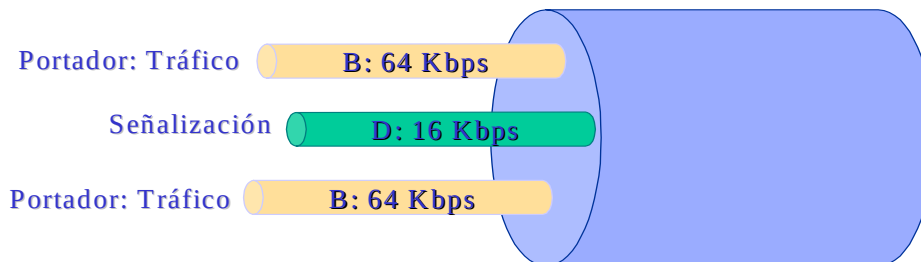


Estructura de transmisión ISDN

7.20 La estructura de transmisión corresponde a la organización de los canales sobre el loop local para acceder a los servicios de soporte. Existen dos estructuras entre el usuario y la central ISDN: la interface de acceso básico (BRI) y la interface de acceso principal (PRI).



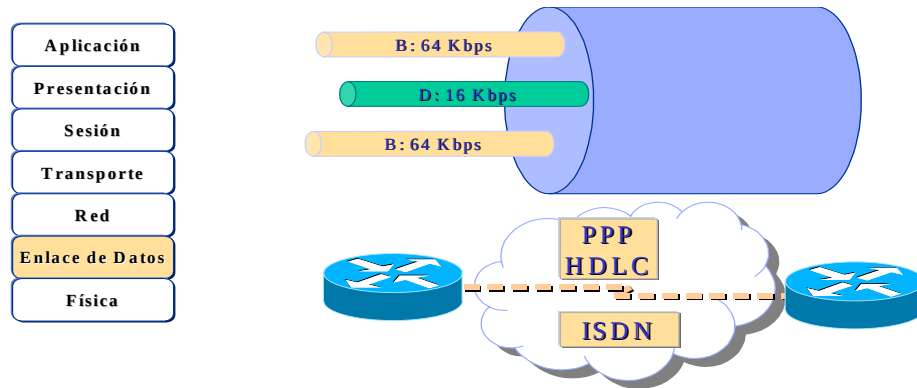
7.21 ISDN BRI opera sobre la mayor parte del cableado de cobre correspondiente al plantel exterior telefónico que existe hoy en día, y entrega un ancho de banda total de una línea de 144-kbps en tres canales separados. Dos de los canales, llamados canales B (portadores), operan a 64 kbps y se utilizan para transportar voz o tráfico de datos. El tercer canal, llamado canal D (datos), es un canal de señalización de 16-kbps utilizado para transportar instrucciones que le indican a la red telefónica cómo manejar cada uno de los canales B. ISDN BRI se denomina a menudo "2B+D."



7.22 ISDN provee de una gran flexibilidad al diseñador de red a causa de su capacidad para utilizar cada uno de los canales B para voz o aplicaciones de datos separadas; por ejemplo, un documento largo podría descargarse de la red corporativa a través de uno de los canales B ISDN de 64-kbps mientras que el otro canal B se está utilizando para examinar una página de la World Wide Web. También podría utilizarse un acceso PRI, con 30 canales B (64 Kbps.) y 1 canal D (64 Kbps.).

Encapsulación de enlace de datos ISDN

7.23 Al emplear soluciones de acceso remoto, están disponibles varias opciones de encapsulación, aunque la de uso más común es el protocolo punto a punto (PPP).

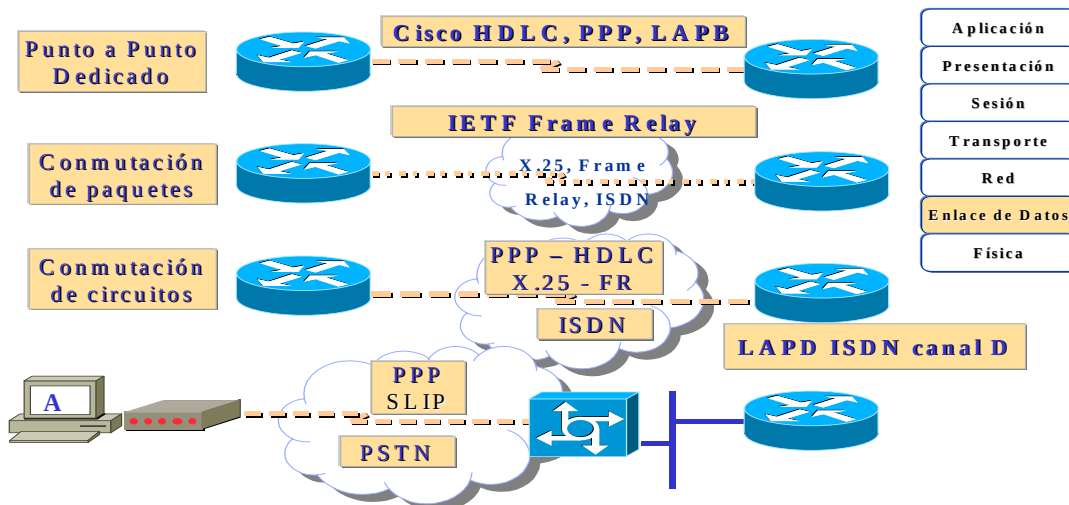


REDES DE CONMUTACIÓN DE PAQUETES

7.24 Las redes conmutadas pueden transportar frames (paquetes) de tamaño variable o celdas de tamaño fijo. El tipo más común de red de paquetes conmutados es Frame Relay. Frame Relay fue diseñada teniendo en mente una velocidad alta y enlaces más fiables. Como resultado, Frame Relay posee una cantidad limitada de características de verificación de errores y fiabilidad. Se espera que los protocolos de capas superiores atiendan estos problemas.

PROTOCOLOS DE ENCAPSULACIÓN WAN

7.25 Cada tipo de conexión WAN utiliza un protocolo de la capa 2 para encapsular⁴ el tráfico mientras éste cruza el enlace WAN. La elección del protocolo de encapsulación depende de la tecnología WAN y el equipo de comunicaciones.



7.25.1 **HDLC**—El tipo de encapsulación por defecto de Cisco en enlaces punto a punto. Se utiliza típicamente al comunicarse con otro dispositivo Cisco. Si la comunicación se está efectuando con un dispositivo no Cisco, la opción más viable puede ser PPP síncrono.

⁴ **Encapsulación** - Envoltura de datos en un encabezado de protocolo particular. Por ejemplo, los datos de Ethernet se envuelven en un encabezado específico de Ethernet antes de su tránsito por la red.

Tunneling - Arquitectura que está destinada a proveer los servicios necesarios para implementar cualquier esquema de encapsulación punto a punto estándar.

7.25.2 **LAPB** (capa 2 del protocolo X.25) – Para las redes de conmutación de paquetes. También puede utilizarse sobre enlaces punto a punto, si el enlace no es fiable o si existe un retraso inherente asociado con el enlace, tal como en el caso de un enlace satelital. LAPB proporciona fiabilidad y control de flujo sobre una base punto a punto.

7.25.3 **PPP**—Común para el acceso por discado telefónico de usuario único a LAN o de LAN a LAN (router a router). PPP está estandarizado, de modo que soporta interoperabilidad entre fabricantes. También soporta la encapsulación de varios protocolos de capa superior incluyendo IP e IPX.

7.25.4 **FR Cisco/IETF**—Utilizado para encapsular tráfico Frame Relay. La opción cisco es propietaria y puede utilizarse sólo entre routers Cisco.

7.26 Se destacan entonces cuatro diferentes métodos de encapsulación de líneas en serie. Aunque presentan características distintas, todas comparten un formato de frame común, como se muestra para HDLC, LAPB y PPP –y en el próximo MD, se realizará para Frame Relay-.



7.27 El frame contiene los siguientes campos:

7.27.1 **Flag**—Indica el principio del frame y se lo determina con el patrón hexadecimal de 7F.

7.27.2 **Dirección**—Un campo de uno o dos bytes para direccionar la estación extrema en ambientes multidrop.

7.27.3 **Control**—Indica si el frame es de tipo de información, de supervisión, o sin numerar. Contiene también códigos de función específicos.

7.27.4 **Datos**—Los datos encapsulados.

7.27.5 **FCS**— (*Frame check secuencia*) La secuencia de verificación de frames.

7.27.6 **Flag**—El identificador de flag 7E de trailer.

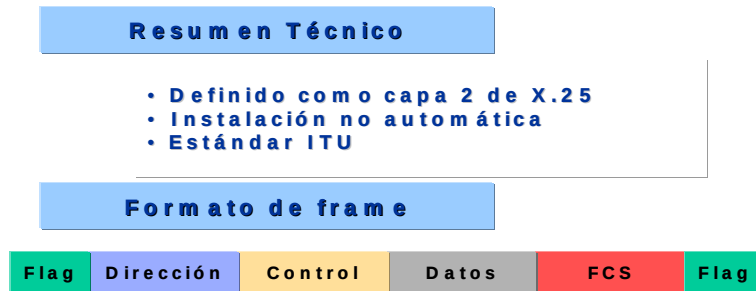
ENCAPSULACIÓN HDLC CISCO

7.28 **HDLC**⁵ es el método de encapsulación por defecto de Cisco para líneas en serie. Esta es una implementación muy reducida para su optimización. No hay windowing⁶ o control de flujo⁷, y sólo se permiten conexiones punto a punto (no multipunto).

⁵ **HDLC** - (*High-Level Data Link Control*) Control de enlace de datos de alto nivel. Protocolo de la capa de enlace de datos, orientado a bit y síncrono desarrollado por ISO. Proveniente de SDLC, HDLC especifica un método de encapsulación de datos sobre enlaces en serie síncronos que utilizan caracteres de frame y checksums. Véase también [SDLC](#).

⁶ **Ventana** - Número de octetos que el remitente desea aceptar, o que el transmisor puede enviar sin reconocimiento.

El campo de dirección siempre se define como todos unos. Además, se inserta un código de tipo propietario de 2 bytes después del campo de control, lo cual significa que el entramado HDLC no es interoperable con equipos de otros fabricantes.



ENCAPSULACIÓN LAPB

7.29 LAPB (Link Access Procedure Balanced) es el protocolo estándar de capa 2 definidos por X.25.

7.30 Posee dos direcciones que identifican si la trama es un comando o respuesta. No posee campo Tipo.

ENCAPSULACIÓN PPP

7.31 El protocolo punto a punto⁸ (PPP) es un método estándar (RFC 1332, 1661) de encapsulación de línea en serie, el cual incluye un campo de tipo protocolo junto con un protocolo de control de enlace. Este protocolo puede, entre otras cosas, verificar la calidad del enlace durante el establecimiento de la conexión.

7.32 Además, existe soporte para la autenticación a través del Password Authentication Protocol⁹ (PAP) y el Challenge Handshake Authentication Protocol¹⁰ (CHAP).

⁷ **Control del flujo** - Técnica utilizada para garantizar que una entidad transmisora, tal como un módem, no sobrecargue a una entidad receptora con datos. Cuando los buffers del dispositivo receptor están llenos, se envía un mensaje al dispositivo transmisor para que suspenda la transmisión hasta que se hayan procesado los datos en los buffers. En redes IBM, esta técnica se llama *padding*.

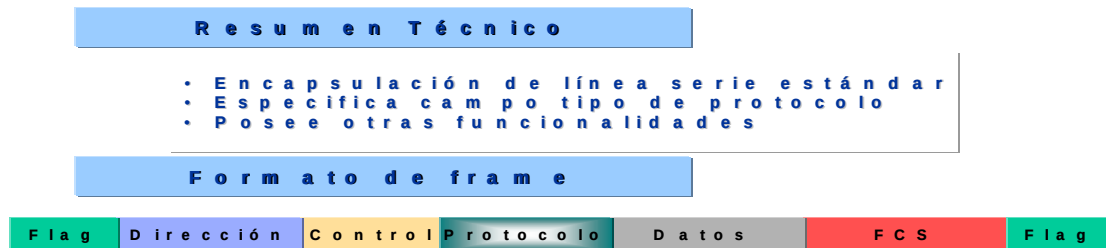
⁸ **PPP** - (*Point-to-Point Protocol*) Protocolo punto a punto. Un sucesor de SLIP, PPP brinda conexiones router a router y host a red sobre circuitos síncronos y asíncronos. Véase también [SLIP](#).

⁹ **PAP** (*Password Authentication Protocol*) - Protocolo PAP. Protocolo de autenticación que permite a los peers PPP autenticarse unos con otros. Se requiere que el router remoto que intenta conectarse al router envíe una solicitud de autenticación. A diferencia de CHAP, PAP pasa la contraseña y nombre de host o nombre de usuario en la zona libre (no cifrada). PAP no evita por sí mismo el acceso no autorizado, sino que simplemente identifica el extremo remoto. El router o servidor de acceso luego determina si se permite el acceso de ese usuario. PAP es soportado solamente en líneas PPP. Compárese con [CHAP](#).

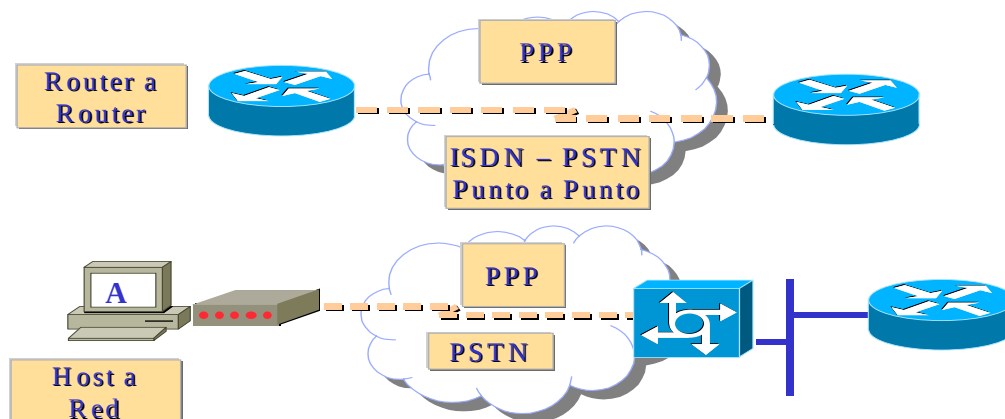
¹⁰ **CHAP** (*Challenge Handshake Authentication Protocol*) - Característica de seguridad soportada por líneas que utilizan encapsulación PPP que evita el acceso no autorizado. CHAP no evita por sí mismo el acceso no autorizado, simplemente identifica el extremo remoto. El router o servidor de acceso determina luego si se le permite el acceso a ese usuario. Compárese con [PAP](#).

7.33 El protocolo punto a punto (PPP) es considerado generalmente como el sucesor del protocolo Serial Line IP (SLIP). PPP proporciona conexiones router a router y host a red a través de circuitos tanto síncronos como asíncronos.

7.34 PPP emergió a finales de la década del '80 en respuesta a una falta de protocolos de encapsulación para la Internet que impedía el crecimiento del acceso en línea en serie. PPP se creó básicamente para



Resolver problemas de conectividad remota a Internet. PPP soporta a diversos protocolos de capa de red, incluyendo a Novell IPX, TCP/IP y AppleTalk.



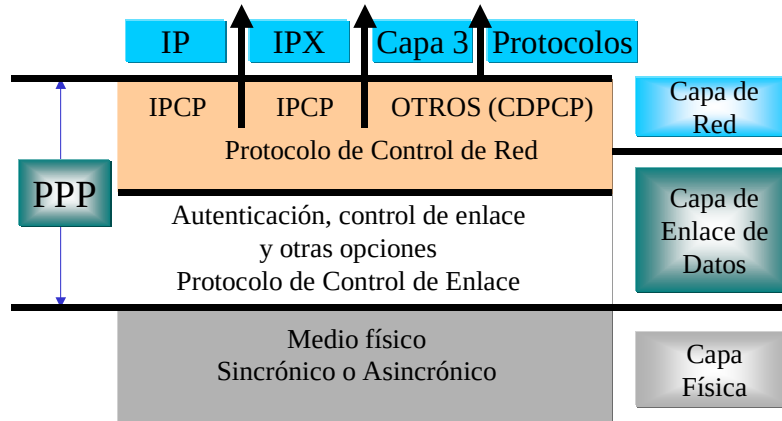
Elementos PPP

7.35 PPP utiliza una arquitectura en capas. Con sus funciones de nivel más bajo, PPP puede utilizar:

7.35.1 Medios físicos síncronos tales como los que conectan a ISDN.

7.35.2 Medios físicos asíncronos tales como los que utiliza el servicio telefónico básico para efectuar conexiones telefónicas vía módem.

7.36 PPP ofrece un rico conjunto de servicios que controlan el establecimiento de un enlace de datos.



7.37 Estos servicios son opciones en LCP y son principalmente la negociación y la verificación de frames para implementar los controles punto a punto que un administrador especifique para la llamada.

7.38 Con sus funciones de nivel más alto, PPP transporta paquetes desde varios protocolos de capa de red en NCPs. Estos son campos funcionales que contienen códigos estandarizados para indicar el tipo de protocolo de capa de red que encapsula PPP.

Operación de PPP

7.39 PPP corre en los siguientes tipos de interfaces físicas WAN:

7.39.1 ISDN

7.39.2 Asincrónica serie

7.39.3 Sincrónica serie

7.40 PPP utiliza otro de sus componentes más importantes, el protocolo de control de enlace (LCP), para negociar y establecer opciones de control en el enlace de datos WAN. PPP utiliza su componente programas de control de la red (NCP) para encapsular diferentes protocolos.

7.41 La transmisión de datagramas PPP emplea tres componentes clave para proporcionar una transmisión de datos efectiva:

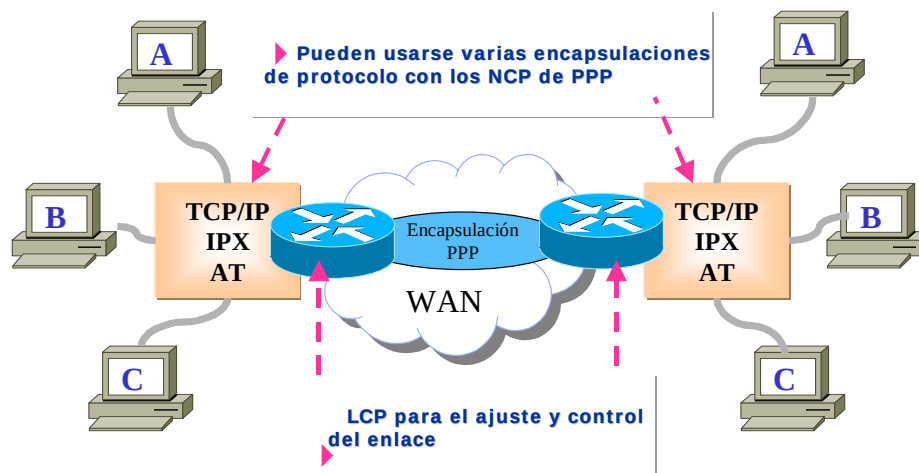
7.41.1 **Encapsulación** - PPP soporta el protocolo de control de enlace de datos de alto nivel (HDLC) para proporcionar encapsulación.

7.41.2 **Protocolo de control de enlace (LCP)** - Se utiliza un LCP extensible para establecer, configurar, y probar la conexión del enlace de datos.

7.41.3 **Protocolos de control de la red (NCP)** - Una familia de NCPs se utiliza para establecer y configurar diferentes protocolos de capa de red.

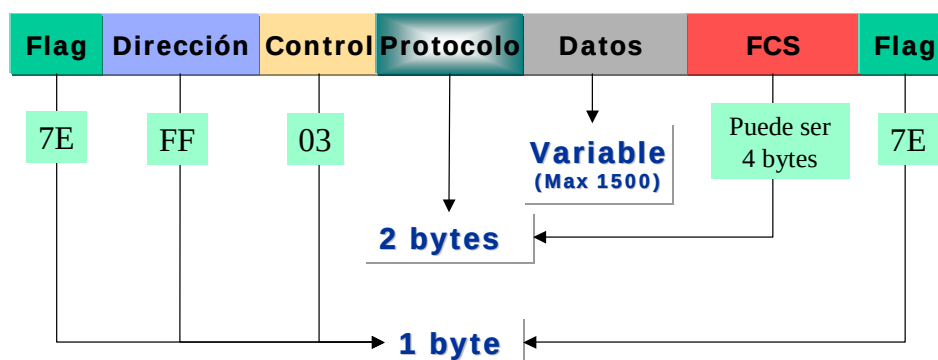
7.42 Las conexiones PPP se establecen en etapas. Un nodo PPP originante envía primero frames LCP para configurar y probar el enlace de datos. A continuación, se establece el enlace, y se negocian las facilidades.

7.43 El nodo PPP originante envía entonces frames NCP para elegir y configurar protocolos de capa de red. Los protocolos de capa de red elegida, tales como TCP/IP, Novell IPX y AppleTalk, se configuran, y se envían los paquetes desde cada protocolo de capa de red.



Formato de frame PPP

7.44 El frame PPP presenta el siguiente formato de campos;



7.44.1 **Flag** - Indica el comienzo o el final de un frame y consiste en la secuencia binaria 01111110.

7.44.2 **Dirección** - Consiste en la dirección de broadcast estándar, secuencia binaria 11111111. PPP no asigna direcciones de estaciones individuales.

7.44.3 **Control** - 1 byte que consiste en la secuencia binaria 00000011, que llama a la transmisión de los datos del usuario en un frame no secuencial. Se proporciona un servicio de enlace sin conexión similar al control de enlace lógico (LLC) tipo 1.

7.44.4 **Protocolo** - 2 bytes que identifican al protocolo encapsulado en el campo de información del frame. Los valores más actualizados del campo de protocolo se especifican en la petición de comentarios (RFC) de los números asignados más recientes.

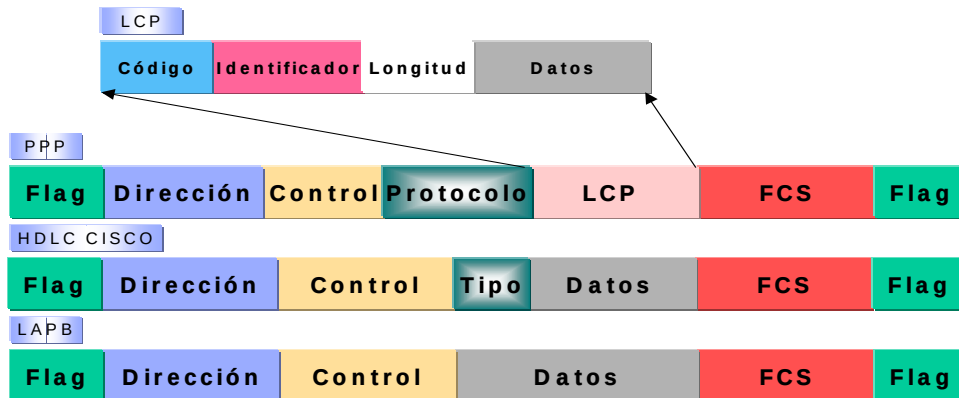
7.44.5 **Datos** - Cero o más bytes que contienen el datagrama para el protocolo especificado en el campo de protocolo. El final del campo información se halla localizando la secuencia del flag de cierre y permitiendo 2 bytes para el campo FCS. La longitud máxima por defecto del campo de información es de 1.500 bytes. Por acuerdo previo, las implementaciones de consentimiento PPP pueden utilizar otros valores para la longitud máxima del campo de información.

7.44.6 **Secuencia de verificación de frames (FCS)** - Normalmente 16 bits (2 bytes). Por acuerdo previo, las implementaciones de consentimiento PPP pueden utilizar una FCS de 32 bits (4 bytes) para una detección de errores perfeccionada.

7.44.7 **Nota** - El protocolo de control de enlace (LCP) PPP puede negociar modificaciones a la estructura de frames PPP estándar. No obstante, los frames modificados serán claramente distinguibles de los frames estándar.

Resumen de Formatos de frames WAN

7.45 El siguiente esquema muestra el resumen de los formatos de frame de los protocolos de encapsulación.



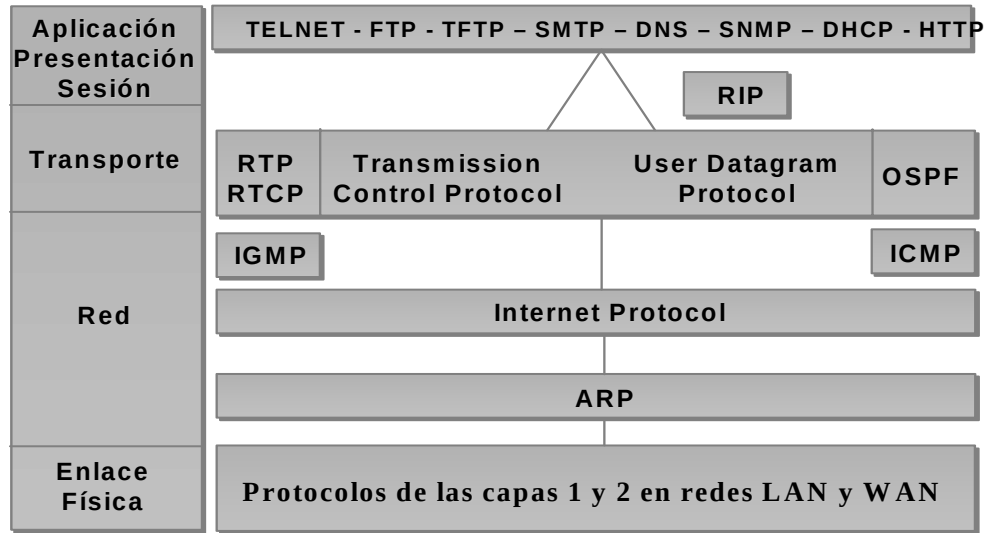
7.46 La siguiente tabla ofrece una síntesis comparativa de los protocolos de enlace de datos más comunes.

Tecnología WAN	Protocolo de Encapsulación	Notas
Dedicado Punto a Punto	> HDLC > LAPB > PPP > Frame Relay	Puede ser cualquier protocolo configurado en ambos extremos.
Conmutación de Paquetes	> Frame Relay > X.25 > ATM	Debe ser el mismo protocolo de la red del carrier.
ISDN	> PPP > X.25 > Frame Relay	En canal D: LAPD. En canal B: cualquiera (similar al punto a punto).
PSTN	> Normalmente PPP > Antiguamente SLIP	Una vez establecido es un punto a punto. Para acceder a Internet PPP.

8. FUNDAMENTOS DE REDES

8.1 El networking evoluciona para soportar tanto las aplicaciones actuales como las futuras. El modelo de referencia OSI organiza las funciones de la red en siete capas. Sin embargo, el “modelo de referencia TCP/IP” solamente establece 4 capas, las que pueden mapearse sobre el primero.

8.2 Los datos fluyen desde las aplicaciones del usuario de nivel superior hasta los bits de menor nivel que se transmiten a través de los medios de red. Las funciones peer-to-peer utilizan la encapsulación y la desencapsulación en las interfaces de las diferentes capas.



8.3 Las principales características de una LAN son:

8.3.1 La red opera dentro de un edificio o dentro del mismo piso de un edificio (extendiéndose hacia el ámbito metropolitano).

8.3.2 Las LAN proporcionan a los diversos dispositivos conectados (generalmente PC) acceso a medios de gran ancho de banda.

8.3.3 Por definición, la LAN conecta computadoras y servicios sobre un medio común.

8.3.4 Los dispositivos de una LAN incluyen: *Bridges* (conectan los segmentos de la LAN y ayudan a filtrar el tráfico), *Hubs* (concentran la conexión a la LAN y permiten el uso de medios de cobre de par trenzado), *Switches Ethernet* (brindan ancho de banda dedicado full duplex a los segmentos o computadoras) y *Routers* que ofrecen muchos servicios entre los cuales se incluyen internetworking y control de broadcasts.

8.4 Los protocolos de la **capa física** de las WAN describen cómo suministrar conexiones eléctricas, mecánicas, operacionales y funcionales para los servicios de WAN. Estos servicios a menudo se obtienen de proveedores de servicios de WAN (carriers).

8.5 Los protocolos de **enlace de datos** de las WAN describen cómo se transportan las tramas entre sistemas a través de un solo enlace de datos. Incluyen protocolos diseñados para operar a través de servicios conmutados dedicados punto a punto, multipunto y multiacceso, como Frame Relay.

8.6 Los estándares de las WAN han sido definidos y administrados por diferentes autoridades reconocidas, tales como las siguientes:

8.6.1 Sector de Normalización de las Telecomunicaciones de la Unión Internacional de Telecomunicaciones (UIT-T), antiguamente denominado Comité Consultivo Internacional Telegráfico y Telefónico (CCITT).

8.6.2 Organización Internacional de Normalización (ISO).

8.6.3 Fuerza de Tareas de Ingeniería de Internet (IETF).

8.6.4 Asociación de Industrias Electrónicas (EIA).

8.7 Normalmente los estándares de WAN describen los requisitos de la capa física y de la capa de enlace de datos (y a veces de red). La capa física de las WAN describe la interfaz entre el equipo terminal de datos (DTE) y el equipo de terminación de circuito de datos (DCE). Normalmente el DCE es el proveedor del servicio, mientras que el DTE es el dispositivo conectado. En este modelo, los servicios ofrecidos al DTE están disponibles a través de un módem o CSU/DSU.

8.8 En la siguiente figura se observa la relación de los protocolos de las capas 1 y 2, en redes LAN y WAN:

OSI	LAN				WAN			
Enlace	Ethernet	802.2 LLC			HDLC	PPP	LAP B	SDL C
Física		802.3	802.5	FDDI	V.24 – EIA/TIA232 – G703 V.35 - EIA/TIA449 - HSSI			

8.8.1 **Control de Enlace de Datos de Alto Nivel (HDLC):** un estándar IEEE que probablemente no sea compatible con los distintos proveedores, ya que cada proveedor puede haberlo implementado de diferentes maneras. HDLC soporta configuraciones punto a punto y multipunto con un gasto mínimo.

8.8.2 **Frame Relay:** Usa instalaciones digitales de alta calidad y entramado simplificado sin mecanismos de corrección de errores, lo que significa que puede enviar información de Capa 2 mucho más rápidamente que otros protocolos de WAN.

8.8.3 **Protocolo Punto a Punto (PPP):** Descrito por RFC 1661. Dos estándares desarrollados por el IETF. Contiene un campo de protocolo para identificar el protocolo de capa de red.

8.8.4 **Protocolo de Control de Enlace de Datos Simple (SDLC):** Protocolo de enlace de datos de WAN diseñado por IBM para los entornos de la Arquitectura de sistemas de red (SNA). Ha sido reemplazado en gran parte por el más versátil HDLC.

8.8.5 **Protocolo Internet de Enlace Serial (SLIP):** Protocolo de enlace de datos de WAN sumamente popular para transportar paquetes IP. Ha sido reemplazado en varias aplicaciones por el más versátil PPP.

8.8.6 **Procedimiento de Acceso al Enlace Balanceado (LAPB):** Protocolo de enlace de datos utilizado por X.25. Posee amplias capacidades de verificación de errores.

8.8.7 **Procedimiento de Acceso al Enlace en el Canal D (LAPD):** Protocolo de enlace de datos de WAN utilizado para señalización y para la configuración de llamada de Canal D de RDSI. Las transmisiones de datos tienen lugar en los canales B de RDSI.

8.8.8 **Trama de Procedimiento de Acceso a Enlaces (LAPF):** Para Servicios de Portadora en Modo de Trama, un protocolo de enlace de datos de WAN, similar a LAPD, utilizado con tecnologías Frame Relay.

9. PROTOCOLO IP (RFC791-RFC760)

9.1 IP (Internet Protocol) es un protocolo situado en la capa 3 (red) del modelo OSI, diseñado para interconectar redes de comunicaciones por conmutación de paquetes, para formar una internet ó inter-red.

9.2 Se transmiten bloques de datos denominados datagramas, desde una computadora origen, hasta una computadora de destino.

9.3 Cada datagrama contiene información de direccionamiento y de control para enrutar los paquetes, proveyéndose un *servicio de entrega sin conexión* (no se establece una conexión previa a la transferencia de información), de mejor esfuerzo, entre el origen y el destino.

9.4 El dispositivo encargado de encaminar los datagramas entre redes con diferentes esquemas de direcciones se denomina *router*. El router es básicamente un administrador de tráfico (díglele adónde quiere ir, y el router le indicará el camino adecuado).

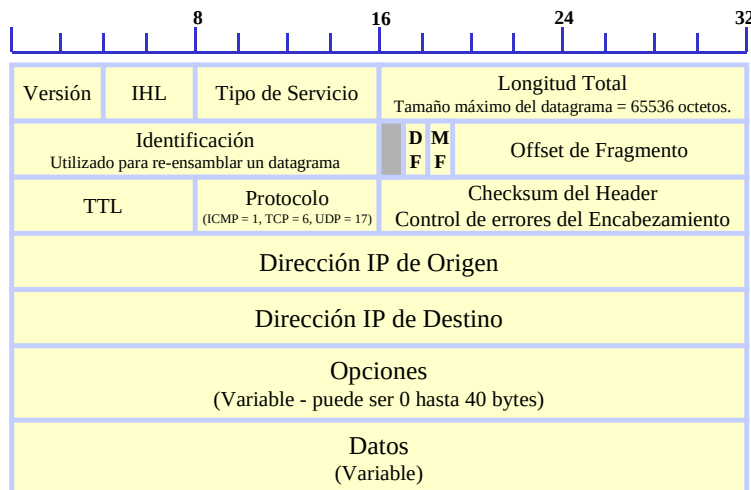
9.5 Los routers poseen puertos, los cuales son conexiones físicas hacia las redes. A cada uno de estos puertos debe asignársele una dirección local. Si existen varios routers, entonces para posibilitar el encaminamiento de los datagramas, cada uno debe conocer la información configurada en los demás.

9.6 Aunque es posible configurar estáticamente todas las direcciones IP y sus puertos asociados, para cada uno de los routers, ello significaría un consumo de tiempo muy grande, para una tarea ineficiente.

9.7 El método apropiado es utilizar protocolos, específicamente diseñados para distribuir la información de encaminamiento entre los routers, llamados *protocolos de enrutamiento*.

Formato del paquete IP (Versión 4)

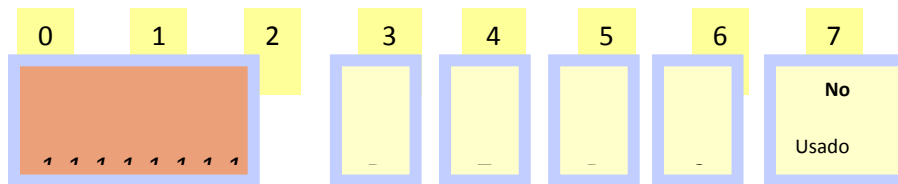
9.8 La siguiente figura muestra el formato del paquete IP versión 4. Los bits se han ordenado de acuerdo con el tratamiento usual de la literatura técnica, es decir en filas de 32 bits (equivalente a 4 octetos).



9.9 **El primer campo, VERS (4 bits, 0 a 3)**, define la versión del paquete IP (actualmente versión 4), con el fin de verificar que emisor, receptor y routers analicen el paquete considerando la versión 4 de la estructura IP, es decir, es el primer parámetro que debe verificarse antes de analizar el mismo ya que en caso de alguna diferencia (entre paquete recibido y software de procesamiento de paquetes) las máquinas rechazarán el paquete para evitar una interpretación incorrecta de su formato.

9.10 **El campo HLEN (4 bits, 4 a 7)**, determina la longitud del encabezado del paquete IP y se expresa en cantidad bytes. Todos los campos de la cabecera tienen una longitud fija, excepto el campo de Opciones IP y Relleno.

9.11 **El Tipo de Servicio**, está a su vez dividido en 5 subcampos de la siguiente forma:



9.11.1 **Prioridad** (3 bits): (o precedencia) indica la prioridad del paquete lo cual permite controlar la información que tendrá mas importancia en el reenvío de los datos, por ejemplo, en la transmisión de VoIP (Voice over IP), el software de aplicación *marca* el paquete en este campo (con cierto valor) para que los routers le den un tratamiento prioritario con respecto a los paquetes de datos.

9.11.2 **D** (1 bit): determina el tipo de transporte requerido para el paquete. Cuando este bit está activado, indica procesamiento con retardos cortos.

9.11.3 **T** (1 bit): determina el tipo de transporte requerido para el paquete. Cuando este bit está activado, indica alta performance.

9.11.4 **R** (1 bit): determina el tipo de transporte requerido para el paquete. Cuando este bit está activado, indica alta confiabilidad.

9.11.5 **Sin Uso** (2 bits).

Por ejemplo, supongamos que un router puede seleccionar entre una línea alquilada de baja velocidad y un enlace satelital de gran ancho de banda (pero con gran retardo) entonces unos paquetes pueden tener activado el bit D y otros tendrán el bit T, en este último caso los paquetes serán reenviados por el enlace satelital. También es muy importante que los algoritmos de ruteo seleccionen la tecnología de red física subyacente que cumpla con las características de bajo retardo, alta performance y alta confiabilidad de manera que en función del estado de estos bits (D, T, R) el algoritmo pueda elegir la interface física que cumpla con el requerimiento definido por el tipo de transporte.

9.12 **El campo Long. Total**, determina la longitud total del paquete IP medido en bytes, por lo tanto como éste tiene una longitud de 16 bits (16 a 31), el tamaño máximo del paquete es de 64 Kbyte ($2^{16}=65.536$).

9.13 **Control de Fragmentación:** Los campos de Identificación, Bandera y Desplazamiento de Fragmentos constituyen los campos que controlan la fragmentación de un datagrama cuando se transmite sobre una red con MTU (Message Transfer Unit)¹¹ menor al tamaño máximo de un datagrama IP.

¹¹ MTU (RFC 1191): NetBios: 512; X.25: 576;; 802.3/802.2: 1492; Eth 2.0: 1500; PPP: 1500; FDDI: 4352; IEEE802.4: 8166; 16M TR: 17914; EtherChannel: 65535

9.14 **El campo de Identificación** determina aquellos fragmentos que son parte de un mismo datagrama original, por lo tanto todos ellos tendrán el mismo valor en dicho campo para que el receptor “entienda” (analizando además la dirección IP origen) que son fragmentos de un mismo paquete.

9.15 **Los campos Bandera y Desplazamientos de Bandera** determinan el orden en el cual deben reensamblarse estos fragmentos. El bit menos significativo del campo Bandera determina si existen más fragmentos (cuando su valor está en “0”) y el campo Desplazamiento, expresado en bytes, determina la posición del fragmento dentro del datagrama original.

9.16 **El campo de Tiempo de Vida:** Expresa el tiempo de vida del datagrama dentro de la red, por ejemplo, cuando un paquete llega a un router, se activa un timer que contabiliza el tiempo de permanencia del mismo dentro del router por lo tanto cuando éste sale, el equipo decrementa el valor del campo Tiempo de Vida en una cantidad igual al tiempo de permanencia del paquete y cuando este valor llega a cero, automáticamente se descarta el paquete de la red y envía un mensaje de error al destino evitando así el viaje indefinido de los mismos dentro de la red.

9.17 **El campo de PROTOCOLO:** Especifica el protocolo de alto nivel que se utilizó para crear el mensaje que se transporta dentro del área de datos.

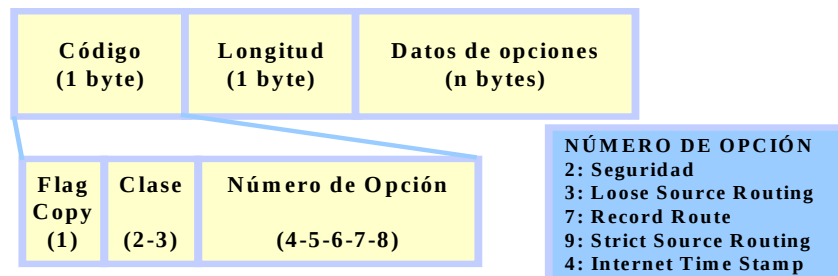
9.18 **El campo Suma de Verificación de Encabezado:** Asegura la integridad de los valores de la cabecera únicamente.

9.19 **Los campos de Dirección Origen y Destino:** Determinan las direcciones de transmisión y recepción del datagrama.

9.20 **El campo de Datos:** Define el área de datos y su longitud es variable.

9.21 **El campo de Relleno:** Depende del contenido del campo Opciones pero pueden usarse para asegurar que la extensión del encabezamiento sea un múltiplo de 32 bits.

9.22 **El campo Opciones:** No está presente en todos los datagramas, y se incluyen en pruebas de red o depuración. Su longitud es variable y dependerá de la opción elegida, por ejemplo, existe un byte dividido en tres partes:



9.23 **Copia:**

9.23.1 1: los routers deben copiar la opción en todos los fragmentos

9.23.2 0: los routers deben copiar la opción en el primer fragmento y no en todos los fragmentos

9.24 **Clase de Opción**

9.24.1 0: Control de red o datagrama

9.24.2 1: Reservado para uso futuro

9.24.3 2: Depuración y mediación

9.24.4 3: Reservado para uso futuro

Clase de opción	Numero de Opción	Longitud	Descripción
0	0	-	Fin de la lista de opciones. Se utiliza si las opciones no terminan al final del encabezado
0	1	-	No operación. Se utiliza alinear octetos en una lista de opciones
0	2	11	Seguridad y restricciones de manejo. Aplicaciones militares
0	3	Var	Ruteo no estricto de fuentes. Se utiliza para rutear un datagrama a través de una trayectoria específica
0	7	Var	Registro de ruta. Se utiliza para registrar el trayecto de una ruta
0	8	4	Identificador de flujo.
0	9	Var	Ruteo estricto de fuente. Se utiliza para establecer la ruta de un datagrama en un trayecto específico
2	4	Var	Sello de tiempo de Internet. Se usa para registrar sellos de hora a lo largo de una ruta

9.25 Las opciones más importantes son las de ruteo y sello de tiempo de Internet porque permite monitorear o controlar la forma en que la red maneja las rutas de los datagramas. La opción de registro de rutas permite a la fuente crear una lista de direcciones IP y arreglar para que cada router que maneja el datagrama añada su propia dirección en cuyo caso el campo Opción tendrá el siguiente formato:

0	7	8	15	16	23	24	31
Código (7)		Longitud (Bytes)			Puntero		
Primera Dirección IP							
Segunda Dirección IP							
...							

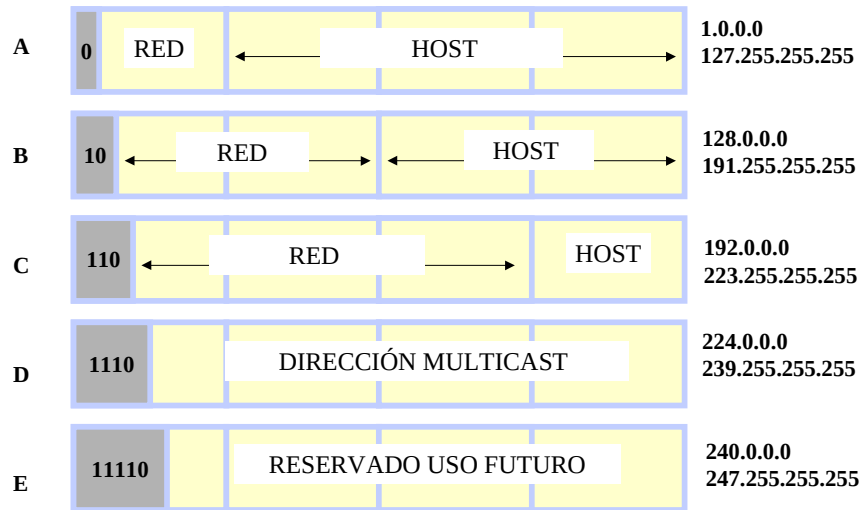
9.26 El campo puntero determina la próxima ranura disponible en la cual el router puede insertar su dirección IP, pero antes de colocar su dirección propia, compara el valor de Longitud (expresado) con el valor de Puntero de manera que si todavía existe “espacio” entonces la incorpora e incrementa el valor del puntero, en caso contrario, enviará el datagrama sin incluirse.

Direcciones IP

9.27 Cada host tiene tantas direcciones IP como puntos de conexión tenga a la red. Existen dos tipos de esquemas de direccionamiento de redes:

9.27.1 **Sin Clase (Classless):** Permite la utilización completa del rango completo de direcciones, sin ningún tipo de reserva de bits para identificar diferentes categorías o clases.

9.27.2 **Con Clase (Classfull):** Esquema de segmentación original (RFC 791) de las direcciones de 32 bits en clases específicas, en las que quedan identificados el número de red y el número de host.



9.28 Los números de red son asignados por el NIC (Network Information Center) para evitar conflictos. En la RFC 1597 se asignan varias direcciones para el uso en redes privadas. Existen protocolos (NAT) para traducir las direcciones privadas (no registradas) a las direcciones públicas y viceversa.

Clase de las Direcciones	Dirección inicial	Dirección final
A	10.0.0.0	10.255.255.255
B	172.16.0.0	172.31.255.255
C	192.168.0.0	192.168.255.255

Valores especiales

9.29 Si una máquina recibe un paquete cuyo campo Net ID de la dirección destino es igual a cero y el campo Host ID de la dirección destino corresponde a su dirección, entonces el receptor interpreta el campo de Net ID como ésta red. Esta dirección se usa durante el proceso de iniciación, es decir, permite que una máquina se comunique temporalmente y una vez que “aprende” su red y su dirección IP correctas, volverá a utilizar el campo Net ID=0.

9.30 Si una máquina recibe un paquete cuyo campo Host ID de la dirección destino son todos unos corresponde a su dirección, entonces el receptor interpreta el campo de Net ID como ésta red.

9.31 La dirección de red Net ID=127 está reservada para la función de LOOPBACK, es decir, es una dirección de troubleshooting que permite determinar si la pila de protocolos TCP/IP, configurada en la terminal, opera correctamente (ping 127.0.0.1).

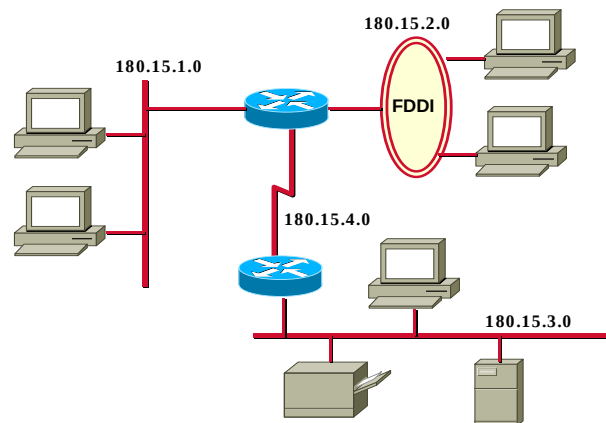
Subdireccionamiento (Subnetting: RFC950)

9.32 Las redes IP pueden ser divididas en redes más pequeñas denominadas subredes. Este procedimiento provee al administrador varios beneficios, incluyendo la flexibilidad, el uso eficiente de las direcciones de red y la capacidad de contener el tráfico broadcast (el broadcast no atraviesa al router). Las subredes se encuentran bajo una administración local, y como tales el resto del mundo ve a la organización como una red única, sin conocer los detalles de la estructura interna.

9.33 Una dirección de red puede ser dividida en varias subredes. Por ejemplo 172.16.1.0, 176.16.2.0, 176.16.3.0, 172.16.4.0, etc., son todas subredes dentro de la red 172.16.0.0 (todos ceros en la parte del número de host de una dirección especifican la red entera).

9.34 Una dirección de subred se crea "robando" bits del campo de host para asignarlos al campo de subred. El número de bits "robado" es variable, y se especifican en la máscara.

9.35 En una organización cuyas direcciones IP no están divididas en subredes, cualquier dirección de la misma se encaminaría en función del valor de su Net ID, por ejemplo, en el caso de la dirección 180.15.0.0 todos los paquetes se encaminarían en base a 180.15 (es un beneficio para el tamaño de las tablas de encaminamiento). Pero tiene el inconveniente que no permite distinguir segmentos individuales dentro de la organización lo cual redundaría en una baja performance de la red, porque todas las terminales "verían" los broadcast de la red.



9.36 El concepto de subdireccionamiento/subnetting/subred facilita una performance más eficiente ya que externamente todo paquete con destino a la organización se encaminará de la misma forma, pero dentro de la organización existen subredes para limitar el tráfico a otros segmentos.

9.37 En el ejemplo, la dirección de red 180.15.0.0 se dividió en 4 subredes: 180.15.1.0, 180.15.2.0, 180.15.3.0 y 180.15.4.0, es decir, en el caso de la dirección 180.15.1.0, 180.15 es la dirección de red, 1 es la dirección de subred y el último campo es la dirección de la terminal de la subred. Desde el punto de vista de la dirección, una subred es una extensión del número de red. Los administradores de red determinarán el tamaño de subred en función de las necesidades.

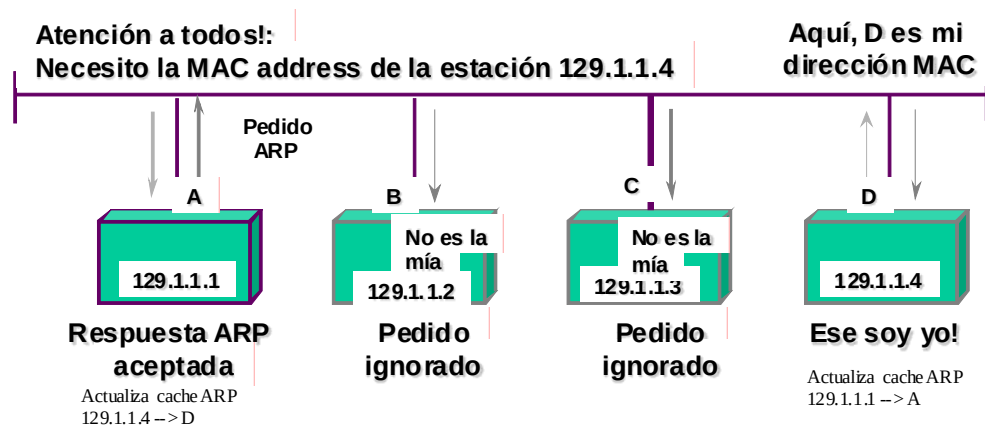
	Red		Host	
	180	15	0	0
Dirección IP	Red		Host	
	255	255	0	0
Máscara Default	Red		Subred	Host
	255	255	255	0
Máscara	Red		Subred	Host
	255	255	255	0

9.38 Los dispositivos usan una "máscara de subred" para determinar la parte de la dirección IP dedicada a la subred. Una "máscara" también tendrá un tamaño de 32 bits, agrupados de 8 como se muestra en la figura.

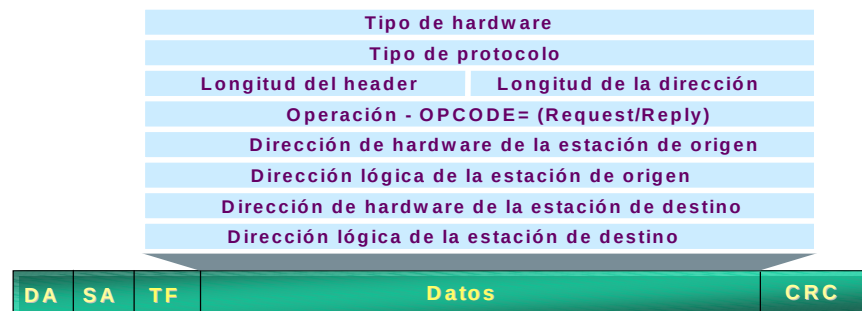
9.39 La forma de calcular la máscara es la siguiente: el campo de red debe ser todos 1's, el campo de subred también deben ser todos 1's y el campo de host deben ser todos 0's, es decir, la máscara de subred indica aquellos bits del campo de host ID, usados para identificar la subred.

ARP (Address Resolution Protocol – RFC826)

9.40 El protocolo ARP, permite mapear la dirección física de la tarjeta de red con la dirección lógica IP del host para encaminar dentro de una subred (segmento de LAN) en función de la dirección IP. Para ello, deberá establecer una relación unívoca entre la dirección física de red (MAC Address) y la dirección lógica IP de la terminal con la cual quiere comunicarse.



9.41 En la siguiente figura se muestra el formato del paquete ARP:



9.41.1 **Tipo de Hardware:** indica el protocolo IEEE802 de LAN. También indica otro tipo de redes.

9.41.2 **Tipo de Protocolo:** indica que es TCP/IP

9.41.3 **Longitud de la Cabecera:** determina la longitud de la cabecera del protocolo

9.41.4 **Longitud de la dirección lógica:** indica la longitud de la dirección lógica

9.41.5 **Operación:** indica si es una interrogación o una respuesta

9.41.6 **Dirección lógica del host transmisor:** indica la dirección lógica del host transmisor

9.41.7 **Dirección física del host transmisor:** dirección física del host transmisor

9.41.8 **Dirección física del host receptor:** dirección física del host destino

9.41.9 **Dirección lógica del host receptor:** indica la dirección lógica del host destino

9.41.10 **TF (Type Field):** determina el tipo de datos que está dentro del paquete: TCP, Apple Talk, XNS

NOTA:

ARP no corre sobre IP, por consiguiente no posee header IP.

Los pedidos ARP son transmitidos en broadcast.

El nuevo EtherType define 0x0806 para los pedidos y respuestas ARP.

Las respuestas ARP se envían directamente a la estación peticionante (unicast, no broadcast).

Las tablas ARP generalmente limitan el tiempo de vigencia de las entradas (age out).

Interface: 168.226.1.203		
Internet Address	Physical Address	Type
168.226.1.1	00-00-0c-03-21-7a	dynamic
168.226.1.6	00-e0-8f-d7-b3-ff	dynamic
168.226.1.43	00-04-00-10-97-cc	dynamic
168.226.1.44	08-00-09-57-53-1e	dynamic

10. TCP¹²

10.1 **TCP (Transmission Control Protocol)** fue específicamente diseñado para proveer un flujo de bytes confiable de extremo a extremo, sobre una interred no confiable. Una interred difiere de una red única porque existen distintas partes de la misma con topologías, anchos de banda, demoras, tamaños de paquetes y otros parámetros sumamente diferentes.

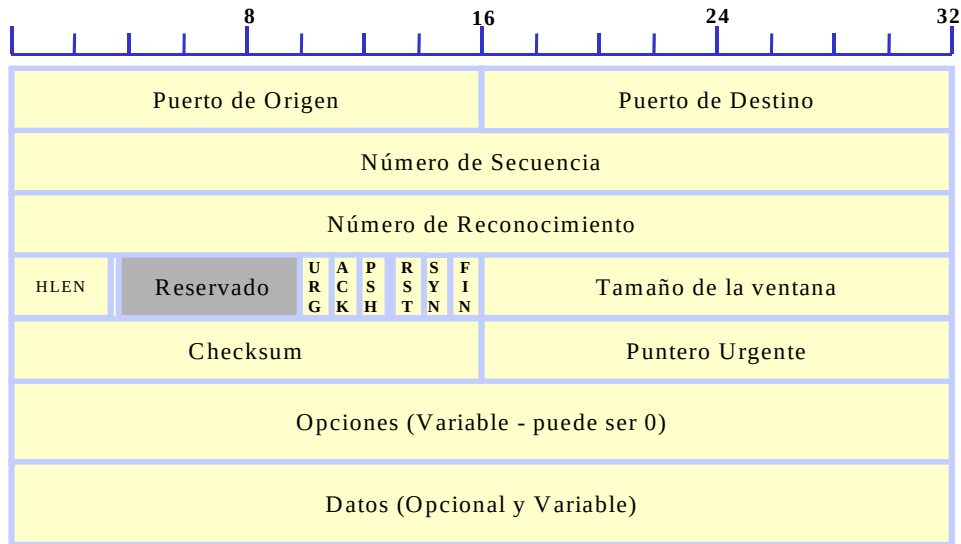
10.2 Cada máquina que soporta TCP debe poseer una entidad de transporte TCP, ya sea en la forma de un proceso de usuario, o parte del kernel que administra los flujos TCP y las interfaces hacia la capa IP.

10.3 Una entidad TCP acepta flujos de datos de los procesos locales, los fragmenta en unidades no mayores de 64 Kbytes (en la práctica unos 1500 bytes), y envía cada parte como un datagrama IP independiente. Cuando los datagramas IP que contienen datos TCP llegan a una máquina, son entregados a la entidad TCP, la cual reconstruye el flujo de bytes original.

10.4 La capa IP no garantiza que los datagramas sean apropiadamente entregados, por ello, es tarea del TCP implementar los mecanismos necesarios para retransmitir, ordenar, reconocer, temporizar, etc. los segmentos, a fin de otorgar la confiabilidad de la transmisión.

10.5 TCP no soporta multicasting, ni tampoco broadcasting.

¹² Las RFC's de TCP son 7 aproximadamente pero las mas importantes son las siguientes: RFC 793; RFC1122: actualización de la anterior (793); RFC 813: administración de ventanas; RFC 816: fallas de aislamiento y recuperación y otras. Las RFC's pueden consultarse en WWW.IETF.ORG



Puertos de origen y destino

10.6 **Los puertos de Origen y Destino:** Identifican los puntos extremos de la conexión. Cada host puede decidir como asignar sus propios puertos, comenzando en 1024. Un port más la dirección IP del host forman un TSAP (Transport Service Access Point) único de 48 bits, también llamado socket. El par de números sockets de origen y destino identifican la conexión.

Socket TSAP	=	Dirección IP	+	Número de Puerto
[48 bits]	=	[32 bits]		[16 bits]

10.7 Los números de puertos desde el 0 hasta 1023 se denominan puertos bien conocidos (well-known ports), y están reservados para servicios estándar (por ejemplo cuando se desea utilizar los servicios FTP, es normal pedir una conexión con el port de destino 21 para contactar al proceso FTP; similarmente Telnet utiliza el port 23). La lista de puertos bien conocidos se brinda en RFC 1700.

Número de secuencia

10.8 **Número de Secuencia y Reconocimiento:** Son los números de segmentos en transmisión y recepción, los cuales implementan el procedimiento usual de la conexión con reconocimiento.

Longitud del header

10.9 **HLEN (Header Length):** Indica la longitud en unidades de 32 bits, que contiene el header TCP, por cuanto el campo de opciones es de longitud variable. Técnicamente el campo indica el comienzo de los datos dentro del segmento (4 bits). Luego aparece un campo de 6 bits no utilizado.

Flags

10.10 A continuación aparecen 6 flags de 1 bit cada uno.

10.10.1 **URG:** Se activa a 1 cuando el puntero de urgencia se encuentra en uso. El puntero de urgencia se utiliza para indicar el desplazamiento en bytes desde el número de secuencia actual, en donde se encuentran los datos urgentes.

10.10.2 **ACK:** Se activa a 1 cuando el número de reconocimiento es válido. Si el valor de ACK es 0, entonces el campo Número de Reconocimiento es ignorado.

10.10.3 **PSH:** Es una forma de indicarle al receptor que entregue los datos a la capa de aplicación inmediatamente, sin ejecutar almacenamiento alguno (generalmente se colocan en un buffer para optimizar la transferencia a la capa superior).

10.10.4 **RST:** Este flag se usa para resetear una conexión que se ha tornado confusa por alguna razón. También se utiliza para rechazar un segmento inválido, o rehusar un intento de abrir una conexión. En general los segmentos con RST=1 representan un problema a resolver.

10.10.5 **SYN:** La activación de este flag se utiliza para establecer conexiones. El pedido de conexión detenta SYN=1 y ACK=0 para indicar que el campo piggyback no está en uso. La réplica a la conexión soporta un reconocimiento, por ello posee SYN=1 y ACK=1. En esencia, el bit SYN se utiliza como Pedido de Conexión y Aceptación de Conexión (el bit ACK se usa para distinguir entre las dos posibilidades).

10.10.6 **FIN:** Es utilizado para liberar una conexión. Indica que el emisor no posee más datos para transmitir. De cualquier manera, después de cerrar una conexión, un proceso puede continuar recibiendo datos indefinidamente. Tanto el segmento SYN como el FIN poseen números de secuencia, para garantizar su procesamiento en el orden correcto.

Valor de ventana

10.11 **Tamaño de Ventana:** Se utiliza para implementar el control de flujo a través de una ventana deslizante de tamaño variable. Indica cuantos bytes pueden ser enviados a partir del byte de reconocimiento. Un tamaño de ventana = 0 indica que se han recibido correctamente todos los bytes hasta el Número de Reconocimiento - 1, pero que por el momento no es posible recibir más datos.

Código de comprobación

10.12 **Checksum:** Control de errores del segmento completo (incluyendo el pseudoheader). El pseudoheader contiene las direcciones IP de las máquinas de origen y destino, el número de protocolo para TCP (=6) y el cómputo en bytes del segmento TCP, incluyendo el header. La inclusión del pseudoheader TCP en el cómputo del checksum ayuda a detectar paquetes erróneamente enviados, pero viola la jerarquía protocolar, ya que las direcciones IP pertenecen a la capa IP, y no a la TCP.

Opciones

10.13 Este campo fue diseñado para proveer una forma de añadir facilidades adicionales no cubiertas en el header regular. La opción más importante es la que permite a cada host especificar la carga máxima del segmento TCP que está dispuesto a aceptar. Durante el proceso de conexión, cada host anuncia su máximo, y analiza el de su contraparte: el más pequeño gana! (si no se utiliza esta opción, el valor asumido es de 536 bytes, por lo que todos los hosts en Internet deben soportar segmentos TCP de 536+20=556 bytes).

10.14 Otra opción importante es la negociación de un factor de ventana propuesta en la RFC 1323, la cual permite desplazar el campo del Tamaño de Ventana hasta 16 bits a la izquierda. Para enlaces con elevado ancho de banda o retardo, o ambos, la ventana de 64 Kbytes es un problema (teniendo en cuenta que a una línea E3 le toma unos 15 milisegundos agotar la ventana completa de 64 Kbytes, y en una fibra transcontinental el tiempo de retardo ida y vuelta es de unos 50 milisegundos, entonces el emisor se encontrará durante el 70% del tiempo esperando por los reconocimientos).

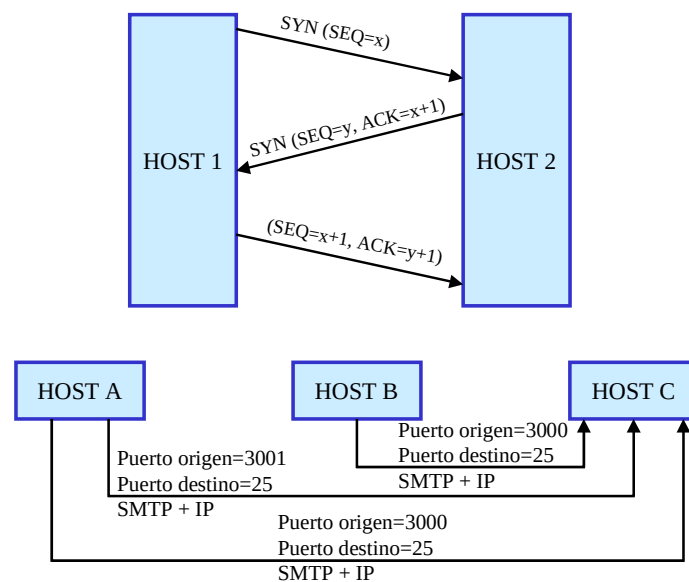
10.15 La RFC 1106 propone la utilización de retransmisión selectiva (NAK), en lugar del protocolo "retroceder hasta N".

Gestión de Conexiones TCP

10.16 Las conexiones en TCP se establecen utilizando un handshaking de tres vías.

10.17 Previamente al pedido de establecimiento, un lado, el server, espera pasivamente el pedido de conexión, ejecutando las primitivas LISTEN y ACCEPT, pudiendo o no indicar una fuente específica.

10.18 El otro lado, el cliente, ejecuta una primitiva CONNECT, especificando la dirección IP y el puerto al cual desea la conexión, el máximo tamaño de segmento TCP dispuesto a aceptar, y opcionalmente algunos datos de usuario (password).



10.19 La primitiva CONNECT envía un segmento TCP con el bit SYN activado, y el bit ACK desactivado, y espera una respuesta. Cuando el segmento llega a su destino, la entidad TCP chequea que algún proceso esté ejecutando un LISTEN en el puerto indicado en el campo Puerto de Destino. Si no es así, envía una réplica con el bit RST=1 para rechazar la conexión.

10.20 Si existe algún proceso "escuchando" en dicho puerto, le es entregado dicho segmento TCP. Éste puede aceptar o rehusar la conexión. Si la acepta, retorna un segmento de reconocimiento (SYN=1, ACK=1)

10.21 A pesar de que las conexiones TCP son full dúplex, es mejor pensar pensarlas como un par de conexiones simplex, a los efectos de entender cabalmente el proceso de liberación. Cada conexión simplex es liberada independientemente de su contraparte. Para ello, cada parte puede enviar un segmento TCP con el bit FIN activado, lo que significa que no existen más datos para transmitir. Cuando dicho segmento es reconocido, ello significa que esa dirección de transferencia ha sido cerrada para el envío de datos, aunque en el otro sentido la transferencia podría continuar indefinidamente.

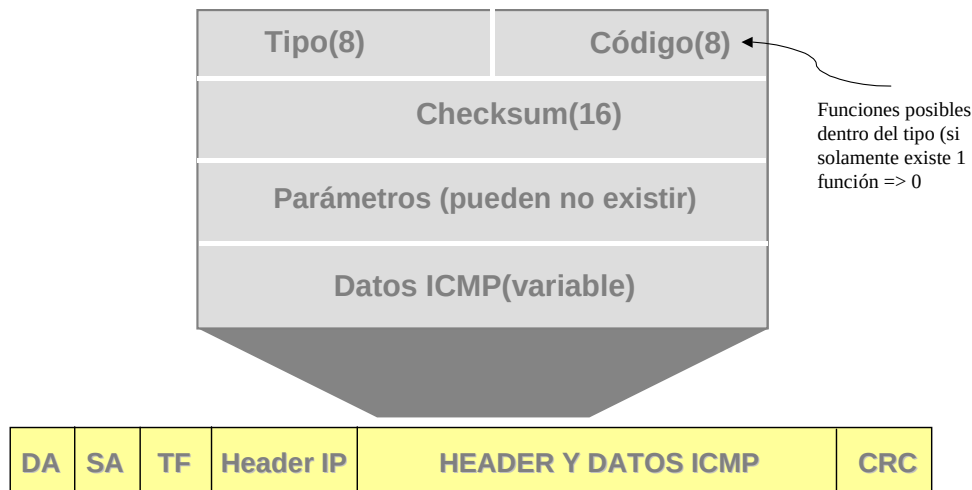
11. ICMP

11.1 Como no existe ninguna provisión por parte de IP para manejar el control de estado y error, ICMP (Mensajes de error y control) es el protocolo que maneja estas instancias para IP.

11.2 Estos mensajes son interpretados por el Protocolo Internet en cada uno de los equipos de red (host/routers).

11.3 Técnicamente el protocolo es un mecanismo de reporte de errores, es decir, permite a los equipos enviar un mensaje a la fuente original cada vez que encuentren un error pero no se especifica del todo la acción a realizar en caso de cierto error.

11.4 Los únicos datagramas que no generan mensajes de error son aquellos que llevan mensajes de error, es decir, si se produce congestión se enviarán mensajes de error los cuales pueden inducir mas congestión pero en este último caso no se generarán mensajes ICMP por lo tanto se evitan los mensajes de los mensajes.



11.5 ICMP no utiliza una capa de transporte -corre directamente sobre IP- por consiguiente es no confiable (no existirán mensajes de error ICMP para un mensaje ICMP. ICMP no pretende convertir a IP en un protocolo confiable, solamente procura reportar errores y proveer feedback ante condiciones específicas.

11.6 El campo Tipo identifica al datagrama ICMP, y el campo Código provee mayor granularidad.

Tipo (8 bits): indica el tipo de mensaje:

- 0: Respuesta de eco
- 3: Destino inaccesible
- 4: Disminución de origen
- 5: Redireccionar (cambiar de ruta)
- 8: Solicitud de eco
- 11: Tiempo excedido para un paquete
- 12: Problemas de parámetros de un paquete
- 13: Solicitud de timestamp

14: Respuesta de Timestamp
15: Solicitud de información
16: Respuesta de información
17: Solicitud de mascara de dirección
18: Respuesta de mascara de dirección

11.7 El campo de código indica posibles funciones dentro de cada tipo (si existe solamente una función, su valor es 0).

Código (8 bit): proporciona más información del tipo de mensajes

0: Red inaccesible
1: Anfitrión inaccesible
2: Protocolo inaccesible
3: Puerto Inaccesible
4: Se necesita fragmentación y configuración DF
5: Falla en la ruta de origen
6: Red de destino desconocida
7: Host de destino desconocido
8: Host de origen aislado
9: Comunicación con la red de destino administrativamente prohibida
10: Comunicación con el host de destino administrativamente prohibida
11: Red inaccesible por el tipo de servicio
12: Host inaccesible por el tipo de servicio

11.8 Por ejemplo el Tipo 3 indica que el host es inalcanzable, pero un código 1 provee una pista más cercana, indicando que el host de destino, y no el port, es inalcanzable (esto podría indicar que aunque se llegó a la red, no hubo ningún host que contestó al ARP REQUEST).

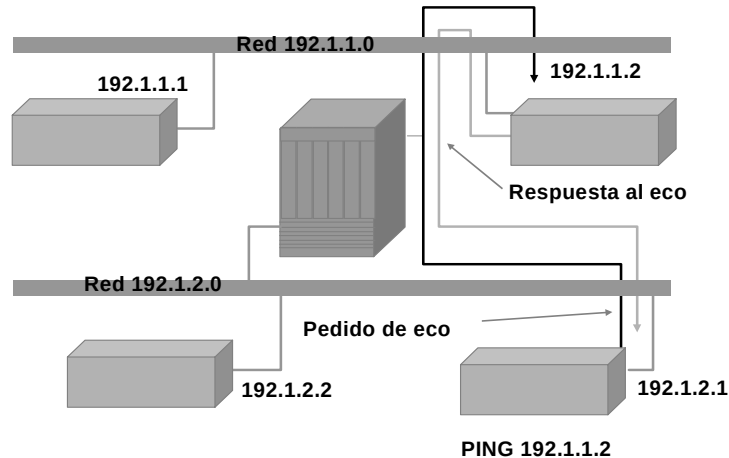
11.9 El checksum computa el complemento a "1" del mensaje ICMP. En los datos se transporta el header y los primeros 64 bits de datos de usuario del datagrama que motivó el mensaje.

ICMP PING

11.10 Uno de los usos más comunes de ICMP es el PING.

11.11 PING se utiliza como herramienta de test y debugging.

11.12 PING es un mensaje ICMP que trata de localizar otras estaciones en Internet para verificar si están activas, o si existe un trayecto habilitado.



12. SWITCHING Y ROUTING

12.1 Existen diferencias y confusiones entre la aplicación rigurosa de los conceptos de bridging, switching y routing y sus implementaciones prácticas.

Switching de capa 2

12.2 El switching (de capa 2) utiliza las direcciones MAC de las tarjetas de interface Ethernet (NIC) para filtrar el tráfico de la red, y está basado en hardware (ASIC). Bridges y switches implementan la función de switching. Como no existen modificaciones en la trama durante el proceso de switching (salvo que se esté bridgeando entre redes heterogéneas, como por ejemplo Ethernet y FDDI), es una operación muy eficiente (bajo costo, alta velocidad y baja latencia).

12.3 Los switches de capa 2 poseen las mismas limitaciones que los bridges (esencialmente están adaptados a los patrones de tráfico locales 80/20). Pero además, aunque segmentan los dominios de colisiones, no pueden quebrar los dominios de bc, pudiendo provocar problemas de performance y limitaciones en el tamaño de las redes. Los mayores inconvenientes que el crecimiento de una red de gran envergadura encuentra con los switches son los bc y mc y la convergencia lenta del protocolo STP (Spanning Tree Protocol).

Bridging:

12.4 El término bridging es completamente análogo al de switching. La diferencia en la aplicación proviene de la elevada densidad de puertos de los switches respecto a los bridges (el switch es como un bridge con múltiples puertos).

Routing

12.5 Los routers no solamente segmentan los dominios de colisiones, sino también los de broadcast. Proveen una determinación óptima de los trayectos porque los routers examinan cada paquete que ingresa a sus interfaces, enviando la información únicamente hacia la red de destino conocida (si el router no conoce la red de destino, el paquete es descartado). La inspección minuciosa de los paquetes es aprovechada para realizar control de tráfico y aplicación de políticas de seguridad. El enrutamiento se realiza en base a las direcciones lógicas de la capa 3 (típicamente IP).

Switching de capa 3

12.6 El switching de capa 3 es funcionalmente similar al routing con todos sus efectos y alcances, sólo que difiere en la forma en la que se implementa en los dispositivos. El switching de capa 3 es un forwarding de paquetes completamente basado en el hardware ASIC.

Switching de capa 4

12.7 El switching de capa 4 es una tecnología similar al switch de capa 3, al que adicionalmente se le han incorporado funciones de enrutamiento relacionadas con las aplicaciones (telnet, FTP, etc.). Es decir que considera los puertos de aplicación de los paquetes para tomar decisiones de enrutamiento.

12.8 La ventaja principal de switching de capa 4 es la posibilidad de implementar calidades de servicio (QOS) basadas en las aplicaciones y usuarios.

Switching de capas múltiples

12.9 El switching de capas múltiples (Multi-layer switching) combina las tecnologías de capas 2, 3 y 4 con características de gran escalabilidad y reducida latencia.

12.10 Un switch multi-layer puede realizar decisiones de switching y routing basándose en:

12.10.1 Las direcciones (MAC) de origen y destino de la trama.

12.10.2 Las direcciones (IP) de origen y destino del paquete.

12.10.3 El campo protocolo del paquete IP.

12.10.4 Los puertos de origen y destino del segmento (TCP o UDP)

DESCRIPCIÓN, COMPONENTES Y OPERACIONES BÁSICAS

DESCRIPCIÓN DEL ROUTER

COMPONENTES DE LA CONFIGURACIÓN INTERNA

CONFIGURACIÓN BÁSICA

MODOS DEL ROUTER

CONFIGURACIONES

PASSWORDS

INICIALIZACIÓN DEL ROUTER

CONFIGURACIÓN DEL ROUTING IP

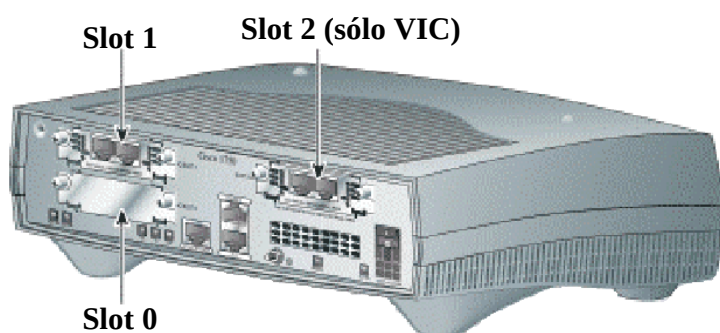
1. DESCRIPCIÓN DE UN ROUTER

1.1 A los efectos de la descripción de los componentes, tomaremos como ejemplo al router Cisco de la línea 1700, el modelo 1751.

Descripción de los componentes básicos

1.2 Los routers de la serie Cisco 1700, proporcionan flexibilidad, seguridad y funcionalidad para las oficinas pequeñas y medianas, al ritmo que evolucionan las redes.

1.3 Para complementar la información, debe consultarse la hoja de datos de la Serie Cisco 1700.¹³



1.4 Los routers de la serie Cisco 1700 conectan las pequeñas oficinas con varias LAN Ethernet a varias WAN a través de conexiones serie síncrona y asíncrona de Red Digital de Servicios Integrados (ISDN).

1.5 El modelo 1751 es un router modular (ofrece tres slots que pueden albergar diferentes módulos de interface). En la figura puede apreciarse la ubicación de los tres slots.

1.6 En la siguiente figura se muestra la parte posterior del router. Dos de los slots han sido ocupados por sendas interfaces de voz FXS.

1.6.1 1 Orificio de bloqueo Kensington.

1.6.2 2 Slot para tarjeta WIC ó VIC (SLOT 1) —Soporta una tarjeta WIC/VIC Cisco.

1.6.3 3 Puerto de consola (azul).

1.6.4 4 Slot para tarjeta VIC (SLOT 2) —Soporta una tarjeta VIC Cisco.

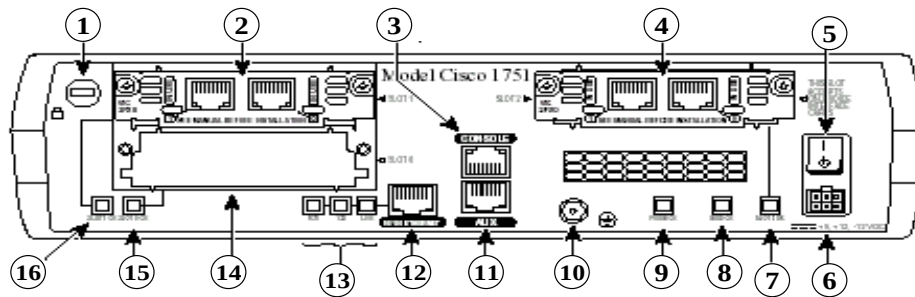
1.6.5 5 Interruptor de energía.

1.6.6 6 Enchufe de energía.

1.6.7 7 LED de estado del Slot 2—On (verde) cuando la VIC esta alojada y funciona correctamente.

¹³ La familia 1700 reemplazo a la familia 1600, a la que se declaró EOS (fin de ventas) y EOL (fin de vida).

1.6.8 **8** LED de estado del MOD—On (verde) cuando el módulo de encriptación VPN (hardware) está instalado y reconocido por el IOS.



1.6.9 **9** LED de estado del PVDM—On (verde) cuando el módulo PVDM (hardware interno) está instalado y reconocido por el IOS.

1.6.10 **10** Tornillo de tierra.

1.6.11 **11** Puerto AUX (negro).

1.6.12 **12** Puerto 10/100 ETHERNET (amarillo) —Conecta a la red Ethernet local. Autosensado de velocidad y duplex.

1.6.13 **13** LEDs de la interface Ethernet:

1.6.13.1 FDX—ON indica que el puerto opera en modo full-duplex (OFF: modo half-duplex).

1.6.13.2 100—ON indica que el puerto opera a 100 Mbps (OFF: 10 Mbps.).

1.6.13.3 LINK—ON cuando el enlace Ethernet está activo.

1.6.14 **14** Slot para tarjeta WIC ó VIC (SLOT 0) —Soporta una tarjeta WIC/VIC Cisco.

1.6.15 **15** LED de estado del Slot 0—On (verde) cuando la WIC ó VIC esta alojada y funciona correctamente.

1.6.16 **16** LED de estado del Slot 1—On (verde) cuando la WIC ó VIC esta alojada y funciona correctamente.

Interfaces y conexiones del router

1.7 Un router necesita ser configurado para poder operar dentro de una red. Una vez configurado, los administradores de la red, necesitarán verificar el estado de varios de sus componentes.

Puertos de Consola y Auxiliar

1.8 Todos los routers poseen un puerto de consola, el cual es utilizado para acceder al dispositivo en forma directa desde una terminal o una PC con emulación de terminal. Este puerto frecuentemente es una interface RJ-45, denominado “Console”.

1.9 Los cables necesarios los provee Cisco con los siguientes pin-outs:

ROUTER			ROLLOVER		RJ-45 a DB9		
SEÑAL	CONSOLE	AUXILIAR	RJ-45	RJ-45	RJ-45	DB9	SEÑAL
RTS	NO	1 (out)	1	8	8	8	CTS
DTR	2 (out)	2 (out)	2	7	7	6	DSR
TxD	3 (out)	3 (out)	3	6	6	2	RxD
SG	4	4	4	5	5	5	SG
SG	5	5	5	4	4	5	SG
RxD	6 (in)	6 (in)	6	3	3	3	TxD
DSR	7 (in)	7 (in)	7	2	2	4	DTR
CTS	NO	8 (in)	8	1	1	7	RTS

1.10 Después de establecer la conexión física desde la terminal o PC al puerto de consola, es necesario configurar la terminal apropiadamente para posibilitar la comunicación con el dispositivo.

1.11 A continuación, se enciende el router, y podrá visualizarse el banner de arranque. El puerto auxiliar puede ser utilizado para conectar un modem, permitiendo la administración fuera de banda, en caso de pérdida de las otras conexiones. Ambos puertos soportan líneas TTY asincrónicas.

Interfaces

1.12 Son las conexiones a la red, a través de las cuales los paquetes entran y salen del router. Cisco soporta una gran variedad de interfaces, incluyendo Ethernet, Token Ring y seriales. Algunas de las interfaces más comunes del router son seriales (para conexión a enlaces WAN) y LAN (como Ethernet, Token Ring y FDDI).

2. COMPONENTES DE LA CONFIGURACIÓN INTERNA

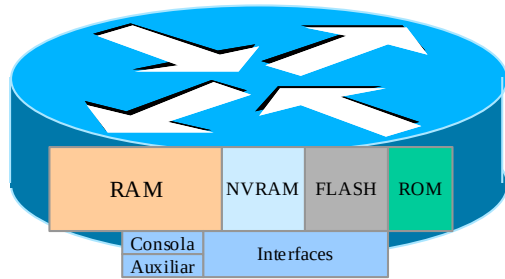
2.1 La arquitectura interna del router (un router es una computadora, y como tal posee elementos de hardware similares a las convencionales) sustenta componentes que juegan un rol muy importante durante el proceso de arranque. Estos componentes son:

2.1.1 Procesador (*CPU*)

2.1.2 *Diferentes tipos de memoria* para almacenar información

2.1.3 Un *sistema operativo* que provee las funciones de operación

2.1.4 *Varios puertos e interfaces* para conectarla a los dispositivos periféricos, o para permitir las comunicaciones con otras computadoras



Elementos del router

2.2 Los componentes de hardware del router incluyen: memoria, procesador, interfaces y líneas.

Memorias

2.3 Existen básicamente 4 diferentes tipos de memoria:

2.3.1 RAM/DRAM

2.3.2 NVRAM

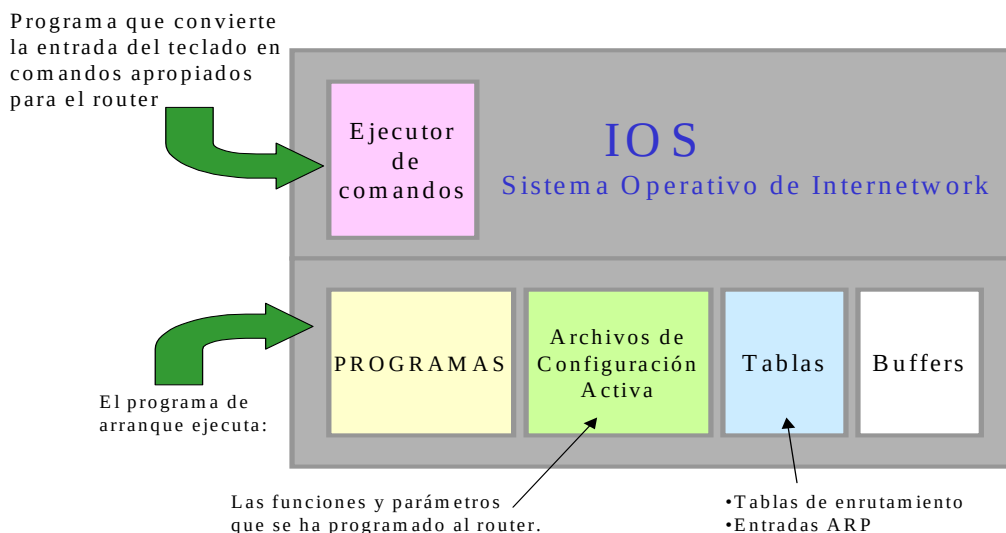
2.3.3 FLASH

2.3.4 ROM

2.4 **RAM/DRAM:** Es el componente de almacenamiento principal para todas las operaciones del router. Se denomina memoria de trabajo y contiene la información de los elementos dinámicos. Parte del IOS también se descomprime en la RAM. Cuando se enciende el router, se ejecuta un programa de bootstrap desde la memoria ROM. Este programa realiza algunas comprobaciones, luego carga el software Cisco IOS en la memoria. El procesador de comandos, o EXEC, es una parte del software Cisco IOS. EXEC recibe y ejecuta los comandos que se ingresan por teclado.

2.5 El router también almacena un archivo de configuración activo y tablas de mapas de redes y listas de direcciones de enrutamiento. Cuando existe una versión de este archivo almacenada en la NVRAM, se accede al archivo guardado y se lo carga en la memoria principal cada vez que se inicia el router. El archivo de configuración contiene información global, de proceso y de interface que afecta directamente la operación del router y de sus puertos de interface.

2.6 La imagen del sistema operativo no puede verse en la pantalla de la terminal. Esta imagen generalmente se ejecuta desde la RAM principal y se carga desde una de varias fuentes de entrada. El software operativo está organizado en "rutinas" que manejan las tareas asociadas a los diferentes protocolos, el movimiento de datos, la gestión de tablas, los buffers, las actualizaciones de enrutamiento y la ejecución de los comandos del usuario.



2.7 **NVRAM:** Este componente es la RAM no volátil (un tipo especial de RAM que no es borrada durante el reboot del router) que contiene una copia de backup de la configuración. Si la energía se pierde, o el router es apagado, la copia de backup de la configuración permite que el router retorne a sus condiciones operativas sin necesidad de una reconfiguración.

2.8 El archivo de la configuración de startup del router es almacenada en la NVRAM, por omisión. Cuando el router sale de fábrica, el archivo de configuración no se halla presente. Este es el primer que se crea durante la configuración. Además guarda el registro de configuración virtual.

2.9 La NVRAM almacena toda la información de configuración del router, definida por el usuario, incluyendo, ente otros: el nombre del host para el router, las tablas de enrutamiento, las configuraciones de protocolos, las configuraciones del caché, y el registro de configuración virtual.

2.10 **FLASH:** Este componente es una clase especial de memoria programable (es como una ROM, pero borrrable y programable, una EEPROM de INTEL). Típicamente la memoria Flash no puede ser modificada durante las operaciones normales del router, pero puede ser actualizada o borrada cuando sea necesario. El contenido de la memoria Flash se mantiene aún después de rebootear el router.

2.11 Esta memoria, normalmente, contiene una copia del software IOS (Cisco Internetwork Operating System). La memoria Flash posee una estructura que admite almacenar copias múltiples del IOS, permitiendo la carga de nuevos niveles del sistema operativo en cada router de la red, y luego, en algún momento conveniente, actualizar toda la red al nuevo nivel.

2.12 La memoria Flash contiene la copia de trabajo del software IOS actual, y es el componente que inicializa el IOS para las operaciones normales del router.

2.13 **ROM:** La memoria de lectura solamente -Read-only memory- almacena el programa de inicialización (**bootstrap**) que permite el arranque básico del hardware del router, y el **POST (power-on self test)**, programas que se utilizan para comprobar la funcionalidad básica del hardware y determinar la presencia de las interfaces.

2.14 La ROM, asimismo contiene el **ROM MONITOR**, un programa monitor de arranque, el cual puede ser utilizado por el administrador para recuperar el sistema ante el evento de una falla de booteo. En algunos routers, la ROM contiene una pequeña versión del software IOS de Cisco, como un backup de emergencia. Los routers Cisco de la serie 7000 and 7500 poseen una versión completa del IOS en ROM.

2.15 En modo ROM monitor el símbolo del prompt es el signo mayor (>).

2.16 Otro componente en la ROM es el Mini-IOS -denominado **RXBOOT** o bootloader-pequeña versión de IOS que puede ser utilizada para activar una interface y cargar un IOS completo en la memoria FLASH, así como otras operaciones de mantenimiento (es como un arranque a prueba de fallos).

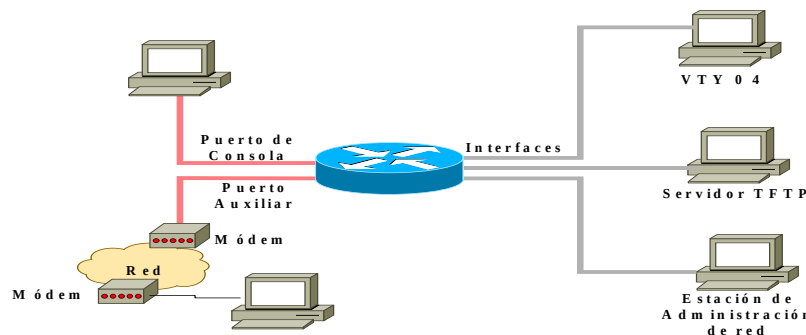
2.17 Los componentes de la ROM no pueden ser modificados durante las operaciones normales del router, pero puede ser actualizado mediante chips de plug-in especiales. El contenido de la ROM se mantiene aún cuando el mismo sea rebooteado.

Fuentes de Configuración

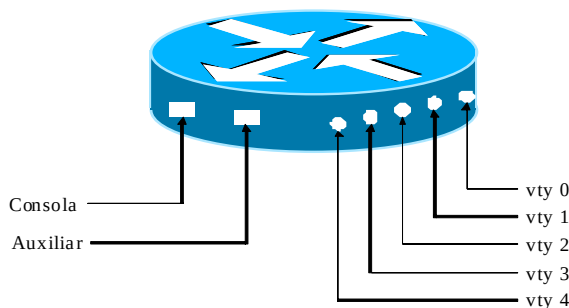
2.18 El router puede configurarse desde diferentes ubicaciones:

2.18.1 En el momento de la instalación inicial, se lo configura desde la terminal de la consola. La terminal de la consola es una computadora conectada al router a través del puerto de la consola. Puede conectárselo por medio de un módem utilizando el puerto auxiliar. Una vez instalado en la red, se lo puede configurar desde las terminales virtuales 0 a 4.

2.18.2 También se pueden descargar archivos desde un servidor TFTP de la red, o gestionarse a través de una aplicación de gestión centralizada.



2.19 La siguiente figura esquematiza los diferentes modos de acceso al router. Las terminales virtuales (vty) son accedidas desde cualquiera de las interfaces para el tráfico normal del router (Ethernet, seriales, TR, etc.).



2.19.1 Los puertos Consola y Auxiliar son puertos físicamente accesibles mediante conectores (EIA-232).

2.19.2 Los puertos denominados VTYx (x= 0, 1, 2, 3 y 4), son virtuales y no existen físicamente, sino que se acceden desde las interfaces que cursan el tráfico normal del router (Ethernet, Serial, TR, ISDN, ATM, etc.), vía el protocolo Telnet. Es decir que debe estar habilitado el protocolo IP.

3. CONFIGURACIÓN BÁSICA

3.1 Una forma de empezar a comprender cómo funciona Internet es configurando un router. Los routers son dispositivos complejos que pueden tener una amplia variedad de configuraciones posibles.

3.2 Después de probar el hardware y cargar la imagen del sistema Cisco IOS, el router encuentra y aplica las instrucciones de configuración. Estas entradas proveen al router detalles de atributos específicos para el router, funciones del protocolo, y direcciones de interface.

3.3 Si el router se halla en una situación de inicio en la cual no puede localizar un archivo de configuración **startup-config** válido, entonces ingresará en un modo inicial de configuración llamado **modo setup**.

MODO SETUP

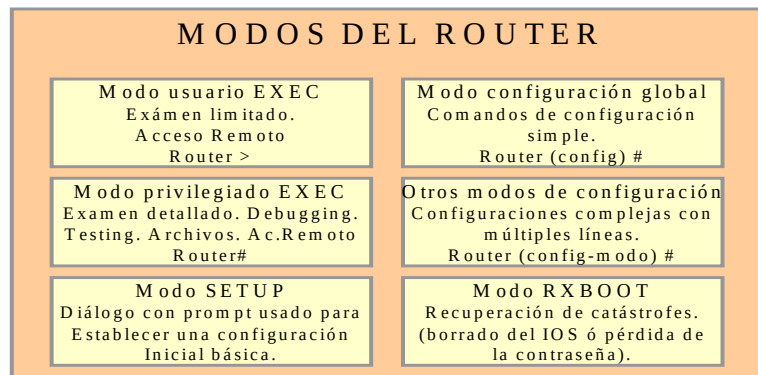
3.4 La rutina para la configuración inicial es el modo **setup**. El propósito principal del modo setup es originar rápidamente una configuración mínima para cualquier router que no puede encontrar su configuración en alguna otra fuente.

3.5 El **setup** no pretende ser el modo de ingresar características complejas del protocolo en el router. Solamente se utiliza setup para una configuración mínima. Es sencillo responder a las preguntas del diálogo de configuración del sistema del comando en modo **setup**, ya que solicita información de configuración básica. Las respuestas permiten al router usar una configuración suficiente, pero de características mínimas, la cual incluirá:

- 3.5.1 Un inventario de interfaces
- 3.5.2 Una oportunidad para ingresar parámetros globales
- 3.5.3 Una oportunidad para ingresar parámetros de interface
- 3.5.4 Una revisión de la información de setup
- 3.5.5 La oportunidad para indicar si quiere que el router use esta configuración

4. MODOS DEL ROUTER

4.1 Ya sea que se acceda desde la consola o mediante una sesión de Telnet a través de un puerto auxiliar, puede colocarse al router en varios modos. Cada modo brinda diferentes funciones:



4.1.1 **Modo de usuario EXEC:** Modo de "sólo mirar" en el cual el usuario puede ver cierta información acerca del router pero no puede modificar nada.

4.1.2 **Modo privilegiado EXEC:** Soporta los comandos de debugging y prueba, el examen detallado del router, la manipulación de archivos de configuración y el acceso a los modos de configuración.

4.1.3 **Modo Setup:** Presenta un diálogo con prompts interactivo en la consola que ayuda a cualquier nuevo usuario a crear una configuración básica de primera vez. Modo de configuración global – Implementa poderosos comandos on-line que realizan tareas simples de configuración. Otros modos de configuración – Brindan configuraciones más complicadas de varias líneas.

4.1.4 **Modo RXBOOT:** Modo de mantenimiento que se puede emplear, entre otras cosas, para recuperar claves perdidas.

4.1.5 **Modos EXEC:** **EXEC interpreta los comandos ingresados y realiza las operaciones correspondientes.**

5. CONFIGURACIONES

5.1 La configuración de los dispositivos de la red determina el comportamiento de la red total.

5.2 Debe procurarse una administración cuidadosa de las configuraciones de los dispositivos: backuppearlos, mantenerlos, almacenarlos en servidores de la red para el acceso compartido a los mismos y realizar instalaciones y actualizaciones de software.

Identificación del router

5.3 Una de las primeras tareas básicas consiste en ponerle un nombre al router.

Banners

5.4 Los routers brindan soporte a diferentes tipos de banners que mostrarán información o advertencias a diferentes usuarios en determinadas circunstancias.

5.4.1 Mensaje del día (motd)

5.4.2 Línea

5.4.3 Incoming

5.4.4 Login

Banner EXEC:

5.5 El banner de activación de línea (exec) se muestra cuando se genera un proceso EXEC (tal como una activación de línea o una conexión entrante en una VTY).

Banner incoming

5.6 El banner incoming se muestra en las terminales conectadas en las líneas de Telnet revertido. Muy práctico para proveer información a los usuarios bajo esta modalidad.

Banner login

5.7 Se muestra en todas las terminales conectadas, después del banner MOTD y antes del prompt para el login. El comando activa o desactiva el banner en todas las líneas.

6. PASSWORDS

6.1 Los routers requerirán la configuración de passwords para proteger cuatro accesos:

6.1.1 EXEC privilegiado (ENABLE)

6.1.2 Consola (CONSOLE)

6.1.3 Línea Auxiliar (AUX)

6.1.4 Terminales virtuales (VTY)

6.2 A menos que el router sea configurado para referenciar a un servidor de autenticación externo, las passwords serán almacenadas (en forma explícita o codificada, dependiendo del entorno de seguridad) en el archivo de configuración del router.

Encripción de passwords

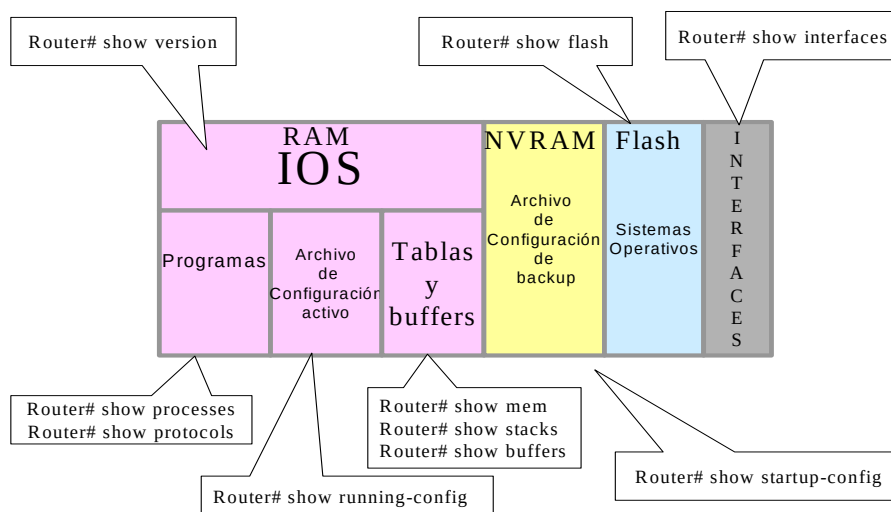
6.3 Cisco ofrece un servicio de encripción de las passwords que normalmente aparecerían en el archivo de configuración en forma explícita (excepto “enable secret”).

6.4 Una vez ingresado el comando, cada password que se configure será almacenada en forma codificada, y no podrá ser recuperada sin un programa de cracking de passwords (muy fácil y ampliamente disponible).

6.5 Cisco utiliza el algoritmo MD5 (no existe forma conocida de revertir este algoritmo) para codificar el “enable secret”. Si se utiliza el “enable secret”, no será posible aplicar las técnicas normales de recuperación de password (salvo por fuerza bruta), las que dependen de visualizar la password en forma explícita en el archivo de configuración, por lo que será menester resetear dicha password.

7. COMANDOS DE ESTADO DEL ROUTER

7.1 En la siguiente figura se muestran los comandos de estado del router:



- 7.1.1 **show versión:** Permite ver en pantalla la configuración de hardware del sistema, la versión de software, los nombres y orígenes de los archivos de configuración y las imágenes de inicio.
- 7.1.2 **show procesos:** Permite ver en pantalla información acerca de los procesos activos.
- 7.1.3 **show protocols:** Permite ver en pantalla los protocolos configurados. Este comando muestra el estado de cualquier protocolo de la capa 3 (la capa de red) configurado.
- 7.1.4 **show mem:** Muestra datos estadísticos acerca de la memoria del router, incluidos datos estadísticos sobre los pools de memoria libre.
- 7.1.5 **show stacks:** Monitorea el uso en pilas de los procesos y rutinas de interrupción y muestra la razón del último reinicio del sistema.
- 7.1.6 **show buffers:** Brinda datos estadísticos sobre los pools de buffer del servidor de la red.
- 7.1.7 **show flash:** Muestra información sobre el dispositivo de memoria flash.
- 7.1.8 **show running-config:** Muestra el archivo de configuración activo.
- 7.1.9 **show startup-config:** Muestra la copia de seguridad del archivo de configuración.
- 7.1.10 **show interfaces:** Muestra datos estadísticos sobre todas las interfaces configuradas en el router.
- 7.2 **Comandos show running-config y show startup-config:** Son quizás los más utilizados de los comandos EXEC del software Cisco IOS, ya que permiten que el administrador vea la configuración actual del router o el tamaño de las imágenes y los comandos de configuración de arranque que utilizará el router la próxima vez que se lo ponga en funcionamiento.
- 7.3 **Comando show interface serial:** El comando show interface serial presenta en la pantalla los parámetros configurables y estadísticas en tiempo real sobre las interfaces serie.
- 7.4 **Comando show versión:** Show version muestra información de la versión del Cisco IOS que ejecuta el router.
- 7.5 **Comando show protocols:** Este comando muestra el estado global y el estado específico de la interface de cualquier protocolo de Nivel 3 configurado (por ejemplo, IP, DECnet, IPX, y AppleTalk).

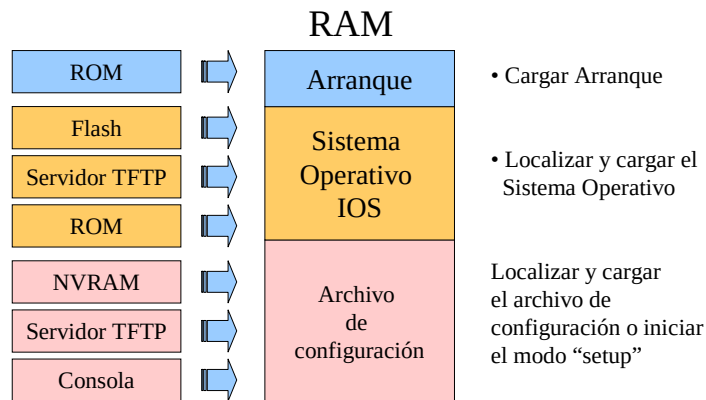
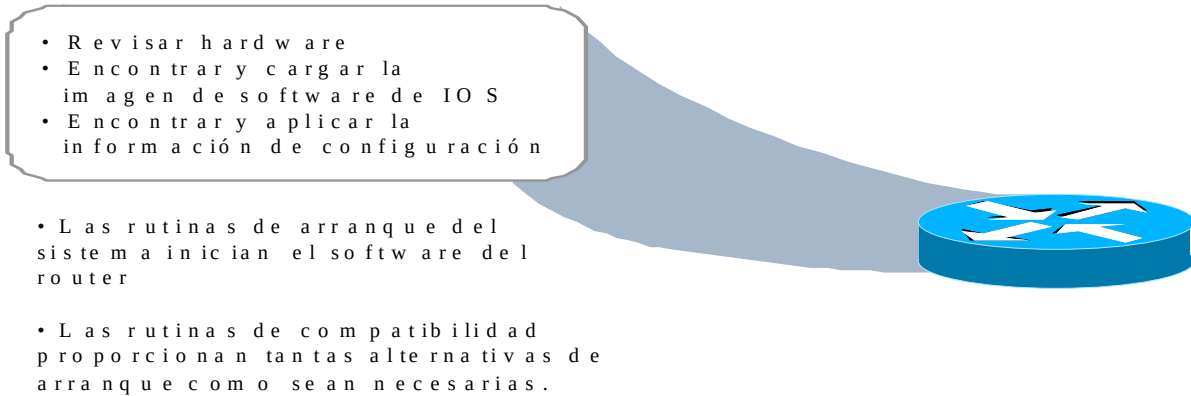
8. INICIALIZACIÓN DEL ROUTER

Rutinas de Arranque

- 8.1 Las rutinas de arranque del software IOS tienen por objeto dar inicio a las operaciones del router. El router debe tener un desempeño confiable en la conexión de las redes de usuario para cuyo servicio fue configurado. Para hacerlo, las rutinas de inicio deben:
- 8.1.1 Asegurarse de que el router tenga todo el hardware probado.
- 8.1.2 Buscar en la memoria y cargar el software IOS que el router utiliza como OS.
- 8.1.3 Buscar en la memoria y aplicar la información de configuración del router, incluidas las funciones del protocolo y las direcciones de las interfaces.
- 8.2 Inmediatamente después del arranque, el router se asegurará de tener el hardware probado, mediante la ejecución de una POST (Power-On-Self-Test).

8.3 La POST, la cual reside y se ejecuta desde la ROM, realiza una auto prueba del sistema, durante la cual, diagnostica todos los componentes. Se verifica la presencia y el funcionamiento básico de la CPU, de la memoria y de los puertos de interface de red.

8.4 Después de verificar las funciones del hardware, el router procede a la inicialización del software.



9. CONFIGURACIÓN DEL ROUTING IP

Tabla inicial de enrutamiento IP

9.1 Inicialmente, el router posee información de las redes o subredes directamente conectadas. Cada interface debe ser configurada con una dirección IP y una máscara. El software IOS debe recibir esta dirección IP e información de máscara desde alguna fuente. La fuente inicial de direccionamiento es la persona que realizar la primera configuración.¹⁴

9.2 Por supuesto, es posible iniciar al router desde una condición de cero -estado que carece de otro origen para una configuración inicial- en modo setup-mode, y responder a los prompts para una información de configuración básica.

¹⁴ El comando global "no ip routing" deshabilita el enrutamiento del protocolo IP.

Información de Rutas

9.3 Los routers conocen las rutas a destinos de tres modos distintos:

9.3.1 **Rutas estáticas:** Definidas manualmente por el administrador del sistema como la única ruta hacia el destino. Son útiles para controlar la seguridad y reducir el tráfico.

9.3.2 **Rutas por defecto:** Definidas manualmente por el administrador del sistema como la ruta a tomar cuando no existe una ruta conocida hacia el destino.

9.3.3 **Enrutamiento dinámico:** El router se entera de las rutas a los destinos al recibir actualizaciones periódicas de otros routers.

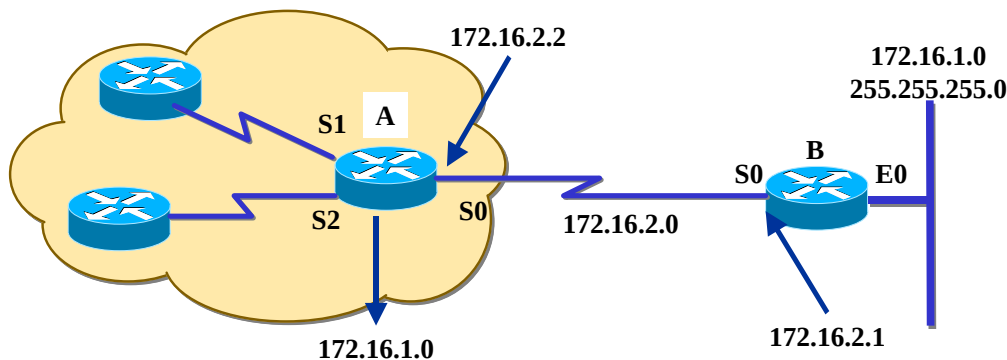
Configuración de rutas estáticas

9.4 Una ruta estática permite una configuración manual de la tabla de enrutamiento. No se producirán cambios dinámicos en una entrada de tabla determinada mientras esté activa la ruta, y en general refleja algún conocimiento especial de la situación de networking conocida para el administrador de red. No se envían actualizaciones de enrutamiento por los enlaces, si sólo se han definido rutas estáticas, conservando el ancho de banda.

9.5 En el ejemplo:

9.5.1 La asignación de una ruta estática para alcanzar la red de conexión única 172.16.1.0 es apropiada para el router A (ISP), porque existe solamente una forma de alcanzar la red del cliente.

9.5.2 La asignación de una ruta estática desde el router B a las redes no visualizadas también es posible. Sin embargo, una asignación de una ruta estática es necesaria para cada red de destino, por lo tanto, una *ruta por defecto puede ser más conveniente*.



```
ip route 172.16.1.0 255.255.255.0 172.16.2.1
```

Comando	Descripción
ip route 172.16.1.0	Especifica una ruta estática a la subred de destino.
255.255.255.0	Una máscara de subred indica que hay 8 bits de conexión en subredes en curso.
172.16.2.1	Dirección IP del router del próximo salto en la ruta al destino.

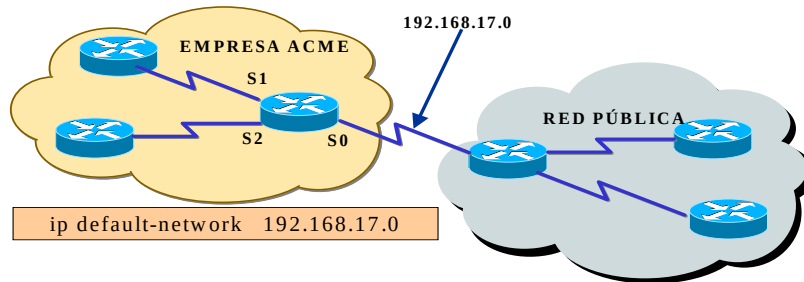
Configuración de rutas por defecto

9.6 Cuando no existe una entrada para la red de destino en la tabla de enrutamiento, el paquete se envía a la red por defecto. La red por defecto debe existir en la tabla de enrutamiento. Las rutas por defecto mantienen la longitud de las tablas de enrutamiento más cortas.

9.7 Debe utilizarse el número de red por defecto cuando se necesite una ruta, de la que solamente se tenga información parcial sobre la red de destino.

9.8 Como el router no tiene un conocimiento completo de todas las redes de destino, puede usar un número de red por defecto para indicar la dirección a tomar para números de redes desconocidas.

9.9 En el ejemplo, el default-network 192.168.17.0 define la red de clase C 192.168.17.0, como la ruta de destino para los paquetes que no tienen una entrada en una tabla de enrutamiento.



Router(config)# ip default-network network-number

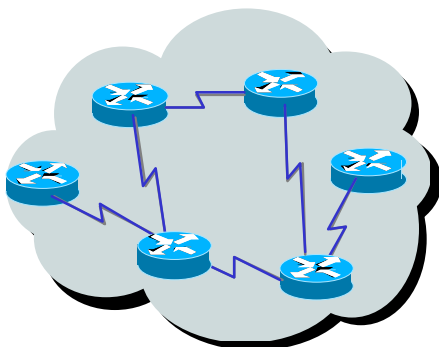
Comando ip default network	Descripción
network-number	Número de red IP o número de subred definido como defecto.

Introducción al enrutamiento dinámico

Sistema autónomo

9.10 En el ejemplo anterior, el Router A podría necesitar un firewall para actualizaciones de enrutamiento. El administrador de la Compañía X no quiere actualizaciones procedentes de la red pública. El Router A puede necesitar un mecanismo para agrupar las redes que compartirán la estrategia de enrutamiento de la Compañía X. Uno de esos mecanismos es un número de sistema autónomo.

9.11 Un sistema autónomo consiste en routers, administrados por uno o más operadores, que presentan una pauta coherente de enrutamiento hacia el mundo externo.

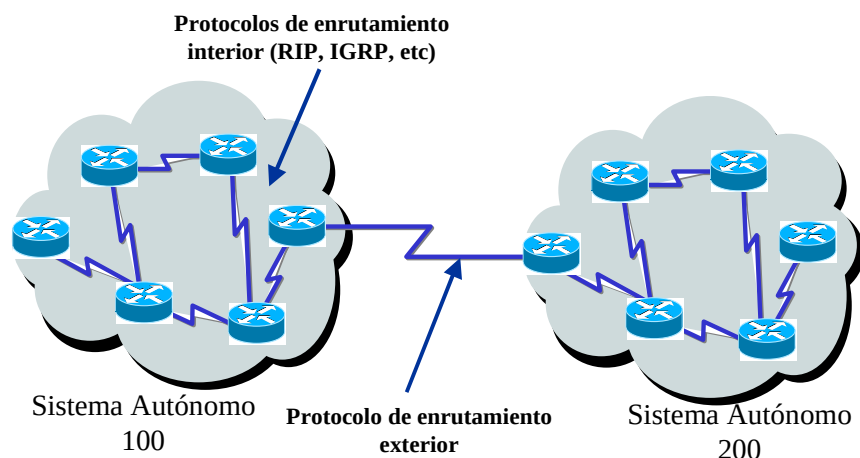


9.12 El Centro de información de la red [Network Information Center] (NIC) asigna un número de sistema autónomo exclusivo para cada empresa. Este sistema autónomo es un número de 16 bits.

9.13 Un protocolo de enrutamiento como el Protocolo de enrutamiento de gateway interior de Cisco [Interior Gateway Routing Protocol] (IGRP) demanda que especifique este número de sistema autónomo exclusivo asignado en su configuración.

Protocolos de enrutamiento interiores o exteriores

9.14 Se utilizan protocolos de enrutamiento exteriores para comunicar entre sistemas autónomos. Se utilizan protocolos de enrutamiento interiores dentro de un único sistema autónomo.



Protocolos de enrutamiento IP interiores

9.15 Los routers pueden utilizar protocolos de enrutamiento -en la capa de Internet del conjunto de protocolos TCP/IP-, mediante la aplicación de algoritmos de enrutamiento específicos.

9.16 Algunos de los ejemplos de protocolos de enrutamiento IP más comunes son:

9.16.1 RIP: Protocolo de enrutamiento por vector de distancia (distance-vector).

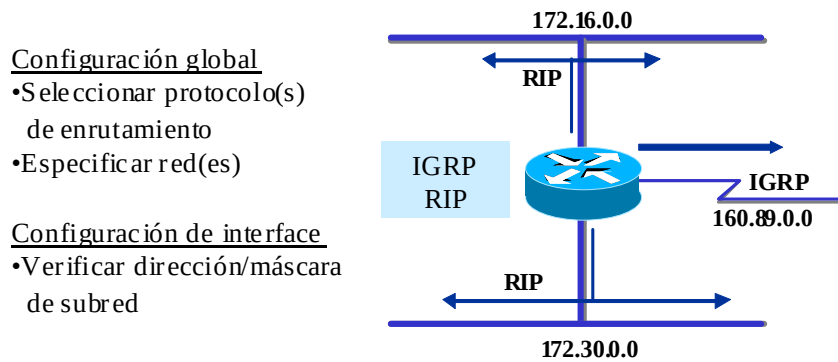
9.16.2 IGRP: Protocolo de enrutamiento por vector de distancia de Cisco.

9.16.3 OSPF: Protocolo de enrutamiento de estado de enlace (link-state).

9.16.4 Enhanced IGRP (EIGRP): Protocolo de enrutamiento híbrido equilibrado.

Tareas de configuración de enrutamiento Dinámico

9.17 Como se indica en la figura, es necesario seleccionar el protocolo de enrutamiento a utilizar desde el modo de configuración global, y a continuación se ingresan tantos subcomandos network como sea necesario para habilitar la actividad del protocolo en las redes correspondientes.

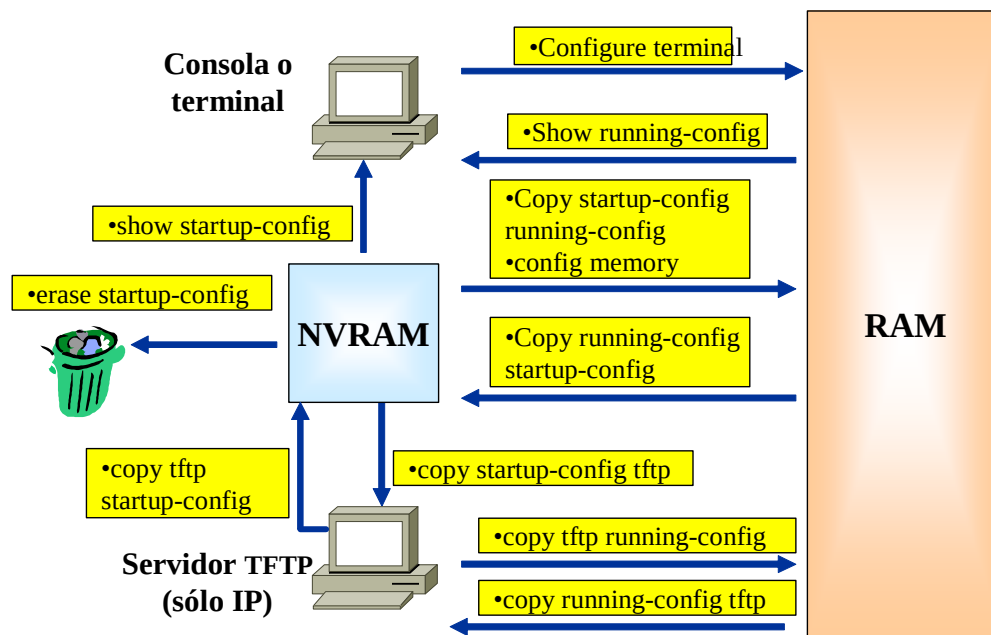


9.18 En la figura se muestra una situación de configuración de un router con 3 interfaces y diferentes protocolos de enrutamiento.

9.19 Debe especificarse mediante el comando global “router” el protocolo de enrutamiento que desea habilitarse.

10. ADMINISTRACIÓN DEL ENTORNO DE CONFIGURACIÓN

10.1 Conforme la red crece y evoluciona, es necesario mantener desde un sitio centralizado el control del software y de los archivos de los dispositivos de la red.



Operaciones con servidor TFTP

10.2 Las configuraciones de los dispositivos pueden almacenarse y descargarse desde un servidor TFTP.

Backup de la configuración

10.3 Se puede almacenar una copia actual de la configuración en un servidor TFTP.

Recuperación de la configuración

10.4 Puede configurar el router recuperando el archivo de configuración almacenado en uno de los servidores de la red.

Convenciones de nombres de Cisco IOS

10.5 Para optimizar la forma en que opera el software en las diversas plataformas, Cisco ha desarrollado muchas imágenes diferentes. Estas imágenes se ajustan a las diversas plataformas, a los recursos de memoria disponibles, y reflejan las necesidades que tienen sus clientes para los dispositivos de la red.

10.6 A lo largo del tiempo, se han acumulado miles de imágenes IOS y conjuntos de características (Feature Sets). Las convenciones sobre la designación de nombres del software Cisco IOS, el significado del nombre del campo, el contenido de la imagen y otros detalles estuvieron siempre sujetos a cambio, debiendo consultarse con frecuencia el sitio Cisco Connection Online (CCO) para obtener datos actualizados.

10.7 A partir de la versión 12.3, Cisco ha simplificado drásticamente la tarea de seleccionar el Feature Set, reduciendo a 8 las alternativas de Feature Sets (de un total de 44 que existían para cada versión previa a la 12.3).

10.8 La siguiente tabla muestra la funcionalidad que se incluye en cada uno de los 8 paquetes de software IOS.

10.9 Como se aprecia, IP BASE es el cimiento sobre el que se construyen los otros 7 paquetes. Así, por ejemplo, si se requiriera voz, deberíamos pensar en paquete IP VOICE.

10.10 Pero, si además fuera necesario incorporar funciones de seguridad (Firewall, IDS y VPN), entonces el paquete adecuado debería ser ENTERPRISE BASE (que incorpora el soporte para ATM, VoATM y MPLS, no requeridos en nuestro caso, pero son las consecuencias de la metodología del packaging decidida por CISCO, en el que ha priorizado la simplicidad).

Funcionalidad	Conectividad Datos	VoIP y VoFR	ATM, VoATM y MPLS	Protocolos AppleTalk, IPX, IBM	Firewall, IDS, VPN
IOS Packaging					
IP Base	X				
IP Voice	X	X			
Advanced Security	X				X
Advanced IP Services	X			X	

SP Services	X	X	X		
Enterprise Base	X	X	X		X
Enterprise Services	X	X	X	X	
Advanced Enterprise Services	X	X	X	X	X

11. ACCESO A OTROS ROUTERS

11.1 Existen diferentes formas de acceder a la información de otros routers. Una de ellas es utilizando el protocolo CDP.

CDP

11.2 El Cisco Discovery Protocol (CDP) ofrece una herramienta, propietaria de Cisco, la cual permite que los administradores de la red accedan a un resumen de la configuración de otros routers directamente conectados. CDP corre sobre la capa de enlace de datos que conecta los medios físicos y los protocolos de las capas superiores. Como CDP opera a bajo nivel, los dispositivos del CDP que soportan diferentes protocolos de la capa de red pueden conocerse entre sí. -la dirección de enlace de datos es similar al concepto de la dirección MAC-.

11.3 Cuando un dispositivo Cisco ejecuta la secuencia inicial, CDP se pone en funcionamiento por omisión, y a partir de allí puede descubrir automáticamente los dispositivos Cisco vecinos que también estén utilizando CDP.

11.4 Los dispositivos descubiertos se extienden más allá de aquellos que tienen TCP/IP, ya que CDP descubre los dispositivos Cisco que estén directamente conectados, independientemente de los protocolos de capa 3 y capa 4 que se encuentren ejecutando.

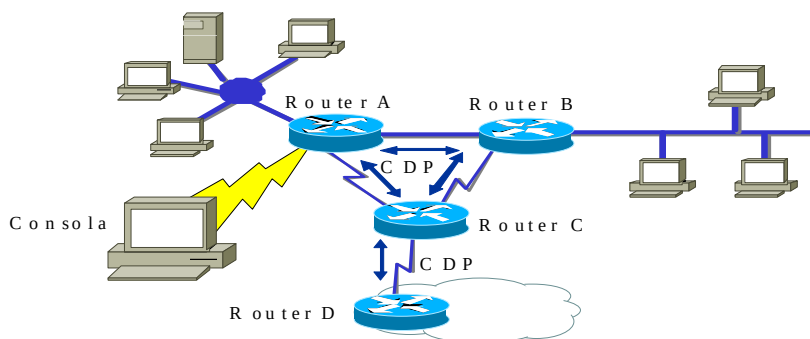
• Direcciones de entrada de la capa superior

• Protocolo de Enlace de Datos propietario de Cisco

• SNAP
Soporte a medios

TCP/IP	Novell IPX	AppleTalk Otros
El protocolo CDP descubre y muestra información de dispositivos Cisco directamente conectados		
LAN's	Frame Relay	ATM Otros

Información CDP



11.5 En el gráfico se ve un ejemplo de la forma en la que CDP ofrece sus beneficios al administrador del sistema.

11.6 Cada router que ejecuta CDP intercambia información relacionada con los datos de cualquier protocolo que conozca con sus vecinos.

11.7 El administrador puede ver en pantalla los resultados de este intercambio de información del CDP en una consola conectada a un router configurado para ejecutar el CDP en sus interfaces.

11.8 El administrador de red utiliza un comando **show** para visualizar en pantalla la información sobre las redes directamente conectadas al router. CDP brinda información sobre cada dispositivo vecino CDP. Entre los posibles datos se incluyen:

11.8.1 **Identificadores de dispositivos:** Por ejemplo, el nombre del host y el nombre de dominio (si lo hubiera) configurados en el router.

11.8.2 **Lista de direcciones:** Una dirección por cada protocolo que esté soportando.

11.8.3 **Identificador de puertos:** Por ejemplo Ethernet 0, Ethernet 1, Serial 0, etc.

11.8.4 **Lista de capacidades:** Por ejemplo su el dispositivo actúa como bridge de ruta de origen además de como router.

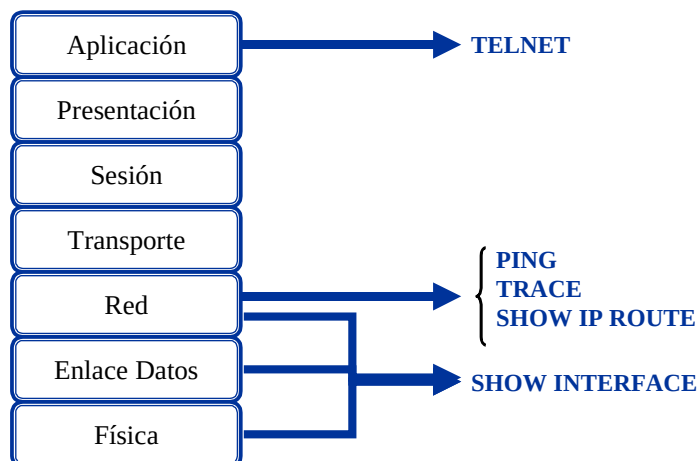
11.8.5 **Versión:** Información como la que ofrece el comando show versión, ejecutado localmente.

11.8.6 **Plataforma:** Plataforma del hardware del dispositivo: por ejemplo, Cisco 7000.

11.9 El router ubicado más abajo en la figura no está directamente conectado al router de la consola del administrador. Por consiguiente, para obtener información de CDP sobre este dispositivo, el administrador necesitaría efectuar una conexión por Telnet con un router directamente conectado a este objetivo.

Proceso de Testing

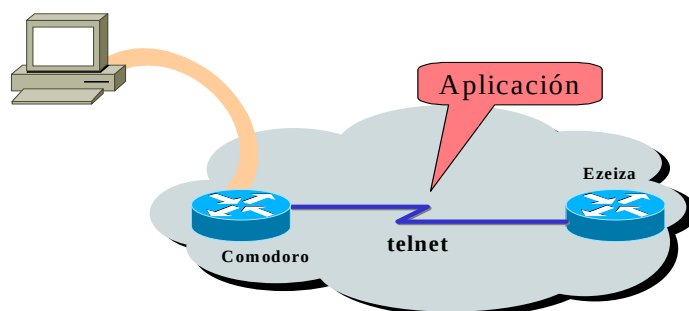
11.10 La prueba básica de una red debería provenir en secuencia desde una capa del modelo ISO/OSI hacia la siguiente. Cada prueba que se presenta en esta sección se refiere a las operaciones de red de una capa específica del modelo OSI.



Testing de la Capa de Aplicación

11.11 Telnet ofrece un servicio de terminal virtual, de modo que el administrador pueda utilizar las operaciones Telnet para conectarse con otros hosts que utilicen TCP/IP (a través de la conexión de una aplicación cliente a una aplicación servidor)

11.12 La prueba tiene el objetivo de determinar si es posible acceder al router remoto. Por ejemplo, ejecutar con éxito Telnet para conectarse desde el router Comodoro con el otro router Ezeiza es una prueba básica para comprobar la conectividad y accesibilidad.



11.13 Si podemos acceder remotamente a otro router a través de Telnet, no solamente se comprobará que una aplicación TCP/IP –aplicación de capa superior- puede llegar al router remoto, sino que también indicará que los servicios de las capas inferiores también funcionan correctamente.

11.14 Si es posible la comunicación vía Telnet con un router pero no con otro router, es probable que el fallo de Telnet esté causado por un nombre de dirección específico o con problemas de permiso de acceso. Estos problemas pueden estar en nuestro router o en el router que falló como objetivo de la comunicación Telnet.

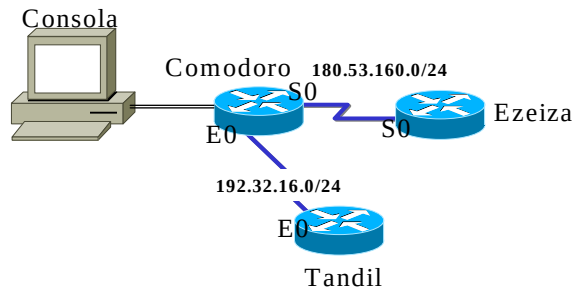
Testing de la Capa de Red

11.15 Las siguientes herramientas permiten dictaminar la salud de la capa de red.

Comando Ping

11.16 Como ayuda para diagnosticar la conectividad básica de la red, muchos protocolos de red soportan un protocolo de eco, que es una prueba para determinar si se están enrutando correctamente los paquetes del protocolo.

```
COMODORO>ping 180.53.160.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 180.53.160.2, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 1/3/4 ms
COMODORO>
```



11.17 El comando **ping** envía un paquete especial al host de destino y luego espera un paquete de respuesta de dicho host. Los resultados de este protocolo de eco pueden ayudar a evaluar la confiabilidad de la ruta al host, las demoras de la ruta y si se puede llegar al host y si éste está funcionando.

11.18 En el gráfico, el objetivo **ping 180.53.160.2** respondió exitosamente a cuatro de los cinco datagramas que se le enviaron. Los signos de exclamación (!) indican cada eco exitoso. Si en vez de recibir estos signos se recibieran uno o más puntos (.), significa que la aplicación del router local se dio por vencido (time out) esperando el eco de un paquete.

11.19 El comando de usuario EXEC **ping** puede utilizarse para diagnosticar la conectividad básica de la red. El protocolo que utiliza ping es ICMP (Internet Control Message Protocol).

Comando trace

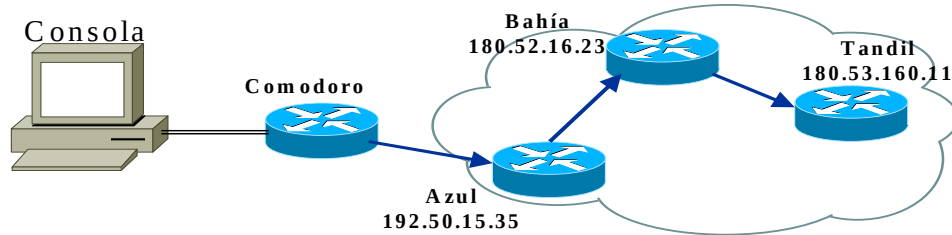
11.20 El comando trace es la herramienta ideal para descubrir a dónde se están enviando los datos en su red. Utiliza el mismo protocolo que el ping, salvo que en lugar de probar la conectividad de extremo a extremo, el comando trace prueba cada paso del camino.

11.21 Esta operación puede realizarse desde cualquiera de los niveles EXEC: usuario o privilegiado.

11.22 El comando trace aprovecha los mensajes de error generados por los routers cuando un paquete excede su valor de tiempo de existencia (TTL), envía varios paquetes y exhibe en pantalla el tiempo de ida y vuelta de cada uno.

11.23 El beneficio del comando trace es que nos dice cuál es el último router de la ruta al que se llega. Esto se denomina aislamiento de fallos.

11.24 En el ejemplo, se rastrea la ruta desde Comodoro hacia Tandil. En su camino, la ruta debe ir a través de Azul y Bahía. Si uno de estos routers no se hubiera podido alcanzar, habríamos visto tres asteriscos (*) en lugar del nombre del router. El comando trace continuaría intentando llegar al próximo paso hasta que hiciéramos una operación de escape.



```
comodoro>trace azul

Type escape sequence to abort.
Tracing the route to azul (180.53.160.11)

 0  azul (192.50.15.35)  4 msec  8 msec  12 msec
 1  bahia (180.52.16.23) 6 msec 10 msec 14 msec
 2  tandil (180.53.160.11) 8 msec 14 msec 16 msec

COMODORO>
```

Comando show ip route

11.25 El router nos brinda algunas herramientas poderosas en este punto de nuestra búsqueda. Podemos efectivamente ver la tabla de enrutamiento – es decir las direcciones que utiliza el router para determinar cómo direccionar el tráfico por la red-.

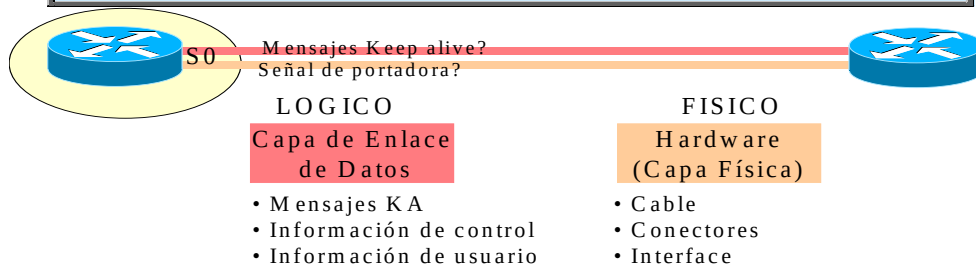
Operatividad del enlace

11.26 El hardware debe efectuar la conexión real entre los dispositivos. El software son los mensajes que se intercambian entre los dispositivos adyacentes. Esta información está constituida por datos que se pasan entre dos interfaces del router conectadas.

La interface tiene dos componentes:

- > Físico (hardware)
- > Lógico (software).

```
COMODORO>show interface serial 0
Serial0 is up, line protocol is up
Hardware is HD64570
Description: INTERFACE SERIE HACIA EZEIZA
Internet address is 192.168.12.1/24
MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec, rely 255/255, load 1/255
```



- 11.27 Cuando se comprueba el enlace físico y el enlace de datos, se formulan estas preguntas:
- 11.27.1 ¿Hay una señal de detección de portadora?
- 11.27.2 ¿Está operativo el enlace físico entre los dispositivos?
- 11.27.3 ¿Se están recibiendo los mensajes de actividad (KA)?
- 11.27.4 ¿Se pueden enviar paquetes de datos a través del enlace físico?

Comando show interface serial

11.28 Uno de los elementos más importantes del resultado del comando **show interface serial** es la representación en pantalla del estado de la línea y el del protocolo de enlace de datos. El gráfico indica la línea de resumen clave que se debe verificar y los significados del estado.

INTERPRETACIÓN DE LA INFORMACIÓN: show interface serial		
FÍSICO	LÓGICO	ESTADO
UP	UP	Operacional
UP	DOWN	Problema de conexión
DOWN	DOWN	Problema de interface
DOWN Administrativo	DOWN	Deshabilitada

11.29 El estado de la línea, en este ejemplo, está condicionado por la señal de detección de portadora y se refiere al estado de la capa física.

11.30 Sin embargo, el protocolo de línea, está condicionado por los frames de actividad, es decir que se aplica a las tramas del enlace de datos.

Tráfico en tiempo real

11.31 El router incluye hardware y software que permiten rastrear problemas del mismo router o de otros hosts de la red. El comando EXEC **debug** del nivel privilegiado da inicio a la representación en la consola de los hechos ocurridos en la red, que se hayan indicado en el parámetro del comando debug.

FUNCIONES DE ENRUTAMIENTO

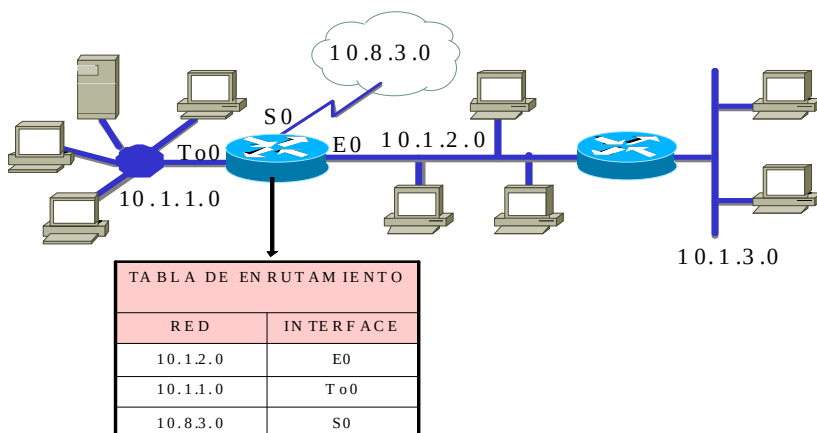
CLASES DE PROTOCOLOS DE ENRUTAMIENTO

1. FUNCIONES DE ENRUTAMIENTO

1.1 Es posible configurar a los routers para que utilicen uno o más protocolos de enrutamiento IP (o de otro protocolo de red). No existe un único algoritmo de enrutamiento que satisfaga los requerimientos de cualquier red. Los administradores de las redes deben analizar diferentes aspectos (técnicos y políticos) para escoger el mejor algoritmo.

CONSIDERACIONES DE ENRUTAMIENTO

Tabla inicial de enrutamiento IP



1.2 Inicialmente, un router debe referirse a las entradas de las redes y subredes que se conectan directamente. Cada interface debe ser configurada con una máscara y una dirección IP. El software IOS de Cisco debe recibir la dirección IP y máscara como información de entrada de configuración de alguna fuente. La fuente inicial de direccionamiento es de la persona que realiza la primera configuración.

1.3 Los routers, por defecto conocen las rutas a destinos de tres modos distintos:

1.3.1 Rutas estáticas -Definidas manualmente por el administrador del sistema como la única ruta hacia el destino. Son útiles para controlar la seguridad y reducir el tráfico.

1.3.2 Rutas por defecto - Definidas manualmente por el administrador del sistema como la ruta a tomar cuando no existe una ruta conocida hacia el destino.

1.3.3 Enrutamiento dinámico - El router se entera de las rutas a los destinos al recibir actualizaciones periódicas de otros routers.

Configuración de ruta estática

1.4 El siguiente comando establece una ruta estática:

Comando ip route	Descripción
network	Red o subred de destino
mask	Máscara de subred
address	Dirección IP del router del próximo salto
interface	Nombre de la interface que se utilizará en la red de destino
distance	Distancia administrativa

1.5 La distancia administrativa es una clasificación de confiabilidad de una fuente de información de enrutamiento, expresada como un valor numérico de 0 a 255. Cuanto mayor es el valor, menos es la clasificación de confiabilidad.

1.6 Una ruta estática permite una configuración manual de la tabla de enrutamiento. No se producirán cambios dinámicos en una entrada de tabla determinada mientras esté activa la ruta.

1.7 Una ruta estática puede reflejar algún conocimiento especial de la situación de networking conocida para el administrador de red. Los valores de distancia administrativa ingresados manualmente son en general números bajos.

1.8 Las actualizaciones de enrutamiento no se envían por un enlace, si sólo son definidas por una ruta estática, y de este modo se conserva el ancho de banda.

Ejemplo:

Comando: ip route 172.16.1.0 255.255.255.0 172.16.2.1	
Comando	Descripción
ip route 172.16.1.0	Especifica una ruta estática a la subred de destino.
255.255.255.0	Una máscara de subred indica que hay 8 bits de conexión en subredes en curso.
172.16.2.1	Dirección IP del router del próximo salto en la ruta al destino.

Configuración de ruta por defecto

Comando ip default network	Descripción
network-number	Número de red IP o número de subred definido como defecto.

1.9 Cuando no existe una entrada para la red de destino en la tabla de enrutamiento, el paquete se envía a la red por defecto. La red por defecto debe existir en la tabla de enrutamiento. Las rutas por defecto mantienen la longitud de las tablas de enrutamiento más cortas.

1.10 Debe utilizarse una red por defecto cuando solamente se posea información parcial sobre la red de destino. Como el router no tiene un conocimiento completo de todas las redes de destino, puede usar un número de red por defecto para indicar la dirección a tomar para números de redes desconocidos.

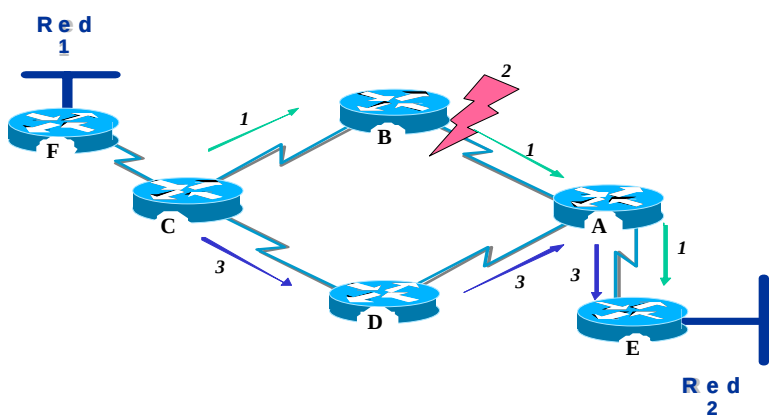
1.11 Por ejemplo el comando global `ip default-network 192.168.17.0` define la red de clase C 192.168.17.0, como la ruta de destino para los paquetes que no tienen una entrada en una tabla de enrutamiento.

Rutas estáticas versus rutas dinámicas

1.12 El conocimiento estático se administra en forma manual: un administrador de red la ingresa en la configuración del router. El administrador debe actualizar manualmente esta entrada de ruta estática¹⁵ cada vez que un cambio de topología de internetwork requiera una actualización.

1.13 El conocimiento dinámico funciona de modo diferente. Después de que el administrador de red ingresó los comandos de configuración para iniciar el enrutamiento dinámico¹⁶, el conocimiento de la ruta se actualiza automáticamente por un proceso de enrutamiento cada vez que se recibe nueva información de la internetwork. Los cambios en el conocimiento dinámico se intercambian entre routers como parte del proceso de actualización.

Adaptación al cambio de topología



1.14 La red que se muestra en el gráfico se adapta de distintas formas al cambio de topología según utilice conocimiento configurado estática o dinámicamente. El enrutamiento estático permite a los routers enrutar un paquete en forma adecuada de una red a otra. El router se remite a su tabla de enrutamiento y sigue el conocimiento estático hasta allí para pasar el paquete al router F, C, B, A y E, hasta entregar el paquete al host de destino.

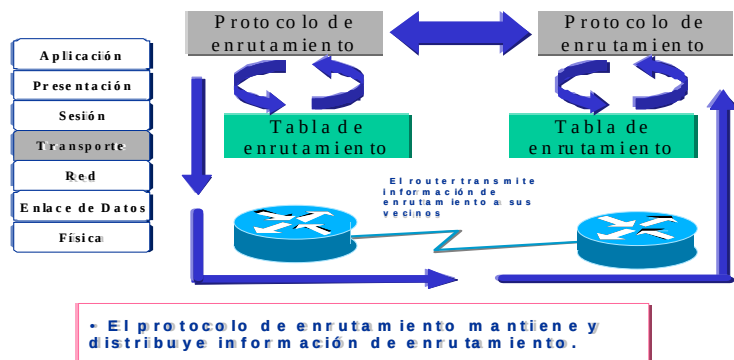
1.15 Pero, ¿qué sucede si falla la ruta entre el router B y el router A? Obviamente, el router B no podrá transmitir el paquete al router A con una ruta estática. Hasta que el router C no sea reconfigurado manualmente para pasar los paquetes por medio del router D, la comunicación con la red de destino es imposible.

¹⁵ **Ruta estática** - Ruta explícitamente configurada e ingresada en la tabla de enrutamiento. Las rutas estáticas tienen prioridad sobre las rutas elegidas por los protocolos de enrutamiento dinámico.

¹⁶ **Enrutamiento dinámico** - Enrutamiento que se ajusta automáticamente a la topología de la red o a los cambios de tráfico. También denominado *enrutamiento adaptable*.

1.16 El enrutamiento dinámico ofrece flexibilidad. Según la tabla de enrutamiento generada por el router C, un paquete puede llegar a su destino por la ruta preferida a través del router B. Sin embargo, existe una ruta alternativa disponible a través del router D. Cuando el router B reconoce que el enlace al router A está caído, ajusta su tabla de enrutamiento, y pasa la información al router C, quién selecciona la ruta a través del router D como ruta preferida hacia su destino. Los routers continúan enviando paquetes a través de este enlace.

1.17 Cuando la ruta entre los routers B y A reanuda su servicio, el router C puede cambiar nuevamente su tabla de enrutamiento e indicar su preferencia por la ruta en el sentido de las agujas del reloj a través de los routers B y A hacia la red de destino. Los protocolos de enrutamiento dinámico también pueden redirigir el tráfico entre las diferentes rutas de una red.



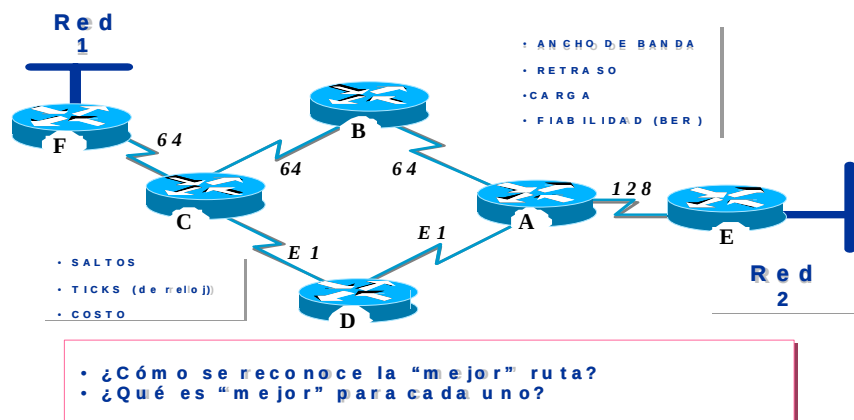
ENRUTAMIENTO DINÁMICO

1.18 El éxito del enrutamiento dinámico depende de dos funciones básicas del router:

1.18.1 Mantenimiento de una tabla de enrutamiento

1.18.2 Distribución a tiempo del conocimiento — en forma de actualizaciones de enrutamiento — a otros routers.

1.19 El enrutamiento dinámico se basa en un protocolo de enrutamiento para compartir el conocimiento. Un protocolo de enrutamiento define el conjunto de reglas utilizadas por el router para comunicarse con sus vecinos.



1.20 Por ejemplo, un protocolo de enrutamiento describe:

1.20.1 Cómo se envían las actualizaciones

1.20.2 Qué información contienen dichas actualizaciones

- 1.20.3 Cuándo enviar esta información
- 1.20.4 Cómo localizar los receptores de las actualizaciones

Representación de distancias mediante métricas

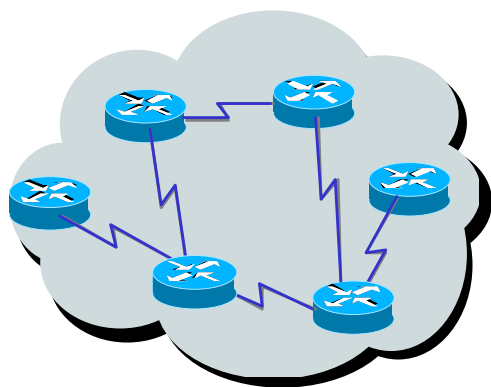
1.21 Cuando un algoritmo de enrutamiento actualiza una tabla de enrutamiento, su objetivo principal es determinar la mejor información para incluirla en la tabla. Cada algoritmo de enrutamiento interpreta el término: mejor, a su propio modo. El algoritmo genera un número -denominado valor de métrica- para cada ruta a través de la red. Cuanto menor sea el número de métrica, mejor será la ruta.

1.22 Las métricas se pueden calcular basándose en una sola característica de la ruta. Se pueden calcular métricas más complejas combinando varias características. Se utilizan varias características de ruta en el cálculo de las métricas. Las métricas que los routers utilizan más comúnmente son las siguientes:

- 1.22.1 **Ancho de banda** - Capacidad de datos de un enlace. Por ejemplo, normalmente, un enlace Ethernet de 10 Mbps es preferible a una línea arrendada de 64 kbps.
- 1.22.2 **Retraso** - Tiempo necesario para mover un paquete desde el origen hasta el destino.
- 1.22.3 **Carga** - Cantidad de actividad en un recurso de red, como un router o un enlace.
- 1.22.4 **Fiabilidad** - Generalmente se refiere a la tasa de error de cada enlace de red.
- 1.22.5 **Número de saltos** - Cantidad de routers que debe atravesar un paquete.
- 1.22.6 **Ticks** - Retraso en un enlace de datos utilizando ticks del reloj de una PC IBM (aproximadamente 55 milisegundos).
- 1.22.7 **Costo** - Valor arbitrario, en general basado en el ancho de banda, gasto en pesos, dólares u otra medida, que lo asigna el administrador de red

Sistema autónomo

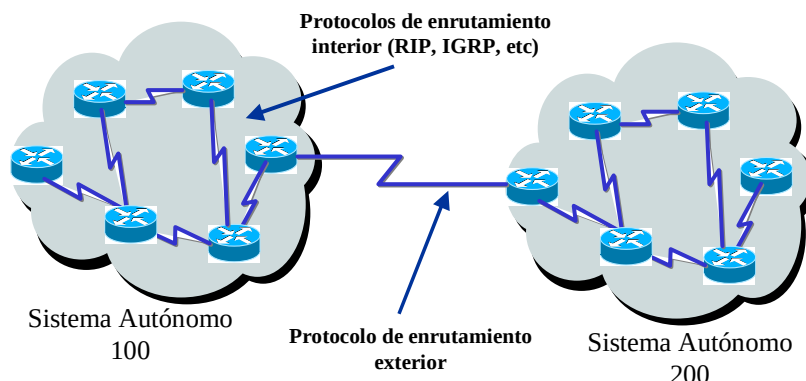
1.23 Un sistema autónomo consiste en routers, administrados por uno o más operadores, que presentan una pauta coherente de enrutamiento hacia el mundo externo.



1.24 El Centro de información de la red [Network Information Center] (NIC) asigna un sistema autónomo exclusivo a las empresas. Este sistema autónomo es un número de 16 bits. Un protocolo de enrutamiento como el Protocolo de enrutamiento de gateway interior de Cisco [*Interior Gateway Routing Protocol*] (IGRP) demanda que especifique este número de sistema autónomo exclusivo asignado en su configuración.

PROTOCOLOS INTERIORES Y EXTERIORES

1.25 Se utilizan protocolos de enrutamiento exteriores para comunicar entre sistemas autónomos. Se utilizan protocolos de enrutamiento interiores dentro de un único sistema autónomo.



Protocolos de enrutamiento IP interiores

1.26 En la capa de Internet del conjunto de protocolos TCP/IP, un router puede usar protocolos de enrutamiento a través de algoritmos específicos. Los ejemplos de protocolos de enrutamiento IP incluyen:

- 1.26.1 RIP—Un protocolo de enrutamiento por vector de distancia.
- 1.26.2 IGRP— Un protocolo de enrutamiento por vector de distancia de Cisco.
- 1.26.3 OSPF—Un protocolo de enrutamiento de estado de enlace.
- 1.26.4 EIGRP (Enhanced IGRP) —Un protocolo de enrutamiento híbrido equilibrado.

2. CLASES DE PROTOCOLOS DE ENRUTAMIENTO

2.1 La mayoría de los algoritmos de enrutamiento se pueden clasificar en uno de dos tipos de algoritmos básicos: vector de distancia¹⁷ o estado de enlace¹⁸.

2.2 El tipo de enrutamiento por vector de distancia determina la dirección (vector) y la distancia a cualquier enlace en la internetwork.

2.3 El tipo de enrutamiento de estado de enlace (también llamado de la ruta más corta - SPF) recrea la topología exacta de toda la internetwork (o al menos la partición donde está situado el router).

¹⁷ **Algoritmo de enrutamiento por vector de distancia (Bellman-Ford)** - Clase de algoritmos de enrutamiento que iteran sobre el número de saltos en una ruta para encontrar un spanning-tree de camino más corto. Los algoritmos de enrutamiento por vector de distancia envían a sus vecinos su tabla de enrutamiento total en cada actualización. Los algoritmos de enrutamiento por vector de distancia son propensos a los bucles de enrutamiento, pero son computacionalmente más simples que los algoritmos de enrutamiento del estado de enlace.

¹⁸ **Algoritmo de enrutamiento del estado de enlace** - Algoritmo de enrutamiento en el cual cada router realiza un broadcast o multicast de información a todos los nodos de la internetwork con el costo de comunicación hacia cada uno de sus vecinos. Los algoritmos de estado de enlace crean una vista consistente de la red y por lo tanto no son propensos a bucles de enrutamiento, pero al costo de dificultades computacionales relativamente mayores y un tráfico más diseminado (comparado con los algoritmos de enrutamiento por vector de distancia).

2.4 El tipo de híbrido balanceado combina aspectos de los algoritmos de estado de enlace y por vector de distancia.

Convergencia

2.5 El algoritmo de enrutamiento es esencial para el enrutamiento dinámico. Cuando la topología de la red cambia debido a crecimiento, reconfiguración, o fallas, el conocimiento base de la red también debe cambiar.

2.6 El conocimiento necesita reflejar una visión precisa y consistente de la nueva topología. Esta visión precisa y consistente se denomina convergencia.

2.7 Cuando todos los routers de una internetwork trabajan con la misma información, se dice que la internetwork ha convergido.

2.7.1 La convergencia tiene lugar cuando todos los routers utilizan una perspectiva consistente de la topología de la red. 2.7.2 Cada vez que la topología cambia, los routers deben recalculan las rutas, provocando un estado de transición.

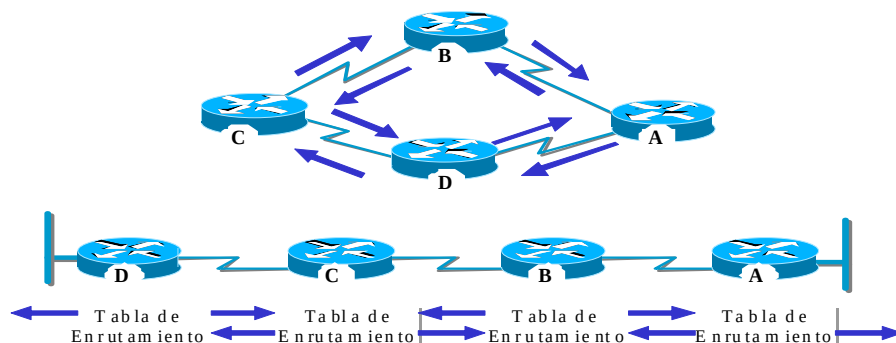
2.7.3 El proceso y el tiempo requeridos para la convergencia varían con los protocolos de enrutamiento. 2.8 La convergencia rápida es una característica de red conveniente, porque reduce el período en que los routers tienen conocimiento desactualizado, para así evitar tomar decisiones de enrutamiento que podrían ser incorrectas, antieconómicas, o ambas cosas a la vez.

VECTOR DISTANCIA

2.9 Los algoritmos de enrutamiento por vector de distancia (también conocidos como algoritmos Bellman-Ford) transmiten copias periódicas de una tabla de enrutamiento de un router a otro. Las actualizaciones regulares entre routers comunican los cambios de topología.

2.10 Cada router recibe una tabla de enrutamiento de su vecino directo. Por ejemplo, en la figura siguiente, el router B recibe información del router A.

2.11 El router B agrega un número de vector de distancia (tal como una cantidad de saltos) que aumenta el vector de distancia, y luego transmite la tabla de enrutamiento a su otro vecino, el router C. Este mismo proceso paso a paso ocurre en todas las direcciones entre routers vecinos directos.

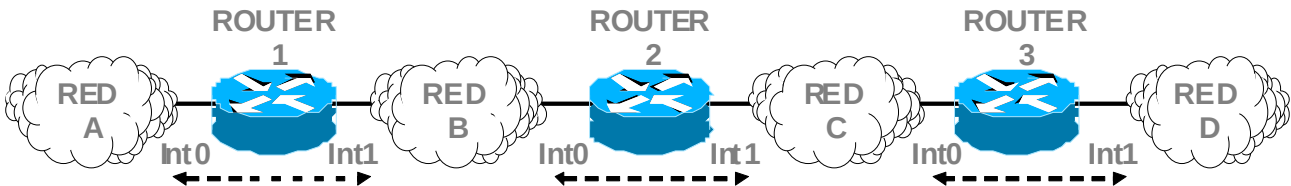


2.12 De este modo, el algoritmo acumula distancias de red para poder mantener una base de datos de información de topología de la red.

2.13 Los algoritmos de vector de distancia no permiten al router conocer la topología exacta de una internetwork.

Descubrimiento de la red por vector de distancia

2.14 Cada router que utiliza el enrutamiento por vector de distancia comienza identificando sus propias redes (conectadas directamente). En el gráfico, el puerto hacia cada red conectada directamente tiene una distancia de 0.



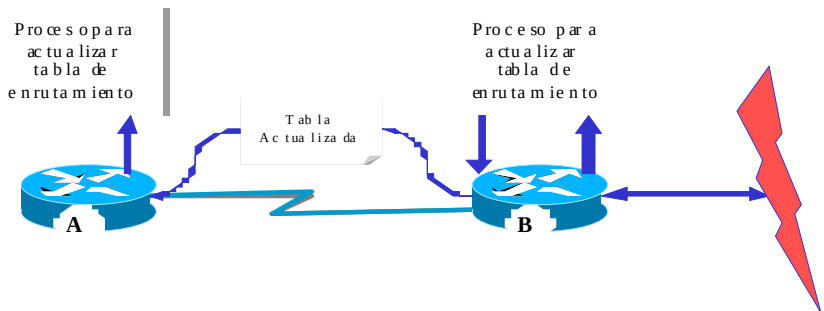
A medida que el proceso de descubrimiento de la red por vector de distancia sigue su curso, los routers descubren la mejor ruta hacia las redes de destino basándose en información de cada vecino.

ROUTER 1	ROUTER 2	ROUTER 3
A → Int0 → 0 B → Int1 → 0	B → Int0 → 0 C → Int1 → 0	C → Int0 → 0 D → Int1 → 0
A → Int0 → 0 B → Int1 → 0 C → Int1 → 1	B → Int0 → 0 C → Int1 → 0 A → Int0 → 1 D → Int1 → 1	C → Int0 → 0 D → Int1 → 0 B → Int0 → 1
A → Int0 → 0 B → Int1 → 0 C → Int1 → 1 D → Int1 → 2	B → Int0 → 0 C → Int1 → 0 A → Int0 → 1 D → Int1 → 1	C → Int0 → 0 D → Int1 → 0 B → Int0 → 1 A → Int0 → 2

2.15 Por ejemplo, el router A adquiere conocimientos acerca de otras redes basándose en información que recibe del router B. Cada una de estas entradas de otras redes en la tabla de enrutamiento tiene un vector de distancia acumulado para mostrar a qué distancia está la red en la dirección dada.

Cambios en la topología por vector de distancia

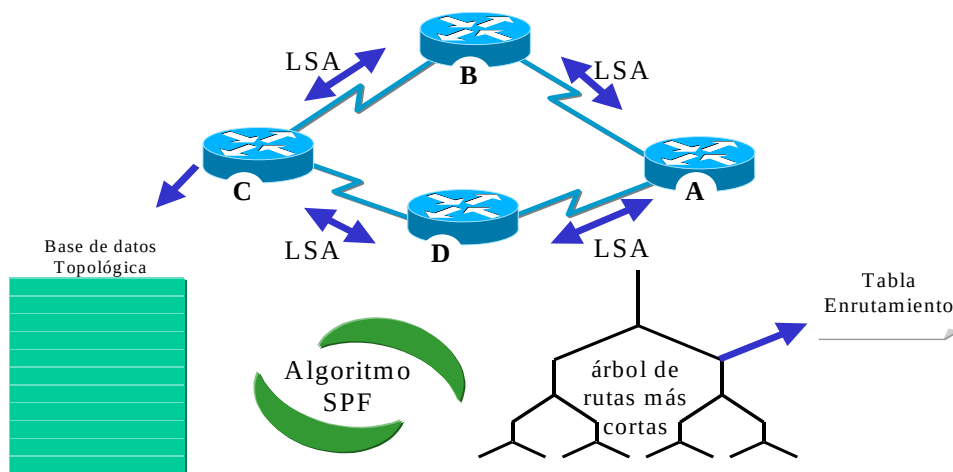
2.16 Cuando cambia la topología en un protocolo por vector de distancia, deben efectuarse actualizaciones de la tabla de enrutamiento. Al igual que en el proceso de descubrimiento de la red, las actualizaciones de cambio de topología tienen lugar paso a paso de router a router.



2.17 Los algoritmos por vector de distancia requieren a cada router que envíe toda su tabla de enrutamiento a cada uno de sus vecinos adyacentes. Las tablas de enrutamiento por vector de distancia incluyen información acerca del costo total de la ruta (definido por su métrica) y la dirección lógica del primer router en la ruta hacia cada red que conoce.

ESTADO DE ENLACE

2.18 Los algoritmos de enrutamiento basados en el estado de enlace - también conocidos como algoritmos de la ruta más corta (SPF) - mantienen una base de datos compleja de información de la topología. Mientras que el algoritmo por vector de distancia tiene información inespecífica acerca de redes distantes y no tiene conocimiento acerca de routers distantes, un algoritmo del estado de enlace mantiene el conocimiento completo de los routers distantes y de cómo se interconectan.



2.19 El enrutamiento del estado de enlace utiliza las publicaciones del estado de enlace (LSAs)¹⁹, una base de datos topológica, el algoritmo SPF²⁰, el árbol SPF resultante, y finalmente, una tabla de enrutamiento de rutas y puertos hacia cada red. Las siguientes páginas explican estos procesos y bases de datos más detalladamente.

2.20 Los ingenieros han implementado este concepto de estado de enlace en el enrutamiento primero la ruta libre más corta (OSPF). RFC 1583 contiene una descripción de los conceptos y operaciones del estado de enlace OSPF.

Descubrimiento de la red por estado de enlace

2.21 El descubrimiento de la red para el enrutamiento por estado de enlace utiliza los siguientes procesos:

¹⁹ **LSA** - (Link-state advertisement) ó *Paquete del estado de enlace (LSP)*. Publicación del estado de enlace. Paquete de broadcast utilizado por los protocolos por estado de enlace que contiene información acerca de los vecinos y los costos de ruta. Los LSAs son utilizados por los routers receptores para mantener sus tablas de enrutamiento.

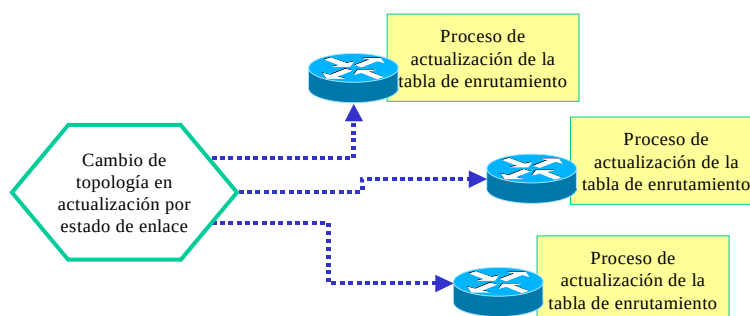
²⁰ **SPF** - (shortest path first algorithm) Algoritmo de enrutamiento que itera sobre la longitud de la ruta para determinar el spanning tree de la ruta más corta. *Algoritmo de Dijkstra*.

2.21.1 Los routers intercambian las LSA entre sí. Cada router comienza con las redes directamente conectadas sobre las cuales tiene información directa. A continuación, cada router en paralelo con los otros, construye una base de datos topológica que incluye todas las LSA de la internetwork.

2.21.2 El algoritmo SPF computa la forma en que se puede llegar a la red, determinando la ruta más corta a cada una de las otras redes de la internetwork de protocolo del estado de enlace. El router construye esta topología lógica de rutas más cortas como un árbol SPF. Consigo mismo como raíz, este árbol expresa rutas desde el router hacia todos los destinos. El router hace una lista con sus mejores rutas y con los puertos hacia dichas redes de destino en la tabla de enrutamiento. También lleva otras bases de datos de elementos topológicos y detalles sobre el estado

Cambios en la topología por estado de enlace

2.22 Los algoritmos del estado de enlace se basan en el uso de las mismas actualizaciones del estado de enlace. Cada vez que se modifica una topología del estado de enlace, los routers que primero conocen dichas modificaciones envían información a los otros routers o a un router designado que todos los demás puedan utilizar para sus actualizaciones. Esto incluye el envío de información común de enrutamiento a todos los routers de la internetwork. Para lograr la convergencia, cada router hace lo siguiente:



2.22.1 Lleva un registro de sus vecinos: nombre del vecino, si el vecino está activo o caído, y costo del enlace hacia el vecino. Construye un paquete LSA que contiene una lista de los nombres y costos de enlace hacia sus routers vecinos. Esto incluye nuevos vecinos, modificaciones en el costo del enlace y enlaces hacia vecinos fuera de servicio.

2.22.2 Envía este paquete de LSA de modo que reciban todos los otros routers. Cuando recibe un paquete de LSA, registra el paquete de LSA en su base de datos de modo de poder almacenar el paquete más recientemente generado de todos los demás routers.

2.22.3 Utilizando los datos de los paquetes de LSA acumulados para construir un mapa completo de la topología de la internetwork, procede desde este punto de inicio común a volver a correr el algoritmo SPF y a computar las rutas hacia cada destino de la red.

2.22.4 Cada vez que un paquete de LSA da origen a una modificación en la base de datos del estado de enlace, el algoritmo del estado de enlace vuelve a calcular las mejores rutas y actualiza la tabla de enrutamiento. Luego todos los otros routers toman en cuenta la modificación de la topología para determinar la ruta más corta que pueden utilizar para la conmutación de paquetes.

COMPARACIÓN VECTOR DISTANCIA - ESTADO DE ENLACE

2.23 El enrutamiento por vector de distancia puede compararse con el enrutamiento del estado de enlace en varias áreas clave:

2.23.1 El enrutamiento por vector de distancia obtiene todos los datos topológicos de la información de la tabla de enrutamiento de sus vecinos. El enrutamiento del estado de enlace obtiene una visión amplia de toda la topología de la red acumulando todas las LSA necesarias.

2.23.2 El enrutamiento por vector de distancia determina la mejor ruta aumentando el valor de la métrica que recibe a medida que las tablas pasan de un router a otro. Para el enrutamiento del estado de enlace, cada router trabaja en forma separada para calcular su propia ruta más corta hacia los destinos.

2.23.3 En la mayoría de los protocolos de enrutamiento por vector de distancia, las actualizaciones de cambios de topología tienen lugar como actualizaciones periódicas de las tablas. Estas tablas se transmiten de un router a otro, lo que generalmente da como resultado una convergencia más lenta.

2.23.4 En los protocolos de enrutamiento del estado de enlace, las actualizaciones son causadas generalmente por cambios de topología. Las relativamente pequeñas LSA que son transmitidas a todos los otros routers suelen dar como resultado un tiempo más rápido para la convergencia en cualquier cambio de topología de la red.

VECTOR DISTANCIA	ESTADO DEL ENLACE
Ve la topología de la red desde la perspectiva de los vecinos. Agrega Vectores distancia de router a router. Actualizaciones frecuentes periódicas: convergencia lenta. Pasa copias de la tabla de enrutamiento a los vecinos.	Obtiene una vista común de toda la topología de la red. Calcula la ruta más corta a los otros routers. Actualizaciones disparadas por eventos: convergencia más rápida. Pasa actualizaciones de enrutamiento por estado del enlace a otros routers.

3. CONFIGURACIÓN DE ENRUTAMIENTO DINÁMICO

3.1 La selección de IP como protocolo de enrutamiento implica determinar parámetros tanto globales como de interface.

3.2 Tareas globales:

3.2.1 Seleccionar un protocolo de enrutamiento, RIP o IGRP.

3.2.2 Asignar números de red IP sin especificar valores de subred.

3.3 La tarea de interface es asignar direcciones de red/subred así como la máscara de red correcta. Un enrutamiento dinámico utiliza broadcasts y multicasts para comunicarse con otros routers. La métrica de enrutamiento ayuda a los routers a encontrar la mejor ruta a cada red o subred.

4. RIP

4.1 El protocolo RIP se especificó originalmente en RFC 1058. Las características claves de RIP incluyen las siguientes:

4.1.1 Es un protocolo de enrutamiento por vector de distancia.

4.1.2 Utiliza un cálculo de saltos como métrica para la selección de la ruta.

4.1.3 El cálculo de saltos máximo permisible es 15 (16 es inaccesible).

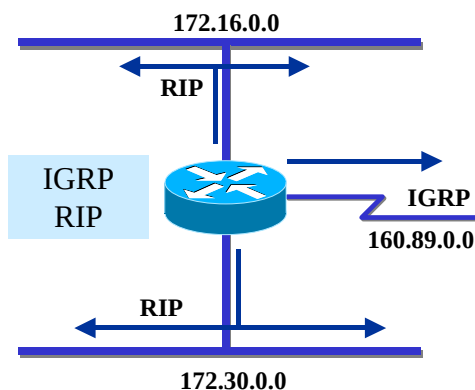
- 4.1.4 Las actualizaciones de enrutamiento se emiten cada 30 segundos por defecto.

Configuración global

- Seleccionar protocolo(s) de enrutamiento
- Especificar red(es)

Configuración de interface

- Verificar dirección/máscara de subred



Ejemplo de configuración de RIP

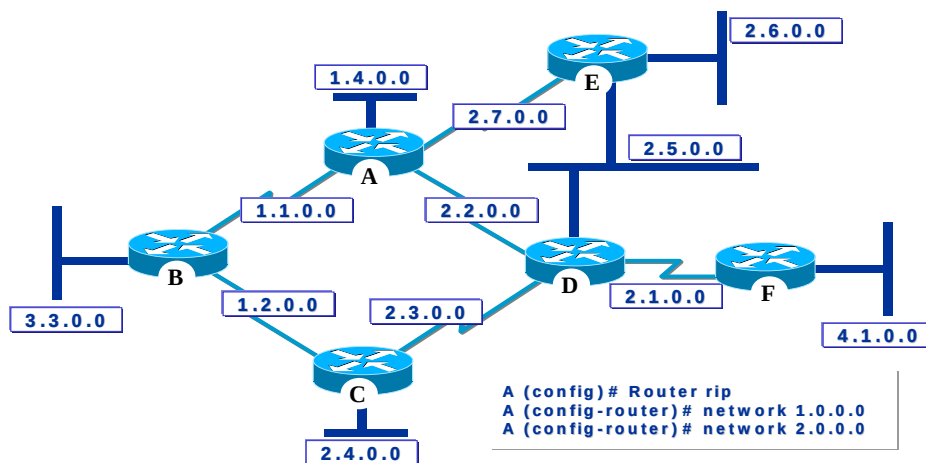
- 4.2 En el siguiente ejemplo:

- 4.2.1 **router rip**—Selecciona RIP como protocolo de enrutamiento

- 4.2.2 **network 1.0.0.0**—Especifica una red conectada directamente.

- 4.2.3 **network 2.0.0.0**—Especifica una red conectada directamente.

- 4.3 Las interfaces del router A de Cisco conectadas con las redes 1.0.0.0 y 2.0.0.0 enviarán y recibirán actualizaciones de RIP. Estas actualizaciones de enrutamiento permiten al router conocer la topología de la red.



MONITOREO RIP

- 4.4 El comando **show ip protocol** visualiza los valores de sincronizadores de enrutamiento e información de la red, asociados con todo el router. Es posible utilizar esta información para verificar la información de enrutamiento. Este router está enviando cada 30 segundos la información de la tabla de enrutamiento actualizada (este intervalo es configurable). La próxima actualización será enviada en 9 segundos. El router inyecta rutas para las redes mencionadas a continuación de la línea "enrutamiento para redes".

Tabla de enrutamiento IP

4.5 El comando **show ip route** visualiza el contenido de la tabla de enrutamiento IP. La tabla de enrutamiento contiene entradas para todas las redes y subredes conocidas, y contiene un código que indica cómo se adquirió esa información.

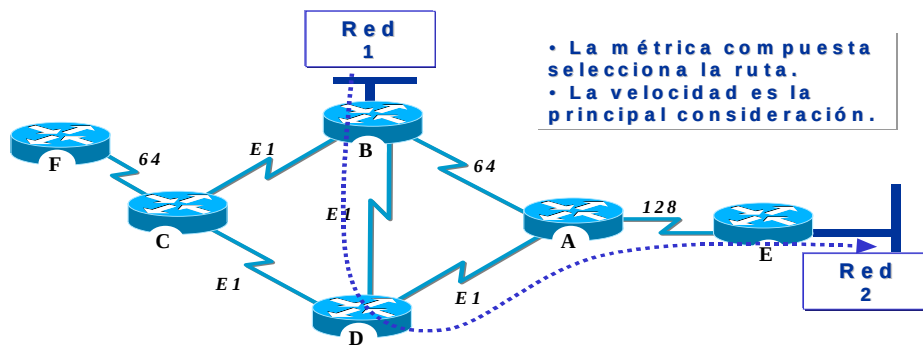
4.6 Todas las rutas hacia las redes que el router aprende le agrega la máscara correspondiente a la interface por la cual recibió la actualización (RIP versión 1).

DEBUG RIP

4.7 El comando **debug ip rip** muestra actualizaciones de enrutamiento RIP, mientras son enviadas y recibidas. En este ejemplo, la actualización es enviada y retransmitida por la interfaces seriales 0 y 2.

5. IGRP

5.1 IGRP es un protocolo de enrutamiento por vector de distancia desarrollado por Cisco. IGRP envía actualizaciones de enrutamiento (que no incluyen información de subredes) a intervalos de 90 segundos que publican redes para un sistema autónomo en particular. Corre directamente sobre IP (protocolo 88)



5.2 Las siguientes son algunas de las características claves de IGRP:

5.2.1 Versatilidad para manejar automáticamente topologías indefinidas y complejas.

5.2.2 Flexibilidad para los segmentos que tienen diferentes características de ancho de banda y retraso.

5.2.3 Escalabilidad para funcionar en redes muy grandes.

5.3 El protocolo de enrutamiento IGRP utiliza una combinación de variables para determinar una métrica compuesta. Las variables que utiliza IGRP incluyen:

5.3.1 Ancho de banda (B)

5.3.2 Retardo fijo entre nodos (D)

5.3.3 Carga por tráfico (L)

5.3.4 Fiabilidad ó tasa de error en el trayecto (R)

5.3.5 Unidad máxima de transmisión (MTU) ²¹

5.3.6 Cuenta de saltos hasta el destino (H)

METRICA IGRP

5.4 IGRP utiliza el conjunto de valores indicado para computar las rutas. Se aplica un algoritmo a dichos valores, ponderándolos mediante coeficientes K1, K2, K3, K4 y K5.²²

$$\text{Métrica} = (K1 * B) + \frac{K2 * B}{256 - L} + (K3 * D) * \frac{K5}{R + K4}$$

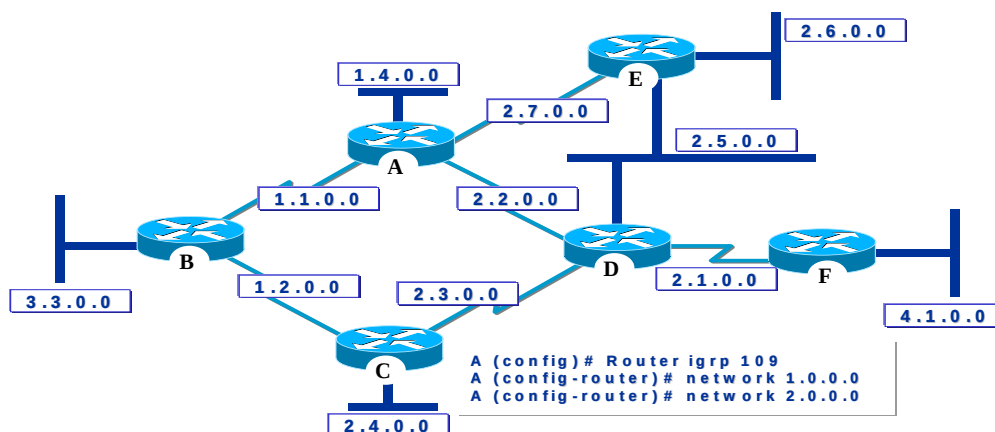
5.5 El B se halla dividiendo 10 millones por el menor de todos los anchos de banda [en Kbps] de las interfaces de salida (si el Bw=1,544 Mbps → 10000000/1544= 6476).

5.6 El D es la suma de todos los retardos de las interfaces de salida, dividido por 10 [decenas de microsegundos] (si los retardos son (20000 useg + 1000 useg)/10 = 2100)

5.7 La métrica sería entonces de 6476+2100= 8576. *El trayecto con la menor métrica es el mejor camino.*

Ejemplo de configuración de IGRP

5.8 En el siguiente ejemplo: se selecciona a IGRP como el protocolo de enrutamiento para el sistema autónomo 109. Todas las interfaces conectadas a las redes 1.0.0.0 y 2.0.0.0 utilizarán IGRP para reunir y distribuir información de enrutamiento.



5.8.1 router igrp 109—Selecciona a IGRP como el protocolo de enrutamiento para el sistema autónomo 109.

5.8.2 network 1.0.0.0—Especifica una red conectada directamente.

5.8.3 network 2.0.0.0—Especifica una red conectada directamente.

²¹ **MTU** - (*maximum transmission unit*) Unidad máxima de transmisión. Tamaño máximo de paquete, en bytes, que puede manejar una interface en particular.

²² Los defaults son K1 = K3 = 1, K2 = K4 = K5 = 0.

MONITOREO IGRP

5.9 El comando **show ip protocol** muestra el protocolo de enrutamiento IP, los temporizadores de enrutamiento y la información de la red asociada con todo el router.

5.10 El algoritmo utilizado para calcular la métrica de enrutamiento para IGRP también se muestra en esta pantalla. También incluye información acerca de las métricas de enrutamiento y filtros de enrutamiento.

Tabla de enrutamiento IP

5.11 El comando **show ip route** muestra los contenidos de una tabla de enrutamiento IP. La tabla contiene una lista de todas las redes y subredes conocidas y las métricas relacionadas con cada entrada.

DEBUG IGRP

5.12 El comando **debug ip igrp transactions** muestra actualizaciones de enrutamiento RIP, mientras son enviadas y recibidas.

```
RouterA#debug ip igrp transactions
IGRP protocol debugging is on
RouterA#
00:21:06: IGRP: sending update to 255.255.255.255 via Ethernet0 (172.16.1.1)
00:21:06:      network 10.0.0.0, metric=88956
00:21:06:      network 192.168.1.0, metric=91056
00:21:07: IGRP: sending update to 255.255.255.255 via Serial2 (10.1.1.1)
00:21:07:      network 172.16.0.0, metric=1100
00:21:16: IGRP: received update from 10.1.1.2 on Serial2
00:21:16:      subnet 10.2.2.0, metric 90956 (neighbor 88956)
00:21:16:      network 192.168.1.0, metric 91056 (neighbor 89056)
```

CISCOWORKS SMNS

INTRODUCCIÓN

SERVIDOR CISCO WORKS

WHATS UP GOLD

RME

1. INTRODUCCIÓN

1.1 CiscoWorks Small Network Management Solution (CWSNMS) es una solución integral de administración de red para redes pequeñas a medianas con hasta 40 dispositivos Cisco. CWSNMS provee un conjunto poderoso de herramientas de configuración y monitoreo para administrar dispositivos Cisco.

Aplicaciones

1.2 CWSNMS incluye las siguientes aplicaciones:

1.2.1 CiscoWorks Server (In Common Services)

1.2.2 Resource Manager Essentials

1.2.3 CiscoView

1.2.4 WhatsUp Gold

CiscoWorks Server

1.3 CiscoWork Server es parte de CiscoWorks Common Services. Este servidor permite ejecutar tareas de administración de red comunes, tales como manejar cuentas de usuario, la base de datos, arrancar y detener los procesos del servidor CiscoWorks, etc.

1.4 También puede comprobarse la conectividad y accesibilidad de dispositivos y diagnosticar dispositivos con fallas.

Resource Manager Essentials

1.5 RME es un conjunto de aplicaciones basadas en web que ofrece soluciones para la administración de switches, servidores de acceso y routers Cisco. La interface browser de RME provee fácil acceso a la información crítica para mantener la operatividad de las redes, y simplifica la ejecución de tareas que, en modo manual, consumen mucho tiempo.

1.6 RME está basado en una arquitectura cliente/servidor que conecta múltiples clientes basados en web a un servidor en la red.

Cisco View

1.7 Básicamente, CV provee vistas gráficas de los paneles frontales y posteriores de los equipos. Las pantallas dinámicas y gráficos a color simplifican el monitoreo del estado de los dispositivos, componentes de diagnóstico específicos de los dispositivos, y su configuración.

1.8 CV puede lanzarse tanto desde el Device Center del escritorio de CWSMNS, o desde Whats Up Gold.

Whats Up Gold

1.9 Whats Up Gold (WUG) es un software de gestión de red de otro proveedor (Ipswitch Inc). WUG permite monitorear concurrentemente múltiples dispositivos sobre un mapa topológico (mientras que CV solamente tiene capacidad para monitorear un dispositivo por vez).

1.10 Por consiguiente, WUG permite el descubrimiento, mapeo, monitoreo y el rastreo de alarmas.

Desktop

1.11 El Desktop de CW es la interface hacia las aplicaciones de administración de red de CWSMNS. Es una interface gráfica de usuario (GUI) que corre sobre un web browser. El desktop ofrece las siguientes características:

1.11.1 Clientes Web

1.11.2 Invocación del Desktop

1.11.3 Logging In

1.11.4 Uso del Desktop

1.11.5 Ayuda en línea

1.12 Cada vez que la aplicación de administración de red sea invocada, CW verifica que el Plug-in Java requerido se encuentre instalado en el sistema cliente. Si así no estuviere, CW requerirá dicha instalación.

Clientes Web

1.13 El servidor puede ser accedido desde cualquier cliente que cumpla con los requerimientos del sistema apropiados. El único software cliente requerido es el web browser Microsoft Internet Explorer.

Uso del Desktop

1.14 El Desktop de CW es la interface de usuario primaria y el punto de partida para todas las tareas. Después de realizado el login, el desktop muestra las siguientes solapas:

1.14.1 WhatsUpGold

1.14.2 Essentials

1.14.3 Device Center

1.14.4 Admin

1.15 Cada una de las solapas de navegación contiene un grupo de enlaces, los cuales a su vez, contienen grupos de tareas asociadas o similares, herramientas, reportes y otras opciones.

Ayuda en línea

1.16 Cada aplicación de CW incluye ayuda en línea con información conceptual y de procedimiento, con el objetivo de facilitar la utilización. Además integra:

1.16.1 Un motor de búsqueda: Búsqueda de tópicos de ayuda por palabras clave.

1.16.2 Un índice: Presentación de tareas de red típicas.

1.16.3 Un glosario: Definición de términos de CW.

1.17 Si se encuentra seleccionada una opción en el árbol de navegación, aparece la ayuda para esa opción.

2. SERVIDOR CISCO WORKS

Conocimientos preliminares

2.1 CW es una familia de productos basados en los estándares de Internet para la administración de redes y dispositivos Cisco. Todos los productos CW utilizan y dependen del servidor CW. El servidor CW ejecuta un conjunto común de servicios de administración, los cuales son compartidos por múltiples aplicaciones de administración de red.

2.2 Adicionalmente, también provee a la administración de los roles y privilegios de los usuarios. Esto permite controlar el acceso a las aplicaciones y a funciones específicas dentro de las aplicaciones. El control de roles y privilegios, además de realizarse a través de servicios de autenticación y control incluidos en CW, también puede ejecutarse utilizando un servidor de autenticación externo.

Servidor y aplicaciones

2.3 Aún cuando muchas aplicaciones dependen del servidor CW, no todas utilizan los servicios con la misma extensión.

2.4 El servidor CW, básicamente provee dos tipos de servicios:

2.4.1 Runtime Services: Desktop, gestión de procesos, seguridad y el motor de ayuda en línea (se habilitan durante la instalación).

2.4.2 System Services: Motor y utilidades de base de datos, servicios de distribución de eventos y administración de tareas (jobs).

2.5 En tanto que los servicios Runtime están siempre habilitados por omisión, los servicios System son habilitados a partir de la instalación de algún software de aplicación que requiera dichos servicios. Finalmente, todas las aplicaciones son integradas por el Desktop.

Ejecución de tareas

2.6 La mayoría de las tareas, directamente requieren privilegios de nivel de administrador porque afectan la performance y el comportamiento del servidor CW. Solamente algunas tareas son accesibles a todos los usuarios.

Descripción
Verificación del estado del servidor
Configuración de la cuenta de usuario
Verificación del estado de procesos
Verificación del estado del archivo de log
Comprobación de conectividad (Nslookup)
Comprobación de conectividad (Traceroute)
Comprobación de conectividad (Ping)
Comprobación de conectividad (Estación-dispositivo)

Configuración del Servidor

2.7 El servidor CW incluye herramientas con el objeto de configurar el servidor apropiadamente para soportar otras aplicaciones Cisco.

2.7.1 Configuración de cuentas de usuario

2.7.2 Instalación del Plug-in Java

2.7.3 Restablecimiento de passwords

Configuración de cuentas de usuario

2.8 Varias operaciones de administración de redes y aplicaciones son potencialmente disruptivas para la red o las mismas aplicaciones y deben ser protegidas. Para prevenir que tales operaciones sean utilizadas accidental o maliciosamente, CW utiliza un sistema de seguridad multinivel que permite el acceso a ciertas funciones solamente a usuarios que puedan autenticarse con el nivel apropiado. CW provee dos IDs (identificaciones) de acceso predefinido, pero el administrador puede crear IDs adicionales:

2.8.1 Guest (se especifica una password durante la instalación, rol de usuario = Help Desk)

2.8.2 Admin (se especifica la password durante la instalación, rol de usuario = combinación de administrador del sistema, administrador de red, operador de red, aprobador y Help Desk). Equivalente al administrador de Windows para CW. Tiene acceso a todas las tareas de CW.

2.9 Los administradores del Sistema determinan los niveles de seguridad de los usuarios. Cuando se configura un usuario, también se le asigna uno o más roles.

2.10 El rol del usuario, o la combinación de roles, determinan cuales son las aplicaciones de CW que se presentan durante la navegación.

Nivel	Descripción
0	Mesa de ayuda [Help Desk]
1	Aprobador [Approver]
2	Operador de red [Network Operator]
4	Administrador de red [Network Administrator]
8	Administrador de Sistemas [System Administrator]
6	Exportación de datos [Export Data]
32	Desarrollador [Developer]

2.11 Los usuarios pueden realizar algunas tareas sobre sus propias cuentas, pero la mayoría de las tareas de seguridad requieren privilegios correspondientes al rol de administrador de sistemas.

2.12 Cuando se ejecuten tareas de seguridad, deben tenerse en cuenta las siguientes consideraciones:

2.12.1 RME no puede recuperar passwords olvidadas/perdidas. Se requiere un nivel de administrador de sistemas para cambiar la password, o borrarla, y luego volver a agregar el rol de usuario.

2.12.2 El usuario admin está reservado y no puede ser borrado.

2.12.3 Si se olvida la password de admin, debe acudir al utilitario indicado en “Restablecimiento de passwords”.

Tarea	Proposition	Nivel
Cambiar password	Modificar la contraseña de su propia cuenta.	Todos
Agregar usuario	Crear nueva cuenta y asignar nivel de acceso	Admin
Borrar usuario	Remover cuenta	Admin
Modificar usuario	Actualización de la información de usuario	Admin
Ver usuarios loggeados	Muestra información de usuarios activos y enviar mensajes	Admin

Restablecimiento de passwords

2.13 El utilitario de restablecimiento de passwords permite cambiar la password de un usuario local CW, desde la línea de comandos. Es indispensable poseer privilegios de administrador ó super usuario para ejecutar este utilitario.

Administración del Servidor

2.14 El servidor CW incluye herramientas administrativas para asegurar que el mismo se comporta adecuadamente. Entre ellas se encuentran:

- 2.14.1 Herramientas básicas
- 2.14.2 Mantenimiento de archivos de Log
- 2.14.3 Tareas de Administración de Datos
- 2.14.4 Gestión de Procesos de Back-end
- 2.14.5 Gestión de Trabajos y Recursos
- 2.14.6 Gestión de eventos de red

Herramientas básicas

2.15 Las herramientas administrativas básicas permiten realizar las siguientes tareas:

TAREA	PROPÓSITO
Visualizar paquetes de software instalados	Lista las aplicaciones instaladas
Visualizar el estado del archivo de log	Muestra el tamaño y la utilización del logfile

Mantenimiento de archivos de log

2.16 Los archivos de registro de actividades (log files) pueden crecer y agotar el espacio en disco. CW incluye un script que permite controla este crecimiento.

2.17 El script está escrito para mantener los siguientes archivos:

2.17.1 Daemon manager

2.17.2 JRUN

2.17.3 Web server log files

Tareas de administración de datos

2.18 Regularmente deben ejecutarse tareas de administración del almacenamiento para asegurarse de que existan backups de la base de datos en caso de que la misma se torne inutilizable o corrompida.

2.19 Al configurar la estrategia de backup de la base de datos, deben considerarse los siguientes lineamientos:

2.19.1 Las tareas de resguardo y restauración de los datos solamente están soportadas dentro de una misma versión (no puede recuperarse una base resguardada con otra versión).

2.19.2 Chequear el tamaño de los archivos almacenados en el directorio de backup. Algunos de ellos podrían requerir mayor espacio en disco.

2.19.3 Los archivos de la base de datos se almacenan utilizando la siguiente estructura de directorios de backup:

2.20 El nombre de suite utilizada por los archivos de base de datos del servidor CW es cmf. La base de datos .cmf incluye el backup de datos de las aplicaciones del servidor CW.

TAREA	PROPÓSITO
Backup de la base de datos	Ejecutar una tarea de backup en este momento.
Programación de backups regulares	Ejecutar tareas de backups en forma programada
Restore de una base de datos	Reemplazar la base de datos actual con otra copia
Cambio de password de la base de datos	Cambiar la password de la base de datos por seguridad

Backup de datos

2.21 Es posible realizar el backup de los datos a la demanda, en lugar de aguardar el próximo backup programado, con la opción “Back up Data Now”.

Gestión de procesos de back-end

2.22 Las aplicaciones CW utilizan procesos de back-end para administrar actividades o trabajos específicos de las aplicaciones. Las herramientas de administración de procesos posibilitan el control de estos procesos para optimizar ó diagnosticar el servidor CW.

TAREA	PROPÓSITO
Arrancar proceso	Reiniciar procesos específicos
Detener proceso	Detiene procesos específicos
Ver procesos	Mostrar información de procesos incluyendo estado, ID y otros datos.

TAREA	PROPÓSITO
Ver fallas de procesos	Muestra los procesos con fallas, información de fallas, y hora de ocurrencia de la falla.

Gestión de Trabajos y Recursos

2.23 La gestión de trabajos (Job Management) provee servicios de notificación de trabajos, recursos y eventos a CW. Se utiliza el Job Management para mostrar trabajos, liberar recursos y detener y/o remover trabajos.

TAREA	PROPÓSITO
Cancelar un trabajo programado	Detiene la ejecución de un trabajo, pero lo mantiene en el Job Management
Remover un trabajo	Remueve un trabajo del Job Management
Destruir un recurso huérfano	Libera recursos trabados por fallas en el sistema. Sólo debe utilizarse si no existen otras opciones.

Gestión de eventos de red

2.24 Existen dos servicios de CW que permiten la administración de eventos. Las aplicaciones utilizan uno u otro.

2.24.1 Event Distribution Service (EDS)

2.24.2 Event Services Software (ESS)

Event Distribution Service (EDS)

2.25 EDS permite administrar las fuentes y los destinatarios de los eventos. Las fuentes de eventos crean los eventos de red, mientras que los destinatarios son los consumidores de estos eventos

Fuente = originador = creador

Destino = consumidor

TAREA	PROPÓSITO
Habilitar o deshabilitar el debugging o la generación de mensajes de trace	Diagnosticar problemas
Configurar servicios individuales	Habilita el setup y la configuración de fuentes de eventos, o servicios destino de eventos, tales como parámetros de colas.
Asociar filtros de eventos a un consumidor genérico.	Permite utilizar un filtro para especificar qué eventos deben pasarse a cada consumidor genérico.
Ver estadísticas de performance de todas las colas de datos internas de las fuentes y consumidores de eventos.	Muestra el trabajo que está realizando EDS. A partir de estas estadísticas puede determinarse si se están perdiendo eventos y la marca máxima para fijar la capacidad de la cola.
Ver eventos recibidos por EDS y el logger de eventos.	Monitorea o diagnostica la red.

Event Services Software (ESS)

2.26 ESS provee los medios para que varios procesos de CW puedan enviar mensajes broadcast a otros procesos en un ambiente de red distribuido. ESS utiliza un modelo de publicación y suscripción, donde existen procesos que realizan broadcast de mensajes, mientras que otros, seleccionadamente, se suscriben a los mensajes. En este modelo, cada proceso se suscribe a un host de tópicos, y otros procesos, cuando necesitan que algún proceso reciba el mensaje, publican sus mensajes a alguno de estos tópicos. Por ejemplo, si el proceso 1 está suscrito a los tópicos a, b y c, otros procesos publicarán mensajes destinados al proceso 1 sobre los tópicos a, b ó c.

3. WHATS UP GOLD

3.1 Whats Up Gold (WUG) es un software de gestión de red de otro proveedor (Ipswitch Inc). WUG permite monitorear concurrentemente múltiples dispositivos sobre un mapa topológico (mientras que CV solamente tiene capacidad para monitorear un dispositivo por vez).

3.2 Por consiguiente, WUG permite el descubrimiento, mapeo, monitoreo y el rastreo de alarmas.

Roles de usuario

3.3 CWSNMS crea dos usuarios privilegiados en WUG: admin y guest. Estos privilegios permiten utilizar un único login para las dos aplicaciones.

3.4 El usuario admin de WUG es mapeado con los roles del Administrador de Red y del Administrador de Sistemas del servidor CW.

3.5 El usuario guest de WUG es mapeado con los otros roles de CW, tales como Help Desk, Operador de red, etc.

Mapeos

3.6 El mapeo EssentialsmanagedDevices contiene los dispositivos gestionados por la base de datos de RME. No puede importarse este mapeo a RME, sino que es creado automáticamente la primera vez, ya sea que:

3.6.1 Se agreguen o importen dispositivos

3.6.2 Se descubran dispositivos utilizando la consola de WUG y luego se utilice la opción “Export to Essentials”.

3.7 Subsecuentemente, cada vez que se agreguen dispositivos a RME utilizando la opción “Recreate Map”, deberá actualizarse manualmente el mapeo. Pueden ejecutarse las siguientes tareas con SNMS WUG en el Desktop de CW:

3.7.1 Recreate Map

3.7.2 Export to Essentials

3.7.3 Lanzar las aplicaciones Device Center y CiscoView

3.7.4 Cambiar las passwords de los usuarios *admin* y *guest*.

Passwords

- 3.8 CW SMNS crea dos cuentas de usuarios privilegiados en WUG: *admin* y *guest*.
- 3.8.1 El usuario *admin* de WUG es mapeado con los roles del Administrador de Red y del Administrador de Sistemas del servidor CW.
- 3.8.2 El usuario *guest* de WUG es mapeado con los otros roles de CW, tales como Help Desk, Operador de red, etc.
- 3.9 Es posible utilizar estos dos IDs de usuario para acceder al servidor de web:
- 3.9.1 ID de usuario *admin*: Posee acceso completo a todas las funciones y vistas de WUG. La password de *admin* se genera durante la instalación del producto.
- 3.9.2 ID de usuario *guest*: Posee acceso a todas las vistas de WUG pero no puede cambiar ninguna configuración. La password de *guest* se genera durante la instalación del producto.

Generación de mapas

- 3.10 Dentro de las tareas de administración figura el descubrimiento de dispositivos en la red y la creación del mapa EssentialsManagedDevices, utilizando la aplicación WUG (se utiliza la consola WUG y el enlace WUG en el Desktop de CWSNMS).

4. RME

Introducción

- 4.1 RME es un conjunto de aplicaciones basadas en web que ofrece soluciones para la administración de switches, servidores de acceso y routers Cisco. La interface browser de RME provee fácil acceso a la información crítica para mantener la operatividad de las redes, y simplifica la ejecución de tareas que, en modo manual, consumen mucho tiempo.
- 4.2 RME está basado en una arquitectura cliente/servidor que conecta múltiples clientes basados en web a un servidor en la red. A medida que el número de dispositivos de red aumenta, pueden agregarse servidores adicionales o puntos de colección de datos para manejar el crecimiento de la red con el mínimo impacto sobre la aplicación browser del cliente.
- 4.3 Aprovechando la inherente escalabilidad de la arquitectura intranet, RME soporta múltiples usuarios conectados desde cualquier parte de la red. La infraestructura basada en web permite el acceso concurrente a las herramientas de gestión de red, aplicaciones y servicios, de operadores, administradores, técnicos, personal de Help Desk, administradores IS, y usuarios finales.
- 4.4 RME permite que los administradores de la red puedan visualizar y actualizar el estado y la configuración de todos los dispositivos Cisco desde cualquier punto de la red, mediante un browser estándar que actúa como cliente de RME. RME mantiene una base de datos con la información de red actualizada. Puede generar una gran variedad de reportes utilizables para el diagnóstico y la planificación de la capacidad.
- 4.5 Aún cuando los dispositivos son agregados al inventario de RME al iniciarse la aplicación, el administrador puede programar la exploración y actualización periódica de la información de los dispositivos para asegurarse de que la información almacenada es la más reciente. Adicionalmente, RME registra automáticamente cualquier cambio realizado sobre los dispositivos de la red, facilitando la tarea de identificar los cambios y el responsable de los mismos.

4.6 Las aplicaciones RME proveen al monitoreo y control de fallas de la red, así como herramientas prácticas para administrar imágenes de software y configuraciones en routers y switches. Las aplicaciones RME, juntamente con los enlaces a los servicios y el soporte de Cisco.com, automatizan el mantenimiento del software para facilitar el control y el soporte de la red.

Características

4.7 RME trabaja en conjunción con el servidor CW, el cual contiene un conjunto de servicios de administración compartidos por múltiples aplicaciones de gestión. Estos servicios de gestión son habilitados cuando se instala una suite y se abre alguna aplicación que depende de alguno de estos servicios.

4.8 Si alguna suite particular de aplicaciones no utiliza un servicio o no lo utiliza en toda su extensión disponible, ese servicio podría no aparecer en el Desktop de CW.

4.9 RME utiliza los siguientes servicios de CW:

4.9.1 Motor y utilidades de base de datos

4.9.2 Desktop para login y lanzamiento de aplicaciones

4.9.3 Gestión de eventos

4.9.4 Sistema de ayuda en línea

4.9.5 Gestión de trabajos (Jobs)

4.9.6 Gestión de Procesos

4.9.7 Seguridad

4.9.8 Servidor de web

Componentes de RME

4.10 La infraestructura basada en web de RME esta integrada por los siguientes componentes:

4.10.1 *CiscoWorks Server*: RME depende de CW para las funciones comunes, tales como el motor de base de datos, ayuda en línea, seguridad, login, lanzamiento de aplicaciones, gestión de trabajos y procesos, y el servidor de web. Provee un marco de trabajo común e interface para todos los productos CiscoWorks. El servidor CW debe permanecer en línea constantemente para sondear los dispositivos, monitorear eventos, y realizar la recolección programada de datos. Si el servidor se cae, se producirá una interrupción en el flujo de información recibido y almacenado por RME.

4.10.2 *Base de datos y funciones de RME*: RME almacena toda la información crítica de gestión de red en una base de datos central, incluyendo el inventario de dispositivos, imágenes de software, archivos de configuración, mensajes de syslog, y registro de cambios. Las funciones de RME interactúan con la base de datos y con los dispositivos de red para recoger la información, mostrar reportes, y automatizar muchas tareas repetitivas. Muchas funciones de RME pueden configurarse para sondear periódicamente los dispositivos y actualizar la base de datos automáticamente. RME utiliza protocolos comunes como SNMP, Telnet, TFTP y RCP para acceder a los dispositivos y recuperar archivos de configuración e imágenes.

4.10.3 *Cisco.com*: RME también se conecta al sistema Cisco.com para obtener actualizaciones de producto e información de asistencia técnica. El acceso a Cisco.com no es mandatorio para RME, pero aumenta sus capacidades. Las funciones de Software Management requieren acceso a Cisco.com.

Aplicaciones y tareas

4.11 Es posible ejecutar una extensa variedad de tareas con las siguientes aplicaciones suministradas por RME:

- 4.11.1 Vistas: [Device Views]
- 4.11.2 Auditoría de cambios: [Change Audit]
- 4.11.3 Gestión de configuraciones: [Configuration Management]
- 4.11.4 Inventario: [Inventory]
- 4.11.4 Aprobación de trabajos: [Job Approval]
- 4.11.5 Gestión de software: [Software Management]
- 4.11.6 Análisis del Syslog: [Syslog Analysis]

Vistas

4.12 RME provee vistas de dispositivos –agrupamientos lógicos utilizados para especificar un dispositivo o grupo de dispositivos. Pueden definirse vistas para agrupar dispositivos seleccionados en un grupo lógico.

4.13 Por ejemplo una vista de dispositivos permite ver, rápidamente, reportes relacionados con los dispositivos de un cierto tipo, o con características específicas, tales como switches Catalyst, o los dispositivos por los que un operador tiene responsabilidad.

4.14 Dado que casi todas las tareas de RME requieren se defina el conjunto de dispositivos sobre los cuales deben ejecutarse, las vistas proveen una forma conveniente de crear grupos de dispositivos. Por ejemplo, antes de desplegar un reporte de inventario, deben seleccionarse los dispositivos a incluir en el reporte. Las vistas pueden acelerar la selección (en lugar de ejecutar el reporte por cada dispositivo). La performance de la interface gráfica (GUI) de RME puede verse afectada si el número de dispositivos seleccionados en la vista es demasiado grande. Debe evitarse incluir en la vista a “todos los dispositivos” cuando el número de dispositivos del inventario es muy grande. Lo más práctico es utilizar vistas de sistema, o crear vistas personalizadas para mantener las vistas con un número de dispositivos manejable.

Tipos de Vistas

4.15 Existen tres categorías de vistas de dispositivos:

4.15.1 *System Views*: Están predefinidas y disponibles inmediatamente después de la instalación de RME. Incluyen la mayoría de las familias de dispositivos Cisco.

4.15.2 *Custom Views*: Definidas por los usuarios, y pueden ser utilizadas por todos los demás usuarios con acceso al servidor.

4.15.3 *PrivateViews*: Definidas por los usuarios, pero solamente pueden ser utilizadas por el usuario que las creó.

4.16 Además, pueden crearse dos tipos diferentes de vistas dentro de la categoría de vistas custom o privadas:

4.16.1 *Dynamic Views*: Son agrupamientos lógicos basados en los atributos de los dispositivos, tales como la clase de dispositivo o la versión de software. Los dispositivos en una vista dinámica pueden cambiar en base al valor de los atributos en el inventario. Por ejemplo, una vista dinámica puede ser la de todos los dispositivos con la versión IOS 12.0. Todas las vistas de sistema ó System Views son dinámicas.

4.16.2 *Static Views*: Son agrupamientos lógicos basados en características definidas por los usuarios. Incluyen a cualquier dispositivo que desee agregarse a la vista. Los miembros del grupo no cambian, a menos que se agreguen o remuevan dispositivos. Debe utilizarse vistas estáticas cuando no se desea que la membresía cambie automáticamente.

Auditoría de cambios

4.17 Las aplicaciones de auditoría de cambios permite rastrear y reportar los cambios en la red. Provee capacidades para que otras aplicaciones puedan loggear información de cambios a un repositorio central.

4.18 Los cambios de Inventario incluyen cualquier modificación realizada sobre la información de los dispositivos almacenada en la base de datos de Inventario, tales como chasis, interfaces e información del sistema.

4.19 Los cambios de Software incluyen actualizaciones a nuevas imágenes de software.

4.20 Los cambios de Configuración incluyen todas las modificaciones realizadas en los archivos de configuración de los dispositivos, tanto si fueron realizado utilizando la funcionalidad de RME, o aún cuando se realizaren externamente a estas funciones.

4.21 Los cambios enviados por los administradores de configuración y de software no pueden ser filtrados. Es posible visualizar los registros de cambios, o realizar búsquedas específicas por tipo, características o tiempo. Puede programarse la eliminación de registros de cambios antiguos.

4.22 Y también puede configurarse para enviar los registros de cambios, bajo la forma de traps SNMP a servers remotos, para monitorear y visualizar cambios desde estaciones de gestión de red remotas con capacidades de recolección de eventos.

4.23 Los registros son almacenados en la base de datos de RME hasta que son borrados, y se requiere un mantenimiento continuo para eliminar los registros antiguos de la base de datos. Gestión de configuraciones

4.24 La aplicación de gestión de configuraciones [Configuration Management] almacena los archivos de configuración (la actual y el número de versiones previas especificadas) de todos los dispositivos Cisco existentes en el Inventario.

4.25 Además, rastrea los cambios y actualiza automáticamente la base de datos. A veces, cambios en la configuración de un dispositivo puede conducir a fallas o problemas de performance en la red. Configuration Management es de gran ayuda para simplificar y automatizar tareas repetitivas de alto consumo de tiempo.

4.26 Cuando se realiza un cambio en la configuración de un dispositivo, se genera un evento automático al fichero que recolecta el último archivo de configuración.

4.27 Por ejemplo, para mejorar la performance de NetConfig, podría utilizarse Telnet para descargar configuraciones al dispositivo y TFTP para explorar las configuraciones.

4.28 Para descargas de configuraciones, los protocolos utilizados son Telnet y SSH (con ese orden, aunque puede cambiarse).

4.29 Para la exploración de configuraciones, los protocolos utilizados son: TFTP, Telnet, RCP y SSH (con ese orden, aunque puede cambiarse).

4.29.1 Verificar los requerimientos de los dispositivos para asegurarse de que RME puede comunicarse con los dispositivos.

4.29.2 Crear listas de aprobadores (si se requieren instancias de aprobación previa de los cambios de configuración) y establecer las preferencias del Fichero de Configuración (programación de actualizaciones, número de copias a mantener, etc.).

4.29.3 Utilizar el Fichero de Configuración (Configuration Archive) para visualizar las configuraciones de los dispositivos e identificar/planificar los cambios necesarios. Luego, pueden utilizarse las aplicaciones NetConfig y Config Editor para ejecutar y confirmar los cambios.

4.29.4 Realizar, como mantenimiento continuo, el chequeo del reporte Configuration Sync para asegurar que todas las configuraciones running y startup son iguales para cada uno de los dispositivos.

4.30 El Administrador de la red puede utilizar los comandos Network Show y reportes customizados para diagnosticar problemas y recoger información.

Inventario

4.31 Las redes son una combinación de sistemas heterogéneos, geográficamente dispersos. Mantener el control de inventario de los activos de hardware y software es una tarea crítica. Además, la mayoría de las tareas de RME se ejecutan sobre conjuntos de dispositivos, por lo tanto la información precisa de los dispositivos debe residir en la base de datos de RME.

4.32 El Inventory Manager tiene la responsabilidad de mantener el inventario. Como RME utiliza diferentes servicios de gestión para recolectar la información de los dispositivos (SNMP, TFTP, Telnet, RCP), cada dispositivo existente en la base de datos (Inventario) debe incluir los parámetros (atributos) de los servicios de gestión (cadena de comunidad, passwords). Cuando esta información existe en el Inventario, se considera que el dispositivo constituye un objeto gestionado por RME.

4.33 Es decir que mientras RME no disponga de la información de los atributos, ese dispositivo no estará bajo el control de RME. RME no realiza el auto-descubrimiento de dispositivos en la red, sino que deben ser agregados manualmente o importados en la base de datos de Inventario.

4.34 Para simplificar el proceso de población de la base de datos de Inventario, la información de los dispositivos puede importarse desde un archivo con formato de texto.

Gestión de Software

4.35 La aplicación de Software Management automatiza los pasos asociados con la planificación, programación y descarga de imágenes de software, y el monitoreo de la red.

4.36 Provee herramientas para almacenar copias de backup de todas las imágenes que corren en los dispositivos de la red. Además puede almacenar copias adicionales que se desee mantener, y planificar y ejecutar upgrades a varios dispositivos concurrentemente.

4.37 La aplicación puede analizar dispositivos e imágenes de software para determinar la compatibilidad y realizar recomendaciones antes del upgrade. Los reportes de Software Management permiten controlar todos los upgrades de versiones de la red.

4.38 Las imágenes deben importarse a RME para ser mantenidas en la Software Image Library. Inicialmente, las imágenes pueden ser importadas desde los mismos dispositivos de la red (o de otra fuente) para crear una copia de backup base de todos los dispositivos.

4.39 Además, después de la importación, puede configurarse a Software Management para que sondee periódicamente los dispositivos de la red para producir reportes ante la existencia de imágenes corriendo en la red que no se hallan almacenadas en la base de datos de RME.

Análisis del Syslog

4.40 La aplicación Syslog Analysis permite registrar eventos en forma centralizada y controlar los mensajes de error del sistema de los dispositivos Cisco. Los mensajes de error son utilizados para analizar la performance de los dispositivos y de la red.

4.41 Pueden almacenarse, como máximo, 1 millón de mensajes y hasta 14 días.

4.42 Es posible realizar el backup de los mensajes purgados en una ubicación especificada (formato CSV). Está permitido seleccionar el tamaño del archivo de backup, y una dirección de e-mail para recibir un aviso si el tamaño del backup excede el indicado.

4.43 Los mensajes recibidos por el servidor RME son periódicamente leídos (cada 30 segundos) por el proceso de análisis [Syslog Analyzer], donde se aplican filtros definidos por el usuario y el resultado se almacena en la base de datos de mensajes de Syslog de RME, y quedan disponibles para obtener reportes e iniciar scripts definidos por el usuario.

APPENDIX C**ACTION PLAN FOR THE IMPLEMENTATION OF ADS-B TRIALS IN THE SAM REGION**

ITEM	ACTIVITY	RESPONSABLE PARTY	EXPECTED RESULT	DATE
1	Define trial objectives, aimed at verifying the possibility that States derive benefits from the ADS-B as surveillance system in the Region.	CNS Task Force	Trial objectives	February 2009
2	Review and describe the activities to be considered for ADS-B trials developed by the GREPECAS mechanism.	Secretariat	Regional Plan of Activities for ADS-B trials reviewed.	February 2009
3	Determine the equipment and configuration required to begin trials. Obtain trial costs.	Rapporteur	Definition of equipment and its configuration for the trial.	March 2009
4	Define the geographical area in which trials will be performed.	Rapporteur	Geographical area defined (CONOPS)	March 2009
5	Consult States and users as to their interest in participating in the trials.	Secretariat	States confirmation of participation.	March 2009
6	Select the organizations or States responsible for conducting the trials.	States	Selection of organization or State.	April 2009
7	Installation of the ADS-B equipment necessary for conducting the trials in the specified geographical area.	Selected organization or State	Equipment installed	May 2009
8	Conduction of trials (data collection).	States	Trial start-up.	June to November 2009
9	Processing of collected data	Selected organization	Data processing	December 2009
10	Presentation of the results obtained	Selected organization	Presentation of results	SAM/IG/5 (April 2010)

APPENDIX D**ACTION PLAN FOR THE INTERCONNECTION OF AMHS SYSTEMS IN THE SAM REGION**

ITEM	ACTIVITY	RESPONSIBLE	EXPECTED RESULT	DATE
1	Review of the ATN Regional Plan as regards AMHS.	Secretariat	Regional Plan of Ground-ground ATN Application (AMHS)	Nov. 2008
2	Review and designation of IP addressing to intra-regional IP routers.	Secretariat	Designation of IP addressing.	Dic. 2008
3	Prepare trial protocol interconnection to determine the bandwidth required for the AMHS application (between MTA's) through REDDIG.	Argentina	Interconnection trials protocol.	Jan. 2009
4	Carry out interconnection trials among Argentina, Brazil, Paraguay and Peru.	REDDIG Administration States	Interconnection trials.	Mar. 2009
5	Analyze results.	REDDIG	Analysis of results.	Apr. 2009
6	Review the CAAS addressing plan.	States		Jan. 2009
7	Define regional AMHS routing policies.	CNS Task Force		SAM/IG/3
8	Analyze the need to establish a regional Administrative Management Centre (AMC).	States		SAM/IG/3
9	Elaborate a guideline or the interconnection of AMHS Systems in the SAM Region.	CNS expert on AMHS systems	Guideline material.	Junio 2009

Agenda Item 6: Operational implementation of new ATM automated systems and integration of the existing systems

6.1 The Meeting took note of the preliminary document regarding the SAM Automation System Requirements, containing common basic functions that the automated systems in the SAM Region ACCs should have, and which was elaborated by the automation expert hired by the Project. This document was a requirement established during SAM/IG/1 meeting, and it has common basic functions that an automated system must have in an ACC. Copy of the document is shown in **Appendix A** to this part of the Report.

6.2 The Meeting considered that this document should be circulated among the States of the Region for their comments and, once the document was amended with the comments received, it could be used by the SAM States as guidance material upon implementing the new automated systems in the ACCs or in the improvement of the automated systems existing in the ACCs.

6.3 With the aim of complying with the activities in the action plan for the regional interconnection of automated systems, elaborated during SAM/IG/1 meeting, the Meeting considered that the Project should develop a draft memorandum of understanding to provide orientation to States in the determination of technical, operational, administrative, institutional and financial considerations necessary for the automated systems interconnection implementation, to be carried out in a bilateral form, between adjacent States in the Region that have automated systems installed in their ACCs.

6.4 The Meeting considered that the draft memorandum of understanding should be elaborated by an expert on ACC automation systems, having extensive experience in automated systems interconnection. The expert to carry out this activity would be hired for a one-week period.

6.5 Likewise, note was taken that the interconnection of automated systems consists in the exchange of flight plan and radar data information. Also, it was considered that the technical aspects in the draft memorandum of understanding should take into account the aspects contained in the System Interface Control Document (SICD) and in the Initial Automated Systems Interconnection Plan elaborated by Project RLA/98/003 and examined during SAM/IG/1 meeting.

6.6 The Meeting considered that the draft memorandum of understanding would be aiding the States of the Region when bilaterally implementing the automated systems interconnection between the two States having adjacent ACCs. The ACCs to interconnect are indicated in the Action Plan for the Interconnection of Automated Systems presented during SAM/IG/1 meeting.

6.7 It was thought that, once the draft memorandum of understanding was elaborated, it would be applied for each of the interconnection requirements specified in the action plan, starting with the interconnection of the automated systems between the Montevideo and Ezeiza ACCs.

6.8 For the interconnection between the aforementioned ACCs, the Meeting, taking into account the fact that the OLDI function had never been tried out in Uruguay, that there had been no training on how to configure the protocol, and that there is a dependence with the software manufacturer, considered that it would be advisable to use the AIDC protocol for the flight plans interconnection between Uruguay and Argentina, through the use of a bilateral agreement to this end.

6.9 The Meeting took note that between Ezeiza ACC and Cordoba ACC, AIDC interconnection trials were being carried out. Therefore, it was considered that Argentina could prepare guidance material with the considerations to bear in mind when interconnecting the AIDC application between ACCs, and that this could be presented at the SAM/IG/3 meeting

6.10 Also, the Meeting deemed it convenient that a study be carried out regarding the possibility to implement a Project for AIDC regional implementation in a multinational form, taking into account the compatibility of this application with the flight plan processors existing in the States of the Region.

6.11 The Meeting, taking into account the review made to the automation activities elaborated during SAM/IG/1 meeting, and the new activities scheduled during the current Meeting, updated the action plan, which is shown in **Appendix B** to this part of the Report.

APPENDIX A / APENDICE A

**PRELIMINARY REFERENCE SYSTEM/SUBSYSTEM SPECIFICATION FOR THE
AIR TRAFFIC CONTROL AUTOMATION SYSTEM**

(Inglés únicamente)

CHANGE RECORD

Rev	Description of Change	Page No's Affected	Date
-	Initial Release	All	22 Sept 2008
A	Preliminary Release	All	04 Oct 2008

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1. SCOPE

1.1 Identification

This document is based on the requirements identified in the OACI Project RLA/06/901 for Air Traffic Control Automation Systems. This System Specification is based on the pre-existing systems used in the SAM Region and it incorporates requirements from the ATM Group as required. SAM Automation Team will update this document to reflect the required refinement.

The main objective of this specification is to consolidate all the requirements, mainly the mandatory ones to be used as a reference for future implantations of new ATCAS Systems and upgrades as well.

These requirements originated in a survey in the States, where each country presented an abstract of all the functionalities available in their automation systems.

This effort is in line with the need of harmonization to provide interchange of flight plan and surveillance data, and establish a minimum common level ground among the several ACC installed in the SAM region and the new systems as well.

1.2 System Overview

1.2.1 Introduction

This specification includes detailed requirements for ATC Automation Systems.

The system's mission is to enhance the safety of air travel by providing controllers with information on flights from surveillance sensors and adjacent centers. The information is presented on different functional displays, including situation displays, flight data displays, supervisor positions and aeronautical information displays.

The system must follow the International Civil Aviation Organization (ICAO) standards to provide routine ATC services for aircraft operating in SAM airspace.

ATM is described in the ICAO Global ATM operational Concept (Doc 9854) as the dynamic, integrated management of air traffic and airspace in a safe, economical and efficient manner through the provision of facilities and seamless services in collaboration with all parties. The operational concept also describes a system that provides ATM through the collaborative integration of humans, information, technology, facilities and services, supported by air, ground and/or space-based communications, navigation and surveillance.

This operational concept identifies seven interdependent components of the future ATM system. They comprise:

- a) Airspace organization and management;
- b) Aerodrome operations;
- c) Demand and capacity balancing;
- d) Traffic synchronization;
- e) Conflict management;
- f) Airspace user operations;
- g) ATM Service Delivery Management.

1.2.2 Context Diagram

The following Figure 1.1 illustrates the relationship of the ATCAS with its external entities:

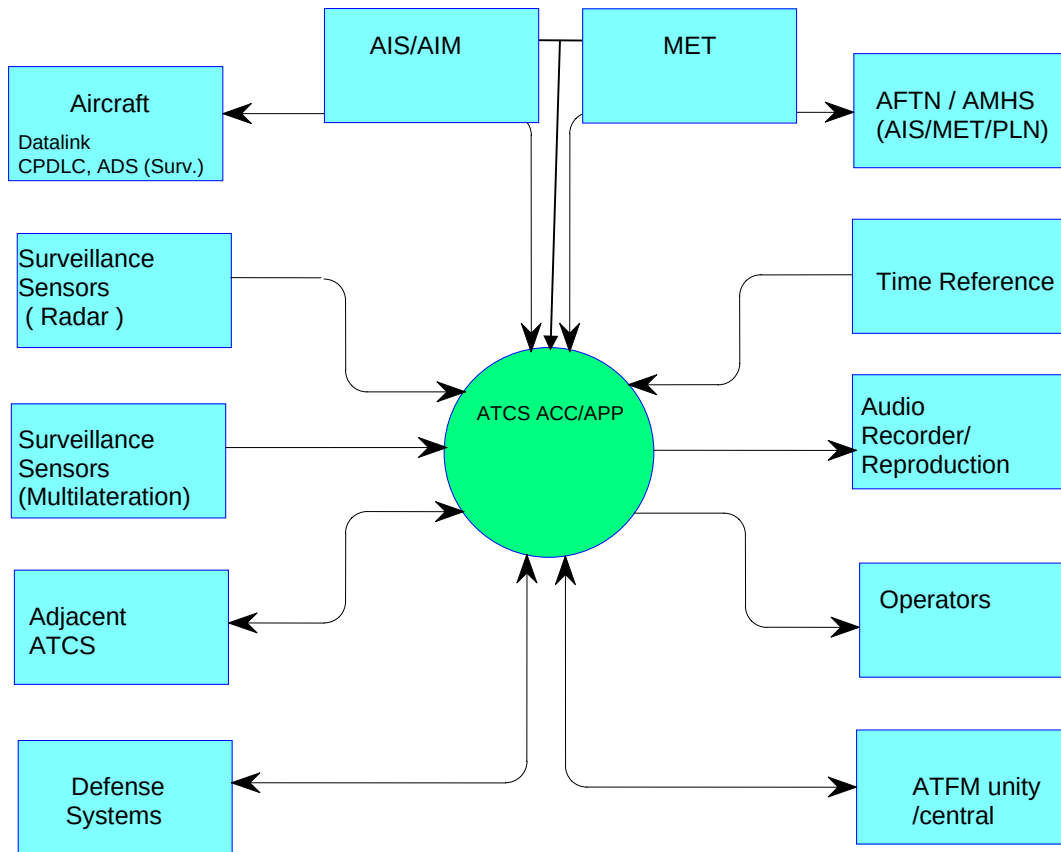


FIGURE 1.1 – CONTEXT DIAGRAM FOR ATCAS

1.2.3 Component and External Interfaces

The main components and External interfaces of the ATCAS are:

1.2.3.1 Components

Operational System

The Operational System takes the information from surveillances systems such as Radar and ADS, and integrates them with other information. Then, all the information is put together to form a representation of the airspace traffic environment.

Simulation and Training

This system is capable to provide a realistic simulation of the Air Traffic environment in order to serve as a training platform for the operational and maintenance personnel. It uses Pilot Workstations to provide the training personnel with skills necessary to operate the ATCAS.

1.2.3.2 External Interfaces

The external interfaces to the ATCAS are:

a) Surveillance Sensors:

- PSR/MSSR surveillance;
- MSSR surveillance;
- ADS-B and ADS-C datalink;
- Multilateration;

The system receives surveillance data, processes the information and presents a synthetic image of the Air Situation to the controller.

b) Aircraft

The controller uses a communication with the pilot through a specific protocol called CPDLC (Controller Pilot Data Link Communications).

The system receives track and flight plan information and sends commands to the pilot.

c) Adjacent ATCAS

The adjacent Centers represent the Area control centers and Approach control. This interface sends and receives mainly flight plan coordination messages, using the standard ICAO 4444 messages or OLDI and AIDC protocols.

The system will share surveillance data with adjacent centers.

d) Time Reference System

Time Reference System receives the UTC Time from the GPS and sends this information to synchronize the ATCAS Workstations time.

e) Audio Recorder

This interface is used to synchronize the recording and the playback system activities with the audio recording and playback.

f) Operators

They are represented by the main controllers, assistant, Flight data Operators and Technical/ Operational supervisors.

g) AFTN Interface

It represents the interface with the AFTN to receive and transmit ATS messages, when the AMHS system is not available.

h) AMHS Interface

It represents the new interface for sending and receiving ATS messages. This system has a gateway to the AFTN.

i) ATFM Unity

This link is used to transmit the flight plan and traffic information and coordinate measures to diminish problems associated with the flow management.

j) Defense Systems

This interface is used to exchange surveillance information and coordination information with defense systems.

k) AIS and MET

This interface is designed for Web interfaces (HTTP) to access AIS and MET database using a Web Browser with a LAN connection.

1.2.3.3 **System Features**

The system includes the following features: Dual Surveillance Data Processing Servers- SDPS; Dual Flight Data Processing Servers- FDPS; Dual Data Recording Servers – DRS; Dual System Monitoring and Control – SMC; Multiple ASTERIX-format surveillance interfaces; Multiple Surveillance input formats; Surveillance Displays with 2048 x 2048 high resolution color monitors; Flight Data Displays; Supervisor Displays with printers; Flight Progress Strip Printers; Dual LAN; Database Management System for site adaptation and map generation; Interface for Time Synchronization with Audio Recorders; Electronic Flight Strip Displays; Direct Surveillance Access; Kalman-filter based Surveillance Tracker; Dual-redundant surveillance input lines; Physical Integration with Voice Control System; Interface with adjacent ACCs; Simulation/Training and Test System; Aeronautical Information System; Datalink interface; Air Defense interface to exchange surveillance data and other coordination information.

1.3 **Document Overview**

This document is identified as the System Subsystem Specification (SSS) for the ATC Automation Systems in the SAM region.

The document is organized as follows:

Chapter 1	Scope: This chapter contains the identification and a overview of the system
Chapter 2	Referenced Documents: contains the list of documents referenced in this document.
Chapter 3	Requirements: contains the list of characteristics and functionalities available in the system.
Chapter 4	Qualification Methods: defines the way that each requirement is tested.
Chapter 5	Requirements Traceability: contains the list of requirements with specific identifiers that will follow till the formal acceptance Test and documentation.
Chapter 6	Notes: Contains the glossary and abbreviations used in this document.

The following diagram shows the hierarchical structure of the documents and identifies the relative position of this document.

1.3.1 **Document Conventions**

These operational requirements and specifications use the words "shall", "will", "should", and "option (ally)" with definite meanings. These are defined below:

1. "Shall" indicates that the requirement or specification it refers to is mandatory.
2. "Will", "should", or "option (ally)" indicates intent to realize the functionality within the system (unless it concerns functionality within the scope of external systems) but such statements are not testable.

Note that "will" is also used to introduce requirements that are more precisely stated elsewhere in the document.

2. REFERENCED DOCUMENTS
INTERNATIONAL ATC DOCUMENTS AND OTHER STANDARDS:

AIDC	<i>International Civil Aviation Organization – Asia and Pacific Office - Asia/Pacific Regional Interface Control Document (ICD) for ATS Interfacility Data Communications (AIDC) – Version 3.0 – September 2007</i>
OLDI	<i>Eurocontrol standard document for On-Line Data Interchange (OLDI) - edition: 3.00, edition date: 31/10/2003.</i>
ICAO Doc 4444 ATM/501	<i>Air Traffic Management - Procedures for Air Navigation Services 15^a edition – 2007 and Amendment 1 (Jan 2008)</i>
ICAO ANNEX 10	<i>Volume I - Aeronautical Telecommunications;, Communication Procedures Volume III, Communication Systems</i>
ICAO ANNEX 15	<i>Aeronautical Information Services</i>
ASTERIX	<i>Eurocontrol Standard for Surveillance Data Exchange Issue 0.1, September 1991</i>
ICAO Doc 9705 AN956	<i>Manual of Technical Provisions for the Aeronautical Telecommunication Network – ATN.</i>
ICAO Doc 9578	<i>Manual of the Aeronautical Telecommunication Network (ATN)</i>
ICAO Doc 9694 AN/955	<i>Manual of Air Traffic Services Data Link Applications</i>
ICAO Doc 9854	<i>Global Ait Traffic Operational Concept - ATM</i>
ICAO Doc 9880 AN/466	<i>MANUAL ON DETAILED TECHNICAL SPECIFICATIONS FOR - Aeronautical Telecommunication Network – ATN - 5 April 2007</i>
ICAO Doc 9896	<i>Aeronautical Telecommunication Network - ATN IPS</i>
ICD for AIDC	<i>Asia/Pacific Regional Interface Control Document version 2</i>
ICAO Doc 9613	<i>Performance Based Navigation Manual – PBN Volume I - concept and implementation guidance</i>
SGN2-8 IP 10	<i>Aeronautical Communication Panel ATN – CPDLC, ADS, FIS – June 2006</i>
(MLAT)	<i>Multilateration Concept of use Edition 1.0 – September 2007</i>
(Doc 9688)	<i>Manual on Mode S Specific Services - 2nd edition, 2004</i>
ICAO Doc 9377 AN/915	<i>Manual on Coordination between Air Traffic Services, Aeronautical Information Services and Aeronautical Meteorological Services. 3rd edition, 2007. 142 pp.</i>
ICAO Doc 9873	<i>Manual on the Quality Management System for the Provision of Meteorological Service to International Air Navigation. 1st edition, 2007. 62 pp</i>
ARINC 622	<i>ATS Datalink Applications over ACARS Air-Ground Network (end-to-end).</i>
RTCA DO-258/EUROCAE ED-100	<i>Interoperability Requirements for ATS Applications Using ARINC 622 Data Communications.</i>
ARINC 620	<i>Datalink Ground System Standard and Interface Specification (ground-to-ground)</i>
ICAO Guidance Material	<i>GUIDANCE MATERIAL OR THE ASIA/PACIFIC REGION FOR ADS/CPDLC/AIDC GROUND SYSTEMS PROCUREMENT AND IMPLEMENTATION Version 1 - September 2007</i>
	<i>Preliminary System Interface Control Document for the Interconnection of ACC Centers of the CARSAM Region</i>
	<i>CAR/SAM Automated ACC Interconnection Plan</i>

3. **REQUIREMENTS**

These requirements represent a database of functionalities that can be shaped accordingly in the system. The States are responsible for the decision of implementation involved in the installation or in the modernization process.

3.1 **Required States and Modes**

SSS 1 - The system shall have the capability to operate in Operational partition or in Simulator Partition.

SSS 2 - The surveillance and Flight display consoles shall have the capability to operate in Operational Mode, Direct Radar Access Mode, Simulator Mode, and Playback Mode.

SSS 3 - The servers shall have the capability to operate in Mode Active, Hot Stand-by and Maintenance Mode.

3.2 **System Capability Requirements**

3.2.1 **Man-Machine Interface**

The surveillance positions will be able to provide surveillance tracks without interruption.

Data will be displayed in a clear way avoiding confusion and/or misunderstanding, and taking into consideration its contents, meaning, or the importance of the data displayed.

3.2.1.1 **Graphic Interface**

3.2.1.1.1 **Predicted Position Indicator**

SSS 4 - The Main Controller Display shall be able to designate a track vector and to define the predicted ahead in time (minutes) what those vectors represent.

SSS 5 - The system shall have a command to designate a track for display and define a specific time ahead.

SSS 6 - The graphic representation of a velocity will be displayed as an extended velocity vector and the length of the vector shall be a function of the controller selected time for predicted positions.

3.2.1.1.2 **Functional Controls**

SSS 7 - The system shall have the capability to cancel or delete any input action that has been initiated, before the completion or confirmation of execution of the command.

SSS 8 - The system shall have functional controls using dedicated function keys and a trackball.

3.2.1.1.3 **Radar Coverage Diagrams and Color Assignment**

SSS 9 - The supervisor position shall have the capability to select colors to be applied to various display elements, in a manner not to degrade or affect the processing of operational functions.

SSS 10 - Selection of color brightness and intensity shall be available as an operational function in the individual workstation.

SSS 11 - The main controller position shall have capability to display coverage diagrams for each surveillance sensor and resultant coverage diagram for all ground based surveillance sensors presented in a specific color.

SSS 12 - These coverage diagrams shall be customized to emulate the theoretical coverage for the heights 5,000 feet, 10,000 feet, and 20,000 feet for each azimuth. Areas with no surveillance coverage shall have a special color.

3.2.1.1.4 **Screen Annotation**

SSS 13 - The surveillance workstations shall have the capability for entering up to TBD annotations for display. Each annotation will have a specific text and color.

SSS 14 - The surveillance workstation shall have the capability to route the screen annotation to other surveillance workstations and to suppress displayed annotations as well.

3.2.1.1.5 **Windows Presentation**

SSS 15 - The surveillance workstation shall organize all the information presented in windows to present surveillance data, flight plan data, alerts, status, commands, where each window shall be selected, resized or moved by the controller.

SSS 16 - The system shall have the capability to notify any critical information shown in a minimized or inactive window.

3.2.1.1.5.1 **Main Surveillance Window**

SSS 17 - The main surveillance window shall present the surveillance data with the capability to zoom and pan.

3.2.1.1.5.2 **Secondary Surveillance Window**

SSS 18 - The secondary surveillance windows shall provide the same capability than the main surveillance window with independent resize, zoom and pan.

3.2.1.1.5.3 **System Status Window**

SSS 19 - The System Status Window shall display the following information:

- Time and Date;
- Selected display range;
- Altitude filter bounds;
- SSR block code selections;
- CJS Designation;
- Presentation mode;
- Magnetic Variation;
- Label line selections.

3.2.1.1.5.4 **General Information Window**

SSS 20 - The system shall provide the capability to display the following information on the Flight Data Display:

- Flight Plan
- MET data
- Aeronautical/Meteorological Information: Notice to Airmen (NOTAM) and Meteorological Report (METAR), and other meteorological messages (SIGMET, AIRMET, GAMET, SPECI and TAF);
- General Purpose Information;
- QNH values for aerodromes and regions.

3.2.1.1.5.5 Messages Windows

SSS 21 - The system shall have the capability to display pending coordination messages between centers, sectors or tracks (via Datalink).

SSS 22 - The system shall have the capability to register all the coordination actions even when the interface between the systems is not working.

SSS 23 - The system shall have the capability to display an alert when a response to a coordination message is not received.

SSS 24 - The system shall have the capability to display the coordination messages received till the operator send the answer correctly.

SSS 25 - The system shall have the capability to display the history of coordination messages.

3.2.1.1.6 **Images**

SSS 26 - The main surveillance window shall have the capability to display georeferenced images representing meteorological information as an overlay under operator control.

3.2.1.1.7 **Surveillance Data Display Elements**

SSS 27 - ADS-B, ADS-C, PSR, SSR, and PSR/SSR plot presentation shall be available as a selectable function.

SSS 28 - Surveillance workstations shall have the capability of manually enable or disable the presentation of plot data besides the presentation of tracked targets.

SSS 29 - The Track information shall indicate:

- Aircraft position;
- Track history information.

SSS 30 - The system shall have the capability to process and display:

- SSR code or callsign when correlated with a flight plan;
- Flight level/altitude based on Mode C or barometric corrected altitude (below the transition level) surveillance information;
- Heading and ground speed (as a speed vector);
- Attitude indicator, i.e., climb, descent, or level flight.

The system will have the capability to calculate and display the predicted position of any track as designated by a controller input action.

SSS 31 - The surveillance position shall have the capability to process and display alphanumerically the ground speed and heading (track) of any track designated.

SSS 32 - The following elements shall be available for display:

- Map information;
- Range rings;
- Time;
- Selected Surveillance Display range;
- Selected height filter;
- Controller jurisdiction indicator;
- Handoff indication;
- Range/bearing line (cursor);
- Indication when the Air Situation Display is not being updated;
- Selected track presentation mode/surveillance sensor;
- Special codes;
- STCA (Short Term Conflict Alert);
- MSAW (Minimum Safe Altitude Warning);
- MTCD (Medium Term Conflict Detection);
- CLAM (Cleared Level Adherence Monitoring);
- AIW (Area Infringing Warning);
- RAM (Route Adherence Monitoring);
- Track information, including:
 - o Position symbols;
 - o Track history information.
- Label information.

SSS 33 - Critical information related to the display of special codes, STCA, MSAW, MTCD, CLAM, AIW Data or information considered to be critical for the operation shall always be displayed in a clear and unambiguous manner.

3.2.1.1.8 Surveillance Data Position Symbols

SSS 34 - Different symbols shall be used for indicating a PSR plot, SSR plot, PSR track, SSR track, PSR/SSR track, ADS-B Track, ADS-C Track, Multilateration Surveillance track, Flight Plan navigated track.

3.2.1.1.9 Track History Information

SSS 35 - The surveillance workstation shall have the capability to enable or disable track history information in each position.

SSS 36 - The surveillance workstation shall have a capability to select the number of track history positions, using a specific symbol.

3.2.1.1.10 Display Range

SSS 37 - The Surveillance Display shall have the capability to select a specific range for each surveillance workstation.

3.2.1.1.11 **Range Rings**

SSS 38 - The system shall have the capability to display Range rings individually selectable at each surveillance workstation as circles centered on the selected ground based surveillance sensor in monoradar mode and multiradar mode.

3.2.1.1.12 **Quick Look**

SSS 39 - The system shall have a capability to display all tracks and labels through an individual quick look function.

SSS 40 - The quick look function shall enable display of label track data bypassing all local filters.

3.2.1.2 **Range Bearing Line**

SSS 41 - Each Surveillance Display shall have the capability to display a minimum of 3 range/bearing lines, displayed at the end of the line, as the following types:

- Between any two operator selectable points;
- Between any two moving targets, including a time field,
- Between a operator selectable point and a moving target, including a time field;

3.2.1.3 **Smart Labels**

The smart label will be the main way to interact with the system.

SSS 42 - The system shall have a capability to display three types of label:

- Standard Label – with the minimal track/flight plan information.
- Extended Label – activated when the cursor pass over the label.
- Selected Label- similar to the extended label but with interaction in the fields.

3.2.1.3.1 **Controller Jurisdiction Indicator (CJI)**

SSS 43 - The system shall have a capability to display an indication an indication of which sector has jurisdiction over the track in question.

SSS 44 - The system shall allocate a separate jurisdiction indicator as defined in adaptation data.

SSS 45 - This CJI shall be shown in conjunction with the handoff function.

SSS 46 - The system shall display involved in a handoff through a distinct presentation.

3.2.1.3.2 **Special Position Indicator (SPI)**

SSS 47 - The system shall display activation of SPI using a unique indication.

SSS 48 - The system shall have the capability to re-position any label relative to the position symbol, manually or using an automatic algorithm.

SSS 49 - The following data shall be displayed in a label, if available:

- SSR code or call sign when correlated with a flight plan or entered manually from a surveillance workstation;
- Mode C flight level/altitude;
- Attitude indicator, i.e., climb, descent, or level flight;
- Controller jurisdiction indicator;
- Calculated ground speed, expressed in tens of knots;
- Cleared flight level;
- Quality Factor;
- ADS Data;
- Coordination Data;
- Free text, entered manually.

SSS 50 - The calculated vertical speed shall be displayed after an appropriate controller input action.

3.2.1.4 **Filters**

SSS 51 - The system shall have a capability to select an upper and lower limit for the level filter, at each surveillance workstation.

SSS 52 - The following conditions shall override the filters:

- Tracks which are under the jurisdiction of this workstation;
- Special condition tracks;
- Tracks that are quick-looked at the display;
- Active handoff tracks;
- Targets that do not currently have valid Mode C data;
- Tracks which are individually selected for display by the controller;
- Unsuppressed tracks in MSAW, STCA, MTCD, CLAM, RAM, AIW alerts.

SSS 53 - The surveillance shall have a capability to display the height filter limits selected.

SSS 54 - The system shall have the capability enable/disable adapted areas within which detected tracks will not be displayed.

SSS 55 - The system shall have a capability to designate specific codes or code groups to filter the track label presentation.

3.2.1.5 **Maps**

SSS 56 - The system shall have a capability to select and present map data in each surveillance workstation.

SSS 57 - The map presented shall have specific graphic representation for the following entities:

- FIR/UIR borders;
- Lateral limits of sectors;
- Terminal control areas;
- Control zones;
- Traffic information zones;
- Airways and ATS routes;
- Restricted areas.

3.2.1.5.1 **Weather Surveillance Data**

SSS 58 - The system shall have the capability to display weather surveillance data from PSR radars or Meteorological radars.

SSS 59 - The system shall have a capability to select the display of high intensity, both high and low intensity, or no weather, if this information is available.

3.2.1.5.2 **Private Maps**

SSS 60 - The surveillance workstation shall provide the capability to define and to display private maps created on-line with different attributes of lines.

SSS 61 - Presentation of each private map shall be individually selectable.

3.2.1.6 **Flight Plan**

3.2.1.6.1 **Flight Strip Window**

SSS 62 - The system shall provide the capability to display up to TBD pages of flight strip information in this window on the ESD.

3.2.1.6.2 **Flight Data Displays**

SSS 63 - The system shall provide functional controls to enter, modify, cancel and display flight plan data.

SSS 64 - The system shall have the capability to insert a change in a flight plan route through graphical point selection.

SSS 65 - The flight plan functions shall include:

- flight plan data entry;
- flight plan update data update;
- Display of flight plan data;
- Edition of stored/displayed information;
- Printing of Flight Progress Strips;
- Edition of departure clearance for inactive and pre-active flight plans;
- Manual edition of ATS messages;

SSS 66 - The system shall have the capability to edit a flight plan using a graphic tool over a specific thematic map.

SSS 67 - The system shall have a capability to display a flight plan history, with all the actions and message updates received or transmitted related to that flight plan.

3.2.1.6.3 **Flight List Presentation**

SSS 68 - The system shall have the capability to display traffic lists, based on the flight plan status, including coast and hold information.

3.2.1.6.4 **Flight Strip Presentation**

SSS 69 - The system shall have the capability to display Electronic Flight Strip and to print Paper Flight Progress Strip.

3.2.1.6.4.1 **Paper flight progress strip**

SSS 70 - The system shall have the capability to define a flight Strip format and layout in adaptation data.

SSS 71 - The system shall distribute flight strips in accordance with the route system and the Strips distribution plan as defined in adaptation, and the capability to print flight strips at any time.

3.2.1.6.4.2 **Electronic Flight Strips**

3.2.1.6.5 **General**

SSS 72 - The system shall have the capability to display electronic flight strips.

SSS 73 - The system shall have the capability to allow the operator to select pre-defined flight level using smart labels.

SSS 74 - The system shall display electronic flight strips associated with the flight under control or prior to control of the associated jurisdiction sector at the position associated to the sector.

SSS 75 - The system shall have the capability to display at least the following sub-states for a flight plan:

- active not controlled;
- active controlled;
- in transfer (donor, receptor and proposed);
- announced;
- holding;
- transferred;

SSS 76 - There shall be specific presentations for the following conditions:

- correlated;
- multicorrelation (two or more tracks having identical SSR code associated to the same flight plan);
- non-conformance route/track position indication;

SSS 77 - There shall be a unique presentation for the first display of the flight plan.

3.2.1.6.6 **Flight Plan Data Retrieval**

SSS 78 - The system shall have the capability to retrieve flight Plans, repetitive flight plans, and flight plan history from the database.

SSS 79 - The system shall have the capability to retrieve flight plan data available on the basis of: Flight identification, in combination with departure aerodrome, and/or EOB/ETA (validity times).

3.2.1.6.7 Repetitive Flight Plan Retrieval

SSS 80 - The Flight plan workstations shall have access to RPL data in the RPL file, and to retrieve RPL data available on the basis of: Flight identification, in combination with departure aerodrome and/or EOBT/ETA.

3.2.1.6.8 Flight Plan History

SSS 81 - The system shall have a capability to display and print all messages concerning a flight plan, including associated update messages, for at least adaptable hours after termination of flight plan.

3.2.1.6.9 Free Text Input and Distribution

SSS 82 - The system shall have the capability to perform "free text" input, and to be able to route this information for output to other designated workstations or any AFTN/AMHS address.

3.2.1.6.10 RVSM

SSS 83 - The system shall have the capability to process and display RVSM status according with the associated flight plan, the operator input data and coordination messages as well, considering the RVSM airspace;

3.2.1.6.11 PBN

SSS 84 - The system shall have the capability to process and display the PBN status associated to the flight plan according with the Amendment 1 of Doc 4444, considering the operator input data and coordination messages as well;

3.2.2 Datalink Communication

SSS 85 - The system shall be linked to aircraft by a datalink service provider (DSP).

SSS 86 - The system shall be capable of transmitting and receiving AFN, ADS and CPDLC messages complying with RTCA/DO258A-EUROCAE/ED-100 and AIDC messages complying with the Asia/Pacific Regional Interface Control Document for AIDC (ICD).

SSS 87 - The system shall include the ACARS Convergence Function (ACF) to convert messages between the character-oriented data of ACARS and the bit-oriented data used in ADS and CPDLC.

SSS 88 - The system shall provide air traffic controllers with:

- Display of message exchanges;
- Display of updated aircraft positions and maps;
- Tools for measuring separation in distance or time;
- Tools for measuring angles between aircraft flight paths;
- Information on aircraft flight status;
- HMI tools for composing ADS and CPDLC messages;
- Alerts for exception conditions;
- Conflict probe capability;
- Electronic flight progress strips, and paper strips if required;
- Presentation of emergency status;
- Other information pertinent to ATS operations.

3.2.2.1 CPDLC

SSS 89 - The system shall have the capability to communicate using the protocol CPDLC (“Controller- Pilot Datalink Communication”).

SSS 90 - The system shall be capable of processing the specified number of message exchanged with each of the aircraft.

SSS 91 - Down-linked CPDLC messages shall be displayed to controllers. Tools shall be provided to allow simple and intuitive initiation of, or response to, CPDLC messages.

SSS 92 - CPDLC position reports shall be used to display aircraft positions when no ADS report is available.

SSS 93 - The system shall have the capability of terminating CPDLC connection with the aircraft.

SSS 94 - The system shall allow transfer of CPDLC between sectors of an ATCAS without changing the data authority and with the same CPDLC link.

SSS 95 - The system shall be capable of handling the message set and the standardized free text messages defined in the FOM, as well as free text.

SSS 96 - The system shall allow controllers to review uplink messages prior to sending.

SSS 97 - Messages shall be handled in order of priority.

SSS 98 - Messages with the same priority shall be processed in the time order of receipt.

SSS 99 - The controller shall be alerted to unsuccessful receipt of the required response in the specified time or receipt of Message Assurance Failure (MAF).

SSS 100 - The system shall allow controllers to send any response messages linking with the reference number of the message received.

SSS 101 - A CPDLC dialogue shall not be closed until an appropriate closure response for that message with same reference number is received.

SSS 102 - When the closure response message is sent, the dialogue is closed and the system shall reject any further attempt to send a response message.

SSS 103 - The capability of closing a CPDLC dialogue, independent of CPDLC closure message receipt, shall be provided.

SSS 104 - The system shall have the capability to send the more frequent CPDLC messages through an interface using the associated track label.

SSS 105 - The system shall have the capability to display aircraft data, received by ADS, in the standard or extended track label.

SSS 106 - The system shall have the capability to display different shapes or symbols to differentiate that the aircraft is ADS/CPDLC capable and it is in contact with the Center.

SSS 107 - The system shall have the capability to allow the operator to differentiate information of course, speed and vertical speed received automatically by ADS.

SSS 108 - The system shall have the capability to uplink messages to the aircraft regarding the controller actions that the pilot need to know.

SSS 109 - The system shall have the capability to display in the outbox message list all the uplink CPDLC messages that are pending for an answer from the pilot.

SSS 110 - The system shall have the capability to display in a unique way the field associated to a change made by the controller till a downlink message is received from a pilot saying the change was made.

SSS 111 - The system shall have the capability to display a communication failure message, when an expected downlink message is not received during a time-out (adaptable).

3.2.2.2 **ADS**

SSS 112 - The capacity of the ADS function shall be determined from the operational policy and procedures and the airspace characteristics, including number of FANS capable aircraft, periodic reporting rate, airspace size, waypoint event report frequency, usage of event and demand contracts, and projected traffic growth.

SSS 113 - The system shall be capable of initiating periodic, event and demand contracts.

SSS 114 - The system shall be able to support a demand, an event and a periodic contract simultaneously with each aircraft.

SSS 115 - The system shall apply validation checks to incoming data by reference to flight plan data in relation to time, altitude, direction and position.

SSS 116 - The system shall be capable of processing ADS reports to display aircraft positions, tracks and altitude. Between ADS reports, aircraft positions shall be extrapolated and displayed automatically at specified intervals.

SSS 117 - Air and earth reference data of ADS reports shall be provided to controllers if required. The types of ADS contract are described at ICAO 9694 and 9880 documents.

SSS 118 - ADS messages shall be processed by the system in the following order:

1. ADS emergency mode.
2. Demand/event reports.
3. Periodic report.

SSS 119 - Within these categories, messages shall be handled in the order received.

SSS 120 - The following errors shall be notified to controllers:

- Message validation error.
- Message sequence error detected with time stamp.
- Time-out of ADS report in response to request.
- Periodic and waypoint event report failure.

3.2.2.3 **Notification of Error Messages**

SSS 121 - The system shall be capable of performing the cyclic redundancy check (CRC) on each message.

SSS 122 - The system shall be capable of verifying the format and validity checks appropriate to each message.

SSS 123 - Controllers shall be notified when the system detects:

- A message error;
- A message sequence error;
- A duplicate message identification number;
- Message non-delivery;
- An expected response not received.

SSS 124 - The system shall have a capability to display ADS or CPDLC emergency message received from an ADS/CPDLC equipped aircraft.

3.2.2.4 **Timestamps and Timers**

SSS 125 - CPDLC and AIDC messages shall be timestamped; however, the form of some timestamps is actually set differently from that specified in Doc 9694.

SSS 126 - By setting and/or deactivating various timer values for the messages received in response to transmitted messages, the system shall monitor whether or not aircraft responses arrive within a specified time limit.

Timers are generally based on the operational requirements of each ATCAS.

SSS 127 - The timers for sending messages relating to the automatic transfer of CPDLC connection and to AIDC shall be set according to bilateral agreements with adjacent ATCAS concerned.

SSS 128 - A timer file shall be provided in the system for:

- Timeout settings for delayed response.
- Timing to initiate actions in ADS/CPDLC operations for:
 - o Connection request (CR);
 - o ADS periodic, event and demand requests;
 - o Automated transfer of connection to the next ATCAS;
 - o Sending Next Data Authority (NDA) message;
 - o Sending AFN Contact Advisory (FN_CAD): at least 30 minutes prior to FIR boundary message;
 - o Sending End Service message prior to the aircraft crossing the FIR boundary (e.g. 5 minutes before);
 - o Timer to trigger actions for sending AIDC messages;
 - o Timer for re-transmission of the message when no response is received within a specified time.

3.2.2.5 **AFN Logon Functions**

The AFN logon functions provide the necessary information to enable ADS and CPDLC communications between the system and aircraft avionics systems for:

- Logon;
- Forwarding logon information to the next ATCAS.

Note: Details of Datalink Initiation Capability (DLIC) functional capabilities are provided in Doc 9694 Part 2.

The required capacity for AFN logons will be determined from the operational requirements, such as estimated number of FANS aircraft at the peak hours and anticipated growth of FANS traffic.

SSS 129 - The system shall be capable of accepting or rejecting AFN logon requests.

SSS 130 - The system shall have the capability to correlate the AFN logon data automatically with the aircraft flight plan.

SSS 131 - The controller's workstation shall be capable of displaying the following data:

- Address and version number of the aircraft applications, if required;
- Response from the aircraft with timestamp;
- Status of correlation of the aircraft with its stored flight plan;
- Indication of 'Acceptance' or 'Rejection' to the logon request from aircraft.

SSS 132 - When an aircraft downlinks its supported applications and their version numbers in an FN-CON message, the ATCAS system response shall indicate whether or not it supports those version numbers.

SSS 133 - The system shall be capable of sending the Acceptance message or the Rejection message with reason, as appropriate.

3.2.3 Surveillance Data Processing

Ideally, surveillance systems shall incorporate all available data to provide a coherent picture that improves both the amount and utility of surveillance data to the user. The choice of the optimal mix of data sources shall be defined on the basis of operational demands, available technology, safety and cost-benefit considerations.

3.2.3.1 Air Situation establishment

SSS 134 - The system shall make available a plot position presentation as a selectable function.

SSS 135 - The system shall have the capability to receive, process and integrate all the messages (plots and tracks) to create and update a dynamic Air Situation received from the following surveillance sources:

- ADS-B: Eurocontrol Asterix Protocol Standard including Categories 10, 11, 21 e 23;
- ADS-C: ACARS Protocol;
- Multilateration: Eurocontrol Asterix Protocol Standard including Categories 10, 11, 19 e 20;
- Mode S: Eurocontrol Asterix Protocol Standard including Categories 10, 11, 34 e 48;
- Adjacent Centers: Eurocontrol Asterix Protocol Standard including Categories 62, 63 e TVT2;
- Radars: Eurocontrol ASTERIX protocols including categories 1, 2, 8, 34, 48 with UAP from Raytheon, Thales, SELEX, Lockheed Martin, INDRA, INVAP;
- Radars: CD2, AIRCAT500, TVT2 legacy Protocols.

SSS 136 - The system shall have the capability to create and update track information based on the flight plan information and controller data input (Flight Plan Navigated tracks);

SSS 137 - All the messages shall be submitted to a process to validate the message format before the surveillance integration, discarding erroneous messages and logging all errors found.

SSS 138 - The system shall have the capability to create a timestamp for all the messages using an UTC Time reference sent by the sensor, or using the local relative time.

SSS 139 - The system shall have the capability to integrate all the meteorological information from the primary radars (cat 8 messages) to display at the surveillance display.

SSS 140 - The system shall have a capability to tracking all the surveillance reports using a Surveillance Multisensor Tracking, improving accuracy and smoothing of the resulting system tracks through adaptative Kalman filters.

SSS 141 - The system shall have the capability to manage the status of all sensors, to determine which of the sensors are available to participate of the data fusion.

SSS 142 - The system shall have the capability to manage the surveillance report aging from all the sensors, and to verify the eventual interruption of message flow.

SSS 143 - The system shall have the capability to manage the surveillance track update and the track suppression for both the system track file and the local track file.

SSS 144 - The system shall have the capability to evaluate in real-time the highest quality information, and use the highest quality component information to update the system tracks, establishing priorities for the sensor types as defined in adaptation.

At the current stage of development of ADS-B systems, radar is generally accepted as the best surveillance data, followed by ADS-B and then by ADS-C. Flight plan tracks have the lowest quality.

3.2.3.2 **Surveillance Data Output**

SSS 145 - The system shall have the capability to forward surveillance track and flight plan information associated to the Adjacent ATCAS, using an ASTERIX interface categories 62, 63, and following a geographical filter previously defined in adaptation.

3.2.3.3 **Surveillance Data Processing Capabilities**

SSS 146 - The SDPS shall support the updating of system tracks with a Surveillance Tracking (ST) method which uses data from multiple sensors when overlapping surveillance coverage exists. The ST capability includes a track filtering algorithm capable of processing data from different surveillances. The data will be received at irregular times and each surveillance data will have unique position error variances.

SSS 147 - The SDPS shall maintain a system track and shall have the capability to display smooth system tracks which are updated based on surveillance data from multiple sensors.

3.2.3.4 **Surveillance Presentation**

SSS 148 - The SDPS will have the capability to present surveillance data in two modes:

- System Track Presentation Mode: A surveillance mosaic (the system mosaic) based on an integration of all surveillance sensors.
- Local Track Presentation Mode: Any single sensor connected to the SDPS.

SSS 149 - Each Surveillance Controller workstation shall individually be able to select a presentation mode, with a clear indication of the mode of presentation selected.

SSS 150 - When switching from one track presentation mode to another, there shall be no noticeable disruption in the presentation of data, except that some targets may not be detected anymore and others will be repositioned.

SSS 151 - When Local Track Presentation Mode has been selected, data processed at system track level shall be maintained for display and cinematic surveillance data presented shall be derived from the designated single sensor.

3.2.3.5 **Surveillance Data Processing Functions**

SSS 152 - The system shall provide the following functions:

- SSR reflection suppression;
- Processing and displaying of aircraft ground speeds, headings, predicted positions, SSR Mode C data, ADS Data;
- Display of position symbols (radar and ADS symbols) and specified track and label data;
- Processing and displaying of SPI and special codes;
- Provision for filtering;
- Display of coasting tracks;
- Surveillance data recording.

3.2.3.6 **Direct Surveillance Access (DSA) Back-up Mode**

SSS 153 - The DSA server shall provide surveillance sensor data onto the DSA LAN for selection by controller surveillance workstations in the DSA Back-up mode.

SSS 154 - The Direct Surveillance Access server shall process all surveillance data formats specified for the SDP.

SSS 155 - The controller specified DSA surveillance information shall be available upon selection of the DSA Back-up mode.

SSS 156 - Each surveillance workstation shall receive and process data from the Direct Surveillance Access server.

SSS 157 - The back-up mode shall provide map selection, range selection, off-centering, and manual code/callsign association, as well as display management functions in each surveillance workstation.

3.2.3.7 **Real-Time Quality Control (RTQC) of Surveillance Data**

3.2.3.7.1 **Automatic Test Target Monitoring**

In accordance with ICAO recommendations, fixed SSR Test Transponders will be installed within the surveillance coverage for each of the SSR sources integrated to the system.

SSS 158 - Test Targets shall be available for presentation in any surveillance position.

SSS 159 - The system shall have the capability to monitor the geographical position of the Test Transponders. If a Test Transponders position falls out of tolerance (adaptation), the SDPS shall notify and log at the Technical and Operational Supervisor Position.

3.2.3.7.2 **Status Message Monitoring**

SSS 160 - The system shall monitor the status messages to detect a change in the status of the surveillance sensor link or an increase in the error rate status message to declare a surveillance link down or up.

3.2.3.7.3 **Surveillance Data Counts Monitoring**

SSS 161 - The system shall maintain a count of the various types of surveillance messages in the system, including SSR and PSR messages. All anomalies in these controls shall be reported to the Technical and Operational Supervisor.

3.2.3.7.4 **Registration Analysis**

SSS 162 - The system shall provide the RTQC capability for ground based radars to perform range deviation and azimuth deviation computations on targets of opportunity. The capability will be continuously active and will monitor target reports received from surveillance pairs identified in adaptation.

SSS 163 - The system shall have the capability to calculate range and azimuth bias errors, and if these errors exceed adapted tolerance standards, an alert message shall be reported to the Technical and Operational Supervisor.

SSS 164 - The system shall have the capability to print a report of the most recent registration analysis on request.

3.2.3.7.5 **Registration Correction**

SSS 165 - The system shall provide the capability to manually update the surveillance registration corrections.

3.2.3.7.6 **SSR Reflections**

SSS 166 - The system shall have the capability to suppress SSR reflections, using the following conditions:

- The plot/track report has an SSR code that is one of the adapted discrete codes;
- The range and azimuth of the report lie within one of the reporting surveillance's adaptable reflection areas;
- Another report from the same radar that has the same code (duplicate) from the same surveillance scan, and its range is less than the range of the current plot/track report minus a design parameter range delta.

3.2.3.7.7 **Altitude Processing**

SSS 167 - The system shall have the capability to process QNH values for a minimum of TBD airports for the calculation of Transition Levels and conversion of Mode C derived data.

SSS 168 - The system shall have the capability to convert Mode C derived flight levels into altitudes for all aircraft in a QNH area below the relevant Transition Level.

SSS 169 - The system shall have the capability to process area QNH values for a minimum of TBD areas for the calculation of minimum usable flight levels on airways and other ATS routes.

3.2.4 **Flight Plan Data Processing**

3.2.4.1 Flight Data Processing Functions

SSS 170 - The system shall have the capability to receive, store, process, update, and display, repetitive flight plans (RPL), flight plans, and other ATS messages.

SSS 171 - The system shall have the capability to receive ATS messages from several sources, including AFTN/AMHS and adjacent centers.

3.2.4.2 **Flight Data Processing Capabilities**

SSS 172 - The system shall include the following capabilities:

- Flight plan routes analysis and flight trajectory and times calculation;
- Flight plan status determination based on inputs and timed events;
- Displaying and/or printing of flight plan data to relevant sectors;
- Automatic and manual Secondary Surveillance (SSR) code allocation;
- MET data processing;
- Flight plan / track association;
- Intersector and interunit coordination;
- Automated updating of flight plans based on Estimated Time Over (ETO) through correlation of flight plan data and surveillance data;
- AFTN Message processing.

SSS 173 - The system shall make available fully automatic processing of the standard ICAO flight plan messages, including the coordination message as foreseen in the OLDI (used only to exchange data with pre-existent ACC/APP that use this interface) and AIDC specification.

SSS 174 - The system shall support the current and new flight plan format, as in the Amendment 1 to the Procedures for Air Navigation Services — Air Traffic Management, Fifteenth Edition (PANS-ATM, Doc 4444) for applicability on 15 November 2012.

SSS 175 - The system shall generate and maintain a system flight plan which will be kept until it is terminated.

SSS 176 - The system shall ensure that equipment or communication unavailability in a sector will not cause any disturbances to the data interchange between other sectors/ centers.

SSS 177 - The system shall process VFR flights in the same manner as IFR flights unless otherwise specified.

3.2.4.3 **Flight Data Database**

SSS 178 - The system shall have the capability to establish and maintain a database of flight plans and to activate these flight plans for further processing, permitting modification, addition, and deletion of previously entered flight plans.

3.2.4.3.1 Repetitive Flight Plan (RPL) Data

SSS 179 - The system shall have the capability to receive RPL data via media, download or manually entered and store them in the RPL file.

SSS 180 - The system shall have a capability to transfer a RPL automatically to a flight plan database at a stipulated (adaptable) time prior to the time of entry into the area of responsibility.

SSS 181 - The FDPS shall provide the operator with the capability to create, modify and delete flight plans from the RPL file.

3.2.4.3.2 AFTN/AMHS Flight Plan Data

SSS 182 - The system shall have the capability to receive and process the following ATS messages received from AFTN/AMHS: FPL, DEP, ARR, RQP, ALR, RCF, RQS, AFP, SPL, CPL, DLA, CNL, EST, CHG, CDN, LAM, ACP and AIREP as foreseen in the ICAO 4444 Document and include other coordination messages.

SSS 183 - The system shall have a capability to enable or disable via a VSP the automatic processing of ATS messages for each message type. When it is enabled, ATS messages shall be processed for display to specific Flight Plan positions in the following conditions:

1. Whenever the message contains an error, discrepancy or other invalid data.
2. Whenever the flight plan contains data in field 18, except when the data are prefixed by "REG/", "SEL/", "OPR/", "ALTN/" or "EET/".

SSS 184 - In the cases where a message is not identified, or contains data that are not valid, or cannot be paired with previously stored data, an "invalid" response as well as the message itself shall be displayed to the specific flight plan positions. The message shall in such cases be displayed in the format in which it was received and with an indication of the "invalid" data.

SSS 185 - The system shall have the capability to check all ATS messages for:

- Format errors;
- Syntax errors;
- Previous receipt of the same message;
- Validity, with respect to whether the flight plan or flight update message will affect the area of responsibility;
- Compatibility, with respect to conformance between aircraft type, True Airspeed (TAS), flight level/altitude, EET, departure aerodrome, route within the defined route system, and destination;
- Validity time;
- Channel sequence number.

3.2.4.3.3 Operator Flight Data Input

SSS 186 - The system shall have the capability to display at the Surveillance Display and Flight Data display and input the following types of flight plan messages:

- FPL and CPL;
- Flight updates messages;
- Departure state transition messages;
- Fix estimate updates;
- Cleared level updates.

3.2.4.3.4 **MET Data**

SSS 187 - The wind direction and speed, referenced as MET Data shall be able to be received through the AFTN/AMHS interface, as defined in the SICD.

SSS 188 - The MET data shall be processed for multiple height layers and areas for use in trajectory and times calculation, employing the data valid for the route (area).

SSS 189 - The Flight Data Display shall have the capability to display and change the MET data.

3.2.4.3.5 **Input Message Processing**

SSS 190 - The FDPS data base shall have the capability to identify, classify, and process the message types received, as well as identify the originator (source) of the message.

SSS 191 - Received CNL-messages with respect to pre-active and active flight plans shall be processed for display to the sectors concerned.

SSS 192 - Flight update messages shall automatically change the parent flight, causing, if necessary, the re-processing of the flight plan.

SSS 193 - The system shall have a capability to do the following actions, as required, when a flight update message is received:

1. New calculation of flight trajectory/flight times;
2. New analysis of flight plan route;
3. New analysis of flight strip distribution plan;
4. New distribution of flight data for display update.

3.2.4.4 **Flight Progress Processing**

SSS 194 - The system shall have a capability to determine the status for each flight plan, reflecting the current state of the flight.

SSS 195 - During a flight plan lifetime, the system shall have a capability to attribute a flight plan the following states and its transitions:

- Inactive - when a new flight plan is created;
- Pre-active – VSP time before the effective realization of the flight;
- Active - corresponds to the effective realization of the flight;
- Terminated - corresponds to the period when the flight plan is ended by operator action or automatically, staying in the system only for consulting features.

3.2.4.5 **Route Processing**

SSS 196 - The system shall have the capability to produce and maintain a continuous flight profile/trajectory for every valid flight plan received.

SSS 197 - The system route system shall include:

- The defined airspace, airways, and ATS route structure;
- Navigational aids/significant positions and Aerodromes;
- Sector boundaries;

- SID/STAR procedures.

SSS 198 - The route processing function shall accept input data based on:

- Route as indicated in the flight plan or, if applicable, as subsequently indicated by an update message;
- Entry of significant positions defining the route by significant points/positions, latitude/longitude positions.

SSS 199 - The system shall have a capability to do a Route analysis/conversion automatically.

SSS 200 - Trajectory estimation shall be based on route, flight planned level/altitude, available wind data, and aircraft performance characteristics.

SSS 201 - The route processing function shall determine significant positions and calculate ETOs for those positions.

SSS 202 - The system shall have the capability to integrate an AMAN (Arrival Management) and/or a DMAN (Departure Management) and/or SMAN (Surface Manager) tools for Tactical Local Planning.

3.2.4.6 **Secondary Surveillance (SSR) Code Allocation**

SSS 203 - The system shall have the capability to process both manual and automatic SSR code allocation.

SSS 204 - The system shall have the capability to maintain lists of codes to be used for automatic code allocation.

SSS 205 - The system shall have the capability to maintain lists of codes to be retained for flights from another ATC Center.

SSS 206 - The system shall have the capability to automatically allocate non-duplicated codes to flight plans for flights generated within the FIR and equipped with a 4096 SSR code transponder.

SSS 207 - The system shall have the capability to assign non-duplicated adapted discrete codes and adapted non-discrete codes to designated flights as specified by controller input action.

SSS 208 - The system shall have the capability to release previously assigned codes for re-allocation.

3.2.4.7 **Flight Plan/Track Association Function**

SSS 209 - The system shall have the capability to automatically associate flight plans with the appropriate surveillance system tracks.

SSS 210 - The system shall have a capability to allow the operator to initiate an association.

SSS 211 - The system shall have the capability to terminate the association (also called disassociation) between a track and a flight plan either automatically or manually.

SSS 212 - The system shall have the capability to do an automatic association only with discrete SSR codes.

SSS 213 - The system shall have the capability to allow the operator to do a manual association with discrete and nondiscrete SSR codes and tracks without an SSR code (primary tracks).

SSS 214 - The system shall allow the manual association only if the track and flight have the same CALLSIGN.

SSS 215 - The system shall have the capability to monitor periodically each controlled flight for conformance with its planned route, using the associated surveillance system track's position to compute the ETO for each fix in the route, and to determine when each fix has been passed.

3.2.4.8 **Sectorization**

The airspace of interest is described geographically in the adaptation data in terms of nonoverlapping volumes of airspace known as geographic sectors.

These volumes are polygons in the horizontal plane and have an up to TBD different levels dividing the airspace that can be controlled by a controller. This unit of airspace is usually called a controlled sector.

SSS 216 - The system shall have the capability to declare up to TBD different levels to define the control sectors.

3.2.4.8.1 **Sector Reconfiguration Function**

SSS 217 - The system shall have the capability to change the definition of control positions and the assignment of control sectors to positions through the consolidation input.

SSS 218 - The system shall check if the new position has the capacity for all the flights affected by the requested consolidation and to automatically change the ownership to this new position.

3.2.4.9 **ATFM Functions**

SSS 219 - The system shall have the capability to analyze the air traffic with anticipation for Air Traffic Flow Management purposes.

SSS 220 - The system shall have the capability to display a graphic of flight plans associated to a predicted period of time , using a filter for a specific:

- Airport: classified by flights in ETA or ETD;
- Coordination point: classified for ETO;
- Sector: classified for time of arrival in the sector;

3.2.4.10 **FDPS Output**

SSS 221 - The system shall have the capability to provide all controller workstations with an up-to-date presentation of the state of all individual flights assigned to, or otherwise of significance to (i.e., to be assigned to) each workstation.

SSS 222 - The system shall have the capability to transmit flight update messages to all ATC workstations and adjacent ATC centers.

3.2.4.10.1 Output of Messages to AFTN/AMHS Network

SSS 223 - The system shall have the capability to support a protocol for communication with interactive ACCs, where adapted, and the transmission of the FPL, DEP, ARR, RQP, ALR, RCF, RQS, AFP, SPL, CPL, DLA, CNL, EST, CHG, CDN, LAM, ACP and AIREP messages.

3.2.4.10.2 Flight plan Handoff

SSS 224 - The system shall have the capability to determine automatically when a surveillance track associated with a flight plan is about to cross sector or FIR boundaries, in order to transfer the flight plan from one controller to another or from one controller to another ATC system sector.

SSS 225 - The system shall have the capability to allow the controller do a handoff between the involved sectors or Adjacent ATCAS involving the main phases:

- handoff warning: it is generated at a time (adaptable) before the ETO of the coordination point to the current owner of the flight to indicate that the handoff to the next sector is due;
- handoff initiation: the owning controller requests the hand-off function to validate and initiate the control transfer to the next sector on the flight's planned route;
- handoff acceptance: the receiving controller can accept and conclude the control transfer processing.

SSS 226 - The system shall have the capability to output flight plan data to the Adjacent ATCAS as specified in the SICD.

SSS 227 - The system shall have the capability to exchange coordination messages, with the following protocols:

- Messages ICAO 4444 standard, using the AFTN/AMHS;
- Messages AIDC as specified in the Asia-Pacific ICD, using the AFTN/AMHS;
- Messages OLDI as specified by EUROCONTROL, using dedicated links.

SSS 228 - For AIDC protocol, the system shall have the capability to exchange the minimum set of messages (ABI, CPL, EST, PAC, ACP, MAC, LAM, LRM, TOC, AOC) for the Notification, Coordination and Handoff phases defined in the referenced AIDC ICD.

SSS 229 - For OLDI protocol, the system shall have the capability to exchange the minimum set of messages (ABI, ACT, REV, PAC, MAC e LAM) for the Basic Procedure, Dialogue Procedure – Coordination Phase and Dialogue Procedure – Transfers Phase as defined in the referenced OLDI ICD.

SSS 230 - The actual protocol used to Exchange flight plan messages with adjacent ATCAS shall be defined in adaptation data.

3.2.4.10.3 ATFM unity

SSS 231 - The system shall have a capability to send coordination information, slot information, predicted and current traffic load and flight plan updates to an ATFM unity.

SSS 232 - The system shall have the capability to send to the ATFM unity the go/no-go status on the major ATCAS subsystems and sensors.

3.2.5 Alerts

SSS 233 - The system shall provide a window dedicated to display all the conflicts detected during the flight plan life.

SSS 234 - The system shall display all the alerts detected during the flight plan route visualization.

SSS 235 - The system shall display all the flights involved in a conflict.

3.2.5.1 Special Codes and Emergency Messages

SSS 236 - The system shall display codes reserved for special purposes, such as A7500, A7600, A7700, using also a time-limited (VSP) audio signal, of individual activation's of special codes.

SSS 237 - The system shall have a capability to display ADS or CPDLC emergency message received from an ADS/CPDLC equipped aircraft.

SSS 238 - The system shall have the capability to display the last detected position of a special code squawk and the associated track history as well, till the controller acknowledges the alert at the supervisor position. The capability to print all the data associated shall be provided.

3.2.5.2 Short Term Conflict Alert (STCA)

SSS 239 - The system shall have the capability to generate a Short Term Conflict Alert (STCA) with respect to tracks, taking into account the CFL and considering the PBN status information. If the system determines that a violation of vertical separation minima (adaptable) and horizontal separation minima (adaptable) is calculated within a pre-determined (adaptable) time period.

SSS 240 - The system shall have the capability to define adapted areas where the STCA feature will be applicable.

SSS 241 - The system shall have the capability to process tracks in respect to heading, speed, altitude/flight level, vertical speed, when available for a pre-determined (adaptable) time ahead.

SSS 242 - The alert STCA generated shall include a visual and aural (time-limited) indication to the workstation(s) that are responsible for the tracks concerned, which will be extinguishable upon acknowledgment by the controller.

3.2.5.3 Minimum Safe Altitude Warning (MSAW)

SSS 243 - The system shall have the capability to generate MSAW with respect to tracks providing SSR Mode C information. A minimum safe altitude warning will be generated when SSR Mode C information indicates that an aircraft:

- In level flight is inside or within (adaptable) NM of an area where the minimum safe flight level is greater than the aircraft flight level.
- Has a rate of descent (adaptable time) indicating that a minimum safe altitude will be penetrated.
- Has a rate of climb (adaptable time) insufficient to obtain a minimum safe altitude.

SSS 244 - The system shall have the capability to define adapted areas where the MSAW feature will be applicable.

SSS 245 - The alert MSAW generated shall include a visual and aural (time-limited) indication to the workstation that has the track, which will be extinguishable upon acknowledgment by the controller.

3.2.5.4 **Medium Term Conflict Detection (MTCD)**

SSS 246 - The system shall have the capability to generate a MTCD when a new or modified flight plan create a conflict in any point of its route with other active flight plan, taking into consideration the PBN status, airspace RVSM and the APP airspace as well.

SSS 247 - The MTCD shall be generated only to the Controller and Assistant that has a sector jurisdiction over the flight plan. This alert will be displayed at the operational supervisor as well.

SSS 248 - When any events or changes in the route, level or estimated time occur the system shall have the capability to recalculate the conflict prediction automatically taking into consideration all others flight plans.

3.2.5.5 **Cleared Level Adherence Monitoring (CLAM)**

SSS 249 - The system shall have the capability to display at the track label an alert when an aircraft is deviating from its Cleared Flight level by a value greater than a threshold.

3.2.5.6 **Route Adherence Monitoring (RAM)**

SSS 250 - The system shall be able to monitor if a trajectory flight is in conformance with its flight route, and to alert when an aircraft is deviating from its planned route, considering the PBN status information.

3.2.5.7 **Area Infringement Warning (AIW)**

SSS 251 - The system shall be able to alert in situations when an aircraft is, or is predicted to be, crossing the border of a reserved area (restricted or dangerous) on-line predefined or off-line adapted.

3.2.5.8 **Conflict Probe**

SSS 252 - The system shall have a tool (Conflict Probe) initiated by the controller for a particular aircraft, to determine whether a proposed flight plan will come into conflict with another during a specified period.

SSS 253 - The system shall compare the proposed trajectory with the current planned trajectories of other aircraft information and displays the position and time of calculated conflicts to the controller, considering the PBN status information.

3.2.5.9 **Approach Funnel Deviation Alert**

SSS 254 - The Approach Funnel Deviation Alert (sometimes also known as Approach Monitoring Aid) is the Safety Net function responsible to alert in situations when an aircraft deviates from the approach funnel, either laterally or vertically.

3.2.6 **Recording and Playback**

SSS 255 - The operational system shall include a data recording facility to record and replay data.

SSS 256 - The recording function shall be able to operate concurrently with the playback function.

3.2.6.1 **Recording**

SSS 257 - It shall be possible to record data continuously for 48 hours without operator intervention. The replacement of the non-volatile removable storage medium shall be limited to a maximum of once every 48 hours.

SSS 258 - It shall be possible to record all displayed targets, weather information, maps, lists, images, filter limits, display control settings, and all Surveillance Display operator actions performed shall be date/time stamped and recorded.

SSS 259 - The system shall record all operational actions and system messages at the Surveillance Display, Flight Data Display and Electronic Flight Display and the Technical/Operational Supervisor.

SSS 260 - The system shall have the capability to record online all the surveillance and flight plan data in a commercial database, in order to execute queries to generate reports.

SSS 261 - The system shall record each system flight plan record whenever its flight state or holding state changes or whenever an item changes as a result of operator input or an external message.

SSS 262 - The system shall record the data while still meeting its response time requirements.

SSS 263 - For archival purposes, recorded data shall also be copied to a non-volatile removable storage medium for permanent storage. The recording computer may use internal hard disks as temporary storage medium.

3.2.6.2 **Playback**

SSS 264 - The system shall have a capability to record data and playback to be used in the following activities:

- to create the air situation display at the surveillance display with all the flight plan events associated;
- to obtain a log of operator actions and system messages;
- to perform data analysis and statistics;

SSS 265 - The recorded information shall be capable of being played back at selected working positions without interrupting the operational system.

SSS 266 - It shall be possible to playback data archived on removable storage medium loaded.

SSS 267 - The system shall be capable of performing a high speed search of the recording medium in relation to time of day.

SSS 268 - It shall be possible to select a specific time to the nearest minute from which the data playback is to commence.

SSS 269 - The system shall be capable of replaying data that has been recorded up to 60 days prior in a slow, normal or fast mode.

SSS 270 - The system shall provide an interface to synchronize the playback with the Audio Recorder.

3.2.6.3 **Surveillance Display Playback**

SSS 271 - The system shall have the capability to change the playback mode to an interactive playback mode in which it is possible to change the Surveillance Display presentation.

SSS 272 - The system shall have the capability to display recorded data at any surveillance display working position configured for playback.

3.2.6.4 **Non-interactive Playback Mode**

SSS 273 - During non-interactive replay, the replayed data shall be presented in a manner that emulates the display presentation at the time of recording including the result of controller display input actions and all functions executed using all input devices.

3.2.6.5 **Interactive Playback Mode**

SSS 274 - In the interactive mode, the selected working position receives all of the recorded data and the user can change the display of this data as if in an operational environment, without interference with the operational system.

SSS 275 - A working position configured to operate in playback mode shall be able to enter interactive mode at any time during the playback.

3.2.6.6 **Flight Data Display Replay**

SSS 276 - The system shall have the capability to provide a log of all previously recorded controller and assistant actions to a printer.

3.2.7 **Architecture and Supervision**

3.2.7.1 **Functional Redundancy**

SSS 277 - Critical functions shall be dualized to provide redundancy ensuring continued full system operation in the event of single failures, such as:

- The Flight Plan Data Processing Servers;
- The Surveillance Data Processing Servers;
- The Data recording servers;
- The Control and Monitoring Servers and Displays;
- The Aeronautical and Meteorological Servers.

3.2.7.2 **System Requirements**

SSS 278 - The system shall have the capability to ensure that the failure of any single functional unit will not cause the total failure of the system.

SSS 279 - The system shall have the capability to distribute a time Reference to all positions in accordance with the mode of operation (on-line, playback or simulation).

SSS 280 - The system shall have the capability to automatically restore itself to normal operation after interruptions due to power failure.

SSS 281 - In case of power return after complete power outage, the ATCAS shall automatically restart and go into operation in the same configuration as before the outage.

SSS 282 - The system shall have the capability to provide the following functions.

- Monitor the status of all system elements;
- Perform manual and automatic system reconfigurations;
- Supply status information for display;

SSS 283 - All events shall be stored on disk and classified depending on its relevance.

SSS 284 - The system shall have the capability to filter and display all the events and system error reports recorded based on its type, relevance and time, as an interactive data base.

SSS 285 - The system shall have the capability to switch over its critical function servers with no loss of information.

SSS 286 - The system shall have the capability to restart any nodes and perform reconfiguration of all servers.

SSS 287 - The system shall have the capability to display and print out the actual operational configuration and status, including the monitored external sources.

SSS 288 - The system shall have the capability to use dual LAN (Local area network) and meet all functional and performance requirements with one of the dual LANs out of service.

SSS 289 - The system shall have the capability to supervise and display the status of the dual LANs and perform automatic reconfiguration to the standby LAN if necessary.

SSS 290 - The system shall have the capability to monitor continuously all the local and remote net nodes using the SNMP protocol.

SSS 291 - The system shall monitor, using the SNMP protocol the following hardware devices status:

- CPU load and temperature;
- RAM memory use;
- Disk partition use;
- Network traffic.

SSS 292 - The system shall monitor, using the SNMP protocol, the availability of UPS and generators used to supply Power to all equipments.

SSS 293 - The system shall have the capability to display the status of all equipments and network in a synoptic view of the system.

SSS 294 - The system shall have the capability to detect and display alerts and alarms at the Supervisor Positions, and all the critical and non critical errors generated by the system.

SSS 295 - The system shall have the capability to configure the acceptable limits, frequency and Time-out values for the events of the system monitored using the SNMP protocol.

SSS 296 - The system shall have the capability to operate each Supervisor position in the Technical, Operational and Read-only (only Display) defined by the login, including also others backup positions. Each mode shall have a specific authorization to execute determined commands in accordance with their role.

SSS 297 - The system shall have the capability to define a regional operational supervisor responsible for a subset of sectors, used for centers with a big number of sectors.

3.2.7.3 **Online Test**

SSS 298 - Online tests of the hardware as well as the software shall be provided to verify the operation of the computer systems.

SSS 299 - The online test functions shall periodically check the subsystem and display alerts for fault situations.

SSS 300 - The online test functions shall periodically verify the communication availability of all nodes in the local network and all the external interfaces.

3.2.7.4 **ATCAS System Control and Reconfiguration**

SSS 301 - The system shall have the capability to execute the following action from the Supervisor Position:

- System Startups;
- Disable/Enable of automatic equipment switchover;
- Reconfigurations;
- Variable System Parameter updates.

3.2.7.5 **ATCAS Sector Reconfiguration**

SSS 302 - The system shall have the capability to provide a graphical display of the ATCAS sector configuration.

SSS 303 - The system shall have the capability to use preset sector configurations defined in the adaptation data.

SSS 304 - Sector reconfigurations shall be performed at the Operational Supervisor.

SSS 305 - The Operational Supervisor shall have the capability to print a consolidation report.

SSS 306 - The system shall have the capability to display and print a current sector load and a predict sector load, based on a specific time ahead.

3.2.8 **Aeronautical and Meteorological Information**

SSS 307 - The system shall have a capability to receive aeronautical and meteorological information from the AFTN/AMHS:

- Meteorological information: MET data as defined in section 3.2.4.3.4 and METAR, according to ICAO Annex 3 and other meteorological messages, such as SIGMET, AIRMET, GAMET, SPECI and TAF, according to Annex 15;
- Aeronautical information: NOTAM, according to ICAO Annex 15.

SSS 308 - The MET data will be received every 6 hours from the AFTN/AMHS; in case of absence or a delay greater than 30 minutes (adaptable), the system shall have the capability to send a message to the Operational Supervisor and it shall use the latest data stored.

SSS 309 - The system shall have the capability to receive aeronautical and meteorological information for display via a Web Browser.

SSS 310 - The system shall have the capability to input and display QNH values.

SSS 311 - The system shall have the capability to check the MET data for format and syntax errors.

SSS 312 - The system shall have the capability to display and modify aeronautical information.

SSS 313 - The system shall have the capability to display and modify the MET data.

SSS 314 - The system shall have the capability to identify and classify MET data messages with respect to type of data and area of validity.

SSS 315 - The system shall have the capability to compose and display a web browser window with general purpose information to be used internally by the controllers.

SSS 316 - The system shall have the capability to compose free text input (no pre-defined format, up to 1800 characters) to be routed to AFTN/AMHS addresses.

3.2.9 **Management, Operational and Technical Information Report Tool**

SSS 317 - The system shall have the capability to produce monthly statistics of end-to-end system datalink performance in daily operations. The system shall have appropriate tools for monitoring and analyzing the performance data for reporting.

SSS 318 - The system shall have the capability to generate reports, using predefined queries or ones defined by the operator, such as: total number of flight plans in a sector during a specific period of time, with filters defined by the user (aircraft type, level, airway, VFR or IFR rules, ATCAS origin, and airport).

SSS 319 - The system shall have a capability to generate reports with a list of all strips updates during a specific flight plan lifetime.

SSS 320 - The system shall have a capability to generate reports with a list of working hours for each operator during a specific time and their respective totals consolidation, based in the logon/logoff records.

SSS 321 - The system shall have a capability to generate reports with a list of sectors allocation hours, taking into account all the sector consolidation/deconsolidation.

SSS 322 - The system shall have a capability to generate reports with a list of all alerts distributed per type, criticality, sector and time.

SSS 323 - The system shall have a capability to execute scheduled (E.g.: annually, monthly, daily, hourly) pre-defined reports.

SSS 324 - The system shall have a capability to provide commercial tools to create user-defined reports.

SSS 325 - The system shall have the capability to define different Access levels for data and reports.

SSS 326 - The system shall have a capability to generate graphical and textual reports and print.

3.3 **System External Interface Requirements**

The network shall conform to the protocol suite defined as part of the ATN concept. For messages from controller to pilot, the ground ATN routers must choose the most suitable data link device available and route the messages to that transmitting station.

It is intended that the ADS and CPDLC functions shall eventually be carried by the ATN. The purpose of the ATN is to “provide data communication services and application entities in support of the delivery of air traffic services (ATS) to aircraft; the exchange of ATS information between ATS units; and other applications such as aeronautical operational control (AOC) and aeronautical administrative communication (AAC).” [Annex 10, Vol III, 3.3].

It is important, therefore, that any new system should either include provisions for, or have a defined upgrade path to provide, interfacing with the ATN. ICAO Doc 9705 - Manual of Technical Provisions for the Aeronautical Telecommunication Network (ATN) is the appropriate source of interface data for the ATN.

At present, the ATN is under development and trials are being carried out in several ICAO Regions.

3.3.1 **Datalink and Surveillance sensors interfaces**

3.3.1.1 **Datalink Service Provider**

In the current FANS 1/A environment, ADS and CPDLC messages are passed between aircraft and the System using the ACARS data messaging system. ACARS was developed by the DSPs to pass information between the airline operating centre (AOC) and the aircraft. ADS and CPDLC required an air-ground datalink and, in the absence of the Aeronautical Telecommunication Network (ATN), the ACARS system was used.

It is essential therefore to specify the appropriate interface port(s) to connect to the chosen DSP. This is typically an RS232 serial port, but the exact requirement needs to be confirmed with the DSP.

3.3.1.2 **Radar Data**

Data imported from a separate radar system will take the form of track data or possibly plot data, using a standardized interface ASTERIX.

3.3.1.3 **Multilateration (MLAT)**

MLAT is an enabling technology that will enhance the provision of ATM in a variety of applications, from “radar-like” air traffic control purposes to enhanced situational awareness of surface movements. MLAT offers most advantages in situations where other surveillance systems (e.g. radar) are not available. It can also be combined with other surveillance systems, such as radar and ADS-B, to improve the total surveillance picture.

MLAT is dependent on the aircraft having at least a Mode A/C transponder. It can receive identity through correlation of a code with the flight plan, or the flight identification transmitted by ADS-B or Mode S transponder.

3.3.2 **AFTN/AMHS**

The AFTN is currently the carrier for ground-ground messaging between ATC units and carries AIDC messages in the FANS 1/A environment. The AMHS (Aeronautical Message Handling System) is the ground-ground messaging application of the ATN.

Any new system AMHS shall include at least one AFTN gateway. AIDC messages generated in AMHS structure can then be transmitted via the AFTN and incoming messages from the AFTN shall be transposed to AMHS structure.

After the ATN becomes operational and the AFTN is no longer used, the gateway can be removed.

The AMHS specification, as defined in ICAO Document 9705 Edition 3 and ICAO Doc 9880, includes only two levels of service which correspond to a different level of functionality for the AMHS. They are the Basic ATS Message Handling Service and the Extended ATS Message Handling Service.

SSS 327 - The system shall accept and transmit ICAO flight plan data messages via the AMHS or AFTN, as defined in ICAO documents Doc 4444 15^a Ed and 9705.

3.3.3 **Adjacent ATCAS interface**

Direct Connection between ATCAS Systems – It is necessary when a full system must be connected directly to an existing system for flight plan coordination and surveillance data sharing.

3.3.3.1 **Flight Plan Coordination**

SSS 328 - The Flight plan data shall be exchanged with adjacent ATC centers (Others ACC). The system shall provide the capability to exchange flight plan data with these ATC centers, using OLDI or AIDC messages.

The OLDI application, which is implemented in the EUR Region, consists of the exchange of messages (a subset of AIDC messages), using a dedicated OLDI protocol operating directly over X.25. This is going to evolve in the short- to mid-term towards FMTP (Flight Message Transfer Protocol), which is a specific protocol operating over TCP/IP.

SSS 329 - For flight plan coordination, the interface shall be AIDC over AMHS/AFTN or the future ATN, but for compatibility with pre-existent legacy systems OLDI may be implemented over X-25 with direct links or over TCP/IP (using a X.25 to TCP/IP converter).

AIDC messages will be passed via the AFTN until the ATN is operational. However, AFTN/AMHS gateways shall increasingly be used to provide a transition between the AFTN and ATN. These gateways transpose AFTN messages into AMHS format and vice versa.

This consists in the exchange of AIDC messages over AFTN, using the "Optional Data Field" included in the header of AFTN messages. This application is governed by the document named "Asia/Pacific Regional Interface Control Document (ICD) for ATS Interfacility Data Communications (AIDC)".

3.3.3.2 **Surveillance Data Sharing**

SSS 330 - The system shall provide an interface to exchange track data with adjacent ATC centers. This can be implemented by sharing the radar sensor using ASTERIX or exchanging system surveillance data between surveillance servers using ASTERIX format cat 62, 63.

3.3.4 **Defense systems interfaces**

This interface will be used to surveillance data sharing, since there will be sensors used in Air Defense Systems that can be useful for Air traffic Control.

This also can be implemented by sharing the radar sensor using ASTERIX or exchanging system surveillance data between surveillance servers using ASTERIX format cat 62, 63.

3.3.5 **Operator interface**

3.3.5.1 **Human Factors**

Human factors play a major part in the success or failure of a system to meet its operational objectives. A system that is uncomfortable to use will lead to controller dissatisfaction. As controllers are an essential part of the overall system, it can only degrade the overall system performance.

Displays and keyboards that are poorly designed from a human factors aspect will be inefficient and may cause actual harm to the users. Bad display design can affect the eyes and bad keyboard design may result in occupational overuse syndrome (repetitive strain injury). The human factors implications of the system specification should be considered very carefully.

3.3.5.2 **Displays**

One or more displays are required to handle the Surveillance, Flight plan interface with ADS, CPDLC and AIDC messages. Many systems incorporate message handling in the situation display.

Modern displays use LCD technology and may be as large as 600 x 600mm, with typical resolution of 2048 x 2048 pixels. Smaller displays may be more appropriate for some uses, particularly if there are 2 displays at a controller position: a second display is often used for flight data handling. However, the arrangement of displays will largely depend on the extent to which the new system is to be integrated with existing systems.

While color displays offer great advantages in differentiating between different categories of data, the choice of colors for the various categories can be very contentious. It is essential that color allocation is not arbitrarily decided, but is based upon sound human factors principles. Inappropriate color choices can contribute to fatigue, confusion and errors.

Different symbols will be used for radar tracks, ADS-B tracks, ADS-C tracks and tracks generated from flight plan information. The track symbol shall be that of the source of the highest quality information. At the current stage of development of ADS-B systems, radar is generally accepted as the best surveillance data, followed by ADS-B and then by ADS-C. Flight plan tracks are the lowest quality.

The status of the CPDLC connection is an important information for the controller and is best displayed in the track label.

3.3.5.3 **Message Handling**

Message handling for ADS, CPDLC and AIDC messages is usually achieved by some form of menu access for generating messages and by pop-up windows for replying to incoming messages. Most systems now offer access via the track label.

For CPDLC, there are two elements to generating most messages: selection of the specific message and entry of necessary data. The message selection shall be simple: there are about 180 uplink messages available. Some systems present a selection of appropriate messages – for example, by offering only height-related messages if the height field in the track label is selected. ADS contract messages are more simple and infrequently required, so that a simple menu-type operation is normally adequate. AIDC messages can usually be generated automatically to form flight plan data.

3.3.5.4 **Input Devices**

The controller input devices include the text input device and the pointing device.

The text input device is normally a keyboard and there are various types of keyboard (standard, ergonomic, etc).

3.3.6 **Time Reference System and Audio Recorder interface**

The system contains a Time Reference System which will establish a common time source for all subsystems. In addition, outputs will exist to synchronize external systems with the common time source, such as the Audio Recorder for Playback activities.

The Time Reference System will be used to keep time synchronization in the Operational and Simulator Partition.

The TRS will be synchronized to GPS signals received by the antenna, and it will be distributed to all net nodes by ntp protocol.

SSS 331 - The system shall have the capability to synchronize all subsystems to a common time source with a maximum deviation of 100 milliseconds.

SSS 332 - Time reference outputs shall be provided to synchronize other clocks with the common time source, typically Audio Recorder Systems.

3.3.7 **ATFM Unity Interface**

SSS 333 - The system shall provide an interface with a central ATFM for flight plan information and coordination.

SSS 334 - An air traffic flow management (ATFM) service shall be implemented for airspace where traffic demand at times exceeds the defined ATC capacity.

ATFM will be implemented on the basis of a national/regional air navigation agreement or, when appropriate, as a multilateral agreement.

The ATFM service within a region or other defined area, will be developed and implemented as a centralized ATFM organization, supported by flow management positions established at each area control centre (ACC) within the region or area of applicability.

SSS 335 - The responsible ATFM unit shall receive the traffic demand continuously from the responsible ATC unit, allowing the ATFM unit to monitor if this demand exceeds, or is foreseen to exceed, the capacity of a particular sector or aerodrome in order to coordinate ATFM measures.

3.3.8 **AIS and MET**

This interface is used for Web interfaces (HTTP) to access AIS and MET data using a Web Browser with a LAN connection. It represents a new tendency to access data information using the future ATN.

3.4 **System Internal Interface Requirements**

The system usually will use a LAN 100/1000 Mbps as specified in the IEEE 802.3x with protocol TCP/IP.

3.5 **System internal data Requirements**

Not applicable.

3.6 **Adaptation requirements**

3.6.1.1 Database Management

SSS 336 - It shall be possible at the Database Management position, to print-out for visual presentation maps entered into the system via the DMS, including graphic presentation.

SSS 337 - The system shall have a capability to edit a database with the following data sets:

- Airways;
- Airports and Runways;
- Restricted areas;
- NAVAIDS;
- SID/STAR Procedures;
- AFTN/AMHS Directions;
- Sectors;
- Adjacent ATCAS;
- Coordination points;
- Adaptable System Parameter;
- Default values for Variable System Parameter;
- FIR/UIR borders;
- Terminal control areas;
- Control zones;
- Traffic information zones;
- Airways and ATS routes;
- Radars sensors information and protocol;
- Configuration files;
- Time Parameters;
- Alerts Parameters;
- Flight Plan parameters;
- Coordination Protocols;
- Aircraft Types and performance;
- Significant points;
- ATS routes;

- TMA Areas;
- PBN data;
- Alerts data;
- Adaptable System Parameters;
- Variable System Parameters;
- Etc.

SSS 338 - The system shall verify the data validation and consistency before the generation of a set of adaptation data.

SSS 339 - The system shall have a capability to download a new set of adaptation data to all positions or a group of positions without interfering with the operation.

3.7 **Safety requirements**

Safety assessments are described in detail in ICAO Doc 9859, Safety Management Manual.

Safety nets are described in the item 3.2.5.

3.8 **Security and Privacy Requirements**

SSS 340 - The system shall have the capability to control users and password and display the list of users logged at the operational supervisor and record all the actions with the responsible user information based in the logon/logoff control.

3.9 **System environment requirements**

SSS 341 - The acoustic noise level shall be no greater than 50 dBA at 1 meter for servers and peripherals normally located in an equipment room.

SSS 342 - The acoustic noise level shall be no greater than 50 dBA from the front surface of fully enclosed consoles normally located at the ATC operations room.

3.10 **Computer Resource Requirements**

SSS 343 - The maximum load admitted in any condition for any processor shall be 50% of maximum capacity.

SSS 344 - The maximum memory occupation admitted in any condition shall be 50 % of the maximum available memory.

3.11 **System Quality Factors**

3.11.1 **System Reliability**

Reliability predictions will be made for all equipment through observation or calculated using a specific standard. The system reliability will be maximized through use of redundant equipment configurations where a single failure would impact system operation. All single point failures will be identified.

3.11.2 **System Maintainability**

The system design will employ system fault detection and fault isolation.

SSS 345 - The system shall have the capability to detect 90% of all system failures.

SSS 346 - The system shall provide the mean time to repair to be less than 30 minutes.

3.11.3 **System Availability**

The system will provide operational availability through use of redundant/fault tolerant system architecture, system fault coverage and fault detection, and preventative and corrective maintenance.

SSS 347 - The system availability of the ATCAS shall exceed 99.999%.

3.12 **Design and Construction constraints**

SSS 348 - The system shall be built using open systems technology, using an operating system like UNIX or similar.

SSS 349 - The system shall make full use of help files and hints for button options to improve the usability.

3.13 **Personnel-related requirements**

Not applicable.

3.14 **Training-related requirements**

Training must involve:

- Controller Training;
- System Operator Training;
- Maintenance Training;
- Simulator Based Training.

3.15 **Logistics-related requirements**

SSS 350 - The system shall have the capability to restore the operating system software on the workstation using the network or the peripheral device required to transfer the operating system from standard distribution media.

3.16 **Other requirements**

3.16.1 **Time Requirements**

SSS 351 - The system shall have a capability to display a track at a maximum time of 500 milliseconds, since the track message reception (95 percentile).

SSS 352 - The system shall have a capability to display all remote status and all external alarms at the Supervisor Position within 3 seconds after the detection of the event.

SSS 353 - The system shall have a capability to execute a switch-over to the stand-by server with the following time requirements:

- Surveillance Server : maximum 2 sec

- Flight Plan Server: maximum 10 sec
- Data recording Server: maximum 2 sec

SSS 354 - The system shall have a capability to restart and become fully operational at up to ten minutes (cold start).

3.16.2 Capacity Requirements

The system shall meet the following operational capacities:

SSS 355 - Size of system plane : 2048 x 2048 NM

SSS 356 - Point of tangency (latitude/longitude): 1

SSS 357 - Surveillance data sources : TBD simultaneous

SSS 358 - Weather data sources : TBD primary surveillances

SSS 359 - Maximum single surveillance data rate : 64 Kbps

SSS 360 - Display update rate : continuous (based on inputs)

SSS 361 - Maximum surveillance reports per second from all surveillances : TBD

SSS 362 - Minimum system track display capability : TBD

SSS 363 - Adjacent ACC interfaces : TBD

SSS 364 - AMHS interfaces : TBD

SSS 365 - AFTN interface: TBD

SSS 366 - Stored flight plans (RPL's) : TBD

SSS 367 - Inactive Flight Plans (stored FPL's) : TBD

SSS 368 - Active flight plans (at any one time) : TBD

SSS 369 - Aircraft classes : TBD

SSS 370 - Wind/temperature layers (MET data) : 8

SSS 371 - Wind/temperature areas (MET data) : 10

SSS 372 - Maps (fully digital – labels and vectors) : TBD

SSS 373 - SID/STAR Procedure: TBD

SSS 374 - Hold Procedures: TBD

The datalink system capacity will be determined from:

- Traffic density at the peak hours.
- Frequency and size of messages per aircraft.

- Airspace size and number of waypoints.
- Number of FANS capable aircraft operating in the airspace.
- Anticipated growth of FANS operation.
- Number of displays.
- Number of connections for terminal systems.

3.17 **Packaging requirements**

Not applicable.

3.18 **Precedence and criticality of requirements**

Each requirement can be classified as a mandatory for Regional Harmonization or optional, for example:

REQUIREMENT PRECEDENCE TABLE

Requirement	Mandatory	Optional	Notes
011		X	
017	X		

4. **QUALIFICATION PROVISIONS**

Special attention must be given to Quality assurance, in all implementation phases such as: design review, manufacture, factory testing, documentation, training, delivery, installation, site acceptance testing and handover.

The main phases include:

_ IMPLEMENTATION SCHEDULE

_ CONTRACT SUPERVISION

_ SYSTEM DESIGN REVIEW

_ FACTORY ACCEPTANCE TEST

_ PREPARATION FOR OPERATION

- Operational Procedures
- System Management Procedures
- Preparation of System Data
- Establishment of System Parameters
- Development of Training Courses
- Operational Transfer Plan
- Safety Assessment

_ TRAINING

- Controller Training
- System Operator Training
- Maintenance Training
- Simulator Based Training

_ SITE ACCEPTANCE TEST

- Physical Checks
- Technical Tests
- Operational Tests
- Results

_ OPERATIONAL TRANSFER

- Parallel Operation Transfer
- Phased Transfer
- Preparation for Transfer

For further details look for *GUIDANCE MATERIAL OR THE ASIA/PACIFIC REGION FOR ADS/CPDLC/AIDC GROUND SYSTEMS PROCUREMENT AND IMPLEMENTATION*.

5. **REQUIREMENTS TRACEABILITY**

TBD.

6. **NOTES**6.1 **Abbreviations**

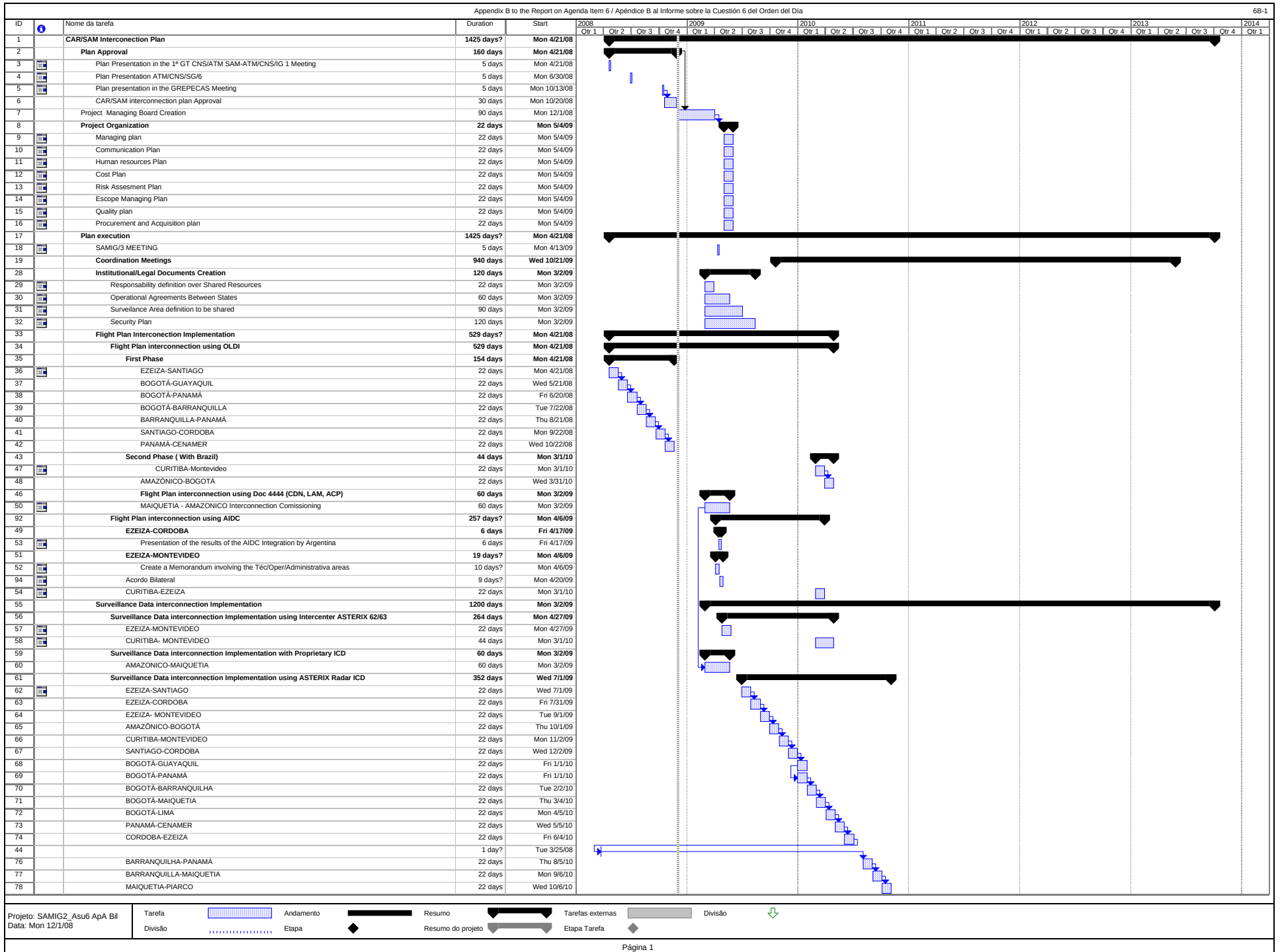
ACARS	<i>Aircraft Communication Addressing and Reporting System</i>
ACC	<i>Area Center Control</i>
ADS	<i>Automatic Dependent Surveillance</i>
ADS-B	<i>Automatic Dependent Surveillance - Broadcast</i>
ADS-C	<i>Automatic Dependent Surveillance Contract</i>
AFN	<i>ATS Facilities Notification</i>
AFTN	<i>Aeronautical Fixed Telecommunications Network</i>
AIDC	<i>ATS Interfacility Data Communication</i>
AIS	<i>Aeronautical Information Service</i>
AIW	<i>Area Infringement Warning</i>
AMAN	<i>Arrival Manager</i>
AMHS	<i>Aeronautical Message Handling System</i>
AOC	<i>Airline Operating Centre</i>
APP	<i>Approach Center</i>
ASTERIX	<i>All-purpose Structured EUROCONTROL Radar Information Exchange Protocol</i>
ATC	<i>Air Traffic Control</i>
ATCAS	<i>Air Traffic Control Automation System</i>
ATFM	<i>Air Traffic Flow Management</i>
ATM	<i>Air Traffic Management</i>
ATN	<i>Aeronautical Telecommunication Network</i>
ATS	<i>Air Traffic Services</i>
CDM	<i>Collaborative Decision Making</i>
CFL	<i>Cleared Flight Level</i>
CJI	<i>Controller Jurisdiction Indicator</i>
CLAM	<i>Cleared Level Adherence Monitoring</i>
CPDLC	<i>Controller-Pilot Data Link Communications</i>
CR	<i>Connection Request</i>
CRC	<i>Cyclic Redundancy Check</i>
DMAN	<i>Departure Manager</i>
DMS	<i>Data Management System</i>
DSA	<i>Direct Surveillance Access</i>
DSP	<i>Datalink Service Provider</i>
EET	<i>Estimated Elapsed Time</i>
EOBT	<i>Estimated Off Blocks Time</i>
ESD	<i>Electronic Strip Display</i>
ETA	<i>Estimated Time of Arrival</i>
ETD	<i>Estimated Time of Departure</i>
ETO	<i>Estimated Time Over</i>
FANS	<i>Future Air Navigation Systems</i>
FDPS	<i>Flight Data Processing Server</i>
FIR	<i>Flight Information Region</i>
FN_CAD	<i>AFN Contact Advisor</i>
FN_CON	<i>AFN CONTACT message</i>
FOM	<i>FANS 1/A Operations Manual</i>
FT	<i>Feet</i>
GPS	<i>Global Positioning System</i>
HTTP	<i>HyperText Transfer Protocol</i>
IAL	<i>Instrument Approach and Landing chart</i>
ICAO	<i>International Civil Aviation Organization</i>
ICD	<i>Interface Control Document</i>
IFR	<i>Instrument Flight Rules</i>

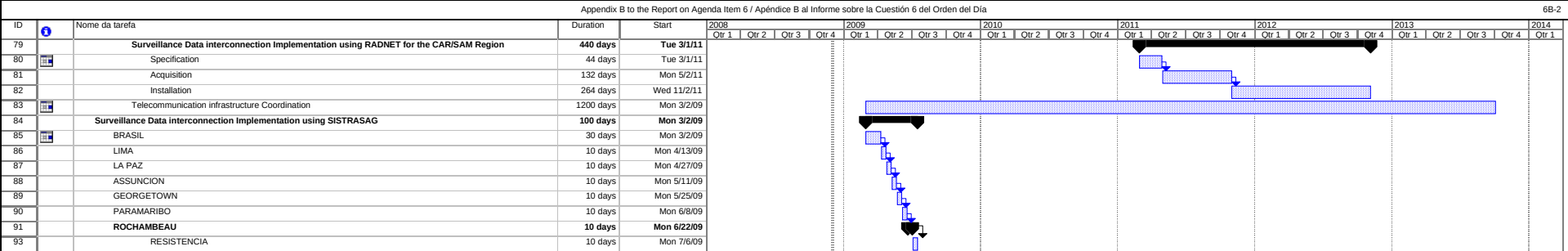
IMM	<i>Interactive Multiple Models</i>
LAM	<i>Logical Acknowledge Message</i>
LAN	<i>Local Area Network</i>
MAF	<i>Message Assurance Failure</i>
METAR	<i>Meteorological Report</i>
MET	<i>Meteorological</i>
MLAT	<i>Multilateration</i>
MRT	<i>Multi-Radar Tracking</i>
MSAW	<i>Minimum Safe Altitude Warning</i>
msec	<i>Milliseconds</i>
MSSR	<i>Monopulse Secondary Surveillance Radar</i>
MTCD	<i>Medium Term Conflict Detection</i>
NAVAIDS	<i>Navigational Aids</i>
NDA	<i>Next Data Authority</i>
NOTAM	<i>Notice to Airmen</i>
OLDI	<i>Online Data Interchange</i>
OST	<i>Off-line System Parameter</i>
PBN	<i>Performance Based Navigation</i>
PEL	<i>Planned Entry Level</i>
PSR	<i>Primary Surveillance Radar</i>
QNH	<i>Regional Pressure Setting</i>
RAM	<i>Route Adherence Monitoring</i>
RPL	<i>Repetitive Flight Plan</i>
RTQC	<i>Real-Time Quality Control</i>
RVSM	<i>Reduced Vertical Separation Minimum</i>
SID	<i>Standard Instrument of Departure</i>
SDP	<i>Surveillance Data Processing</i>
SDPS	<i>Surveillance Data Processing Server</i>
SICD	<i>System Interface Control Document</i>
SMAN	<i>Surface Manager</i>
SMC	<i>System Monitoring and Control</i>
SNMP	<i>Simple Network Management Protocol</i>
SPI	<i>Special Position Indicator</i>
SSR	<i>Secondary Surveillance Radar</i>
SSS	<i>System/Subsystem Specification</i>
ST	<i>Surveillance Tracking</i>
STAR	<i>Standard instrument Arrival</i>
STCA	<i>Short Term Conflict Alert</i>
TAF	<i>Terminal Aerodrome Forecast</i>
TBD	<i>To Be Defined</i>
TFL	<i>Transfer Flight Level</i>
TMA	<i>Traffic Management Area</i>
UIR	<i>Upper Information Region</i>
UTC	<i>Universal Time Coordinated</i>
VFR	<i>Visual Flight Rules</i>
VSP	<i>Variable System Parameter</i>

6.2

Glossary

- **Air traffic services interfacility data communication (AIDC):** A data link application that provides the capability to exchange data between air traffic service units during the notification, coordination and transfer of aircraft between flight information regions.
- **Automatic dependent surveillance (ADS-C):** A surveillance technique in which aircraft automatically provide, via a data link, data derived from on-board navigation and position-fixing systems, including aircraft identification, fourdimensional position, and additional data as appropriate. ADS-C is a data link application.
- **Automatic dependent surveillance-broadcast (ADS-B):** ADS-B is a surveillance application transmitting parameters, such as position, track and ground speed, via a broadcast mode data link, at specified intervals, for utilization by any air and/or ground users requiring it. ADS-B is a data link application.
- **Controller-pilot data link communications (CPDLC):** A data link application that provides a means of communication between controller and pilot, using data link for ATC communications.





Agenda Item 7: Impact in ACCs due to multiple reception of a same flight plan

7.1 The Meeting recalled that during AP/ATM/13 Meeting (Bogota, Colombia, July 2007), United States presented information received in the control centers related to ICAO m flight plans multiplicity/duplicity, and how this affects international flight management and causes concern when related to safety. Also, during ATM/CNSSG/6 Meeting, this subject was extensively analyzed. The Meeting recognized that some SAM States could be facing this problem, but also recalled that GREPECAS/15 (Rio de Janeiro, Brazil, 13 -17 October 2008) while analyzing this item, concluded that each one of the States affected, should solve the problem individually, taking in consideration specific requirements and according to their own necessities.

7.2 Likewise, the Meeting recalled that in the APATM/13 Meeting Report as well as in the ATM/CNS/SG/6 Meeting Report, some measures are shown, that if adopted, could help in reducing multiple reception of a same flight plan.

7.3 The Meeting particularly expressed the view that each State affected by this problem should immediately analyze -together with aircraft operators- the sources that generated flight plans duplicity/multiplicity entered to the system.

7.4 The Meeting considered that it would be of great help that the ICAO Regional Office develops an assessment with the purpose to identify those States that at present may be affected by this problem or that already have been affected in some way, and in that case, identify the measures adopted by the State referred, in order to confirm its application by other States of the Region.

Agenda Item 8: Other business**ATM SAM Regional Plan**

8.1 The Meeting took note of a proposal to incorporate in Project RLA/06/901 the task of developing an ATM SAM Region Plan in harmony with ICAO Global Plan initiatives, useful for States as a guidance for the development of new systems implementation plans. The Meeting considered that there were other short term priorities in which the Project's main activities should be focused in, but at the same time understood that this task should be maintained in the Region's agenda due to its importance.

Aeronautical information regulation and control chart

8.2 Regarding this subject, IATA/Jeppesen presented the meeting with an IP that highlighted the importance for users that states publish their aeronautical information in accordance with the established AIRAC dates. Also, the Meeting recalled that, to make necessary coordinations among States involved in the implementation/realignment/elimination of routes, three AIRAC periods have been used in order to establish the validity of any of the actions mentioned, and considered that this period of time should be maintained without changes.

1.6. The ICAO Manual on Performance-Based Navigation (Doc. 9613) establishes various different navigation specifications that can be applied globally. Given the air traffic characteristics for en-route operations in the South American Region, RNAV-5 is most appropriate for use there, inasmuch as the approval requirements will make it possible for most aircraft equipped with RNAV systems to meet those requirements. RNAV-5 use does not demand a navigation database, specify compliance with the ARINC 424 “leg types” nor require dual area navigation systems. RNAV-5 implementation aims to optimize the use of aircraft RNAV capacity as soon as possible, without requiring significant changes in airborne equipment for most aircraft.

2. **Purpose**

2.1. This AIC serves as a Note of Intent to implement RNAV-5 in the _____ FIR, on ____ November 2010.

3. **Area of application**

3.1. RNAV-5 will be implemented on all RNAV routes in the _____ FIR with the exception of routes _____ (applicable in routes which have other navigation specification – i.e.: UL780 and UL 302)

4. **RNAV-5 operations within the _____ FIR.**

4.1. Starting on November 18, 2010, only aircraft approved for RNAV-5 (airworthiness and operations approval) will be authorized to operate on RNAV routes in the _____ FIR.

4.2. RNAV-5 will be implemented in accordance with the Regional Air Navigation Agreements. Airworthiness and operations approval will be granted by state of operator or by state of registry, according to each case, under national regulations.

4.3. Updated documentation and information about RNAV-5 implementation may be found at the following website of the ICAO South American Office:
<http://www.lima.icao.int/submenu1.asp?Url=/ICAOSAMNET/AirNav-eDocumentsMenu.asp>.

4.4. Additional information, could be obtained through the following contacts:

- (States must add the RNAV-5 contacts for each ATS provider here)
- ICAO Lima

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