International Civil Aviation Organization

ELEVENTH MEETING OF THE
ASIA/PACIFIC AIR NAVIGATION PLANNING AND
IMPLEMENTATION REGIONAL GROUP (APANPIRG/11)
Bangkok, Thailand, 2 - 6 October 2000

Agenda Item 3: **CNS/ATM Implementation and Related Activities**

EVOLUTIONARY TRANSITION TO CNS/ATM IN THE CAR/SAM (CARIBBEAN AND SOUTH AMERICAN) REGIONS

(Presented by the Secretariat)

SUMMARY

ICAO commissioned a technical cooperation project for the States of CAR/SAM Regions to assist in their transition to CNS/ATM systems..This paper presents an interim report of the project which was submitted to GREPECAS/9 meeting held from 7 to12 August 2000.

Action by the APANPIRG is proposed at paragraph 2.

1. Introduction

1.1 ICAO commissioned a technical cooperation project for the States of CAR/SAM Regions to assist in their transition to CNS/ATM systems. This three years project has been funded by the participating States through UNDP and was established in 1999.This paper presents an interim report of the project which was submitted to ninth meeting of GREPECAS held from 7 to12 August 2000 at Buenos Aires, Argentina.

2. Action by the APANPIRG

2.1 The APANPIRG is invited to note the information provided in this paper.

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EVOLUTIONARY TRANSITION TO CNS/ATM IN THE CAR/SAM (CARIBBEAN AND SOUTH AMERICAN) REGIONS

1. Background

1.1 The ICAO methodology developed for the CAR/SAM Regions and projects based on it indicate that implementation of some of the CNS/ATM elements as well procedures can achieve significant economic, operational and environmental benefits. The figures below are related to the air routes in Latin America/Caribbean alone, but similar calculations could be done for other air routes and regions.

1.2 Operational cost savings associated with the implementation of air routes based on area navigation (RNAV) and required navigation performance (RNP), specifically RNP-10, appear to be significant. For the RNAV routes analyzed during Phase 1, the aircraft operators cost savings is estimated over $10.4 million (all dollar figures given in U.S. currency) per year initially. The cost savings and environmental benefits are achieved through reduced flying time and lower fuel consumption.

1.3 Projected over the life cycle of the CNS/ATM systems implementation phase, operational savings associated with RNAV for the routes studied are expected to amount to some $22.6 million and 23.7 million kilograms of fuel in 2015.

1.4 In the longer term, once the CNS/ATM systems are in place, a saving of some $260 million could be achieved in the CAR/SAM Regions simply by decommissioning the conventional navigation aids (navaids). These economic benefits will be further improved when one considers that some $18.9 million is spent every year on the maintenance, inspection and calibration of the conventional navaids in the two regions.

1.5 The preliminary results of the Phase 1 analysis (explained in paragraph 4.2) are encouraging in part because many more traffic flows remain to be analyzed and their results are likely to add significantly to the operational and economic savings identified to date.

2. Traffic flow analysis

2.1 Before proceeding with detailed planning of the new systems in the CAR/SAM Regions and as recommended by the civil aviation authorities of South America, and endorsed by GREPECAS, ICAO commenced a new project to support GREPECAS in its planning activities and undertake, in consultation with the States concerned, an analysis of traffic flows with the goals of:

a) identifying present and future requirements;
b) evaluating alternative technical and operational solutions;
c) evaluating alternative implementation scenarios;
d) evaluating the viability of the different implementation scenarios; and
e) recommending the most appropriate implementation options.

3. **Current situations**

3.1 Just as in any large and sparsely populated area, the main issues are not related to traffic congestion or complex traffic situation, but are rather associated with the provision of air navigation services necessary to support safe and efficient traffic movements. While some air traffic congestion is being experienced in some parts of the regions, the main issues related to CNS/ATM systems implementation is to provide CNS facilities in a cost efficient manner throughout a vast and thinly populated land mass and large oceanic areas.

3.2 The current lack of coverage available from the conventional CNS systems and the difficulty in sustaining reliable operations in some part of the regions has prevented establishment of uniform separation standards and procedures. Furthermore, complicated coordination procedures for civil and military operations have resulted in the development of less than optimum air routes.

3.3 Consequently, a two-pronged approach has been initiated. In the immediate term, introduction of some CNS/ATM oriented solutions will enhance safety and efficiency and produce significant operational savings for aircraft operators. Secondly, the gradual transition to largely satellite-based CNS systems well suited for this type of operating environment will bring large savings to service providers. The savings will accrue mainly because it will no longer be necessary to replace totally the conventional systems at the end of their service life. Pending the results of operational trials, some portion of the conventional systems might need to be retained for backup purposes.

3.4 In summary, while in regions with dense and complex traffic the main benefits are usually derived from improved air traffic management, regions such as the Caribbean and South America will derive their main benefits from improved CNS infrastructure which in turn will still provide ATM improvements.

4. **Project=s Scope**

4.1 As the immediate benefits are best achieved on the major traffic flows, the project is currently analyzing the 18 traffic flows identified in the CAR/SAM regional plan for the implementation of the CNS/ATM systems. The purpose of these detailed analyses is to eliminate shortcomings such as the present lack of surveillance and communications coverage in remote areas; identify future operational requirements; propose technical and operational solutions and perform the necessary cost-benefits and sensitivity analysis to substantiate the evolutionary introduction of CNS/ATM systems.

4.2 Given the magnitude of the study, the analyses are being undertaken in four phases. The first, in addition to analyzing three traffic flows (Buenos Aires-New York; Sao Paulo/Rio de Janeiro-Miami; and Sao Paulo/Rio de Janeiro-New York) also developed and documented the procedures to be used in all of the analyses.

4.3 From a technical and operational standpoint, the main objectives of the project is to eliminate congestion and improve efficiencies by enabling aircraft to follow their preferred flight profiles and more direct routes, and also establish the foundation from which the transition to CNS/ATM systems, including implementation scenarios, will be accomplished.

4.4 The first three phases of the project have important operational, financial and administrative aspects. To ensure accuracy of the analyses, checkpoints have been established along each of the routes being studied and every air movement recorded. The information gathered includes the origin and destination of the flight; the time over the checkpoints; the type of aircraft in use; the type of flights (scheduled or non-scheduled, cargo, general aviation, etc.) and an indication whether the aircraft were assigned the altitude requested. By knowing the current air traffic patterns and using statistics to forecast traffic growth to the year 2015, it is possible to identify the immediate and long-term requirements and solutions along with their potential economic and environmental benefits.

4.5 By removing shortcomings and deficiencies affecting present operations, one of the immediate benefits is the possibility for early introduction of RNAV/RNP-10 routes. These routes offer shorter distances and reduced flight time will also help to address environmental concerns. From the above, **Appendix A** shows the annual savings that would result from the introduction of RNAV routes on the flows studied during Phase 1, while **Appendix B** provides an estimate of the fuel savings for the same routes. **Appendix C** presents a projection of the savings and environmental benefits over the life-cycle of the CNS/ATM implementation.

4.6 The first part of Phase 2 has also been completed and questionnaires sent to States for the collection of data. The results of the survey will be analyzed in the fourth quarter of 2000. The flows being studied during this phase are:

- Sao Paulo/Rio de Janeiro-Europe
- Santiago-Lima-Los Angeles
- Santiago-Lima-Miami
- Sao Paulo/Rio de Janeiro-Los Angeles
- Buenos Aires-Miami
- Mexico-Dallas/Houston/Los Angeles/Miami

The third phase of the project will complete the analyses of the remaining 9 flows identified in the CAR/SAM regional plan and will tabulate the results.

4.7 The final phase of the project will focus on consolidation. While some immediate improvements can be achieved in the first three phases by establishing RNAV routes and by implementing some of the CNS/ATM elements, the major transition to CNS/ATM systems will only be possible once all of the results have been integrated (for example, it would not be possible to replace a conventional navaid on which an airway is based if that station is also being used for other types of operations.) This fourth phase will go about solidifying the ATM requirements and their related CNS services on a regional or sub-regional basis.

4.8 With Phase 4 consolidation, it will be possible to determine optimum operational and technical solution, and suggest implementation strategies including the provision of services through multinational arrangements. The final phase of the project is really where the introduction of new technologies will support the integration of systems and services resulting in greater efficiencies. This is when the major savings to air navigation services providers will be realized.

4.9 The biggest savings, will come from phase-out of the conventional navaids and from the integration, rationalization and harmonization of systems and procedures and improved services to users. As cited above, the savings associated with the non-replacement of conventional navaids alone could amount to as much as $260 million. As a result of operational trials, should a minimum network of conventional navaids need to be retained, this amount would need to be adjusted accordingly.

4.10 The present inventory of navaids in the CAR/SAM Regions consist of :

- 370 VORs
- 338 DMEs
- 251 NDBs
- 71 PSRs
- 81 SSRs (including those planned as per Regional Plan)
- 58 CAT 1
- 16 CAT II
- 58 CAT II (special)
- 3 CAT III (planned as per Regional Plan)
- 64 DME (co-located with landing system)
- 46 Locators

The results presented in the tables are preliminary and will be refined as more information is made available during the life of the project. One of the key factor in the end results will be the kind of institutional arrangements used to provide services. These services could, for example, be provided through the sharing of some functions or systems or through the delegation of airspace.

4.11 The fourth and final phase of the ICAO project is expected to be completed in early 2002.

5. **Conclusion**

5.1 Having completed the first phase of a project to assist CAR/SAM States in transitioning to CNS/ATM systems, it is evident that significant immediate benefits can be achieved through the implementation of some aspects of CNS/ATM, including RNAV routes on the traffic flows. In the long term, the use of satellite-based technology to provide CNS will bring major economic and operational benefits that can be further augmented through the use of appropriate implementation arrangements.

AIRCRAFT OPERATING COSTS

1. Introduction

1.1 The decision by airlines and States as to whether and when to enter into financial commitments necessary to implement CNS/ATM is not a simple matter and will require numerous studies to first determine the viability and second appropriate timing for the transition. This will be achieved through the performance of costs/benefits analysis by both States and aircraft operators and based on a comparison with the existing systems and operating procedures.

2. Discussion

2.1 Aircraft operators play a major role in the gradual introduction of CNS/ATM. While States have the responsibility for the provision of safe and efficient air navigation services, aircraft operators, who are the end users, must be able to afford these services.

2.2 As part of the evaluation, aircraft operator=s costs/benefits analysis must be performed initially by GREPECAS through Project RLA/98/003 to establish the viability of the project from a user standpoint. No doubt, aircraft operators will and should perform their own analysis to satisfy themselves, confirm the findings and adjust as necessary the figures to their specific operating environment.

2.3 In performing the user aspect of the costs/benefits analysis there are obviously costs associated with the equipage of aircraft, training and ongoing expenses associated with the new CNS/ATM. On the other hand, there are also significant operational benefits such as more direct routes, reduce delays through reduction of separation and the ability to fly their preferred flight profile. These operational benefits translate into reduced flying time and lower fuel-burn.

2.4 In order to keep the analysis manageable, there is a need for average operating cost figures for the most frequently used types of aircraft in the regions. Recognizing that there are no two flights alike (weather, payload, operating environment, staffing, administrative arrangements, etc.) and that for a multitude of reasons costs figures vary significantly between aircraft operators (fleet composition, cost of fuel, maintenance, personnel, etc), consultations with carriers and international organizations were carried out and a review of industry publications and trade journals made. The resulting costs figures and average fuel-burn per block hour of flying time have been developed and are presented in the **Base-Line Aircraft Operating Cost** table. It should be noted that fuel cost, which accounts for roughly 30% of the operating cost, varies significantly and is based on international prices.

2.5 Accepting that the information contained in the table will vary from time to time, it is also recommended that, at regular intervals, the table be reviewed and updated as necessary to ensure the relevance of the information contained and the integrity of the resulting analysis.

2.6 Throughout the different phases of the project, the costs and benefits achieved will vary. For example, the early introduction of RNAV routes and reduced separation will bring immediate important benefits to the airlines through reduced operating cost while requiring minimal additional expenses. At a later stage, the result of the analysis might not be so favorable for the airlines considering that the transition to CNS/ATM will require from the aircraft operators important investments without apparent comparable savings. But, keeping in mind that at that stage, with the increased traffic and resulting congestion, the cost of doing nothing (lost efficiencies) will be the decisive factor.

3. Conclusions

3.1 As part of the evaluation of the viability of transiting to CNS/ATM, costs/benefits analysis will need to be performed, including those for aircraft operators who play a significant role in the overall program. Considering the many operators involved in the CAR/SAM Regions and the many influencing factors affecting cost, a weighted average cost for the different types of aircraft as been produced and is presented in the **Appendix**.

3.2 In order to simplify the evaluation of the potential operational savings and environmental benefits, the **Base-Line Aircraft Operating Cost** table presented in the Appendix should be used in the performance of these analysis keeping in mind that it will need to be updated from time to time to take into consideration price variations for the different elements of the cost.

3.3 In line with the above, the following decision has been formulated:

Decision: Base-Line Aircraft Operating Cost table

That GREPECAS and its subordinate bodies:

a) use the cost figures contained in **Base-Line Aircraft Operating Cost** table in the performance of aircraft operator's costs/benefits analysis; and

b) from time to time, verify and updates as necessary the cost variations associated with the different elements of the table.

4. Action by the Meeting

4.1 The meeting is invited to note the information and approve the decision proposed in paragraph 3.3.

Cost table of CNS/ATM elements

1. Introduction

1.1 The decision by airlines and States as to whether and when to enter into financial commitments necessary to implement CNS/ATM is not a simple matter and will require numerous studies. To assist in the decision making process, costs/benefits analysis comparing existing systems and procedures with the new proposed approach to the provision of air navigation services will need to be performed by both States and aircraft operators.

2. Discussion

2.1 As per ICAO=s Article 28, States have the responsibility for the provision of safe and efficient air navigation services, but nevertheless, transition to new systems should be done in close coordination with aircraft operators, who are the end users of the systems. Their close implication in the planning process will go a long way towards fine-tuning the implementation process and reducing systems overlap or duplication and in turn make the systems affordable.

2.2 The transition from the conventional systems to CNS/ATM will engender very significant expenses and benefits. Among the costs involved are:

a) cost of installing new CNS/ATM elements;
b) cost of certifying new systems;
c) cost of training;
d) cost of running in parallel both the new and conventional systems; and finally
e) cost of removing conventional systems.

Among the benefits are:

a) savings associated with the non-replacement of conventional navaids;
b) savings associated with integration of ATC functions;
c) savings associated with the rationalization of systems and procedures; and
d) savings associated with more efficient routing and reduce separation.

2.3 To measure the viability of the project, the above elements need to be evaluated through costs/benefits analysis. This means that we first need to establish the cost of the present operation including capital cost, the cost of the proposed new CNS/ATM systems and the resulting value of the benefits that would be derived. The analysis are being initially performed by GREPECAS through project RLA/98/003 but no doubt States and aircraft operators will perform their own analysis to satisfy themselves, confirm the findings and adjust as necessary the figures to their specific operating environment.

2.4 In order to keep these analysis manageable and comparisons possible, there is a need to, at least initially, introduce some conformity in the analysis process and costing of the most frequently used types of communications, navigation and surveillance systems utilized in the regions as well as best estimates of the new CNS/ATM systems elements being developed. Consultations with States, international organizations, equipment manufacturers, service providers and aircraft operators have been carried out as well as a review of industry publications and trade journals made with a view to establish such a costing table recognizing that there are:

a) no two installations alike (Site preparation, operational environment, etc.);
b) that for a multitude of reasons costs figures vary significantly between States and regions of the world; and
c) cost of aircraft fitting vary significantly from type to type.

2.5 While it is expected that satellite-based technology will offer significant technical and operational improvements over conventional systems it, can be said that the major financial and operational benefits will be achieved through the integration, rationalization and harmonization of systems. The performance of costs/benefits analysis, using different technical solutions and implementation options, will assist in the determination of the most cost efficient arrangements and implementation schedule noting that improper scheduling will necessitate a longer transition period and as result in increased cost of operation.

2.6 Accepting that the information contained in the cost tables will be a critical element of the costs/benefits studies it is imperative that this information be kept up to date. Recognizing that prices for the conventional systems will vary from time-to-time and that many elements of the new CNS/ATM systems are still at the prototype level, it is recommended that, at regular intervals, the table be reviewed and updated as necessary to ensure the relevance of the information contained and the integrity of the resulting analysis.

2.7 Furthermore, considering that in the analysis of the different traffic flows in the CAR/SAM Regions, two major blocks are involved (USA and States of the CAR/SAM Regions) and that, for a multitude of reasons, the cost of implementing systems and services differ significantly, two prices are being proposed, FAA prices and ICAO prices. This approach will make the analysis closer to reality and as such more credible in the development of business cases.

3. Conclusions

3.1 As part of the evaluation of the viability of transiting to CNS/ATM, costs/benefits analysis will need to be performed to optimize the technical solutions, implementation options and most appropriate timing for the transition. In order to simplify and harmonize these evaluations, the cost figures represented in the **Cost of CNS/ATM elements** table (**Appendix**) should be used as a base, keeping in mind that it will need to be updated from time to time to take into consideration price variations for the different elements of the cost and the evolution of new technology. In line with the above, the following decision is proposed to be formulated by GREPECAS:

Decision: Cost of CNS/ATM elements

That GREPECAS and its subordinate bodies:

a) use the cost figures contained in **Cost of CNS/ATM elements** table in the performance costs/benefits analysis; and

b) from time to time, verify and update, as necessary, the cost variations associated with the different elements of the CNS/ATM systems.

4. Action by the Meeting

4.1 The meeting is invited to examine the information presented in this working paper and approve the decision proposed in paragraph 3.1.

DETERMINING THE COST BASIS FOR AIR NAVIGATION SERVICES (DEPRECIATION/AMORTIZATION)

1. Introduction

1.1 The quality of planning has a considerable influence on the successful outcome of a project and as a final step, must include a business plan that translates the operational and technical requirements into economics.

1.2 As part of this exercise, costs/benefits analysis must be performed to not only establish the viability of the project but also assist in determining the most cost efficient technical solution and implementation scenario. To achieve the above, we need to determine the cost of the new systems contemplated as well as the residual value of existing systems (amortized/depreciated assets) to establish a sound cost base to be used in the performance of costs/benefits analysis and eventually the development of a business plan.

2. Discussion

2.1 While it is important that all costs be included in the analysis, It is essential that these costs be determined in accordance with generally accepted accounting and costing principles. It is recognized that practices and procedures will differ from State to State but nevertheless to make these cost determination acceptable in a multi-national environment, we must strive to harmonize to the extent possible, the rules, procedures, standards or conventions used in the determination of these costs.

2.2 During the Conference on the Economics of Airports and Air Navigation Services (Montreal, 19-28 June 2000), it became evident that most States did not adequately include into their accounting procedures, cost of capital assets (depreciation/amortization of systems). As a result, it was believed that most States not only did not recover the full cost of providing services but also did not have an adequate cost base from which to plan any system transition.

2.3 While the above might have some immediate financial implication, it will, in the planning of the transition to CNS/ATM really complicate if not make impossible the cost benefit analysis process. As a result, the viability of the project might be questionable, the optimum timing of the transition and the allocation of assets/liabilities not acceptable especially in the evaluation of implementation scenarios using multinational facilities and services.

2.4 In line with the above, it was proposed in WP/3 that a common cost table of CNS/ATM elements be used as a base in the performance of costs/benefits analysis. To complement the process, it is also proposed that a common amortization/depreciation period and method of depreciation be used for the determination of the value of the assets.

2.5 **Amortization/Depreciation**

2.5.1 Depending on the state organizational structure, the assets for example, may be depreciated according to government accounting standards which may not reflect the true operating life of the assets concerned or as observed in many cases, they may not be depreciated at all.

2.5.2 In normal accounting practices, the original value of an asset should be depreciated over its estimated life and such depreciation included in the annual cost of the service concerned. In calculating the amount of the cost chargeable, for the depreciation of any item of equipment, it is appropriate to include in the figure established for this purpose, the cost of installation and of any calibration and testing required to render the equipment operational. Similarly, cost of capital incurred on capital invested in fixed assets during their pre-operational phase should also be included as should any non-refundable duties or taxes paid in conjunction with their acquisition.

2.5.3 Because of the lack of accounting information, the determination of costs of existing systems might be difficult if not impossible, therefore, if no historical cost is available, present replacement cost adjusted over time should be used (see paragraph 2.6.6).

2.6 **Amortization/Depreciation Methods**

2.6.1 While practices varies in the calculation of depreciation, the most commonly used methods are the straight-line, the reducing balance method and the annuity method.

2.6.2 **Straight-Line method**. The most commonly used and simplest method is the straight-line method whereby depreciation is charged as a constant amount year after year during the life-cycle of the system concerned. That is, the acquisition and installation costs less the residual value (if any) divided by the expected number of service years.

2.6.3 **Reducing Balance method**. The reducing balance method involves the application of a fixed percentage to the book value of the asset i.e. the historical cost less accumulated depreciation already charged at the beginning of each accounting period. The actual amount of the depreciation charged each year according to this method decreases each year.

2.6.4 **Annuity method**. A third method used is the annuity method where the depreciation charged to each year remains the same throughout the life of the asset concerned. It should be noted that amount charged when this method is applied, includes cost of capital in addition to depreciation.

2.6.5 It should be observed that whatever depreciation method is used, it should be consistently applied throughout the depreciation period of the asset. Furthermore, in order to make the analysis consistent at all levels, (State, Sub-Region, Region) and permit the evaluation of multi-national implementation scenarios, the same method should be used throughout all the states involved in the analysis. Obviously, whatever method is used, the cumulative depreciation should never exceeds 100% of its historical cost.

2.6.6 **Historical cost**. The historical cost mentioned in the preceding paragraph refers to the cost of an asset at the time of its initial acquisition/installation.. In most cases, this cost is not available therefore, an estimate of the cost of the asset concerned needs to be made. This might be done by discounting the replacement cost of the equipment concerned over the period it has been in operation or by using approximations based on the known costs of equipment with similar operational and technical characteristics which performs the same or similar functions. The historical cost should obviously be adjusted if portion of the system has been disposed of or addition made to and the remaining net value depreciated over the remaining or revised life cycle of the system. In cases were systems have been made obsolete, the resid ual value of the asset less any proceeds from disposal (if any) may be added in full to the depreciation charged in the last year of the revised operating life of the asset.

2.7 **Depreciation/amortization period**

2.7.1 Because of the diversity of climatic and other physical, functional or economic factors determining the operating life of a system in different geographical locations, it is difficult to specify specific rates of depreciation for general applications. Nevertheless, considering the magnitude of the project, the many systems involved and the many diverse conditions that exist throughout the regions, it would be impossible to perform the necessary analysis unless a fix depreciation period is agreed to.

2.7.2 Based on information received from States and equipment manufacturers the useful life of electronic equipment can extend to 20 years or so. considering other factors such as obsolescence, changing requirements, etc. it would be prudent to set the depreciation period to 15 years. This figure, while being within the expected life cycle of the systems is also economically reasonable and generally accepted.

3. Conclusion

3.1 The performance of costs/benefits analysis and eventually the development of a business depends on the availability of a good cost base. Considering that it would be impractical if not impossible to establish a detail cost base for all the elements of the systems in the CAR/SAM Regions and that we must strive to keep the planning process manageable, some rules and procedures need to be established to simplify the process while still maintaining the integrity of the analysis. In line with the above, it is propose that GEPECAS accept the following decision concerning rules and procedures to be used in the establishment of the cost base for the performance of costs/benefits analysis (Project RLA/98/003) concerning the planning and implementation of CNS/ATM in the regions.

Decision - Rules and Procedures on the establishment of a cost base for the planning of CNS/ATM in the CAR/SAM Regions

That GREPECAS agrees that, in the establishment of a cost base to be used in the performance of costs/benefits analysis and eventually the development of a business plan that:

a) the depreciation periods for electronic systems (navaids, ACC and the likes) be fixed at 15 years; and

b) the straight-line depreciation method be retained.

5. Suggested action

4.1 The meeting is invited to analyze the information provided in this working paper and take the action suggested in paragraph 3.1.

- END -

Annual savings associated with the introduction of **Rnav routes**

Sao Paulo-Rio de Janeiro/Miami (TF9)

Routes	Conv. Dist	Rnav Dist	Difference	Time saved	Total by types of aircraft Small	Medium	Large	Total savings per AC Types Small	Medium	Large	Total savings Per route/year.
Sao Paulo/Miami	3571	3507	64	8.258	29	203	81	$249,063.23	$2,905,737.63	$1,884,077.42	$5,038,878.28
Rio de Janeiro/Miami	3718	3624	94	12.129	0	82	1	$0.00	$1,723,939.78	$34,163.44	$1,758,103.23
	Total savings per aircraft types/year							$249,063.23	$4,629,677.42	$1,918,240.86	

Sao Paulo-Rio de Janeiro/New York (TF10)

Route	Conv. Dist	Rnav Dist	Difference	Time saved	Total by types of aircraft Small	Medium	Large	Total savings per AC Types Small	Medium	Large	Total savings Per route/year.
Sao Paulo/New York	4168	4106	62	8.000	0	43	55	$0.00	$596,266.67	$1,239,333.33	$1,835,600.00
Rio de Janeiro/NY	4239	4174	65	8.387	0	3	19	$0.00	$43,612.90	$448,849.46	$492,462.37
	Total savings per aircraft types/year							$0.00	$639,879.57	$1,688,182.80	

Buenos Aires/New York (TF11)

Route	Conv. Dist	Rnav Dist	Difference	Time saved	Total by types of aircraft Small	Medium	Large	Total savings per AC Types Small	Medium	Large	Total savings Per route/year.
Buenos Aires/NY	4681	4605	76	9.806	0	64	6	$0.00	$1,087,862.37	$165,729.03	$1,253,591.40
	Total savings per aircraft types/year							$0.00	$1,087,862.37	$165,729.03	

Total savings for the routes/year **$10,378,635.27**

Nominal speed of aircraft = 465 knots. 7.75 nm/min

Aircraft operating cost/hr **Small** = $2,400.00
" " " " " **Medium** = $4,000.00
" " " " " **Large** = $6,500.00

Note: The number of movements is for the sampling period of 19 July to 1 August 1999 **(Two weeks)**

Environmental benefits associated with the introduction of Rnav routes (FUEL-BURN in Kilograms)

Sao Paulo-Rio de Janeiro/Miami (TF9)

Routes	Conv. Dist	Rnav Dist	Difference	Time saved	Total by types of aircraft Small	Medium	Large	Total fuel-burn savings per AC Types Small	Medium	Large	Total savings Per route/year.
Sao Paulo/Miami	3571	3507	64	8.258	29	203	81	280,196	2,687,807	2,376,836	5,344,840
Rio de Janeiro/Miami	3718	3624	94	12.129	0	82	1	0	1,594,644	43,098	1,637,743
	Total fuel-burn savings (Kg) per aircraft types/year							280196	4282452	2419935	

Sao Paulo-Rio de Janeiro/New York (TF10)

Route	Conv. Dist	Rnav Dist	Difference	Time saved	Total by types of aircraft Small	Medium	Large	Total fuel-burn savings per AC Types Small	Medium	Large	Total savings Per route/year.
Sao Paulo/New York	4168	4106	62	8.000	0	43	55	0	551,547	1,563,467	2,115,013
Rio de Janeiro/NY	4239	4174	65	8.387	0	3	19	0	40,342	566,241	606,583
	Total fuel-burn savings (Kg) per aircraft types/year							0	591,889	2,129,708	

Buenos Aires/New York (TF11)

Route	Conv. Dist	Rnav Dist	Difference	Time saved	Total by types of aircraft Small	Medium	Large	Total fuel-burn savings per AC Types Small	Medium	Large	Total savings Per route/year.
Buenos Aires/NY	4681	4605	76	9.806	0	64	6	0	1,006,273	209,074	1,215,346
	Total fuel-burn savings (Kg) per aircraft types/year							0	1,006,273	209,074	

Total fuel-burn savings in Kilogrammes for the routes/year **10,919,525** Kilogrammes

Nominal speed of aircraft = 465 knots. 7.75 nm/min

Aircraft avg. fuel-burn/hr **Small** = 2,700 Kg/hr
" " " " " **Medium** = 3,700 Kg/hr
" " " " " **Large** = 8,200 Kg/hr

Note: The number of movements is for the sampling period of 19 July to 1 August 1999 **(Two weeks)**

Projected Economic and fuel-burn benefits associated with the introduction of **Rnav routes**

Sao Paulo-Rio de Janeiro/Miami (TF9) — **Growth factor** **5.7%**

Routes		1999	2001	2003	2005	2007	2009	2011	2013	2015
Sao Paulo/Miami	$ savings	$5,038,878	$5,629,682	$6,289,756	$7,027,224	$7,851,159	$8,771,699	$9,800,172	$10,949,233	$12,233,019
	Fuel-burn savings	5,344,840	5,971,517	6,671,672	7,453,918	8,327,883	9,304,319	10,395,241	11,614,072	12,975,811
Rio de Janeiro/Miami	$ savings	$1,758,103	$1,964,239	$2,194,544	$2,451,852	$2,739,329	$3,060,513	$3,419,355	$3,820,271	$4,268,194
	Fuel-burn savings	1,637,743	1,829,767	2,044,305	2,283,998	2,551,794	2,850,990	3,185,265	3,558,734	3,975,992

Sao Paulo-Rio de Janeiro/New York (TF10) — **Growth factor** **3.8%**

Route		1999	2001	2003	2005	2007	2009	2011	2013	2015
Sao Paulo/New York	$ savings	$1,835,600	$1,977,756	$2,130,922	$2,295,949	$2,473,756	$2,665,334	$2,871,748	$3,094,147	$3,333,771
	Fuel-burn savings	2,115,013	2,278,808	2,455,288	2,645,435	2,850,309	3,071,048	3,308,882	3,565,135	3,841,233
Rio de Janeiro/NY	$ savings	$492,462	$530,601	$571,692	$615,967	$663,670	$715,067	$770,444	$830,111	$894,398
	Fuel-burn savings	606,583	653,559	704,173	758,707	817,465	880,773	948,983	1,022,476	1,101,661

Buenos Aires/New York (TF11) — **Growth factor** **2.5%**

Route		1999	2001	2003	2005	2007	2009	2011	2013	2015
Buenos Aires/NY	$ savings	$1,253,591	$1,317,054	$1,383,730	$1,453,781	$1,527,379	$1,604,702	$1,685,941	$1,771,291	$1,860,963
	Fuel-burn savings	1,215,346	1,276,873	1,341,515	1,409,429	1,480,781	1,555,746	1,634,505	1,717,252	1,804,188

Total savings over life cycle of project

		1999	2001	2003	2005	2007	2009	2011	2013	2015
All routes	$ savings	$10,378,635	$11,419,332	$12,570,644	$13,844,773	$15,255,293	$16,817,315	$18,547,660	$20,465,053	$22,590,345
	Fuel-burn savings	10,919,525	12,010,524	13,216,953	14,551,488	16,028,231	17,662,874	19,472,876	21,477,670	23,698,885

Base-line

June 12, 2000

Aircraft Operating Costs

Average per block hour

Price of fuel per US Gallon: **$0.80**
(International prices)

Aircraft Type	Max. Cruising Speed mph	Long Range Speed mph	Typical/Max Number Seats	Max Cruise Fuel Cons US GPH/HR	Long Range Fuel Cons US GPH/HR	Long range Fuel cost Block Hr.	Other Flying Ops costs	Aircraft Total Maintnce	Depreciation Other Espenses	Operating Cost block Hr.
A300-600	552	530	266/361	2162	1556	$1,244.80	$1,022.00	$671.00	$230.00	**$3,167.80**
A320-100/200	550	520	125/180	1544	1228	$982.40	$980.00	$483.00	$155.00	**$2,600.40**
A340-500		547	313/+							
DC9-30	579	496	105/119	1333	691	$552.80	$694.00	$666.00	$152.00	**$2,064.80**
DC10-10	547	520	250/380	3108	2277	$1,821.60	$1,179.00	$1,492.00	$458.00	**$4,950.60**
DC10-30	609	563	250/380	3206	2407	$1,925.60	$1,632.00	$1,465.00	$568.00	**$5,590.60**
DC10-40				3210	2400	$1,920.00	$1,179.00	$2,023.00	$390.00	**$5,512.00**
MD-11				2952	2323	$1,858.40	$1,693.00	$643.00	$656.00	**$4,850.40**
MD-80	573	510	130/172	1342	843	$674.40	$985.00	$524.00	$153.00	**$2,336.40**
L-1011-200	596	562	256/400	2508	2284	$1,827.20	$1,076.00	$1,374.00	$365.00	**$4,642.20**
L-1011-500	596	559	256/330	2582	2299	$1,839.20	$1,052.00	$1,422.00	$333.00	**$4,646.20**

Base-line
Aircraft Operating Costs
Average per block hour

June 12, 2000

Price of fuel per US Gallon: **$0.80**
(International prices)

Aircraft Type	Max. Cruising Speed mph	Long Range Speed mph	Typical/Max Number Seats	Max Cruise Fuel Cons US GPH/HR	Long Range Fuel Cons US GPH/HR	Long range Fuel cost Block Hr.	Other Flying Ops costs	Aircraft Total Maintnce	Depreciation Other Espenses	Operating Cost block Hr.
B727-200	610	538	145/189	1494	1418	$1,134.40	$914.00	$795.00	$209.00	**$3,052.40**
B737-200	562	483	95/124	1318	930	$744.00	$1,058.00	$657.00	$230.00	**$2,689.00**
B737-300	565	494	126/149	1280	740	$592.00	$831.00	$496.00	$115.00	**$2,034.00**
B737-400	566	495	147/168	1088	782	$625.60	$1,294.00	$281.00	$91.00	**$2,291.60**
B737-500	566	495	110/132	1176	691	$552.80	$849.00	$554.00	$102.00	**$2,057.80**
B747-100	584	557	374/490	4239	3508	$2,806.40	$2,057.00	$2,775.00	$118.00	**$7,756.40**
B747-200	584	557	374/490	4275	3521	$2,816.80	$2,764.00	$2,384.00	$457.00	**$8,421.80**
B747-400	584	571	420/524	3742	3275	$2,620.00	$2,739.00	$901.00	$501.00	**$6,761.00**
B757-200	581	531	201/231	1658	1142	$913.60	1101	612	273	**$2,899.60**
B757-300	581	531	243/279							
B767-200	566	526	181/255	1767	1209	$967.20	$1,043.00	$911.00	$595.00	**$3,516.20**
B767-300	566	529	218/350	1803	1273	$1,018.40	$1,357.00	$650.00	$391.00	**$3,416.40**
B777	574	557	305/440		1833	$1,466.40	$1,444.00	$476.00	$544.00	**$3,930.40**

July 10, 2000

Cost of CNS/ATM elements

Avionics

Avionics Packages	Estimated Cost.
AMSS	$650,000.00
FANS-1 (B-767) (See Note 4)	$134,000.00
VHF digital voice/data	$14,000.00
VHF voice	$8,000.00
HF Data Upgrade	$20,000.00
GPS for FANS-1(dual)	$58,000.00
FMS Retrofit (MD-11)	$300,000.00
FMS Retrofit (B747-400)	$100,000.00
MMR for GBAS digital	$30,000.00
MMR for GBAS analog	$40,000.00
Controller for analog ILS	$4,000.00

Notes:

1. The target aircraft for the fitting of FANS-1 packages are the B-747-400, B-757, B-767 and B-777
2. All B-777 come factory equiped but not switched on.
3. Factory options are available for the B-747, B-757 and B-767
4. The cost, includes new cockpit printer and MCDU to provide for ATC menus, HMI etc and FMC software upgrades. (Does not include Dual TSO GPS)
5. Presently, there are some 3000 aircraft equiped with FANS-1 and some 50s are bing added every month.
6. It should be noted that the prices provided above, are estimates and relate to the FANS-1 Package. No Figures are yet available for the FANS-A Package.
7. Furthermore, it should be observed that FANS-1 is not an ICAO Standard but is used in the mean time for the transmission of AOC messages, ADS report and other related messages.
8. Prices related to AMSS Packages will be included as they become available.
9. Cost of crew and ATC personel training very significant but yet to be quantified (uniform procedures, etc.).
10. FANS-1 is usually fitted during an aircraft "C" check and takes approximately 2 additional days.

Sources: ICAO Procurement, ICCAIA, Inmarsat, Janes, Finnely Aviation Associates, manufacturers and Industry Documentation

July 10, 2000

Cost of CNS/ATM elements

Navigation

	VOR	DME	VOR/DME	DVOR/DME
Basic Cost (Note 1)	$135,000.00	$125,000.00	$265,000.00	$525,000.00
Installation cost same site (Note 2.)	$50,000.00	$50,000.00	$90,000.00	$100,000.00
Installation cost New Site (Note 3)	$110,000.00	$110,000.00	$150,000.00	$250,000.00
Commisioning (Note 4.)	$50,000.00	$50,000.00	$50,000.00	$50,000.00
Upgrade Kits (Note 5)	$45,000.00	$38,000.00	$80,000.00	$160,000.00
Flight Check updrades (Note 4 & 6.)	$25,000.00	$25,000.00	$25,000.00	$25,000.00

	NDB-100W	NDB-1000W
Basic Cost (Note 1)	$30,000.00	$50,000.00
Installation cost same site (Note 2.)	$15,000.00	$20,000.00
Installation cost New Site (Note 3)	$45,000.00	$50,000.00
Commisioning (Note 4.)	$35,000.00	$35,000.00
Upgrade Kits (Note 5)	$10,000.00	$15,000.00
Flight Check updrades (Note 4 & 6.)	$18,000.00	$18,000.00

Notes

1. All basic equipment configuration is, where applicable, dual TX/RX, monitors, ups, etc.
2. Installation cost, (Same site) include services like FAT, SAT, training etc.
3. Installation at new site also includes normal civil works and appropriate shelter. This figure could be even higher if access roads and the likes were to be added.
4. Flying cost for flight check/calibration/commissioning is $2500.00/hr.
5. Upgrade kits are usually between 30% and 40%. In this table 30% has been used
6. Usually a "flight check" is only to check major parameters unlike commisioning
7. cost of freight, insurance not included but usually amount to 5-10% of the basic cost.

FAA simplified cost table.

Technical Refresh	Low	Mid	High	Disposal
NDB	$10,000.00	$10,000.00	$20,000.00	$30,000.00
VOR/DME	$250,000.00	$300,000.00	$350,000.00	$150,000.00
TACAN	$240,000.00	$270,000.00	$300,000.00	$150,000.00

(FAA) Technical refresh (upgrade kits) have a low and high value. (Includes commissioning).

July 10, 2000

Cost of CNS/ATM elements

Navigation

Navigation Equipment	Estimated Cost	
GNSS UPLINK Master station	$22,000.00/yr	(First year $24,000,000.00)
GNSS Master Station (Note 1)	$8,000,000.00	
GNSS Reference Station	$1,000,000.00	
GBAS (Note 2.)	$850,000.00	

Notes

1 In addition to the uplink to broadcast corrections, a ground communication network will be required to link the different reference stations to the master station.

2 When GBAS is also used as a reference station, it also requires the appropriate ground communication network to link it to a master station.

July 10, 2000

Cost
of
CNS/ATM elements

Communications

Ground Systems	VHF	VHF digital voice/data	HF	HF data	AMSS
Basic Cost (Note 1, 3)	$170,000.00	????	$160,000.00	Leased	Leased
Install same site (Note 2)	$20,000.00	????	$20,000.00	n/a	n/a
Upgrade kits (Note 4)	$51,000.00	????	$48,000.00	n/a	n/a
Freight and insurance (Note 5)	$11,900.00	????	$11,200.00	n/a	n/a

Com. Systems	Cost
ATN Router	$120,000.00
ATN Gateway	$100,000.00

Com. Systems (avionics)	Cost
VHF digital voice/data (Note 7)	????
HFDL Upgrade (Note 6)	$40,000.00
HF voice/data new radio	$60-80,000.00

Notes

1 A typical ground station is composed of 10 frequencies, TX/RX 25 watts, antennas, remote control, batteries, etc.
2 If a voice communication switching system is also involved, add $200,000 to the cost of the basic equipment.
3 A typical HF ground Station is composed of 10 frequencies TX/RX 100 watts
4 As a rule, it is expected that the cost of upgrade kits would be around 30% of the basic cost and very seldom exceed 40%
5 Freight and insurance cost are usually between 5 and 10% of basic cost. In this case 7 1/2% has been used
6 Assumes that the aircraft has a MU or CMU capable of HFDL communications, including antenna and antenna coupler and using existing radio control panel
7 ???? It should be observed that because of the limited demand on this item, no cost figures are yet available

July 10, 2000

Cost Sheet
of
CNS/ATM Elements

Landing Aids

PA and Landing Aids	ILS Cat I/Cat I sp	ILS Cat II	ILS Cat III
Basic Cost (Note 1)	$400,000.00	$425,000.00	$450,000.00
Installation cost same site (note 2)	$100,000.00	$100,000.00	$110,000.00
Installation cost New site (Note 3.)	$200,000.00	$225,000.00	$225,000.00
Commissioning	$75,000.00	$80,000.00	$80,000.00
Upgrade kits (Note 4,7)	$120,000.00	$127,500.00	$135,000.00
Flight check upgrades (Note 5)	$37,500.00	$40,000.00	$40,000.00
Freight and insurance (Note 6.)	$30,000.00	$31,875.00	$33,750.00
Disposal			

Notes

1 Basic cost for the FAA includes installation and commisioning. The mid value is shown in the columns for more details see reduced table below.

2 Installation same site includes services like FAT & SAT, training, etc.

3 Installation on new site includes item identified in note 2 plus civil works and new shelters. This could double the cost.

4 As a rule, it is expected that the cost of upgrade kits would be around 30% of the basic cost and very seldom exceed 40%

5 In the case of upgrades, the flight check would only be to confirm major parameters.

6 Freigt and insurance cost are usually between 5 and 10% of basic cost. In this case, 7 1/2% has been used.

7 For the FAA, the technical refresh includes all aspects right up to certification.

FAA simplified cost table.

New systems	Low	Medium	High	Disposal of systems/restauration
ILS	$398,000.00	$490,000.00	$650,000.00	$150,000.00
CATII ALSF	$778,000.00	$1,110,000.00	$1,440,000.00	$200,000.00
CAT II RVR	$65,000.00	$70,000.00	$80,000.00	
CAT III	$1,200,000.00	$1,250,000.00	$1,300,000.00	
Technical Refresh				
ILS	$220,000.00	$290,000.00	$480,000.00	
ALSF	$400,000.00	$540,000.00	$700,000.00	

July 10, 2000

Cost Sheet
of
CNS/ATM Elements

Area Control Center

ACC Equipment	Estimated Cost
Work Station	
CPDLC	
Single Sector	
Stand Alone	$350,000.00
FANS-1 Work Station.	
Single Sector	
Stand Allone	
CPDLC/ADS	
Air Situation Display	
Limited Controller Tools	$540,000.00
ATM FDPS	
Multi Sector FDPS	$950,000.00
CNS/ATM Work Station	
ATM FDPS	
Single Seat Multi Sector	
CPDLC/ADS/AIDC	
Electronic Flight Strip	
Air Situation Display	
Controller Automation Tools	$2,000,000.00
Each additional seats	$650-700,000.00
Redundanccy (See note 1.)	Special price

Notes

1 With appropriate communications facilities, back-up can be provided by an adjacent ACC.

2 Software support usually amounts to 20% of the software cost of the application whcich is appx 50% of the system cost.

3 Interface to radar processors cost appx $250,000.00

July 10, 2000

Cost Sheet of CNS/ATM Elements

Maintenance and Calibration

Systems		Parts	Labour	Site	Transport	Flight hours # Hours	eq/Ye	Cost
ILS		$2,000.00	$11,800.00	$3,000.00	$300.00			
	Periodical inspection					5	4	$50,000.00
	Commissioning					8		$20,000.00
	Signal check					2 1/2		$6,250.00
VOR		$1,500.00	$7,100.00	$1,000.00	$100.00			
	Periodical inspection					2		$5,000.00
	Commissioning							$0.00
	Signal check					2 1/2		$6,250.00
VOR/DME		$4,000.00	$7,100.00	$1,000.00	$100.00	5		$12,500.00
	Periodical inspection					2	3	$15,000.00
	Commissioning							
	Signal check					2 1/2		$6,250.00
NDB		$2,450.00	$4,700.00	$2,941.00	$250.00			
	Periodical inspection					2	1	$5,000.00
	Commissioning					2		$5,000.00
	Signal check					2		$5,000.00
PSR								
	Periodical inspection					10	2	$50,000.00
	Commissioning					20		$50,000.00
	Signal check							
SSR								
	Periodical inspection					10	2	$50,000.00
	Commissioning					20		$50,000.00
	Signal check							

Note:

1 Flying cost per hour for inspection/commissioning is $2500.00

2 Parts and Labour for the maintenance of the radars are estimated to be 3% of the total value of the equipement per year

ILS Cat I
ILS Cat II
ILS Cat II spec.
ILS Cat III
DME (co-located)
Locolizer
ALS
RVR

Systems/ CNS elements	New installation (1)		Technical Refresh (2)		Maintenance/Yea	DISPOSAL
	ICAO	FAA	ICAO	FAA	ICAO (3,4)	FAA (5)
VHF radio system (6)						
VDL2 radio system						
VDL3 radio system						
VDL4 radio system						
HF Data radio system						
HFradio system						
NDB-100W						
NDB-1000						
VOR						
DME						
VOR/DME						
DVOR/DME						
TACAN						
GNSS Ref Station						
GNSS Master Station						
GNSS uplink						
GNSS grd.net for ref Stns						
GBAS						