AERONAUTICAL TELECOMMUNICATIONS NETWORK OF THE SAM REGION (SAM ATN)

STUDY FOR THE IMPLEMENTATION OF A NEW DIGITAL NETWORK FOR THE SAM REGION

SAM ATN NETWORK

(REDDIG II)

TABLE OF CONTENTS

REFERENCES

- Final Report of the Fifth Workshop/Meeting of the SAM Implementation Group (SAM/IG/5), Lima, 10-14 May 2010;
- RCC/13 report – Financial Status of Project RLA/03/901;
- Air Navigation Plan for the Caribbean and South American Regions – FASID – Tables CNS1A and CNS1C;
- Table CNS 1Ba – Regional Plan for Routers / SAM Region;
- REDDIG Channelling Plan, V. June 2010, provided by the REDDIG Administrator;
- Manaus AMHS documents – Ezeiza tests;
- Ezeiza AMHS documents – Ezeiza tests;
- Informal quote of *Telefónica SA* for a South American ground network;
- Informal quote of *Empresa Brazileira de Telecomunicaciones* (EMBRATEL) for a South American ground network;
- Informal quote of *Global Crossing Latin America* for a South American ground network;
- Telesat quotes for Brazil; and
- SES quote for the MEVA II – REDDIG interconnection.

GLOSSARY OF TERMS

- ATN — Aeronautical Telecommunication Network
- FOB — Free on Board, as defined in the INCOTERMS (International Commercial Terms) and published by the ICC (International Chamber of Commerce)
- ISO — International Organization for Standardization
- MPLS — Multiprotocol Label Switching
- OPEX — Operating Expenditure
- OSI — Open System Interconnection
- RFC — Request for Comments
- SLA — Service Level Agreement
- QoS — Quality of Service
- VPN — Virtual Private Network

INTRODUCTION

1. The Fifth Workshop/Meeting of the SAM Implementation Group (SAM/IG/5), held in Lima on 10-14 May 2010 and sponsored by Regional Project RLA/06/901, considered the conduction of studies on the implementation of a new regional satellite, ground, or mixed (satellite and ground) digital network to serve as the backbone for the SAM Aeronautical Telecommunication Network (SAM ATN), which shall support the current aeronautical fixed voice and data requirements, the exchange of radar and flight plan data, as well as the new ground-ground ATN applications between SAM States/Territories, foreseen to be implemented in the short and medium term.

2. In this regard, *Appendix B to the Report on Agenda Item 6* of the cited workshop clearly describes the Action plan for the implementation of a new digital network in the SAM Region, listing a programme of activities, actions and deliverables.

3. In this regard, the deliverables corresponding to activities 1 to 10, inclusive, are organised according to the following structure:

3.1 *Chapter 1*: Service requirements in support of air navigation in the SAM Region, including those foreseen for the short, medium and long term.

3.2 *Chapter 2*: Interfaces and bandwidth required to support the specified requirements.

3.3 *Chapter 3*: Definition and cost of a satellite REDDIG II structure model.

3.4 *Chapter 4*: Definition and cost of a ground REDDIG II structure model.

3.5 *Chapter 5*: Comparative study of the REDDIG II satellite and ground models and costs.

3.6 *Chapter 6*: Analysis of the mixed model and proposal of a final infrastructure.

4. First of all, some clarifications regarding the *SAM Aeronautical Telecommunication Network (SAM ATN)* are in order to define the work to be carried out subsequently.

5. The SAM ATN will be based on IP. Thus, its core structure will be made up by routers linking the domestic services (either current or future) to the backbone access; that is, to the new digital network.

6. So as not to have a common point of failure, each State will have a dual router. Thus, the basic operating scheme will be that shown at the end of this chapter, in Figure 1.

7. There we can see that, regardless of the technology available in each State, all services are connected to the routers, either directly or through the existing LAN.

8. Some possible options are listed below:

8.1 ATS speech service or teleconference, without PABX or VCS, with the telephone connected directly to the router.

8.2 ATS speech service or teleconference, with PABX or VCS, with interfaces connected directly to the router.

8.3 ATS speech service or teleconference, with PABX or VCS, connected to the LAN.

8.4 AFTN service, with the terminal connected to the corresponding router interface.

8.5 AFTN/AMHS service, with servers and terminals connected to the LAN.

8.6 Automated systems and their terminals, connected to the LAN.

9. Finally, it should be noted that, in order to distinguish the current digital network (REDDIG) from the new digital network, the latter will hereinafter be called as REDDIG II, without this meaning that this should be its definitive name in the future.

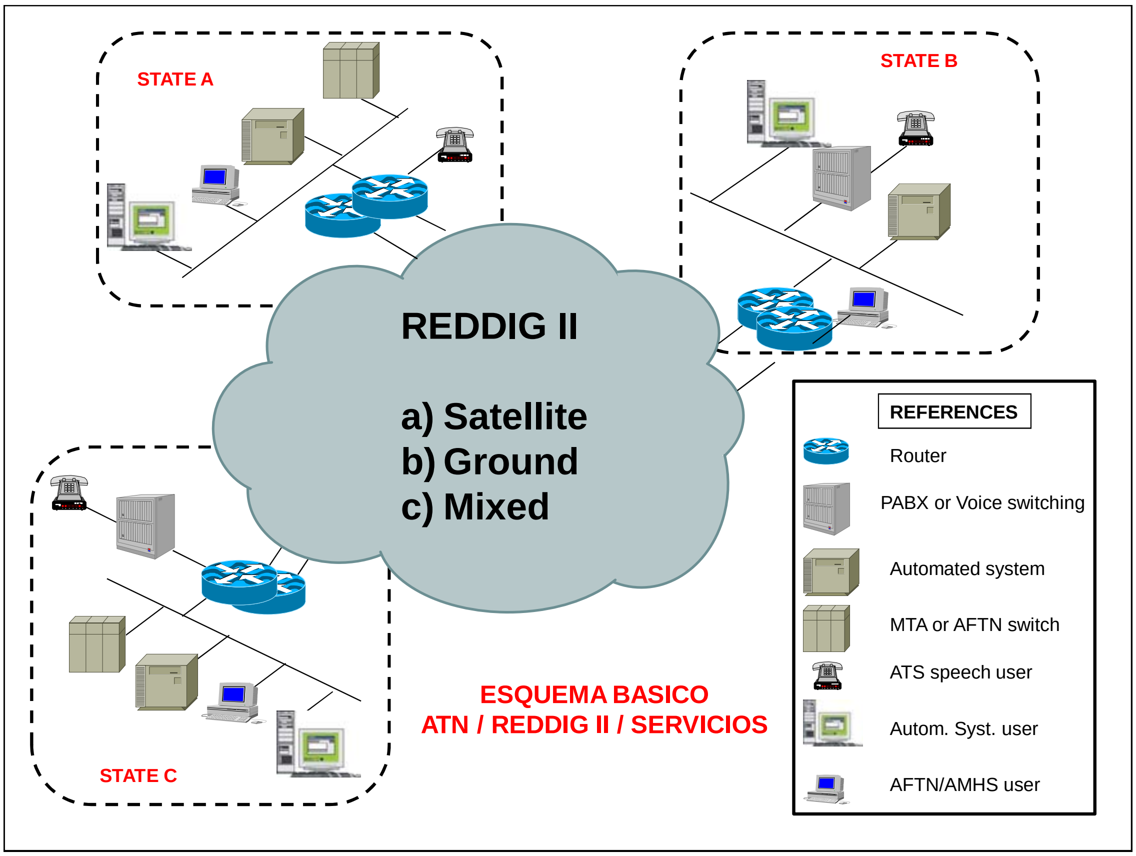


Figure 1: Basic ATN-REDDIG II--Service scheme

Chapter 1 - Service Requirements to Support Air Navigation in the SAM Region, Including those foreseen for the Short, Medium and Long Term

1. The list of services in support of air navigation in the SAM Region, including those foreseen for the short, medium and long term, to be carried by the new digital network include:

1.1 Current services:

1.1.1 Those resulting from the requirements contained in the Air Navigation Plan for the Caribbean and South American Regions, and which are almost fully operational to date, namely:

1.1.1.1 Table CNS1A (AFTN Plan)

1.1.1.2 Table CNS1C (ATS direct speech circuit plan)

1.2 Future services:

1.2.1 Those emerging from the MEVA II – REDDIG interconnection.

1.2.2 The teleconference service for flow management units (FMU) or flow management positions (FMP) to be provided on a daily basis between all units in the Region, initially for twenty users.

1.2.3 The exchange of flight plans and/or radar information, using conventional methods, according to the respective MoUs (Memoranda of Understanding) already signed or to be signed.

1.2.4 AMHS interconnection requirements, gradually replacing the AFTN service, according to the respective MoUs signed or to be signed.

1.2.5 AIDC interconnection requirements, gradually replacing the ATS speech service.

1.2.6 ADS-B data exchange and multilateration between all the ACCs of adjacent FIRs.

1.2.7 The interconnection of automated systems, using Asterix 62 and 63, of all the ACCs of adjacent FIRs.

1.2.8 AIM requirements: to date, there are no concrete requirements.

Chapter 2 – Interfaces and Bandwidths Required to Support the Specified Requirements

1. This Chapter and its Appendices analyse in detail the various services to be maintained (current) or provided (future) by the ATN, which determines the minimum *interfaces* that the routers to be installed in each State should have.

2. The existing interfaces that are needed to maintain the MEVA II – REDDIG interconnection have been included in the respective tables.

3. On the other hand, the interfaces of services that correspond to the AFI (Brasilia – Johannesburg, Brasilia – Dakar – both *via* Recife – and Ezeiza – Johannesburg), EUR (Brasilia - Madrid, Venezuela – Madrid) and ASIA/PAC (Santiago - Brisbane and Santiago – Christchurch (circuits specified in the Plan. In this respect, Chile has informed same would not be implemented)) Regions have been excluded since they use PTT or CAFSAT, and therefore are not related to the problems being addressed.

4. Likewise, an estimate is made of the additional *bandwidth* that will be required from the REDDIG II for the new services, based on the tests conducted and other specified parameters.

5. At the end of this chapter, the following appendices are included:

5.1 *Appendix A*: Interfaces and additional bandwidth for the AFTN.

5.2 *Appendix B*: ATS speech interfaces and additional bandwidth.

5.3 *Appendix C*: Interfaces and additional bandwidth for radar data exchange.

5.4 *Appendix D*: Interfaces and additional bandwidth for teleconferencing.

5.5 *Appendix E*: Interfaces and additional bandwidth for AMHS.

5.6 *Appendix F*: Interfaces and additional bandwidth for AIDC.

5.7 *Appendix G: Interfaces and additional bandwidth for the exchange between automated systems.*

5.8 *Appendix H: Interfaces and additional bandwidth for ADS-B.*

5.9 *Appendix I*: Modification of Table CNS 1Ba – Regional Routers Plan / SAM Region.

6. **Summary of results**

6.1 Based on the individual summaries provided in each of the aforementioned appendices, Tables 2-1 (Interfaces required for routers) and 2-2 (Approximate additional bandwidth) are shown below:

6.1.1 Interfaces

State	Location	Minimum interfaces					
		Universal I/O	**Ethernet**	**Digital**	**E&M**	**FXO**	**FXS**
Argentina	Ezeiza	11	1	0	11	0	1
Bolivia	La Paz	4	1	0	4	0	4
Brazil	Curitiba	4	1	0	6	2	1
	Manaus	6	1	0	7	0	5
	Recife	1	1	0	7	0	1
Chile	Santiago	2	1	0	8	0	0
Colombia	Bogota	7	1	1	0	0	0
Ecuador	Guayaquil	3	1	1	0	0	0
French Guiana	Rochambeau	2	1	0	0	0	5
Guyana	Georgetown	4	1	0	0	0	5
Paraguay	Asunción	3	1	0	3	0	3
Peru	Lima	9	1	1	0	0	0
Suriname	Paramaribo	3	1	0	0	0	4
Trinidad and Tobago	Piarco	2	1	0	0	0	6
Uruguay	Montevideo	2	1	0	0	4	5
Venezuela	Maiquetía	10	1	0	7	0	4

Table 2-1: Interfaces required for routers

6.1.1.1 This table may be modified only if:

a) Any of the Administrations decides to change analogue voice interfaces (E&M, FXO and FXS) for digital ones.
b) If the foreseen exchange of radar signals is conducted through Universal I/O (DB25) instead of Ethernet (RJ45).

6.1.2 Additional bandwidth

6.1.2.1 The rules for the preceding calculation are presented in the respective appendices and from their application it may be assumed that the estimate must be used only as guidance.

6.1.2.2 However, it should be noted that what is not used in the AFTN shall be deducted from the cited increases, since the service is either AFTN or AMHS, never in parallel.

6.1.2.3 Therefore, the value obtained from Table 2A-1 is inserted in the final lines of Table 2-2, providing the net value of the required increase in bandwidth.

State	Location	Service (each in Kbps)			
		AFTN	Radar	AMHS	ADS-B
Argentina	Ezeiza		76.8	28.8	19.2
Bolivia	La Paz		115.2	14.4	19.2
Brazil	Curitiba		76.8	19.2	19.2
	Manaus	9.6	134.4	33.6	19.2
	Recife		0	4.8	19.2
Chile	Santiago		57.6	9.6	19.2
Colombia	Bogota	19.2	76.8	38.4	19.2
Ecuador	Guayaquil		38.4	14.4	19.2
French Guiana	Rochambeau		38.4	9.6	19.2
Guyana	Georgetown		57.6	19.2	19.2
Paraguay	Asunción		57.6	9.6	19.2
Peru	Lima	9.6	96	43.2	19.2
Suriname	Paramaribo		76.8	14.4	19.2
Trinidad and Tobago	Piarco		19.2	9.6	19.2
Uruguay	Montevideo		19.2	9.6	19.2
Venezuela	Maiquetía		76.8	38.4	19.2
Partials (Kbps)		38.4	1017.6	316.8	307.2
Overall partial (Kbps)		1680			
AFTN difference		-103.2			
Net bandwidth increase		**1576.8**			

Table 2-2: Estimated additional bandwidth

6.1.2.4 REDDIG II: 1.576.8 Kbps.

Appendix 2A: Required interfaces and additional bandwidth – AFTN

1. In order to determine the **interfaces** required for the routers, Table 2A-1 shows the AFTN circuits of the SAM Region and of Trinidad and Tobago, member of the REDDIG. Individual values of each circuit have been taken from the parameters established in the REDDIG management.

AFTN TABLE			Rate (Kbps)	Installed interfaces
Argentina	Ezeiza	Bolivia (La Paz) MET	1.2	9
		Paraguay (Asunción) MET	2.4	
		Peru (Lima) MET	1.2	
		Bolivia (La Paz)	2.4	
		Chile (Santiago)	2.4	
		Brazil (Curitiba)	2.4	
		Paraguay (Asunción)	2.4	
		Peru (Lima)	2.4	
		Uruguay (Montevideo)	2.4	
Bolivia	La Paz	Argentina (Ezeiza)	2.4	4
		Argentina (Ezeiza) MET	1.2	
		Brazil (Curitiba)	2.4	
		Peru (Lima)	2.4	
Brazil	Curitiba	Argentina (Ezeiza)	2.4	4
		Uruguay (Montevideo)	2.4	
		Paraguay (Asunción)	2.4	
		Bolivia (La Paz)	2.4	
	Manaus	Colombia (Bogota)	2.4	6
		Colombia (Bogota) - USA	9.6	
		Guyana (Georgetown)	2.4	
		French Guiana (Cayenne)	2.4	
		Peru (Lima)	2.4	
		Suriname (Paramaribo)	2.4	
	Recife	Venezuela (Maiquetía)	2.4	1
Chile	Santiago	Argentina (Ezeiza)	2.4	2
		Peru (Lima)	2.4	
Colombia	Bogota	Ecuador (Guayaquil)	2.4	7
		Brazil (Manaus) - USA	9.6	
		Brazil (Manaus)	2.4	
		Peru (Lima)	9.6	
		Peru (Lima) - USA	2.4	
		Venezuela (Caracas)	2.4	
		Panama (Panama)	2.4	
Ecuador	Guayaquil	Colombia (Bogota)	2.4	3
		Peru (Lima)	2.4	
		Venezuela (Maiquetía)	2.4	

AFTN TABLE			**Rate (Kbps)**	**Installed interfaces**
French Guiana	Cayenne	Venezuela (Maiquetía)	2.4	2
		Brazil (Manaus)	2.4	
Guyana	Georgetown	Brazil (Manaus)	2.4	4
		Suriname (Paramaribo)	2.4	
		Trinidad and Tobago (Piarco)	2.4	
		Venezuela (Caracas)	2.4	
Panama	Panama	Colombia (Bogota)	2.4	1
Paraguay	Asunción	Argentina (Ezeiza)	2.4	3
		Argentina (Ezeiza) MET	2.4	
		Brazil (Curitiba)	2.4	
Peru	Lima	Venezuela (Maiquetía)	2.4	9
		Argentina (Ezeiza)	2.4	
		Argentina (Ezeiza) MET	1.2	
		Bolivia (La Paz)	2.4	
		Brazil (Manaus)	2.4	
		Chile (Santiago)	2.4	
		Colombia (Bogota) - USA	9.6	
		Colombia (Bogota)	2.4	
		Ecuador (Guayaquil	2.4	
Suriname	Paramaribo	Brazil (Manaus)	2.4	3
		Venezuela (Maiquetía)	2.4	
		Guyana (Georgetown)	2.4	
Trinidad and Tobago	Piarco	Venezuela (Maiquetía)	2.4	2
		Guyana (Georgetown)	2.4	
Uruguay	Montevideo	Argentina (Ezeiza)	2.4	2
		Brazil (Brasilia)	2.4	
Venezuela	Maiquetía	Peru (Lima)	2.4	10
		Ecuador (Guayaquil)	2.4	
		Brazil (Recife)	2.4	
		Colombia (Bogota)	2.4	
		Guyana (Georgetown)	2.4	
		Suriname (Paramaribo)	2.4	
		French Guiana (Cayenne)	2.4	
		Curaçao ACC	2.4	
		San Juan ACC	2.4	
		Trinidad and Tobago (Piarco)	2.4	
Current AFTN bandwidth			103.2	

Table 2A-1: AFTN Interfaces

2. Bandwidth: The only two additional requirements of 9.6 Kbps each, with final destination in Atlanta (USA), both *via* Colombia (Bogota), with end points in Brazil (Manaus) and Peru (Lima) have been highlighted in colour. Accordingly, the additional AFTN bandwidth is: 38.4 Kbps.

Appendix 2B: Required interfaces and additional bandwidth - Speech ATS

1. In order to determine the **interfaces** required for the routers, Table 2B-1 shows the ATS speech service requirements of the SAM Region and of Trinidad and Tobago, member of the REDDIG.

2. Likewise, for a better understanding, Table CNS1C (direct and switched) shows both the foreseen circuits as well as those effectively installed in the REDDIG.

ATS TABLE			ATS Req. CNS1C			REDDIG		Installed voice interfaces			
			Direct	Switched Partial	Switched Total	Direct	Switch	E1 Digital	E&M	FXO	FXS
Argentina	Ezeiza	Bolivia (La Paz)		1	14		5	0	11	0	1
		Chile (Santiago)	1	6		1					
		Brazil (Curitiba)		3							
		Paraguay (Asunción)		1							
		Uruguay (Montevideo)	4	3		4					
		Administrative					2				
Bolivia	La Paz	Argentina (Buenos Aires)		1	7		3	0	4	0	4
		Chile (Santiago)		1							
		Brazil (Manaus)		1		1					
		Brazil (Curitiba)		2							
		Paraguay (Asunción)		1							
		Peru (Lima)		1		1					
		Administrative					3				
Brazil	Curitiba	Argentina (Buenos Aires)		3	9		4	0	6	2	1
		Uruguay (Montevideo)		1		1					
		Paraguay (Asunción)		3		1					
		Bolivia (La Paz)		2							
		Administrative					3				
	Manaus	Colombia (Bogota)		1	7	3	3	0	7	0	5
		Guyana (Georgetown)		1							
		French Guiana (Cayenne)		1							
		Bolivia (La Paz)		1		1					
		Venezuela (Maiquetía)		1		1					
		Peru (Lima)		1							
		Suriname (Paramaribo)		1							
		Administrative					4				
	Recife	Uruguay (Montevideo)		1	2		5	0	7	0	1
		French Guiana (Cayenne)		1							
		Administrative					3				
Chile	Santiago	Argentina (Buenos Aires)	1	6	8	1	4	0	8	0	0
		Bolivia (La Paz)		1							
		Peru (Lima)		1		1					
		Administrative					2				

ATS TABLE			ATS Req. CNS1C			REDDIG		Installed voice interfaces			
			Direct	Switched		Direct	Switch	E1 Digital	E&M	FXO	FXS
				Partial	Total						
Colombia	Bogota	Panama (Panama)		5	13	1	7	1	0	0	0
		Cenamer ACC		1							
		Kingston ACC		1							
		Curaçao ACC		1							
		Ecuador (Guayaquil)	2	2		1					
		Brazil (Manaus)		3		3					
		Peru (Lima)		2		1					
		Venezuela (Maiquetía)		1		2					
		Administrative					2				
Ecuador	Guayaquil	Colombia (Bogota)	2	2	3	1	4	1	0	0	0
		Peru (Lima)		1		1					
		Cenamer ACC									
		Administrative					3				
French Guiana	Cayenne	Piarco ACC		1	4	1	2	0	0	0	5
		Brazil (Recife)		1							
		Brazil (Manaus)		1							
		Suriname (Paramaribo)		1							
		Administrative					2				
Guyana	Georgetown	Piarco ACC		1	4	1	3	0	0	0	5
		Brazil (Manaus)		1							
		Suriname (Paramaribo)		1							
		Venezuela (Maiquetía)		1							
		Administrative					1				
Panama	Panama	Colombia (Bogota)	3	2	3	N/A	N/A	N/A	N/A	N/A	N/A
		Kingston ACC		1							
		Cenamer ACC	2								
Paraguay	Asunción	Argentina (Buenos Aires)		1	4		1	0	3	0	3
		Bolivia (La Paz)		1							
		Brazil (Curitiba)	1	2		1					
		Administrative					4				
Peru	Lima	Bolivia (La Paz)		1	6	1	5	2	0	0	0
		Brazil (Manaus)		2							
		Chile (Santiago)		1		1					
		Colombia (Bogota)		1		1					
		Ecuador (Guayaquil		1		1					
		Administrative					3				
Suriname	Paramaribo	Brazil (Manaus)		1	4		2	0	0	0	4
		French Guiana (Cayenne)		1							
		Guyana (Georgetown)		1							
		ACC Piarco		1		1					
		Administrative					1				

ATS TABLE			**ATS Req. CNS1C**			**REDDIG**		**Installed voice interfaces**			
			Direct	**Switched**		**Direct**	**Switch**	**E1 Digital**	**E&M**	**FXO**	**FXS**
				Partial	**Total**						
Trinidad and Tobago	Piarco	Guyana (Georgetown)		1	5	1	0	0	0	0	6
		Venezuela (Maiquetía)		1		1					
		Suriname (Paramaribo)		1		1					
		French Guiana (Cayenne)		1		1					
		ACC San Juan		1							
		Administrative					2				
Uruguay	Montevideo	Argentina (Buenos Aires)	4	3	5	4	2	0	0	4	6
		Brazil (Recife)		1							
		Brazil (Curitiba)		1		1					
		Administrative					2				
Venezuela	Maiquetía	ACC Piarco		1	6	1	6	0	7	0	4
		ACC Curaçao		2							
		ACC San Juan		1							
		Brazil (Manaus)		1		1					
		Colombia (Bogota)	2	3		2					
		Guyana (Georgetown)		1							
		Administrative					1				

Table 2B-1: ATS speech service interfaces

3. Additional ATS speech bandwidth: There are no additional requirements for this service.

Appendix 2C: Required interfaces and additional bandwidth - Radar data

1. In order to determine the **interfaces** required for the routers, Table 2C-1 shows the radar data exchange service, listing the circuits going from each State to the adjacent routers. It includes synchronous circuits (through DB25 ports) as well as those transmitted *via* Ethernet interfaces:

Radar exchange to automated centre			Signal generation				Interfaces	
			Serial		Ethernet			
			Tx	Rx	Tx	Rx	Serial	Ether.
Argentina	Ezeiza	Bolivia (La Paz)	0	TBD	1	TBD	TBD	1
		Chile (Santiago)	TBD	TBD	4	TBD	TBD	
		Brazil (Curitiba)	0	TBD	2	TBD	TBD	
		Paraguay (Asunción)	0	TBD	2	TBD	TBD	
		Uruguay (Montevideo)	1	1	1	TBD	2	
Bolivia	La Paz	Argentina (Buenos Aires)	TBD	TBD	TBD	TBD	0	1
		Chile (Santiago)	TBD	TBD	TBD	TBD	TBD	
		Brazil (Manaus)	TBD	TBD	TBD	TBD	TBD	
		Brazil (Curitiba)	TBD	TBD	TBD	TBD	TBD	
		Paraguay (Asunción)	TBD	TBD	TBD	TBD	TBD	
		Peru (Lima)	TBD	TBD	TBD	TBD	TBD	
Brazil	Curitiba	Argentina (Buenos Aires)	TBD	TBD	TBD	TBD	TBD	1
		Uruguay (Montevideo)	TBD	TBD	TBD	TBD	TBD	
		Paraguay (Asunción)	TBD	TBD	TBD	TBD	TBD	
		Bolivia (La Paz)	TBD	TBD	TBD	TBD	TBD	
	Manaus	Colombia (Bogota)	TBD	TBD	TBD	TBD	TBD	1
		Guyana (Georgetown)	TBD	TBD	TBD	TBD	TBD	
		French Guiana (Cayenne)	TBD	TBD	TBD	TBD	TBD	
		Bolivia (La Paz)	TBD	TBD	TBD	TBD	TBD	
		Peru (Lima)	TBD	TBD	TBD	TBD	TBD	
		Venezuela (Maiquetía)	TBD	TBD	TBD	TBD	TBD	
		Suriname (Paramaribo)	TBD	TBD	TBD	TBD	TBD	
Chile	Santiago	Argentina (Buenos Aires)	TBD	TBD	TBD	TBD	TBD	1
		Bolivia (La Paz)	TBD	TBD	TBD	TBD	TBD	
		Peru (Lima)	TBD	TBD	TBD	TBD	TBD	
Colombia	Bogota	Panama (Panama) (*)	TBD	TBD	TBD	TBD	TBD	1
		Cenamer ACC (*)	TBD	TBD	TBD	TBD	TBD	
		Kingston ACC (*)	TBD	TBD	TBD	TBD	TBD	
		Curaçao ACC (*)	TBD	TBD	TBD	TBD	TBD	
		Ecuador (Guayaquil)	TBD	TBD	TBD	TBD	TBD	
		Brazil (Manaus)	TBD	TBD	TBD	TBD	TBD	
		Peru (Lima)	TBD	TBD	TBD	TBD	TBD	
		Venezuela (Maiquetía)	TBD	TBD	TBD	TBD	TBD	

Radar exchange to automated centre			**Signal generation**				**Interfaces**	
			Serial		**Ethernet**			
			Tx	**Rx**	**Tx**	**Rx**	**Serial**	**Ether.**
Ecuador	Guayaquil	Colombia (Bogota)	TBD	TBD	TBD	TBD	TBD	1
		Peru (Lima)	TBD	TBD	TBD	TBD	TBD	
French Guiana	Cayenne	Brazil (Manaus)	TBD	TBD	TBD	TBD	TBD	1
		Suriname (Paramaribo)	TBD	TBD	TBD	TBD	TBD	
Guyana	Georgetown	Brazil (Manaus)	TBD	TBD	TBD	TBD	TBD	1
		Suriname (Paramaribo)	TBD	TBD	TBD	TBD	TBD	
		Venezuela (Maiquetía)	TBD	TBD	TBD	TBD	TBD	
Panama (*)	Panama (*)	Colombia (Bogota)	N/A	N/A	N/A	N/A	N/A	N/A
		Kingston ACC (*)						
		Cenamer ACC (*)						
Paraguay	Asunción	Argentina (Buenos Aires)	TBD	TBD	TBD	TBD	TBD	1
		Bolivia (La Paz)	TBD	TBD	TBD	TBD	TBD	
		Brazil (Curitiba)	TBD	TBD	TBD	TBD	TBD	
Peru	Lima	Bolivia (La Paz)	TBD	TBD	TBD	TBD	TBD	1
		Brazil (Manaus)	TBD	TBD	TBD	TBD	TBD	
		Chile (Santiago)	TBD	TBD	TBD	TBD	TBD	
		Colombia (Bogota)	TBD	TBD	TBD	TBD	TBD	
		Ecuador (Guayaquil	TBD	TBD	TBD	TBD	TBD	
Suriname	Paramaribo	Brazil (Manaus)	TBD	TBD	TBD	TBD	TBD	1
		French Guiana (Cayenne)	TBD	TBD	TBD	TBD	TBD	
		Guyana (Georgetown)	TBD	TBD	TBD	TBD	TBD	
		ACC Piarco	TBD	TBD	TBD	TBD	TBD	
Trinidad and Tobago	Piarco	ACC San Juan (*)	TBD	TBD	TBD	TBD	TBD	1
		Venezuela (Maiquetía)	TBD	TBD	TBD	TBD	TBD	
Uruguay	Montevideo	Argentina (Buenos Aires)	1	1	TBD	TBD	0	1
		Brazil (Brasilia)	TBD	TBD	TBD	TBD	TBD	
Venezuela	Maiquetía	ACC Piarco (*)	TBD	TBD	TBD	TBD	TBD	1
		ACC Curaçao (*)	TBD	TBD	TBD	TBD	TBD	
		ACC San Juan (*)	TBD	TBD	TBD	TBD	TBD	
		Brazil (Manaus)	TBD	TBD	TBD	TBD	TBD	
		Colombia (Bogota)	TBD	TBD	TBD	TBD	TBD	
		Guyana (Georgetown)	TBD	TBD	TBD	TBD	TBD	

Table 2C-1: Radar data exchange service interfaces

(*): States or ACCs that do not belong to the REDDIG. Consequently, although the interfaces are foreseen, the required bandwidth is be calculated.

TBD: to be developed.

2. Additional bandwidth

2.1 A quick review of the table above clearly shows that the additional bandwidth requirement for the exchange of radar data depends exclusively on the MoUs (Memoranda of Understanding) signed or to be signed by the States.

2.2 In this regard, in order to have an initial calculation, it is estimated that each State will transmit and receive either data from a radar or summarised information from its neighbouring States, giving a total of 106 signals (53 transmitted and 53 received).

2.3 Therefore, consideration should be given to the following bandwidth increases contained in Table 2C – 2:

Radar exchange with automated centre		**Total Tx/RX**	**BW (Kbps)**
Argentina (*)	Ezeiza	8	76.8
Bolivia	La Paz	12	115.2
Brazil	Curitiba	8	76.8
	Manaus	14	134.4
Chile	Santiago	6	57.6
Colombia (+)	Bogota	8	76.8
Ecuador	Guayaquil	4	38.4
French Guiana	Cayenne	4	38.4
Guyana	Georgetown	6	57.6
Paraguay	Asunción	6	57.6
Peru	Lima	10	96
Suriname	Paramaribo	8	76.8
Trinidad and Tobago	Piarco	2	19.2
Uruguay (*)	Montevideo	2	19.2
Venezuela (+)	Maiquetía	8	76.8
Total additional bandwidth			**1017.6**

Table 2C-2: Foreseen bandwidth increases

(*): For Argentina and Uruguay, exchange consumption since 1999 has not been included, since it forms part of the current bandwidth of the REDDIG.

(+): For Colombia and Venezuela, only the links with the REDDIG States have been taken into account.

2.4 Additional bandwidth for the exchange of radar data: 1017.6 Kbps.

Appendix 2D: Required interfaces and additional bandwidths – Teleconferencing

1. Table 2D-1 identifies the **interfaces** required for the routers for the teleconferencing service, listing the flow management units/flow management positions to be interconnected.

Teleconferencing		FMU/ FMP (*)	Interfaces	
			E&M FXS	Digital E1
Argentina	Ezeiza	1	1	
	Mendoza	1		
	Córdoba	1		
	Resistencia	1		
	Comodoro Rivadavia	1		
Bolivia	La Paz	1	1	
Brazil	Curitiba	1	1	
	Manaus	1		
	Atlántico	1		
	Brasilia	1		
	Recife	1		
Chile	Santiago	1	1	
	Puerto Montt	1		
	Punta Arenas	1		
Colombia	Bogota	1		1
	Cali	1		
	Medellín	1		
	Barranquilla	1		
Ecuador	Guayaquil	1		1
French Guiana	Rochambeau	1	1	
Guyana	Georgetown	1	1	
Paraguay	Asunción	1	1	
Peru	Lima	1		1
Suriname	Paramaribo	1	1	
Trinidad and Tobago	Piarco	1	1	
Uruguay	Montevideo	1	1	
Venezuela	Maiquetía	1	1	

Table 2D-1: Required (existing) interfaces for the teleconferencing service

2. **Additional bandwidth for teleconferencing:** For this non-permanent service, it is estimated that the interfaces and remaining bandwidth capacity of the REDDIG are sufficient to absorb the demand, even during peak voice and data traffic. Therefore, **no additional bandwidth is required**.

Appendix 2E: Required interfaces and additional bandwidth – AMHS

1. In order to determine the minimum bandwidth required for the operation between two MTAs, two tests (Test No. 1 and Test No. 2) were conducted in completely different scenarios.

2. **Test No. 1: Ezeiza (CIPE) MTA – Manaus MTA**

2.1 *IP addresses*: Assigned according to the Regional IP Addressing Plan. The following test scheme was used (Figure 2E-1)

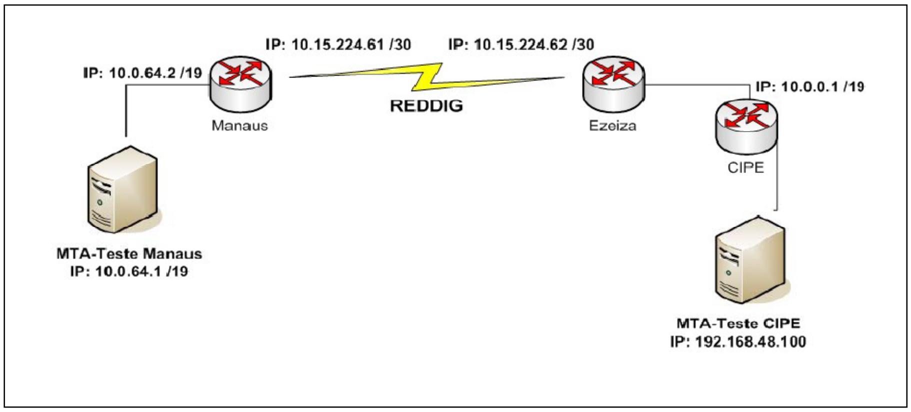


Figure 2E-1: Connectivity scheme

2.2 *Configurations*:

2.2.1 Manaus MTA: PRMD=EG, O=EGGA, OU=EGGA, CN=EGGAXXYY

2.2.2 CIPE MTA: PRMD=SA, O=CIPE, OU=CIPE, CN=CIPE****, (****) ten different terminals.

2.2.3 In this respect, Figure 2E-2 shows the routing configuration in the CIPE MTA.

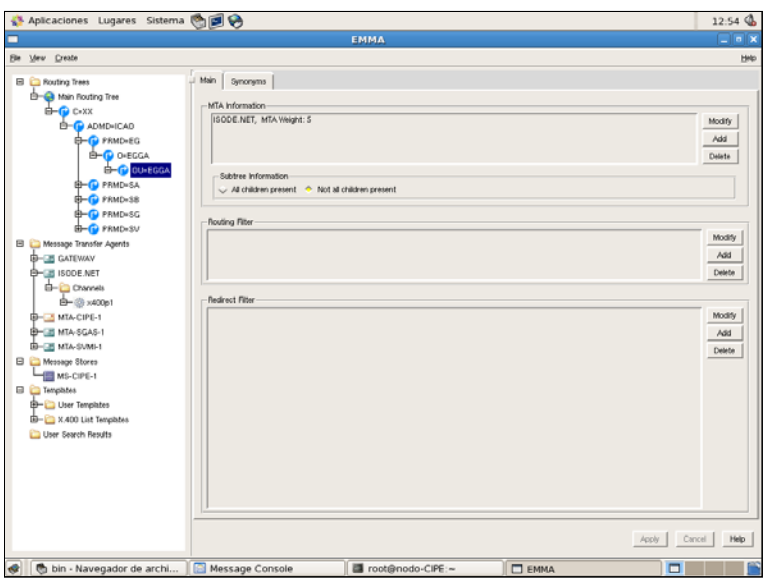


Figure 2E-2: CIPE MTA routing

2.3 *Tests*:

2.3.1 These tests were scheduled with a view to establishing the capacity of the REDDIG for various transmission speeds and message sizes.

2.3.2 In this respect, Table 2E-1 presents a summary of the part of the trials (those conducted with 1-KB messages and configured speeds of 64, 32 and 4,8 kbps).

Test No.	Description	Link rate (Kbits/s)	Total time (hh/mm/ss)	Exchange of messages / hour	Exchange of messages / second	Transit time of each message (seconds)	Remarks
1	Delivery of 5,000 1-KB messages	64	0:59:21	5000	1.39	0.72	
2	Delivery of 5,000 1-KB messages	32	2:18:00	2174	0.6	1.66	
3	Delivery of 25 1-KB messages	4.8	11:42:00 (*)	427	0.12	8.43	To be completed

(*): if the test had been with 5,000 messages

Table 2E-1: Tests and results obtained

(*) A calculation is made of the equivalent time if traffic had been of 5,000 messages

2.4 *Evidence*: Figure 2E-3 presents parts of the CIPE MTA event log, showing the different sizes of the scripts received (different colours), the time used for the transfer, and the transfer rates:

8/ 5 00:00:28 x400p1 07177 (#501) N-MTA_X400-Notice <<< [/PRMD=EG/ADMD=ICAO/C=XX/; isode.net.1841201-100804.191103] message received from cn=x400p1, cn=ISODE.NET, cn=Messaging Configuration,ou=Address Book,c=AR

8/ 5 00:00:28 x400p1 07177 (#501) N-MTA-Notice Transfer Completed (inbound): 6604 bytes in 2.54 seconds (2.53 Kbytes/s)

8/ 5 00:00:29 x400p1 07174 (#501) N-MTA-Notice Recipient 1 '/CN=CIPEZTZX/OU=CIPE/O=CIPE/PRMD=SA/ADMD=ICAO/C=XX/' mta 'MTA-CIPE-1'

8/ 5 00:00:29 x400p1 07174 (#501) N-MTA-Notice Transfer Completed (inbound): 6604 bytes in 1.27 seconds (5.04 Kbytes/s)

8/ 5 00:00:31 x400p1 07177 (#501) N-MTA-Notice Transfer Completed (inbound): 6604 bytes in 2.29 seconds (2.81 Kbytes/s)

8/ 5 00:00:31 x400p1 07174 (#501) N-MTA-Notice Transfer Completed (inbound): 6604 bytes in 1.19 seconds (5.39 Kbytes/s)

8/ 5 00:00:33 x400p1 07174 (#501) N-MTA-Notice Transfer Completed (inbound): 6604 bytes in 1.19 seconds (5.38 Kbytes/s)

8/ 5 00:19:39 x400p1 07737 (#501) N-MTA-Notice Transfer Completed (inbound): 11722 bytes in 2.83 seconds (4.04 Kbytes/s)

8/ 5 00:19:40 x400p1 07740 (#501) N-MTA-Notice Transfer Completed (inbound): 11722 bytes in 1.82 seconds (6.27 Kbytes/s)

Figure 2E-3: CIPE MTA test log Manaus - CIPE

2.5 *Analysis of test results in relation to current traffic*:

2. Buenos Aires – Ezeiza (ARGENTINA)

dir 383 = BUENOS AIRES

Dia	Tráfego Total	Hora de Pico	Tráfego na Hora de Pico
1/7/2009	4.201	11:24 AS 12:24	250
2/7/2009	4.257	16:54 AS 17:55	242
3/7/2009	3.961	11:10 AS 12:10	228
4/7/2009	3.301	16:54 AS 17:54	173
5/7/2009	3.218	16:54 AS 17:54	179
6/7/2009	3.549	22:39 AS 23:39	174
7/7/2009	3.753	18:09 AS 19:09	318
8/7/2009	3.522	10:55 AS 11:54	179
9/7/2009	3.411	16:54 AS 17:54	158
10/7/2009	3.550	10:39 AS 11:40	236
11/7/2009	3.335	10:54 AS 11:54	210
12/7/2009	3.162	11:09 AS 12:09	142
13/7/2009	3.816	16:54 AS 17:54	201
14/7/2009	3.615	12:09 AS 13:09	218
15/7/2009	3.610	22:54 AS 23:57	175
16/7/2009	3.653	10:39 AS 11:39	186
17/7/2009	3.763	10:09 AS 11:09	246
18/7/2009	3.302	10:54 AS 11:54	189
19/7/2009	2.988	16:24 AS 17:24	170
20/7/2009	3.442	14:39 AS 15:39	176
21/7/2009	3.832	10:39 AS 11:39	214
22/7/2009	3.839	10:39 AS 11:39	233
23/7/2009	3.796	10:54 AS 11:54	216
24/7/2009	3.514	23:24 AS 00:24	151
25/7/2009	3.228	16:54 AS 17:54	162
26/7/2009	3.258	11:24 AS 12:25	166
27/7/2009	3.593	16:39 AS 17:39	179
28/7/2009	3.748	16:54 AS 17:54	198
29/7/2009	3.844	10:39 AS 11:39	203
30/7/2009	3.748	04:54 AS 05:54	167
31/7/2009	3.825	10:54 AS 11:54	190
Total geral	111.634		

Table 2E-2: SBBR-SAEZ AFTN peak hour traffic

2.5.1 Table 2E-2 presents the monthly traffic of messages between Brazil and Argentina whose average numbers repeat themselves in the last 12 months.

2.5.2 An analysis of the maximum number of messages during peak hour (7/7/2009), which was **318 messages**, leads to the conclusion that a bandwidth of 4,8 kbit/s is reasonable for the configuration of the AMHS circuit between Brazil and Argentina. Since the transmission between the two countries currently accounts for the highest bandwidth utilisation for said application in the REDDIG, it may be concluded that the rate of 4,8 kbit/s or 2,4 kbit/s could be used for all cases in the SAM States.

2.5.3 However, Table 2E-3 summarises AFTN peak hour traffic between Brazil and Atlanta, which has a maximum number of messages during peak hour (2/7/2009) of **1745 messages**. For that circuit, a rate of 9,6 kbit/s may be enough, but must be checked with continued testing of the 16-kbit/s and 9,6-kbit/s rates.

1. Atlanta (EUA)

dir 94 = ATLANTA

Dia	Tráfego Total	Hora de Pico	Tráfego na Hora de Pico
1/7/2009	17.337	11:40 AS 12:39	940
2/7/2009	19.728	18:25 AS 19:25	1.745
3/7/2009	19.794	10:54 AS 11:54	1.668
4/7/2009	17.145	16:39 AS 17:40	1.075
5/7/2009	17.684	16:09 AS 17:09	914
6/7/2009	17.486	16:39 AS 17:39	1.201
7/7/2009	17.661	18:09 AS 19:09	1.090
8/7/2009	18.596	15:54 AS 16:54	1.184
9/7/2009	17.044	06:24 AS 07:25	1.200
10/7/2009	17.606	22:39 AS 23:39	939
11/7/2009	13.803	00:00 AS 00:54	717
12/7/2009	13.071	12:09 AS 13:09	741
13/7/2009	15.186	19:10 AS 20:09	824
14/7/2009	13.159	21:09 AS 22:09	763
15/7/2009	12.682	21:54 AS 22:54	687
16/7/2009	12.473	21:09 AS 22:09	710
17/7/2009	12.816	15:39 AS 16:39	598
18/7/2009	11.722	03:54 AS 04:54	779
19/7/2009	9.418	12:24 AS 13:24	621
20/7/2009	12.863	18:54 AS 19:54	986
21/7/2009	13.310	23:09 AS 00:09	955
22/7/2009	12.822	20:39 AS 21:39	651
23/7/2009	12.337	20:24 AS 21:24	736
24/7/2009	9.958	19:54 AS 20:54	369
25/7/2009	11.208	21:24 AS 22:24	593
26/7/2009	10.661	20:24 AS 21:24	678
27/7/2009	13.051	11:54 AS 12:54	661
28/7/2009	13.139	21:39 AS 22:39	755
29/7/2009	13.171	17:09 AS 18:09	995
30/7/2009	13.177	18:54 AS 19:54	682
31/7/2009	11.776	20:09 AS 21:09	658
Total geral	441.884		

Table 2E-3: SBBR-Atlanta AFTN traffic during peak hour

3. **Test No. 2: MTA Ezeiza (CIPE) –XX MTA** (XX: test, simulating another country, Ethiopia in this case)

3.1 *IP addresses*: according to the following test scheme (Figures 2E-3 and 2E-4):

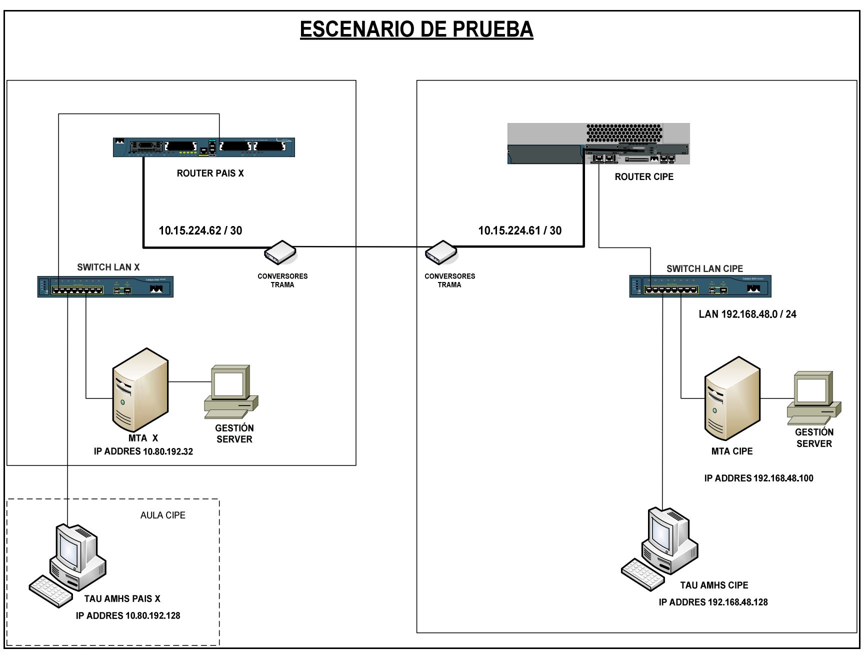


Figure 2E-3: CIPE MTA / XX MTA connectivity scheme

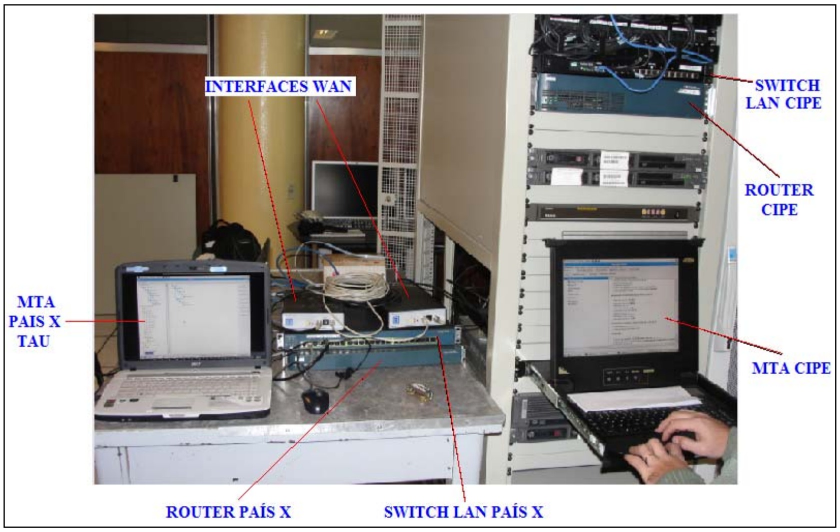


Figure 2E-4: Image of the test scenario

3.2 *Configurations*:

3.2.1 XX MTA: PRMD=HA, O=HAAB, OU=HAAB, CN=HAABYFYX

3.2.2 CIPE MTA: PRMD=SA, O=CIPE, OU=CIPE, CN=CIPE****, where **** are ten different terminals.

3.2.3 Next, Figure 2E-5 shows a print screen (in CIPE) of the connectivity test with the other MTA:

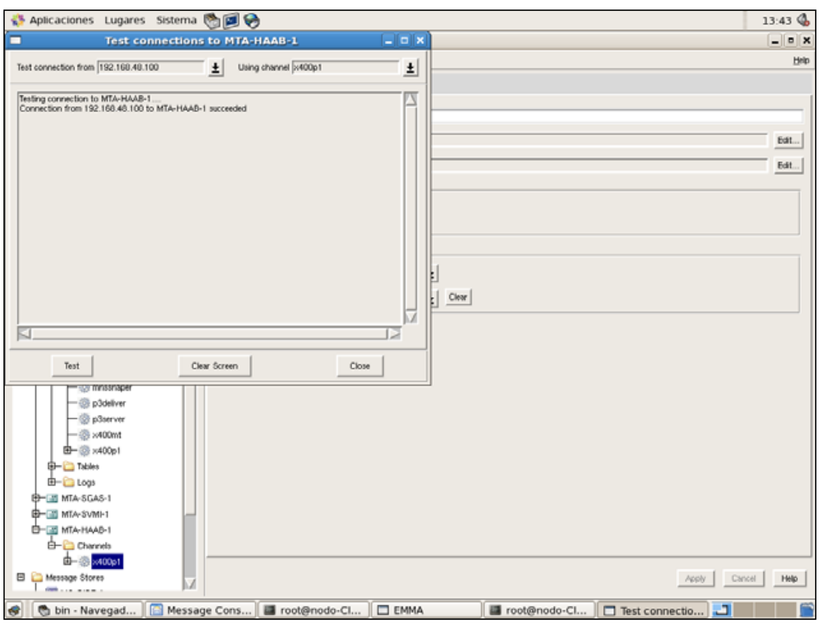


Figure 2 E-5: Certifying the connectivity with the other MTA

3.3 *Tests*

3.3.1 Two-way delivery of 500-message packages, checking the delivery rate at the terminal of the opposite MTA, varying the link rate by modifying the parameters of the associated routers.

3.3.2 Next, Figure 2E-6 presents part of the event log of the XX MTA, showing the size of the messages, transfer time, and incoming and outgoing transfer rates:

Examples of messages received at the XX MTA (MTA Event)

8/11 13:42:00 x400p1 20693 (#501) N-MTA_X400-Notice <<< [/PRMD=HA/ADMD=ICAO/C=XX/; localhost..0309501-100806.121319] message received from cn=x400p1,cn=MTA-HAAB-1, cn=Messaging Configuration,ou=Address Book,c=AR
8/11 13:42:00 x400p1 20693 (#501) N-MTA-Notice Transfer Completed (inbound): 674 bytes in 0.01 seconds (47.01 Kbytes/s)
8/11 13:42:00 x400p1 20692 (#501) N-MTA_X400-Notice <<< [/PRMD=HA/ADMD=ICAO/C=XX/; localhost..0302901-100806.120935] message received from cn=x400p1,cn=MTA-HAAB-1, cn=Messaging Configuration,ou=Address Book,c=AR
8/11 13:42:00 x400p1 20692 (#501) N-MTA-Notice Transfer Completed (inbound): 672 bytes in 0.01 seconds (54.69 Kbytes/s)
8/11 13:58:02 x400p1 20773 (#501) N-MTA_X400-Notice <<< [/PRMD=HA/ADMD=ICAO/C=XX/;localhost..0465701-100806.123120] DR received from cn=x400p1,cn=MTA-HAAB-1,cn=Messaging Configuration,ou=Address Book,c=AR
8/11 13:58:02 x400p1 20773 (#501) N-MTA-Notice Transfer Completed (inbound): 464 bytes in 0.00 seconds (90.62 Kbytes/s)
8/11 14:05:21 x400p1 20811 (#501) N-MTA_X400-Notice <<< [/PRMD=HA/ADMD=ICAO/C=XX/; localhost..2943401-100806.123839] DR received from cn=x400p1,cn=MTA-HAAB-1,cn=Messaging Configuration,ou=Address Book,c=AR
8/11 14:05:21 x400p1 20811 (#501) N-MTA-Notice Transfer Completed (inbound): 464 bytes in 0.00 seconds (113.28 Kbytes/s)

Examples of messages sent by the XX MTA (MTA Event)

8/11 14:09:30 pp.qmgr2 20287 (pp) N-IOevent-ConnectionClosed Normal Connection Closure
8/11 14:09:30 x400p1 20848 (pp) N-MTA-Notice Transfer Completed (outbound): 663 bytes in 0.10 seconds (6.29 Kbytes/s)
8/11 14:09:30 x400p1 20848 (pp) N-MTA_X400-Notice >>> Message [/PRMD=SA/ADMD=ICAO/C=XX/; localhost..2083107-100811.170928] transfered to <cn=x400p1,cn=MTA-HAAB-1, cn=Messaging Configuration,ou=Address Book, c=AR>
8/11 14:09:30 x400p1 20848 (pp) N-MTA-Notice Transfer Completed (outbound): 665 bytes in 0.03 seconds (17.55 Kbytes/s) 8/11 14:09:30 x400p1 20848 (pp) N-MTA_X400-Notice >>> Message [/PRMD=SA/ADMD=ICAO/C=XX/; localhost..2083108-100811.170928] transfered to <cn=x400p1,cn=MTA-HAAB-1,cn=Messaging Configuration,ou=Address Book,c=AR>
8/11 14:09:30 x400p1 20848 (pp) N-MTA-Notice Transfer Completed (outbound): 665 bytes in 0.01 seconds (34.18 Kbytes/s)

Figure 2E-6: MTA Log

3.4 *II test results*:

3.4.1 Delivery times practically did not vary, regardless of router configuration (the transfer rate was high in all cases), since the physical connection medium did not change. Therefore, it was not possible to determine the minimum link rate under message stress conditions.

3.4.2 Consequently, these tests did not add any important additional information to the tests conducted between Manaus and Ezeiza.

4. Additional bandwidth

4.1 Next, Table 2E-4 presents the conventional **AMHS connectivity** in the SAM Region and in Trinidad and Tobago.

4.2 Likewise, for the purpose of calculating the additional bandwidth, the primary conclusions of the tests conducted between Manaus and Ezeiza have been adopted. This involves assigning 4.8 Kbps between each pair of States, with the exception of messages from (or switched by) Brazil and Peru to USA (Atlanta), and which will travel between each of the cited States and Colombia (Bogota), to enter the MEVA II at this location to continue to its final destination, *via* Miami, for which 9.6 Kbps were assigned, in addition to the 4.8 Kbps assigned to the traffic between each pair of States.

4.3 Consequently, between Brazil (Manaus) – Colombia (Bogota) and Peru (Lima) – Colombia (Bogota), the width assigned is 14.4 Kbps (9.6 Kbps + 4.8 Kbps). The cited values are shown in column BW (Kbps).

AMHS TABLE			**BW (Kbps)**
Argentina	Ezeiza	Bolivia (La Paz)	4.8
		Chile (Santiago)	4.8
		Brazil (Curitiba)	4.8
		Paraguay (Asunción)	4.8
		Peru (Lima)	4.8
		Uruguay (Montevideo)	4.8
Bolivia	La Paz	Argentina (Ezeiza)	4.8
		Brazil (Curitiba)	4.8
		Peru (Lima)	4.8
Brazil	Curitiba	Argentina (Ezeiza)	4.8
		Uruguay (Montevideo)	4.8
		Paraguay (Asunción)	4.8
		Bolivia (La Paz)	4.8
	Manaus	Colombia (Bogota) (*)	14.4
		Guyana (Georgetown)	4.8
		French Guiana (Cayenne)	4.8
		Peru (Lima)	4.8
		Suriname (Paramaribo)	4.8
	Recife	Venezuela (Maiquetía)	4.8
Chile	Santiago	Argentina (Ezeiza)	4.8
		Peru (Lima)	4.8
Colombia	Bogota	Ecuador (Guayaquil)	4.8
		Brazil (Manaus) (*)	14.4
		Peru (Lima) (*)	14.4
		Venezuela (Caracas)	4.8
Ecuador	Guayaquil	Colombia (Bogota)	4.8
		Peru (Lima)	4.8
		Venezuela (Maiquetía)	4.8
French Guiana	Cayenne	Venezuela (Maiquetía)	4.8
		Brazil (Manaus)	4.8
Guyana	Georgetown	Brazil (Manaus)	4.8
		Suriname (Paramaribo)	4.8
		Trinidad and Tobago (Piarco)	4.8
		Venezuela (Caracas)	4.8
Paraguay	Asunción	Argentina (Ezeiza)	4.8

AMHS TABLE			**BW (Kbps)**
Peru	Lima	Venezuela (Maiquetía)	4.8
		Argentina (Ezeiza)	4.8
		Bolivia (La Paz)	4.8
		Brazil (Manaus)	4.8
		Chile(Santiago)	4.8
		Colombia (Bogota) (*)	14.4
		Ecuador (Guayaquil	4.8
Suriname	Paramaribo	Brazil (Manaus)	4.8
		Venezuela (Maiquetía)	4.8
		Guyana (Georgetown)	4.8
Trinidad and Tobago	Piarco	Venezuela (Maiquetía)	4.8
		Guyana (Georgetown)	4.8
Uruguay	Montevideo	Argentina (Ezeiza)	4.8
		Brazil (Brasilia)	4.8
Venezuela	Maiquetía	Peru (Lima)	4.8
		Ecuador (Guayaquil)	4.8
		Brazil (Recife)	4.8
		Colombia (Bogota)	4.8
		Guyana (Georgetown)	4.8
		Suriname (Paramaribo)	4.8
		French Guiana (Cayenne)	4.8
		Trinidad and Tobago (Piarco)	4.8
			316.8

Table 2E-4: AMHS connectivity and bandwidth calculation

(*): As already stated, the combined traffic between each pair of States (Brazil – Colombia and Peru – Colombia) and the one originating in Peru and Brazil, but which continues to Miami/Atlanta *via* MEVA II, are added.

4.4 **Estimated additional AMHS bandwidth**: 316.8 Kbps.

Appendix 2F: Required interfaces and additional bandwidth – AIDC

1. Interfaces

1.1 Table 2F-1 below shows the future AIDC service in the SAM Region and in Trinidad and Tobago.

1.2 It includes all the services that should go from each State to the adjacent routers, either for ACC/ACC, ACC/APP or APP/TWR communications.

AIDC TABLE			Number	Total	Ethernet Interfaces
Argentina	Buenos Aires	Bolivia (La Paz)	1	5	1
		Chile (Santiago)	7		
		Brazil (Curitiba)	3		
		Paraguay (Asunción)	1		
		Uruguay (Montevideo)	7		
Bolivia	La Paz	Argentina (Buenos Aires)	1	6	1
		Chile (Santiago)	1		
		Brazil (Manaus)	1		
		Brazil (Curitiba)	2		
		Paraguay (Asunción)	1		
		Peru (Lima)	1		
Brazil	Curitiba	Argentina (Buenos Aires)	3	4	1
		Uruguay (Montevideo)	1		
		Paraguay (Asunción)	3		
		Bolivia (La Paz)	2		
	Manaus	Colombia (Bogota)	1	7	1
		Guyana (Georgetown)	1		
		French Guiana (Rochambeau)	1		
		Bolivia (La Paz)	1		
		Venezuela (Maiquetía)	1		
		Peru (Lima)	1		
		Suriname (Paramaribo)	1		
	Recife	Uruguay (Montevideo)	1	2	1
		French Guiana (Rochambeau)	1		
Chile	Santiago	Argentina (Buenos Aires)	7	3	1
		Bolivia (La Paz)	1		
		Peru (Lima)	1		
Colombia	Bogota	Panama (Panama)	5	5	1
		Ecuador (Guayaquil)	4		
		Brazil (Manaus)	3		
		Peru (Lima)	2		
		Venezuela (Maiquetía)	1		
Ecuador	Guayaquil	Colombia (Bogota)	4	2	1
		Peru (Lima)	1		

AIDC TABLE			Number	Total	Ethernet Interfaces
French Guiana	Rochambeau	ACC Piarco	1	4	1
		Brazil (Recife)	1		
		Brazil (Manaus)	1		
		Suriname (Paramaribo)	1		
Guyana	Georgetown	ACC Piarco	1	4	1
		Brazil (Manaus)	1		
		Suriname (Paramaribo)	1		
		Venezuela (Maiquetía)	1		
Paraguay	Asunción	Argentina (Buenos Aires)	1	3	1
		Bolivia (La Paz)	1		
		Brazil (Curitiba)	3		
Peru	Lima	Bolivia (La Paz)	1	5	1
		Brazil (Manaus)	2		
		Chile(Santiago)	1		
		Colombia (Bogota)	1		
		Ecuador (Guayaquil	1		
Suriname	Panamaribo	Brazil (Manaus)	1	4	1
		French Guiana (Rochambeau)	1		
		Guyana (Georgetown)	1		
		ACC Piarco	1		
Trinidad and Tobago	Piarco	Guyana (Georgetown)	1	4	1
		Venezuela (Maiquetía)	1		
		Suriname (Paramaribo)	1		
		French Guiana (Cayenne)	1		
Uruguay	Montevideo	Argentina (Buenos Aires)	7	3	1
		Brazil (Recife)	1		
		Brazil (Curitiba)	1		
Venezuela	Maiquetía	ACC Piarco	1	4	1
		Brazil (Manaus)	1		
		Colombia (Bogota)	5		
		Guyana (Georgetown)	1		

Table 2F-1: AIDC Service

2. **Bandwidth**

2.1 Regarding this service, there are 3 operational exchange modalities:

2.1.1 *Via* AFTN

2.1.2 *Via* AMHS

2.1.3 Directly between automated systems, *via* ATN over IP.

2.2 For the *first two cases*, these are AFTN messages generated/received by the automated systems and that travel through the respective AFTN or AMHS systems (or a combination of the two). Therefore, the increase in information will be reflected only as an increase in the number of AFTN messages circulating over the ATN.

2.3 Since ATS traffic historically accounts for only 15% of the total AFTN traffic, a hypothetical 300% increase in ATS messages will only be reflected in a 30% increase of AFTN traffic.

2.4 For the *third case*, each centre will send the information to the corresponding adjacent centre, and the increase in bandwidth will depend on the number of control messages that each switched centre will generate, which obviously will depend on the surrounding air traffic.

2.5 Furthermore:

2.5.1 As the service is installed in the various States, the need for greater bandwidth for this service will gradually and slightly increase.

2.5.2 A greater bandwidth will be required once this service has been operationally disseminated throughout the Region, while voice handover of flights continues to be *temporarily* mandatory.

2.5.3 Once this phase is completed and voice communications gradually are deactivated, bandwidth consumption drops until there is no longer the need to continue using speech circuits.

2.6 At that moment, the net bandwidth (increase through AIDC – reduction of ATS speech) will be negative, that is, there will be a reduction of bandwidth requirement.

3. **Additional bandwidth for AIDC**

3.1 No additional bandwidth is required for this service.

Appendix 2G: Required interfaces and additional bandwidth - Exchange between automated systems

1. Interfaces

1.1 Table 2G-1 below shows the data exchange service using Asterix 62 and 63 between automated systems in the SAM Region and in Trinidad and Tobago.

Automated system interconnection table			Number	Total	Ethernet
Argentina	Ezeiza	Bolivia (La Paz)	1	6	1
		Chile (Santiago)	1		
		Brazil (Curitiba)	1		
		Paraguay (Asunción)	1		
		Uruguay (Montevideo)	1		
Bolivia	La Paz	Argentina (Buenos Aires)	1	6	1
		Chile (Santiago)	1		
		Brazil (Manaus)	1		
		Brazil (Curitiba)	1		
		Paraguay (Asunción)	1		
		Peru (Lima)	1		
Brazil	Curitiba	Argentina (Buenos Aires)	1	4	1
		Uruguay (Montevideo)	1		
		Paraguay (Asunción)	1		
		Bolivia (La Paz)	1		
	Manaus	Colombia (Bogota)	1	8	1
		Guyana (Georgetown)	1		
		French Guiana (Cayenne)	1		
		Argentina (Buenos Aires)	1		
		Bolivia (La Paz)	1		
		Peru (Lima)	1		
		Venezuela (Maiquetía)	1		
		Suriname (Paramaribo)	1		
Chile	Santiago	Argentina (Buenos Aires)	1	3	1
		Bolivia (La Paz)	1		
		Peru (Lima)	1		
		Panama (Panama)	1		1
		Ecuador (Guayaquil)	1		
		Brazil (Manaus)	1		
		Peru (Lima)	1		
		Venezuela (Maiquetía)	1		
Ecuador	Guayaquil	Colombia (Bogota)	1	2	1
		Peru (Lima)	1		
French Guiana	Rochambeau	ACC Piarco	1	3	1
		Brazil (Manaus)	1		
		Suriname (Paramaribo)	1		

Automated system interconnection table			Number	Total	Ethernet
Guyana	Georgetown	ACC Piarco	1	4	1
		Brazil (Manaus)	1		
		Suriname (Paramaribo)	1		
		Venezuela (Maiquetía)	1		
Paraguay	Asunción	Argentina (Buenos Aires)	1	3	1
		Bolivia (La Paz)	1		
		Brazil (Curitiba)	1		
Peru	Lima	Bolivia (La Paz)	1	5	1
		Brazil (Manaus)	1		
		Chile (Santiago)	1		
		Colombia (Bogota)	1		
		Ecuador (Guayaquil	1		
Suriname	Paramaribo	Brazil (Manaus)	1	4	1
		French Guiana (Rochambeau)	1		
		Guyana (Georgetown)	1		
		ACC Piarco	1		
Trinidad and Tobago	Piarco	Venezuela (Maiquetía)	1	1	1
Uruguay	Montevideo	Argentina (Buenos Aires)	1	2	1
		Brazil (Brasilia)	1		
Venezuela	Maiquetía	ACC Piarco	1	4	1
		Brazil (Manaus)	1		
		Colombia (Bogota)	1		
		Guyana (Georgetown)	1		

Table 2G-1: Exchange of data between automated centres

2. **Bandwidth**The evolution of the new system utilisation/required bandwidth ratio follows the same analogy as the AIDC service, that is:

2.1.1 As the service is installed in the various States, the need for greater bandwidth for this service will gradually and slightly increase.

2.1.2 A greater bandwidth will be required once this service has been operationally disseminated throughout the Region, while "radar to automated centre" transmissions continue to be *temporarily* mandatory.

2.1.3 Once this phase is completed, the net bandwidth (increase due to exchange between centres - traditional reduction) will be negative, that is, the bandwidth requirement will be reduced or, at least, will remain the same.

3. **Conclusion**

3.1 **Additional bandwidth for the exchange between automated centres:** No additional bandwidth is required for this service.

Appendix 2H: Required interfaces and additional bandwidth - ADS-B

1. Interfaces

1.1 There should be no major *interface* requirements, since the market currently offers data output over IP. Since this offering is expected to grow, only ATN access switch free ports shall be used.

1.2 This service will replace or supplement radar information transmission in two stages, in a similar way as for radar exchange, that is:

1.2.1 *¨ADS-B sensor-to-automated centre¨ modality*: As the service is installed in the various States, the need for greater bandwidth for this service will gradually increase. The corresponding calculation is done at the end of this Appendix.

1.2.2 *¨Radar information exchange between automated centres¨ modality*: A greater bandwidth will be required once this service has been operationally disseminated throughout the Region, while "ADS-B sensor-to-automated centre¨ transmissions continue to be *temporarily* mandatory.

1.2.3 Once this phase is completed, the net bandwidth (increase due to exchange between centres - traditional reduction) will be negative, that is, the bandwidth requirement will be reduced or, at least, will remain the same.

2. Bandwidth

2.1 In this case, it is assumed that each State will exchange information of one (1) ADS-B sensor with one (1) adjacent State, that is two (2) signals are calculated per State, each of 9.6 Kbps (identical to data radar).

2.2 Accordingly, Table 2H-1 shows the additional bandwidth increase for the service:

Data exchange with an automated centre		**Total Tx/RX**	**BW (Kbps)**
Argentina	Ezeiza	2	19.2
Bolivia	La Paz	2	19.2
Brazil	Curitiba	2	19.2
	Manaus	2	19.2
	Manaus	2	19.2
Chile	Santiago	2	19.2
Colombia	Bogota	2	19.2
Ecuador	Guayaquil	2	19.2
French Guiana	Cayenne	2	19.2
Guyana	Georgetown	2	19.2
Paraguay	Asunción	2	19.2
Peru	Lima	2	19.2
Suriname	Paramaribo	2	19.2

Data exchange with an automated centre		**Total Tx/RX**	**BW (Kbps)**
Trinidad and Tobago	Piarco	2	19.2
Uruguay (*)	Montevideo	2	19.2
Venezuela	Maiquetía	2	19.2
Total (Kbps)			**307.2**

Table 2H-1: Additional bandwidth for ADS-B

3. Conclusion

3.1 **Additional bandwidth requirement for ADS-B**: 307.2 Kbps

Appendix 2I - Table CNS1b - Plan of Routers for the SAM Region

1. The REDDIG II shall be based on IP and the boundary elements will be the routers. Therefore, all the services listed in Activity 1 (and described in detail in the previous Appendices) shall be based on them.

2. In this case, Table CNS 1Ba – Regional Router Plan/SAM Region**,** should be thoroughly reviewed to make sure that voice communications follow the direct path between the routers of two adjacent ACCs (avoiding double hop, in the case of a satellite solution).

3. Furthermore, it was deemed important, without modifying the original structure, to subdivide the columns of said Table in order to accommodate aggregate parameters to quickly visualize the already established links and services, the initial bandwidth, the backbone technology currently supporting them, the protocols used or to be used, etc.

Appendix 2I - Table CNS1b - Routers Plan of the SAM Region

Administration and location		Type of router	Type of interconnection	Connected router	Link rate		Link Protocol						*Via*		Target date	Remarks	
							Physical layer - link		IP version		Routing protocol						
Admin.	Location				Current	Future	Current	Future	Current	Future	Current	Future	Current	Future		Current	Future
1		2	3	4	5		6							7	8	9	
Argentina	Ezeiza	IP	Inter Regional	AFI (Johannesburg)	N/A	TBD	FDMA FR	TBD	N/A	IPv6	N/A	TBD	CAFSAT	CAFSAT	TBD	B	E
				EUR (Canary Is.)	19.2	TBD			IPv6	IPv6	BGP	TBD			2010	D	D
		IP	Intra Regional	Bolivia (La Paz)	N/A	TBD	TDMA FR - ISDN	TBD	N/A	IPv4	N/A	BGP4	REDDIG	REDDIG II	2012	B	F
				Chile (Santiago)	N/A				N/A		N/A				2011	B	F
				Brazil (Curitiba)	N/A				N/A		N/A				2011	B	F
				Brazil (Manaus)	64k				IPv4		Static				2010	D	N/A
				Paraguay (Asunción)	64K				IPv4		Static				2009	B	F
				Uruguay (Montevideo)	64k				IPv4		Static				2010	C	F
Bolivia	La Paz	IP	Intra Regional	Argentina (Ezeiza)	N/A	TBD	TDMA FR + ISDN	TBD	N/A	IPv4	N/A	BGP4	REDDIG	REDDIG II	2012	B	F
				Chile (Santiago)	N/A				N/A		N/A				2012	B	F
				Brazil (Manaus)	N/A				N/A		N/A				2012	B	F
				Brazil (Curitiba)	N/A				N/A		N/A					B	F
				Paraguay (Asunción)	N/A				N/A		N/A					B	F
				Peru (Lima)	N/A				N/A		N/A				2012	B	F

A	AFTN
B	AFTN + ATS speech
C	AFTN + ATS speech + radar
D	AMHS
E	AMHS + AIDC + teleconference
F	AMHS + AIDC + teleconference + radar

Administration and location		Type of router	Type of interconnection	Connected router	Link rate		Link Protocol						Via		Target date	Remarks	
							Physical layer - link		IP version		Routing protocol						
Admin.	Location				Current	Future	Current	Future	Current	Future	Current	Future	Current	Future		Current	Future
1		2	3	4	5		6							7	8	9	
Brazil	Curitiba	IP	Intra Regional	Argentina (Ezeiza)	N/A	TBD	TDMA FR + ISDN	TBD	N/A	IPv4	N/A	BGP4	REDDIG	REDDIG II	2010	B	F
				Uruguay (Montevideo)	N/A				N/A		N/A				2012	B	F
				Paraguay (Asunción)	N/A				N/A		N/A				2012	B	F
				Bolivia (La Paz)	N/A				N/A		N/A				2010	B	F
			Intra Regional	Colombia (Bogota)	N/A	TBD	TDMA FR + ISDN	TBD	N/A	IPv4	N/A	BGP4	REDDIG	REDDIG II	2010	B	F
				Guyana (Georgetown)	N/A				N/A		N/A				2012	B	F
				French Guiana (Cayenne)	N/A				N/A		N/A				2012	B	F
				Argentina (Ezeiza)	64k				IPv4		Static				2010	D	D
				Bolivia (La Paz)	N/A				N/A		N/A				2012	B	F
				Venezuela (Caracas)	N/A				N/A		N/A					C	F
				Peru (Lima)	N/A				N/A		N/A				2010	B	F
				Suriname (Paramaribo)	N/A				N/A		N/A				2011	B	F
	Recife	IP	Intra Regional	French Guiana (Cayenne)	N/A	TBD	TDMA FR + ISDN	TBD	N/A	IPv4	N/A	BGP4	REDDIG	REDDIG II		B	E
				Uruguay (Montevideo)	N/A				N/A		N/A					B	F
			Inter Regional	AFI (Dakar)	N/A	TBD	FDMA FR	TBD	N/A	IPv6	N/A	TBD	CAFSAT	CAFSAT	TBD	B	E
				EUR (Canarias)												A	D

A	AFTN
B	AFTN + ATS speech
C	AFTN + ATS speech + radar
D	AMHS
E	AMHS + AIDC + teleconference
F	AMHS + AIDC + teleconference + radar

Administration and location		**Type of router**	**Type of interconnection**	**Connected router**	**Link rate**		**Link Protocol**						**Via**		**Target date**	**Remarks**	
							Physical layer - link		**IP version**		**Routing protocol**						
Admin.	**Location**				**Current**	**Future**	**Current**	**Future**	**Current**	**Future**	**Current**	**Future**	**Current**	**Future**		**Current**	**Future**
1		2	3	4	5		6							7	8	9	
Chile	Santiago	IP	Inter Regional	PAC (Christchurch)	N/A	TBD	N/A	N/A	N/A	IPv6	N/A	BGP4	PTT	PTT	TBD	A	D
			Intra Regional	Argentina (Ezeiza)	N/A		TDMA FR + ISDN	TBD	N/A	IPv4	N/A		REDDIG	REDDIG II	2010	B	F
				Bolivia (La Paz)	N/A				N/A		N/A					B	F
				Peru (Lima)	N/A				N/A		N/A				2010	B	F
Colombia	Bogota	IP	Inter Regional	NAM (Atlanta)	N/A	TBD	TDMA FR	TBD	N/A	IPv4	N/A	TBD	MEVA II	MEVA II	2010	A	D
				ACC Kigston	N/A				N/A		N/A					B	F
				ACC Curacao	N/A				N/A		N/A					B	F
				ACC Cenamer	N/A				N/A		N/A					B	F
				Panama (Panama)	N/A				N/A		N/A					B	F
		IP	Intra Regional	Ecuador (Guayaquil)	N/A	TBD	TDMA FR + ISDN	TBD	N/A	IPv4	N/A	BGP4	REDDIG	REDDIG II	2011	B	F
				Brazil (Manaus)	N/A				N/A		N/A				2010	B	F
				Peru (Lima)	N/A				N/A		N/A				2010	B	F
				Venezuela (Caracas)	N/A				N/A		N/A				2011	B	F
Ecuador	Guayaquil	IP	Intra Regional	Colombia (Bogota)	N/A	TBD	TDMA FR + ISDN	TBD	N/A	IPv4	N/A	BGP4	REDDIG	REDDIG II	2011	B	F
				Peru (Lima)	N/A				N/A		N/A				2011	B	F
			Inter Regional	ACC Cenamer	N/A	TBD	TDMA FR	TBD	N/A	IPv4	N/A	TBD	MEVA II	MEVA II		B	F

A	AFTN
B	AFTN + ATS speech
C	AFTN + ATS speech + radar
D	AMHS
E	AMHS + AIDC + teleconference
F	AMHS + AIDC + teleconference + radar

Administration and location		Type of router	Type of interconnection	Connected router	Link rate		Link Protocol						Via		Target date	Remarks	
							Physical layer - link		IP version		Routing protocol						
Admin.	Location				Current	Future	Current	Future	Current	Future	Current	Future	Current	Future		Current	Future
1		2	3	4	5		6							7	8	9	
French Guiana	Cayenne	IP	Inter Regional	ACC Dakar	N/A	TBD	TBD	TBD	N/A	IPv6	N/A	TBD	TBD	TBD		B	F
				ACC Piarco	N/A	TBD	TDMA FR + ISDN	TBD	N/A	IPv4	N/A	BGP4	REDDIG	REDDIG II		B	F
			Intra Regional	Brazil (Recife)	N/A				N/A	IPv4	N/A					B	F
				Brazil (Manaus)	N/A				N/A		N/A				2012	B	F
				Suriname (Paramaribo)	N/A				N/A		N/A				2012	B	F
Guyana	Georgetown	IP	Inter Regional	ACC Piarco	N/A	TBD	TDMA FR + ISDN	TBD	N/A	IPv4	N/A	TBD	MEVA II	REDDIG II	2012	B	F
		IP	Intra Regional	Brazil (Manaus)	N/A	TBD		TBD	N/A	IPv4	N/A	BGP4	REDDIG	REDDIG II	2012	B	F
				Suriname (Paramaribo)	N/A				N/A	IPv4	N/A				2012	B	F
				Venezuela (Caracas)	N/A				N/A	IPv4	N/A				2012	B	F
Panama	Panama	IP	Intra Regional	Colombia (Bogota)	N/A	TBD	TDMA FR	TBD	N/A	IPv4	N/A	TBD	MEVA II	MEVA II		B	F
			Inter Regional	ACC Cenamer	N/A				N/A		N/A					B	F
				ACC Kigston	N/A				N/A		N/A					B	F
Paraguay	Asunción	IP	Intra Regional	Argentina (Ezeiza)	64K	TBD	TDMA FR + ISDN	TBD	IPv4	IPv4	Static	BGP4	REDDIG	REDDIG II	2009	B	F
				Bolivia (La Paz)	N/A				N/A		N/A					B	F
				Brazil (Curitiba)	N/A				N/A		N/A				2010	B	F

A	AFTN
B	AFTN + ATS speech
C	AFTN + ATS speech + radar
D	AMHS
E	AMHS + AIDC + teleconference
F	AMHS + AIDC + teleconference + radar

Administration and location		Type of router	Type of interconnection	Connected router	Link rate		Link Protocol						Via		Target date	Remarks	
							Physical layer - link		IP version		Routing protocol						
Admin.	Location				Current	Future	Current	Future	Current	Future	Current	Future	Current	Future		Current	Future
1		2	3	4	5		6							7	8	9	
Peru	Lima	IP	Intra Regional	Bolivia (La Paz)	N/A	TBD	TDMA FR + ISDN	TBD	N/A	IPv4	N/A	BGP4	REDDIG	REDDIG II	2012	B	F
				Brazil (Manaus)	N/A				N/A	IPv4	N/A				2010	B	F
				Chile (Santiago)	N/A				N/A	IPv4	N/A				2010	B	F
				Colombia (Bogota)	N/A				N/A	IPv4	N/A				2010	B	F
				Ecuador (Guayaquil	N/A				N/A	IPv4	N/A				2011	B	F
Suriname	Paramaribo	IP	Intra Regional	Brazil (Manaus)	N/A	TBD	TDMA FR + ISDN	TBD	N/A	IPv4	N/A	BGP4	REDDIG	REDDIG II	2012	B	F
				French Guiana (Cayenne)	N/A				N/A		N/A					B	F
				Guyana (Georgetown)	N/A				N/A		N/A					B	F
			Inter Regional	ACC Piarco	N/A	TBD	TDMA FR	TBD	N/A	IPv6	N/A	TBD	MEVA II	MEVA II		B	F
Trinidad and Tobago	Piarco	IP	Intra Regional	French Guiana (Cayenne)	N/A	TBD	TDMA FR + ISDN		N/A	IPv4	N/A	BGP4	REDDIG	REDDIG II		B	F
				Guyana (Georgetown)	N/A				N/A		N/A					B	F
				Venezuela (Caracas)	N/A				N/A		N/A					B	F
				Suriname (Paramaribo)	N/A				N/A		N/A					B	F
			Inter Regional	ACC San Juan	N/A	TBD	TDMA FR		N/A	IPv4	N/A	TBD	MEVA II	MEVA II		B	F

A	AFTN
B	AFTN + ATS speech
C	AFTN + ATS speech + radar
D	AMHS
E	AMHS + AIDC + teleconference
F	AMHS + AIDC + teleconference + radar

Administration and location		**Type of router**	**Type of interconnection**	**Connected router**	**Link rate**		**Link Protocol**						**Via**		**Target date**	**Remarks**	
							Physical layer - link		**IP version**		**Routing protocol**						
Admin.	**Location**				**Current**	**Future**	**Current**	**Future**	**Current**	**Future**	**Current**	**Future**	**Current**	**Future**		**Current**	**Future**
1		2	3	4	5		6							7	8	9	
Uruguay	Montevideo	IP	Intra Regional	Argentina (Ezeiza)	64K	TBD	TDMA FR + ISDN	TBD	IPv4	IPv4	Static	BGP4	REDDIG	REDDIG II	2011	C	F
				Brazil (Recife)	N/A				N/A		N/A					B	E
				Brazil (Brasilia)	N/A				N/A		N/A				2012	B	F
Venezuela	Maiquetía	IP	Inter Regional	EUR (Madrid)	N/A	TBD	TBD	TBD	N/A	IPv6	N/A	TBD	PTT	PTT	TBD	A	D
				ACC San Juan	N/A	TBD	TDMA FR	TBD	N/A	IPv4	N/A	TBD	MEVA II	MEVA II		B	F
				ACC Curacao	N/A				N/A		N/A					B	F
				ACC Piarco	N/A	TBD	TDMA FR + ISDN	TBD	N/A	IPv4	N/A	BGP4	REDDIG	REDDIG II		B	F
			Intra Regional	Brazil (Manaus)	N/A				N/A		N/A				2011	C	F
				Colombia (Bogota)	N/A				N/A		N/A				2011	B	F
				Guyana (Georgetown)	N/A				N/A		N/A				2012	B	F

A	AFTN
B	AFTN + ATS speech
C	AFTN + ATS speech + radar
D	AMHS
E	AMHS + AIDC + teleconference
F	AMHS + AIDC + teleconference + radar

Chapter 3 – Definition and Cost of a REDDIG II Satellite Structure Model

1. General

1.1 Satellite communications are the ideal solution for the interconnection of geographically distant sites. Currently, the market offers many technological solutions for these communications, with equipment developed by different manufacturers for different applications.

1.2 It is important to note that, in terms of satellite transmission, the main problem is recurrent monthly costs (OPEX). Also important are matters related to coding and compression, modulation used, and the medium access technique, such as: Time-division multiple access (TDMA), frequency-division multiple access (FDMA) or code-division multiple access (CDMA).

1.3 The REDDIG is a VSAT network made up by sixteen nodes in fourteen countries, with a space segment leased to INTELSAT. The network operates full-meshed, with two management and control centres, the main one being installed in Manaus (Brazil) and the alternate in Ezeiza (Argentina).

Figure 3-1: REDDIG satellite scheme

2. Spectral efficiency

2.1 The REDDIG uses the TDMA medium access method and the Frame Relay layer 2 protocol. It uses two 1,25 Msym/s-carriers, which means a space segment occupation of 1,75 MHz for each, and a smaller one of 0,625 Msym/s, consuming 0,875 MHz. Thus, total utilisation of the space segment is 4,38 MHz.

2.2 Another very important aspect is that the modulation used by the REDDIG is QPSK; which means that it transmits *two bits of information for each symbol*.

2.3 Since the transmission channel can distort and cause information errors, an Error Correction Code is applied, which, in the case of the REDDIG is VITERBI ½, which means that, of every 2 bits transmitted, only *one corresponds to information and the other is used as redundancy for error detection and correction*.

2.4 The 8-PSK is currently used in modern modulation techniques for satellite transmission, which means that 3 bits are sent for each symbol. Likewise, error correction techniques have evolved and modern systems use Turbo-Coding 7/8, where *one redundancy bit is used for every seven bits of useful information*. Therefore, it is felt that a change in the REDDIG satellite platform will significantly improve spectral efficiency.

3. **Medium access technology**

3.1 Regarding the medium access technology to be used, the experience of the Brazilian Administration indicates that it should not be restricted to a specific medium access technology, modulation, error correction code, etc.; the focus should be on the services instead of selecting a specific platform, as long as the basic principle illustrated in the ¨*Introduction Chapter, Figure 1: Basic ATN-REDDIG II Scheme* - *Services*¨ is followed.

4. **Cost**

4.1 The required services can be obtained in different ways, which are analysed below:

4.1.1 <u>Option 1 (current): Leasing of the space segment and management by States, with/without participation of the ICAO Technical Cooperation</u>

4.1.1.1 In terms of investment for the acquisition of the satellite equipment, the FOB costs quoted by various manufacturers to the Brazilian Administration for replacing the TELESAT satellite platform were used as a reference.

4.1.1.2 The most reliable figures suggest an average investment of USD 130,000.00 for each Brazilian TELESAT node. However, the values consider that the Brazilian satellite system is redundant with the land medium, which is the main medium. Thus, the equipment does not have fully duplicated chains.

4.1.1.3 The investment for the REDDIG (which provides an availability of 99,998%) is estimated in *USD 250,000.00 per node*, which is equivalent to a total cost of USD 4,000,000.00 for the sixteen REDDIG nodes. This value includes the two routers required by State. Of course, the values for the REDDIG II will need to be quoted subsequently in the preliminary phase of the project.

4.1.1.4 Table 3-1 summarises the estimated costs for the implementation of the REDDIG II, where both recurrent and non-recurrent charges are considered, with updated partial values:

Satelital			
NRC (Non Recurring Charges)	Valor (USD)	ARC (Annual Recurring Charges)	Valor (USD)
Estaciones Terrenas Completas	4.000.000,00	Repuestos	50.000,00
		Segmento Espacial	227.500,00
		Administrador de la REDDIG	240.000,00
Total	4.000.000,00		517.500,00

Table 3-1: Summary of satellite implementation costs

4.1.1.5 It should be noted that the value for ground stations includes the two routes required by State (USD 20,000.00 each, USD 40,000.00 per earth station).

4.1.2 Option 2: Service contract

4.1.2.1 Another way of providing satellite services is through a service contract, as is the case of the SES service provider for the members of MEVA II, which is the communication network of the CAR Region, which uses the same technology as the REDDIG.

4.1.2.2 Table 3-2 shows the costs of a hypothetical contract with the service provider (SES) for the REDDIG. These costs were derived from the values presented by the company in 2006, based on a cost comparison between the REDDIG (under Regional Cooperation Project RLA 03/901) and the budget submitted by the US company for the services being provided at the time when the interconnection of the two communication networks (MEVA II and REDDIG) was agreed upon.

4.1.2.3 The values are expressed in US dollars and the company proposed to aggregate the REDDIG to MEVA II; prices are considered to be reasonable by comparison. SES charges by number and types of circuits charged, based on which the REDDIG requirements (current circuits) were quantified and quoted.

Nó	PAMA	DAMA	AFTN	RADAR	GNSS	GERÊNCIA	PAMA	DAMA	AFTN	RADAR	GNSS	GERÊNCIA	TOTAL	ANUAL
SAEZ	5	7	9	2	1	1	540,00	826,00	2.205,00	490,00	245,00	1.080,48	5.386,48	64.637,76
SBCT	3	7	4	0	1	1	324,00	826,00	980,00	0,00	245,00	1.080,48	3.455,48	41.465,76
SBMN	5	7	5	1	0	1	540,00	826,00	1.225,00	245,00	0,00	1.080,48	3.916,48	46.997,76
SBRF	0	8	1	0	0	1	0,00	944,00	245,00	0,00	0,00	1.080,48	2.269,48	27.233,76
SCEL	2	6	2	0	1	1	216,00	708,00	490,00	0,00	245,00	1.080,48	2.739,48	32.873,76
SEGU	2	10	3	0	0	1	216,00	1.180,00	735,00	0,00	0,00	1.080,48	3.211,48	38.537,76
SGAS	1	5	4	0	0	1	108,00	590,00	980,00	0,00	0,00	1.080,48	2.758,48	33.101,76
SKED	8	9	10	0	0	1	864,00	1.062,00	2.450,00	0,00	0,00	1.080,48	5.456,48	65.477,76
SLLP	2	6	5	0	0	1	216,00	708,00	1.225,00	0,00	0,00	1.080,48	3.229,48	38.753,76
SMPM	1	5	3	0	0	1	108,00	590,00	735,00	0,00	0,00	1.080,48	2.513,48	30.161,76
SOCA	1	4	2	0	0	1	108,00	472,00	490,00	0,00	0,00	1.080,48	2.150,48	25.805,76
SPIM	4	8	9	0	0	1	432,00	944,00	2.205,00	0,00	0,00	1.080,48	4.661,48	55.937,76
SUMU	5	5	2	3	0	1	540,00	590,00	490,00	735,00	0,00	1.080,48	3.435,48	41.225,76
SVMI	7	4	11	0	0	1	756,00	472,00	2.695,00	0,00	0,00	1.080,48	5.003,48	60.041,76
SYGC	1	5	4	0	0	1	108,00	590,00	980,00	0,00	0,00	1.080,48	2.758,48	33.101,76
TTZP	4	2	2	0	0	1	432,00	236,00	490,00	0,00	0,00	1.080,48	2.238,48	26.861,76
TOTAL	**51**	**98**	**76**	**6**	**3**	**16**	**5.508,00**	**11.564,00**	**18.620,00**	**1.470,00**	**735,00**	**17.287,68**	**55.184,68**	**662.216,16**

Table 3-2: SES costs for the REDDIG

4.1.3 Comparison of Options 1 and 2

4.1.3.1 For comparison purposes, the provision of satellite services takes into account the number and type of circuits charged.

4.1.3.2 *It is also assumed that, in both modalities, the States are responsible for purchasing the equipment for earth stations*. That is, the quote of USD 250,000.00 of SES for a station with duplicated chains is the same as for the REDDIG.

4.1.3.3 Table 3-3 shows a summary of REDDIG costs obtained from the final report of the RCC/13 meeting. Column 2009 shows the cost charged to all nodes, a total of *USD 676,000.00*.

4.1.3.4 It should be noted that this total value includes a significant growth in spare parts due to obsolescence and discontinuation of the main equipment of the REDDIG.

4.1.3.5 A simple analysis leads to the initial conclusion that hiring services is more advantageous than managing and controlling the REDDIG, as is done today.

4.1.3.6 However, the REDDIG uses 73,5% of the hired space segment. In case of a 100% utilisation, the value of USD 662,216.16 presented by SES would increase to an average value of **USD 837,000.00.**

Cuadro 2
Desglose detallado de gastos al 31 de diciembre de 2009

Rubro	2003	2004	2005	2006	2007	2008	2009	TOTAL
BL 11 Expertos								
Administrador REDDIG	22.359	87.650	101.296	157.561	197.784	177.449	207.289	951.388
Experto CNS						1.504		1.504
BL 13 Apoyo Adm.								0
13-01 Secretaría	354	12.185	12.551	0	15.718	18.988	14.069	73.865
13-02 Técnico REDDIG		12.000	12.108	712	250		2.080	27.150
BL 15 Viajes Oficiales		321	925	499				1.745
BL 16 Misiones	3.504	4.110	16.733	18.642	18.357	25.718	11.789	98.853
BL 20 Sub-Contratos								0
21-01 PanAmSat (1 Oct -31 Dic 2003) P.O. 30473	62.727							62.727
21-01 PanAmSat (2004) P.O. 40670		168.849	231.264	231.264	231.264	231.264	231.264	1.325.169
21-98 Seguro Responsabilidad Profesional		845	1.156	3.469			1.156	6.626
BL 39 Capacitación		3.014	53.862	30.553	34.044	32.852	31.084	185.409
BL 40 Equipo								0
45-01 Repuestos		-12.752	59.542	36.312	71.637	34.758	122.925	312.422
45-02 Equipo para Oficina	82		2.083	-30	0			2.135
45.03 Operación y mantenimiento de equipo		1.716	1.781		0			3.497
45.04 Traslado del NCC de SPIM a SBMN								0
PO 40694 VIASAT		8.250						8.250
PO 40687 MEMOTEC		4.250						4.250
45.05 PO 40489 Extensión contrato SEEE		50.000						50.000
45.06 PO 40090 Red de Back-up SEEE		24.820						24.820
45.98 Seguro de responsabilidad profesional(PLI)		444	284	246			1.092	2.066
BL 53.01 Tel., Gastos Bancarios, courier, etc.	643	4.726	4.475	1.150	8.688	5.918	3.016	28.616
BL 53.02 Gastos por Servicios del PNUD		118	505	337	0			960
55.01 Costos Administrativos AOSC	6.439	28.795	35.817	34.695	34.601	33.188	50.897	224.432
TOTAL	96.108	399.341	534.382	515.410	612.343	561.639	676.661	**3.395.884**

Table 3-3: Annual costs of the REDDIG

4.1.3.7 On the other hand, for a proper comparison, the values for spare parts and training for the maintenance of the REDDIG nodes must be eliminated from column 2009 of Table 3-1, giving a corrected value of **USD 522,652.00** for Option 1. The resulting annual difference, **USD 314.348**, *is in favour of the current mode*.

4.1.3.8 *Accordingly, the current operational option is clearly more advantageous.*

4.1.4 <u>Option 3: Leasing of earth stations and hiring of services</u>

4.1.4.1 SES offers another way of providing satellite services to its customers, through hired services and the leasing of earth stations. Even in the absence of a direct quote from the provider of said stations, 2006 values were considered for the equipment and the cards that would need to be installed in the REDDIG and MEVA II nodes involved in the interconnection.

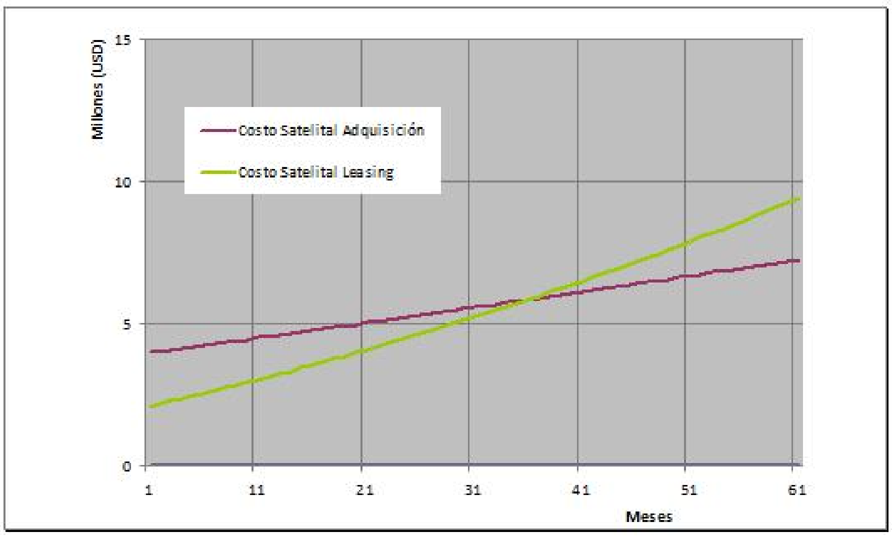
4.1.4.2 The SES quote assumed that the State would be able to purchase the equipment after a period of 5 years of contract, at the symbolic price of USD 1.00. However, it was noted that all the offers included an interest rate of 1.6% per month for *half the total value of the equipment*, since the leasing contract presupposed *a payment of 50% of the total value on the first month*.

4.1.4.3 Accordingly, the *application* of the model to the acquisition of earth stations through a leasing contract results in the costs shown in Table 3.4.

Red Satelital Leasing			
NRC (Non Recurring Charges)	Valor	ARC (Annual Recurring Charges)	Valor
Estaciones Terrenas Complestas	2.000.000,00	Servicios	662.216,16
		Leasing	400.000,00
Total	2.000.000,00		1.062.216,16

Table 3.4: Cost of a satellite network with leased earth station services

4.1.4.4 Another way of comparing costs is shown in Graph 3-1, which reflects the cost of hiring services under the equipment leasing modality, compared to the current REDDIG model, with the purchase of new equipment and the hiring of the space segment. Since the States have the possibility of buying the equipment after 5 years, the comparative time space is limited to 60 months.



Graph 3.1: Satellite network with leased services - Current REDDIG model

5. **Conclusion**

5.1 Studies show that the current method of managing and controlling the satellite network and hiring the space segment represents a clear advantage for SAM States, compared to the modality of hiring the services from a provider, either through leasing or through the purchase of the ground equipment.

Chapter 4 – Definition and Cost of a REDDIG Ground Structure Model

1. Original requirement

1.1 During the thirteenth Technical Cooperation Meeting of the REDDIG (RCC/13), held at the ICAO Regional Office in Lima-Peru, on 9-10 March 2010, an *ad-hoc* group was established with the participation of delegates of Argentina, Brazil and Peru with the purpose of beginning studies for changing the REDDIG platform. The results are shown in Appendix D to Agenda Item 2, which are transcribed as Table 4-1 below:

ESTUDIOS PRELIMINARES A REALIZAR PARA EL CAMBIO DE LA PLATAFORMA TECNOLOGICA DE LA REDDIG

(Información elaborada por el Grupo ad Hoc conformado por Argentina, Brasil y Perú)

1.1 Para el estudio se tuvieron en cuenta los siguientes criterios:

- 1.1.1. Disponibilidad.
- 1.1.2. BER
- 1.1.3. Ancho de Banda (BW).
- 1.1.4. Tecnología actual (equipamiento instalado).
- 1.1.5. Tipos de servicios a ser implementados.
- 1.1.6. Proveedor de telecomunicaciones único.

1.2 Considerando los criterios determinados anteriormente se propone:

1.2.1. Caso 1:

- 1.2.1.1. Analizar una red terrestre principal para las aplicaciones actuales y ATN y los anchos de bandas necesarios.
- 1.2.1.2. Analizar una red satelital de backup para casos de contingencia.

1.2.2. Caso 2:

- 1.2.2.1. Analizar una red satelital principal para las aplicaciones actuales y ATN y los anchos de bandas necesarios.
- 1.2.2.2. Analizar una red de backup para casos de contingencia.

1.2.3. Determinar el equipamiento apropiado.

1.2.4. Realizar estudios de costo beneficio para cada una de las soluciones propuestas.

1.2.5. La solución definitiva (cambio progresivo o completo) será analizada luego de disponer de los costos asociados para poder estudiar el impacto en cada una de ellas.

Table 4-1: Document of the *ad-hoc* Group

1.2 Initially, the idea was to follow the criteria listed in item 1.1. Based on a simple analysis of criteria, it may be concluded that the quotes for ground circuits would be requested for "clear channel" circuits, that is, those that are dedicated and seamless to the protocol.

1.3 It was assumed that this type of circuit isolated the user completely from the ground provider, and ensured that the hired bandwidth was at its full disposal.

1.4 Furthermore, the States would purchase the terminal equipment for multiplexing and routing the services provided by the service provider and entering the equipment of the physical layer (layer 1). Likewise, it was noted that services would be offered by a single company to facilitate maintenance (to avoid proliferation of problems when a complaint must be filed regarding the failure or degradation in the quality of the services).

2. Market offerings

2.1 For this activity, the proposals and quotes submitted by *Telefónica S.A*, *Global Crossing Latin America* and *Empresa Brazileira de Telecomunicaciones* (EMBRATEL) were taken into account. It should be noted that the Administration of Argentina provided the *Telefónica* quote, while the Brazilian Administration provided the other two.

2.2 All of the companies submitted their proposals with circuit availability variations, mentioning the services covered, such as network management and control, and the speed associated to the communication channels. However, *the three companies presented the IP/MPLS* solution as the most feasible for implementation, taking into account network coverage, which many times has the last mile provided by third parties under contract.

2.3 In this sense, other matters should be taken into account for the adoption of the proposed solution, which differs from that stated in paragraph 1.1 of the study conducted by the RCC-13 *ad-hoc* group. Consequently, some important aspects related to MPLS are presented below.

3. MPLS technology

3.1 MPLS is a label-based packet routing technology that, in essence, works with the addition of labels by given routers of the network. The MPLS is indifferent to the types of data transmitted, which can be traffic using the IP (Internet Protocol) or other types of protocol at the entrance of the backbone. From there on, all the routing is based on those added labels.

3.2 Compared with IP routing, MPLS is more efficient since the routing tables for all network assets no longer need to be consulted. Furthermore, its flexibility permits the transmission of messages independently from the stack of protocols used in the upper layers.

3.3 MPLS permits the creation of VPN (Virtual Private Networks), ensuring full isolation of traffic through the creation of label tables that are exclusive for each VPN. It is also possible to do QoS (quality of service) prioritising critical applications, giving differential treatment to traffic between the various points of the VPN. The QoS creates the necessary conditions for a better use of network resources, also enabling the traffic of voice and video applications and other continuous applications in real time.

3.4 Figure 4-1 illustrates packet transmission in a traditional IP network.

3.5 As may be noted in this figure, the routing table is consulted in all the routers, which consumes processing resources and causes a greater delay in the transmission of information.

3.6 This is due to the fact that headers are deleted in each router up to level 3 of the ISO (*International Organization for Standardization*) OSI (*Open Systems Interconnection*) layer.

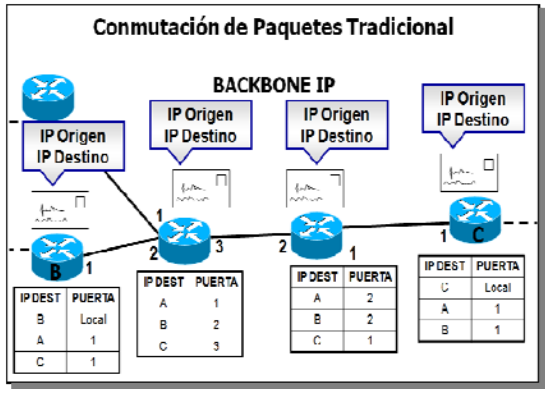


Figure 4-1: IP Switching

3.7 Figure 4-2 shows that packet routing using MPLS is accomplished through a label table, thus eliminating the need to delete packet headers up to OSI level 3. MPLS operates in an intermediate layer in relation to the traditional definitions of layer 2 (link) and layer 3 (network), reason why it was called layer 2.5 protocol.

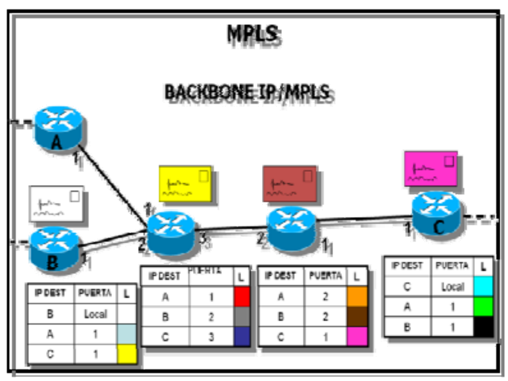


Figure 4-2: MPLS Switching

3.8 In order to achieve complete success in MPLS contracts, it is necessary to establish characteristics in the SLAs *(Service Level Agreements)* to ensure the creation of the VPN using the MPLS, in keeping with RFC 2547 and RFC 3031, and enable QoS configuration over MPLS/VPN, as provided for in RFC 3270 and RFC 2938.

3.9 According to the required SLA priorities and levels, the various types of packets that will circulate through the network will be classified in at least five types of service, following thRFC 2474 and 2475 (*DiffServ*) patterns, supplemented by RFC 2597 (*Assured Forwarding PHB*) and RFC 2598 (*Expedited Forwarding*).

3.10 An example of classification that might be used for QoS configuration follows. *Real time:* Delay- and jitter-sensitive applications, which require packet prioritising and band reservation.

3.10.2 *Critical mission*: Critical interactive applications for the transmission of critical operational information that requires guaranteed delivery and priority treatment.

3.10.3 *Management*: Network management applications using ICMP, SNMP, Telnet, and other protocols.

3.10.4 *Non-critical:* Applications with messages of varying size that do not require immediate attention by users. Even if the contents may be important, these applications may wait until network resources are available.

3.10.5 *Standard*: All the traffic that is not explicitly assigned to the aforementioned classes will be classified as standard or ¨*best-effort*¨. This type of traffic may be transmitted if network resources are available, but should not have a negative impact on the other classes.

4. Proposed MPLS network topology

4.1 Figure 4-3 shows a map illustrating an IP/MPLS network topology in each of the existing REDDIG nodes.

Figure 4-3: Ground Network Model

5. Cost of the MPLS service for the REDDIG II

5.1 With respect to comparative costs of the three aforementioned telecommunication providers, it may be stated that the most advantageous offer in terms of cost-benefit ratio is the one from *Telefónica*. The presence of *Telefónica* in the SAM States is illustrated in Figure 4-4 below, which shows its penetration in most of South America.

Figure 4-4: Current Presence of *Telefónica* in South America

5.2 The main points of the offer from *Telefónica* are listed below:

5.2.1 Availability/link: 99,5% in average.

5.2.2 Transmission rate: 256 kbps.

5.2.3 Monthly cost of each link (average): USD 2,941.00.

5.2.4 Installation of equipment: USD 54.080 (total).

5.3 However, in order to make a proper assessment of the costs of *Telefónica* (with respect to REDDIG expenditure), an availability of 99,998% is required, which is equal to that expected with the existing satellite platform.

5.4 The study contemplated the installation of a second link per node, resulting in an availability increase to 99,9975%. It should be noted that the cost of the backup link normally tends to be higher, since the provider will have to establish another communication medium for the establishment of the last mile, or hire it from a third party.

5.5 Furthermore, the quote did not consider the cost of the routes in each node. Thus, considering an average cost of USD 20,000.00 per router for equipment redundancy, the investment is in the order of USD 40,000.00 for each REDDIG node.

5.6 Table 4-2 contains a summary of the prices of *Telefónica*, in US dollars:

5.6.1 Routers: USD (20,000.00 x 2 x 16), that is, two routers in each of the 16 nodes.

5.6.2 Installation: as proposed by *Telefónica*.

5.6.3 Spare parts: 10% per year of the cost of the routers (0.1 x 640,000.00).

5.6.4 Cost of MPLS: USD (2,941.00 x 2 x 16 x 12), that is, the unit monthly payment x 2 accesses x the number of nodes x 12 months.

Red Terrestre			
NRC (Non Recurring Charges)	Valor (USD)	ARC (Annual Recurring Charges)	Valor (USD)
Costo de Enrutadores	640.000,00	Repuestos	64.000,00
Instalación de Equipos Proveedor	54.080,00	Costo de MPLS (32 accesos)	1.129.344,00
Total	694.080,00		1.193.344,00

Table 4-2: Prices of the Ground Network

Chapter 5 - Comparative Study of Satellite and Ground REDDIG II Models and Costs

1. General

1.1 In the current structure of the REDDIG, the space segment is hired and said segment is managed and controlled by the REDDIG Administration. There is also a backup network made up by ISDN BRI circuits, whose technology is being discontinued by the service providers.

1.2 It is also a fact that the amount of space segment required is directly related to the technology used in earth stations and to the services supported, as stated above.

1.3 However, it should be noted that in the space segment hired, payment is based on the amount of bandwidth hired, whether or not the available capacity is used. Likewise, as already stated, the OPEX is a major problem in satellite communications.

1.4 Furthermore, when hiring ground services based on IP/MPLS, payment is made for the link between the client and the point of presence (PP) of the provider, and for the use of network (cloud) resources involving the QoS configuration of the applications. If network demand is sized consistently, services may be readily added to the hired network.

2. Availability and logistics

2.1 The concept of *availability* is very important in telecommunication networks. Two factors are involved when talking of availability: Mean Time Between Fail (MTBF) and Maximum Time to Repair (MTTR).

2.1.1 MTBF is more related to the quality of the equipment--which is directly related to the manufacturer--and to the health of the facilities (quality of electric power and grounding).

2.1.2 MTTR is related to the logistics available for maintenance and how fast the team in each State conducts such maintenance. Statistically, in case of failure, the shorter the time of unprotected operation of the redundant module while the main equipment is being maintained, the less likely it will be for the system to remain inoperative.

2.2 It should be noted that the REDDIG technicians have received (and continue to receive) proper training through a cyclic training programme, which provides for excellence in the services rendered.

2.3 Meantime, logistics *is a weak point in the process*. This is because the REDDIG lacks expeditious customs procedures for receiving and returning the parts to the ICAO Regional Office in Lima, where spare parts are kept for Project RLA03/901.

2.4 The RCC/9 meeting formulated Conclusion RCC 9/03 “Alternatives for improving spare part logistics for the REDDIG”, which contemplated a study for the creation of a REDDIG spare part warehouse under the free-zone modality, which in the end, did not occur. The practical result, as reflected in the RCC/10 report, is that the equipment import/export times are not as desired, in some cases, taking as much as *12 months*.

2.5 A solution might be the creation of the South American Air Navigation and Safety Organisation, one of whose functions would be to manage the REDDIG. An organisation in which all the States of the SAM Region participate *may* succeed in the development of mechanisms to facilitate and expedite the management of spare parts.

2.6 It may be concluded that the current availability of the REDDIG *could be seriously compromised* because of spare part logistics, and there seems to be no solution until the future regional organisation is created (without concrete implementation times).

3. **Comparative costs**

3.1 The costs associated to the ground and satellite modalities are compared in Tables 5-1 and 5-2, extracted from the respective chapters.

Red Terrestre			
NRC (Non Recurring Charges)	Valor (USD)	ARC (Annual Recurring Charges)	Valor (USD)
Costo de Enrutadores	640.000,00	Repuestos	64.000,00
Instalación de Equipos Proveedor	54.080,00	Costo de MPLS (32 accesos)	1.129.344,00
Total	694.080,00		1.193.344,00

Table 5-1: Cost of the ground solution

3.2 It should be noted that, for the satellite solution, the REDDIG will use more efficient equipment in terms of modulation and error correction codes, resulting in bandwidth optimisation in the order of 30%, as shown in Table 5-2.

Satelital			
NRC (Non Recurring Charges)	Valor (USD)	ARC (Annual Recurring Charges)	Valor (USD)
Estaciones Terrenas Completas	4.000.000,00	Repuestos	50.000,00
		Segmento Espacial	227.500,00
		Administrador de la REDDIG	240.000,00
Total	4.000.000,00		517.500,00

Table 5-2: Cost of the satellite solution

3.3 This comparison should be done through time, since recurrent and non-recurrent charges differ, as shown in Table 5-3:

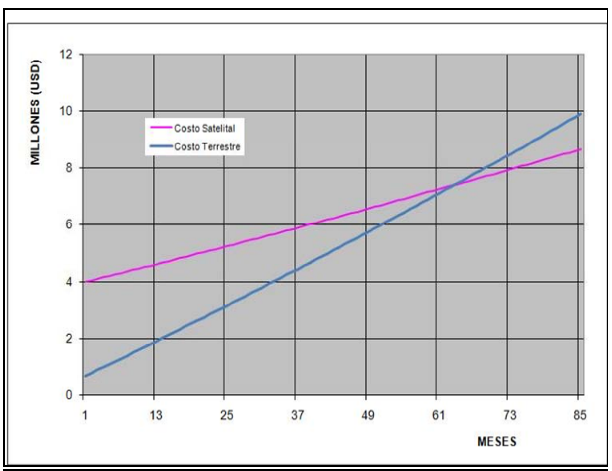


Table 5-3: Comparison of satellite and ground costs through time

3.4 For comparison purposes in the table, a period of seven (7) years was considered--the estimated period currently contemplated for technological changes--, since the old ten-year rule is now obsolete given the fast pace of technological change. An interest rate of 0.2% per month was considered, which represents an annual rate of 2.4% (which reflects the FED in the last 8 years).

3.5 As may be seen in the table, *after five years, ground costs are higher than satellite costs*.

4. Conclusions

4.1 From the *economic* point of view, the final costs at the end of seven years favour the *satellite* solution.

4.2 From the *technical-operational* point of view, it must be recognised that all States have skilled personnel to support their respective stations; thus, the *satellite* solution seems to be the most logical one.

4.3 As to the *availability associated to logistics*, it is felt that the *ground* solution is the most appropriate due to the uncertainty (or potential hazard) involved in the satellite solution.

Chapter 6 - Analysis of the Mixed Model and Proposal of a Final Infrastructure

1. Mixed model

1.1 From the economic and technical-operational point of view, the satellite structure is advantageous to SAM States compared to a purely ground network. On the other hand, the hiring of a parallel ground network guarantees availability (in the first place) and offers a natural increase of such availability. Accordingly, a mixed network configuration, as shown below, could be applied until the South American Air Navigation and Safety Organisation is created.

2. Infrastructure

2.1 The infrastructure is based on the scheme shown in Figure 6-1:

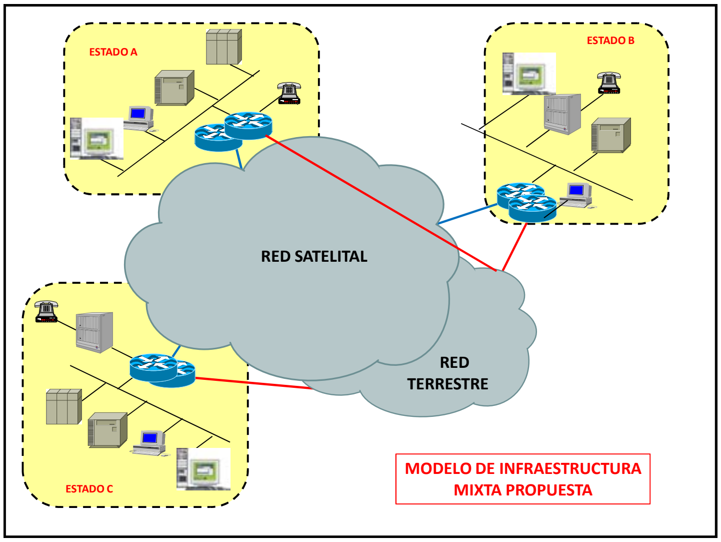


Figure 6-1 – Proposed infrastructure scheme

2.2 The aforementioned network would be a combination of a *main satellite network and a ground network*, which would increase network capacity, for the transmission of new ATN applications and, as already stated, to increase system availability.

2.3 To that end:

2.3.1 The satellite part would have duplicated chains to ensure high availability.

2.3.2 The ground part would have a chain, with the practical availability provided by most ground networks.

3. Availability

3.1 Table 6-1 shows the theoretical availability of the two systems, ground and satellite, in parallel, considering, for calculation purposes, an 8-year average MTBF and a 30-day MTTR. The table shows the significant improvement obtained in this aspect.

Disponibilidad Satélite			
D1	D2	Dparalelo	Descrição
99,900000%	99,900000%	99,999900%	Disponibilidad FRAD
99,900000%	99,900000%	99,999900%	Disponibilidad MODEM
99,900000%	99,900000%	99,999900%	Disponibilidad SSPA
	99,990000%	99,990000%	Disponibilidad Seg. espacial/año
Dsistema:		99,989700%	

Disponibilidad Terrestre			
D1	D2	Dparalelo	Descrição
	99,500000%	99,500000%	Equipo de Capa 1
Dsistema:		99,500000%	

Disponibilidad de dos sistemas e paralelo:	99,9999485002%
Indisponibilidad en minutos por mes:	0,02

Table 6-1: Availability

3.2 It is important to highlight that, under the present circumstances, *there is the potential for the REDDIG availability to be seriously compromised*, as already discussed extensively in the previous chapter. This single reason would warrant a mixed system.

4. **Cost**

4.1 For the adoption of the mixed solution, consideration has been given to a main satellite network with duplicated chains, and a parallel ground backup network, the associated cost of which appear in Table 6-2.

4.2 Another form of mixed network includes a satellite network with a simple chain, which reduces the investment in equipment, as shown in Table 6.3.

4.3 In the proposed model, the cost difference between the mixed and the satellite network will be smaller the sooner the South American Air Navigation and Safety Organisation is created.

Red Mixta			
NRC (Non Recurrin Charges)	Valor	ARC (Annual Recurring Charges)	Valor
Estaciones Terrenas Completas	4.000.000,00	Segmento Espacial	227.500,00
Instalación Equipos Proveedor	54.080,00	Administrador de la REDDIG	240.000,00
		MPLS (16 accesos)	564.672,00
		Repuestos	50.000,00
Total	4.054.080,00		1.082.172,00

Table 6-2: Cost of the mixed network with duplicated satellite chain

Red Mixta (Cadena Satelital Simple)			
NRC (Non Recurrin Charges)	Valor	ARC (Annual Recurring Charges)	Valor
Estaciones Terrenas Completas	2.000.000,00	Segmento Espacial	227.500,00
Instalación Equipos Proveedor	54.080,00	Administrador de la REDDIG	240.000,00
		MPLS (16 accesos)	564.672,00
		Repuestos	25.000,00
Total	2.054.080,00		1.057.172,00

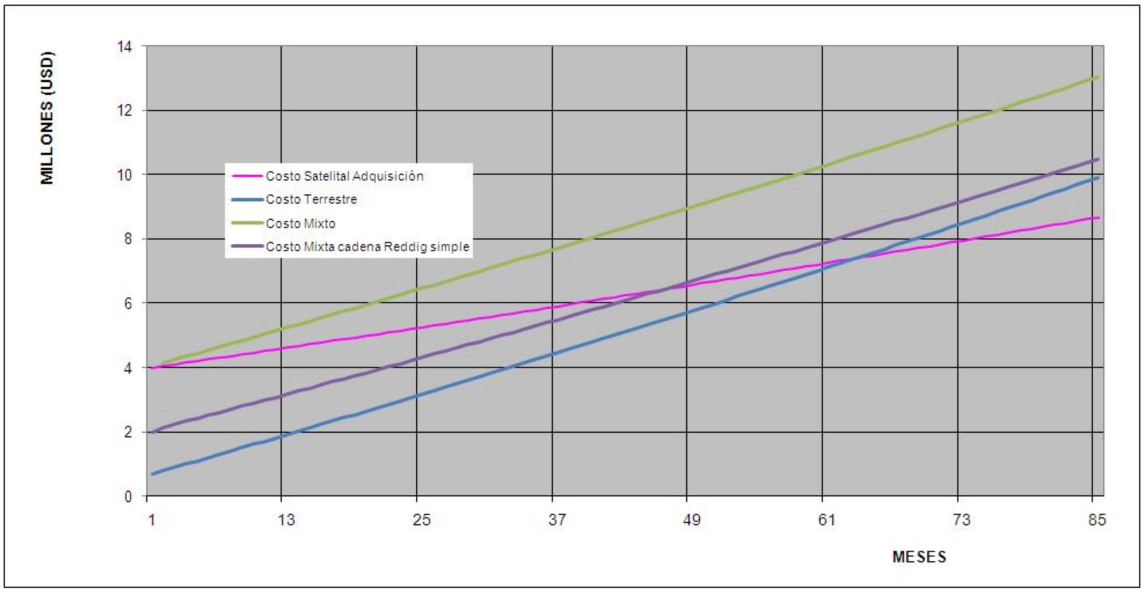
Table 6-2: Cost of the mixed network with duplicated satellite chain

4.4 The quote for the ground proposal assumed that all services would revolve around it, which resulted in a 256K access, with the indicated costs.

4.5 However, used as a redundant system, only critical services (those currently in operation) would have access and only half of the access bandwidth (128K) would be used, thus reducing recurrent costs by at least 2/3 of the indicated value (USD 376,448.00 per year, instead of USD 564,672.00). Thus, at the end of the seven years analysed, there would be a reduction of USD 1,317,568.00.

5. **Comparison of the satellite, ground and mixed models**

5.1 Graph 6-1 shows the associated costs of the four types of networks under study: satellite, ground, mixed (duplicated satellite chain) and mixed (single satellite chain).



Graph 6-1: Comparison of satellite, ground and mixed costs

5.2 It is obvious that the mixed solution with duplicated satellite chain is more expensive. However, it should be noted that:

5.2.1 The required availability is guaranteed, although the potential satellite availability risk will persist until a regional mechanism that ensures the normal mobilisation of spare parts is found.

5.2.2 The States may chose to have access to the redundant network, or stay linked only to the satellite network.

5.2.3 The leasing of 128K of ground access is considered sufficient *prima facie*, thus reducing total cost.

5.2.4 If the South American Air Navigation and Safety Organisation is created prior to the implementation of the mixed solution, it will not be necessary to hire the ground network. Likewise, the ground network service contract may be terminated if said Organisation is not created before implementing the mixed solution.

5.3 Table 6-3 contains a summary of all the numbers presented so far:

Partial cost of the mixed solution after seven years			
Item	**Satellite**	**Ground 1 (256K)**	**Ground 2 (256K)**
Earth stations	4,000,000.00		
Installation		54,080.00	54,080.00
Space segment	1,592,500.00		
REDDIG administration	1,680,000.00		
MPLS		3,952,704.00	2,635,136.00
Spare parts	350,000.00		
Total cost of the mixed solution after seven years			
Pure satellite	7,622,500.00		
Mixed 1 (Satellite + ground 1)		11,629,284.00	
Mixed 2 (Satellite + ground 2)			10,311,716.00
Differences	**Net**	**Percent**	
Mixed 1 - satellite	4,006,784.00	52.57%	
Mixed 2 - satellite	2,689,216.00	35.28%	

Table 6-3: Summary of costs

6. Implementation of services

6.1 A mixed network allows for a wide variety of configuration options. For example, Table 6-4 shows the applications that could be initially used in the ground portion of the mixed network, with the corresponding bandwidth consumption. In this case, *half* of the essential services of each node have been considered, which, for current applications, correspond to AFTN/AMHS, radar data and non-switched speech communications.

State	Location	AFTN			Hot line			Radar			Partial
		Circ.	Vel.	BW	Circ.	Vel.	BW	Circ.	Vel.	BW	
Argentina	Ezeiza	4	2.4	9.6	3	10.0	30.0	2	9.6	19.2	58.8
Bolivia	La Paz	2	2.4	4.8	1	10.0	10.0	0	9.6	0.0	14.8
Brazil	Curitiba	2	2.4	4.8	1	10.0	10.0	0	9.6	0.0	14.8
	Manaus	3	2.4	7.2	3	10.0	30.0	0	9.6	0.0	37.2
	Recife	1	2.4	2.4	0	10.0	0.0	0	9.6	0.0	2.4
Chile	Santiago	1	2.4	2.4	1	10.0	10.0	0	9.6	0.0	12.4
Colombia	Bogota	4	2.4	9.6	4	10.0	40.0	0	9.6	0.0	49.6
Ecuador	Guayaquil	2	2.4	4.8	1	10.0	10.0	0	9.6	0.0	14.8
French Guiana	Rochambeau	1	2.4	2.4	1	10.0	10.0	0	9.6	0.0	12.4
Guyana	Georgetown	2	2.4	4.8	1	10.0	10.0	0	9.6	0.0	14.8
Paraguay	Asunción	1	2.4	2.4	1	10.0	10.0	0	9.6	0.0	12.4
Peru	Lima	4	2.4	9.6	2	10.0	20.0	0	9.6	0.0	29.6

State	Location	AFTN			Hot line			Radar			Partial
		Circ.	Vel.	BW	Circ.	Vel.	BW	Circ.	Vel.	BW	
Surinam	Paramaribo	2	2.4	4.8	1	10.0	10.0	0	9.6	0.0	14.8
Trinidad y Tobago	Piarco	1	2.4	2.4	2	10.0	20.0	0	9.6	0.0	22.4
Uruguay	Montevideo	1	2.4	2.4	3	10.0	30.0	2	9.6	19.2	51.6
Venezuela	Maiquetía	5	2.4	12.0	2	10.0	20.0	0	9.6	0.0	32.0
Total bandwidth of the ground medium											**394.8**

Table 6-2: Example of ground applications of the mixed network