INTERNATIONAL CIVIL AVIATION ORGANIZATION
SOUTH AMERICAN REGIONAL OFFICE

FOURTH INFORMAL MEETING ON THE PLANNING AND IMPLEMENTATION OF THE SAM DIGITAL NETWORK

(REDDIG/4)

(Lima, 4 to 8 September 2000)

Agenda Item 3: Administrative aspects for the implementation and operation of the REDDIG
Space Segment

(Presented by the Secretariat)

This working paper presents for the meetings consideration, matters regarding the satellite communications service provider that will be used by the REDDIG. At the same time details related with aspects of the available satellites, the best current options, the type of capacity to be rented, as well as matters dealing with the reservation and payment of the spatial segment once the REDDIG begins its continuous operation.

1. Introduction

1.1 One of the first works that the REDDIG Project Office have done and which results are contained in this working paper and in the technical specifications document (see WP/1), has been the study of the possible satellite communications service provider, and the family of satellites that they offer.

1.2 The election of the service provider is, in a long period of time, a fundamental aspect in this kind of private networks, since it is based in the use of the bandwidth available in a certain satellite, and which cost is recurrent and non amortizable. The correct election of a satellite repeater will provide an important reduction in the costs of the earth equipment to be installed and in the rented bandwidth needed.

2. Election of the service provider

2.1 The first consideration to take into account in order to make a correct election of the communications service provider, involves meeting the nature of the communications to be established. The REDDIG is a private communications network, that rises from the necessity of increase, modernize and improve the current communications of the Aeronautical Fixed Service (AFS) for the actual air navigation services, through the implementation of cost-efficient, fast, reliable and high quality communications. At the same time, it is intended to establish the digital platform that will support the Aeronautical Telecommunications Network of the ICAO CNS/ATM systems and the GNSS augmentation.

2.2 In order to comply with the objective, it must be taken into consideration some aspect detailed below:

a) The service provider must be highly deployed, must own different satellites having similar coverage, to increase security to the network in case of satellite repeater failure.

b) The provider must own satellites with continental coverage are continental and that are in the accurate band frequency, in order to get a bandwidth unique solution for the whole network, and so making possible to decrease the number of transmission carriers at the sites, so the RF equipment to be installed will be of low cost.

c) The provider must have an adequate signatory policy. The final users of the satellite communications private networks are in force to sign contracts with the service providers' through their official signatories in the correspondent State. The International Civil Aviation Organization (ICAO), as a United Nations agency, is a full right signatory of INTELSAT; due to the origin of INTELSAT, which was formed from an international agreement inside of the United Nations. This fact and the REDDIG nature, which was born as an ICAO' Technical Cooperation Regional Project, determine that it is not necessary another signatory for the relation between the REDDIG and INTELSAT, so it can be avoided the administrative costs (markups) that the mentioned signatories are allowed to add to the real cost of the spatial segment in the final users' bills. These markups may vary from State to State but are rarely lower than the 10% of the bandwidth total bill. In a network of this performance where the estimated bandwidth is around 3 MHz., the elimination of these markups is very significant in at long term.

2.3 To prepare the information presented in this working paper, it has been requested, through the INTELSAT United Nations' representative, access to the IBN (*Intelsat Business Network).* In this web site, accessible through a code, it can be obtained all kind of information regarding satellites, available capacities for short and long-terms, reference and consultation material, standards, etc.
This documentation has been the principal source of information that has allowed the satellite election for the implementation of the VSAT nodes of the REDDIG network.

3. The election of the satellite

3.1 Before the revision of the INTELSAT satellites families, that are or will be available and that will have the enough capacity to take the correspondent election, it must be taking into consideration several aspects, among the following:

a) Frequency bands:

The frequency band to be used, must consider the location of the nodes. The weather conditions in each place are fundamental in this election. Moreover, it must be considered that in lower frequencies the power beams of the satellites increase their footprints and decrease their power, affecting the equipment sizes that have to be installed. The parabolic antennas are of larger diameter on lower frequency. In the REDDIG there are nodes located in torrid Equatorial zones, where precipitations are very relevant.
Currently, there are three frequency bands used in satellite communications. Those are C (4-6 GHz.), Ku (12-14 GHz.) and Ka Band (16-18GHz.). The beams of the Ka band, newly used since a short time ago, offering satellite switching for IP traffic applications, are characterized by its small and very located beam an its very high effective isotropic radiant power (e.i.r.p.). This band is highly affected by the weather conditions, and by the moment, there are only a few services providers who offer this kind of *spots* for satellite private communications. The Ku band, very used by the television broadcasting services, and recently by the Internet service providers (ISP), presents located power beams are on the range of 50dBw. The weather conditions of rains affects, in this range of frequencies, in a very important way, reason why Ku Band system installation is not recommended in Equatorial zones. Finally the C band (4-6 GHz.) presents as main characteristic that its beams are hemispherical or zonal, depending of the number of downlink antennas installed in the satellite. The C band has evident advantages regarding the focal area that covers, they are less sensible to the adverse weather conditions, and what is more important, the last generation of satellites presents

e.i.r.p values in C band, on the range of 45 dBw., very close to the Ku band system, so the parabolic antenna diameters in C band as well as it earth stations costs, has decrease significantly in the current installed applications in this band in contrast with its proceedings.

Therefore, considering the REDDIG needs regarding coverage and adverse weather conditions in its Equatorial nodes (Cayenne, Georgetown, Paramaribo, Guayaquil, Bogota, Recife and Manus), it seams to be evident the necessity to reserve capacity in **C band.**

b) Type of beams

In C band, there are at least three types of beams; which has a associated transponder series in the geostationary orbit. This beam varies in its cover, and as a result in its power, in a proportionally inverse relation. The global beams covers approximately a third to the planet, centered in the perpendicular over the Equatorial satellite (sub-satellite point). Its principal advantage is that with the same frequency, networks that cover 3 continents can be developed; for that reason C band is being used in radio-diffusion in those earth areas where does not exist spots of Ku band. GlobalC band beams have two important inconveniences, which are its low e.i.r.p. power (in the range of 35 dBw.) and that the cost of the spatial segment in global beam is a 30% higher than in the zonal or hemispheric beams. The zonal and hemispheric beams have an almost continental cover. The zonal beams divide, in some cases, the continents in different zones. In the new INTELSAT satellites families, there are equal in area coverage with the hemispherical footprints. The difference between the zonal beams and the hemispheric beams is their differences in power. Approximately, zonal beams provide 5 dBw power (almost 4 times) than the hemispherical beams, but both have equal space segment cost. Therefore, it seams reasonable to try to find a **zonal beam with hemispherical cover** in order to take advantage of the power excess of the zonal beam and to decrease the RF equipment costs in the earth stations.

c) Satellites with coverage in South America

With the intention of taking advantage of the features of covering some continents, the communications satellites, commonly have geosincronous Equatorial orbits, which longitudes vary over the oceans. In this regard, INTELSAT distinguishes its IOR satellites constellation (over the Indic Ocean), POR (over the Pacific Ocean) and AOR (over the Atlantic Ocean). The satellites are divided into

families, which incorporate with the time, new technological advantages and more available bandwidth capacity. The AOR satellite families, that are susceptible of being used by the REDDIG, are those of VIII an IX series, due to the lack of useful life time (10years) of the older satellites, and therefore they are not accurate for the REDDIG. The Atlantic satellites of the VIII series, which can be used, are the IS-801 (328,5 °E) and the IS-805 (304.5 °E). The IS-801 presents a hemispheric footprint in South America that does not cover Recife (notice that in the CAFSAT network it is used a global carrier to access this site). In the case of the satellite IS-805, the cover is total in the continent, presenting 40 dBW of e.i..r.p in the west hemispheric beam (WH), but according to IBN information, by the end of the next year, there will not be available capacity in it, and its useful life could be in the limit of the operational period of the REDDIG network, in the step of using of satellites as principal way of transmission.

INTELSAT, once the needs of the REDDIG network were explained to them, have recommended the use of the series IX satellites, that are being planned for service. Over the Atlantic Ocean, there will be orbiting three (3) satellites of this series which are the following: the IS-903 (335,5 °E), the IS-904 (325,5 °E) and the IS-905 (332,5 °E). If it is desirable to take advantage of the continental zonal coverage of this satellites. In this regard the IS-904 (325,5 °E) should be avoided, due to its double South America zonal beams and which use will increase the number of transmission needs carriers. The IS-903 (335,5 °E) will be put into orbit in April 2001 and it is expected to be operational 90 days later. It has a zonal beam power of 45,0 dBW, and of 40 dBW in the hemispheric beam. It will be available for the start of operation of the REDDIG, and INTELSAT accept reservations of spatial segment at large-term in it. The IS-905 (332,5 °E) will be operational after February 2002, with 46,4 dBW of e.i.r.p in the zonal beam, and 40.0 dBW in the hemispheric one.

While the difference between powers (1,4 dbW) significant, all seams to point that the **INTELSAT IS/903, geostatic in 335,5 °E,** is the most appropriate satellite for the REDDIG requirements, nowadays.

As Appendix A to this working paper, the coverage and beams of these satellites in its commercial version, are included.

4. Election of the bandwidth' reservation system

4.1 There are two reservation forms of space segment for the REDDIG bandwidth necessities. Anyone of them will depend on the solution (MCPC – Multiple channels per carrier or TDMA- Time division multiplexing access) and power calculations made by the company that result adjudicated in the biding process.

This ways are the following:

a) IBS Carriers

The fixed IBS carriers (*Intelsat Business Service)* are channel/carrier service. Therefore, each carrier is measured in Kbps. It is a very accurate service for those applications that requires always the same transmission bandwidth in each earth station and which transmitters are simplex asymmetric or duplex. Each carrier has multiple values of 64 Kbps. The IBS carriers can be rented at short or long-term and are available with index of FEC ¾ of ½. Likewise, when transmitting to big earth stations, the FEC ¾ is more efficient. In this service, the antenna requirements, are also more restrictive. The IBS carriers are billed according with the configured capacity of the carrier, so this service is suitable when using a low traffic MCPC system.

With IBS carriers the bandwidth is wasted most of the time, due to the need of completing carriers of 64 Kbps and is almost impossible to assure the expansion of more capacity because of the unavailability of adjacent frequencies to rent within the transponder.

b) Service of transponder rent (lease)

The INTELSAT renting services offers much more flexibility. The rent of bandwidth measured in MHz, allows the establishment of all the need services, including expansion bandwidth. These result are really profitable for the international expandable networks, because it is possible to make transitions from the national to the regional traffic, and also to the international traffic with the growing of both market and traffic volume. They are specially recommended for TDMA networks with wide growing capacity, and allow establishing the ATM or Frame Relay clouds in the space.

The renting segment services can be **NON INTERRUPTUBLE,** in the INTELSAT' highest priority and which service cannot be interrupted once it is rented; they are supported by frequencies in other transponders in case of failure. Evidently, it is obvious to think that the services that will be established for the REDDIG network, in case of a solution of a rented bandwidth type *lease,* this must be **NON INTERRUPTABLE.**

Likewise, INTELSAT establishes two types of tariff categories, normal capacity and premium due to the lower power offered by the series VI and VII satellites. INTELSAT has informed that all series IX satellites should be based onPREMIUM capacity.

In this case the INTELSAT requirement with respect to FEC rates as seen in IBS carriers, disappears, giving the possibility to state if the art options, such as the Turbo Codec®, which use represents a big bandwidth saving.

5. Approximate costs of spatial segment

5.1 From the preliminary studies of topology and link necessities, detailed in Appendixes A and B of the Technical specifications document (REDDIG WP/1), it is obtained the approximated bandwidth necessary to comply with the REDDIG requirements. Even though those depend on the solution adopted by the contractor in the tender process, the exercise of cost of spatial segment, included in this paragraph, is orientative and has as unique purpose, to inform the meeting about its possible approximate costs.

5.2 As the ICAO, through the United Nations, is a signatory of full right of INTELSAT services, the costs expresses in this document, do not have added markups, but the used tariff whenever the REDDIG will be ready to start operations may vary.

5.2.1 Costs orientative exercise

a) **IBS carriers**

In case of a MCPC solution and as the most critical case that can be produced which is the simultaneous communication in all services, using the data of the Appendix B of the technical specifications document and considering a expansion of the space segment of a 30%, the following calculations appear in each earth station:

NODE	BW (Kbps)	BW (Kbps) + 30 %	IBS carriers n x 64kbps	Average of effective use BW (%)
SAEZ	206.4	268.3	320	83.8
SLLP	132.0	171.6	192	89.4
SBCW	152.0	197.6	256	77.2
SBRE	117.6	152.9	192	79.6
SBMU	159.2	207.0	256	80.9
SCEL	145.6	189.3	192	98.6
SKED	192.0	249.6	256	97.5
SEGU	114.4	148.7	192	77..4
SOOO	96.0	124.8	128	97.5
SYGC	98.4	127.9	128	99.9
SGAS	112.0	145.6	192	75.8
SPIM	186.0	241.8	256	94.4
SMPM	98.4	127.9	128	99.9
SUMU	175.2	227.7	256	88.9
SVMI	153.6	200.0	256	78.1
Total	**2138.8**	**2780.7**	**3200**	**86.89**

As detailed in the above table, including the 30% of expansion, the space segment required in the technical specifications document produce a **13%** of wasting space segment.

The IBS carriers cost is fixed. This cost is calculated according with the type of antenna used (commonly standard F1 in this type of applications, with all antennas with equal diameter) and with the same operative number of years, as well as the same types of modulation and FEC (f.e. QPSK ½), and the frequency band. In our case, a cost of USD475.00 per each 64 Kbps each month can be estimated, what shall represent USD 285,000 per year, considering the bandwidth required. If all nodes are quoted in the same way regarding traffic, the annual cost per spatial segment in each node will approximate to **USD 20,500.**

b) **Transponder lease**

Considering Appendixes A and B of the technical specifications document, and adding a thirty percent (30%) of space segment expansion, results the following values of bandwidth measured in KHz may result:

NODE	BW (Kbps)	BW (KHz) + 30 % (QPSK ½)	Cost of annual segment QPSK ½ (*)	Cost of annual segment 8PSK ½ (*)
SAEZ	206.4	375.65	28.565	21.250
SLLP	132.0	240.24	18.268	13.590
SBCW	152.0	276.64	21.036	15.650
SBRE	117.6	214.03	16.275	12.107
SBMU	159.2	289.74	22.032	16.390
SCEL	145.6	264.99	20.150	14.990
SKED	192.0	349.44	26.572	19.767
SEGU	114.4	208.20	15.832	11.778
SOOO	96.0	174.72	13.286	9.884
SYGC	98.4	179.09	13.618	10.130
SGAS	112.0	203.84	15.500	11.531
SPIM	186.0	338.52	25.742	19.150
SMPM	98.4	179.09	13.618	10.130
SUMU	175.2	318.86	24.247	18.038
SVMI	153.6	279.55	21.257	15.814
Total	**2138.8**	**3892.6**	**USD 296.000**	**USD 220.200**

Note that in this case, the real percentage of space segment used for each node is known and the tariff for each node could be exactly calculated (*).

As detailed in the above table, including a 30% if spatial segment expansion required in the technical specifications document, it is not produce any spatial segment wasting, excepting the percentage that goes from 3,893 MHz. to 4 MHz which is required to rent and that represent the **2,67%**.

The cost of transponders bandwidth renting is also fixed. This cost depends only if it is required a renting of a large-term, non interruptible and with premium capacity of limited connectivity, as must be placed for obvious security reasons. In this case the total cost of 4 MHz. shall be **USD 296.000,** in case of lease. It is possible to move from QPSK to 8PSK with which the segment cost decrease an additional 33%, remaining the total required bandwidth in 2,6 MHz, with a cost of **USD 220,200.**

Notice that in this case, the expansion of services or the incorporation of new nodes are much easier, and typical problems of IBS carriers are not presented when trying to find adjacent space segment.

c) Notes

- The data contained in the above paragraphs can be found i the current INTELSAT tariff manual. These tariffs may vary whenever the REDDIG operation could be ready to start.

- The exercise produced in this section is merely informative, so it can be not exact. Likewise, in case of TDMA solutions, it is not being taking into account; the existing traffic burst capacity, which cause a reduction even higher of total bandwidth required in the network. The contractor will be who have to make, according with the presented engineering solution, the calculation of the real costs, coordinating their results with the REDDIG Project Office.

- The preceding calculation is based on the lack of markups due to the existence of local signatories. In case of being necessary to rent through a local signatory, the spatial segment costs could increase substantially.

- It has been considered for calculation all the services specified in Appendix B of the technical specifications document. Any modification on the mentioned Appendix will imply a new analysis of the exercise.

- In this exercise, the derived costs of the ISDN backup lines had not being taken into account. This lines are going to be used upon demand, when a fault may occur in the main transmission way. The cost of this line should be similar to a PSTN line.

6. Conclusions

6.1 The meeting is invited to:

a) Consider INTELSAT as the more suitable service provider to supply the space segment required for the REDDIG network;

b) agree that the INTELSAT IS-903 satellite, geostationary at 335.5 °E, using C band and with continental zonal transponder (CWZ) is the best current option to make the implementation;

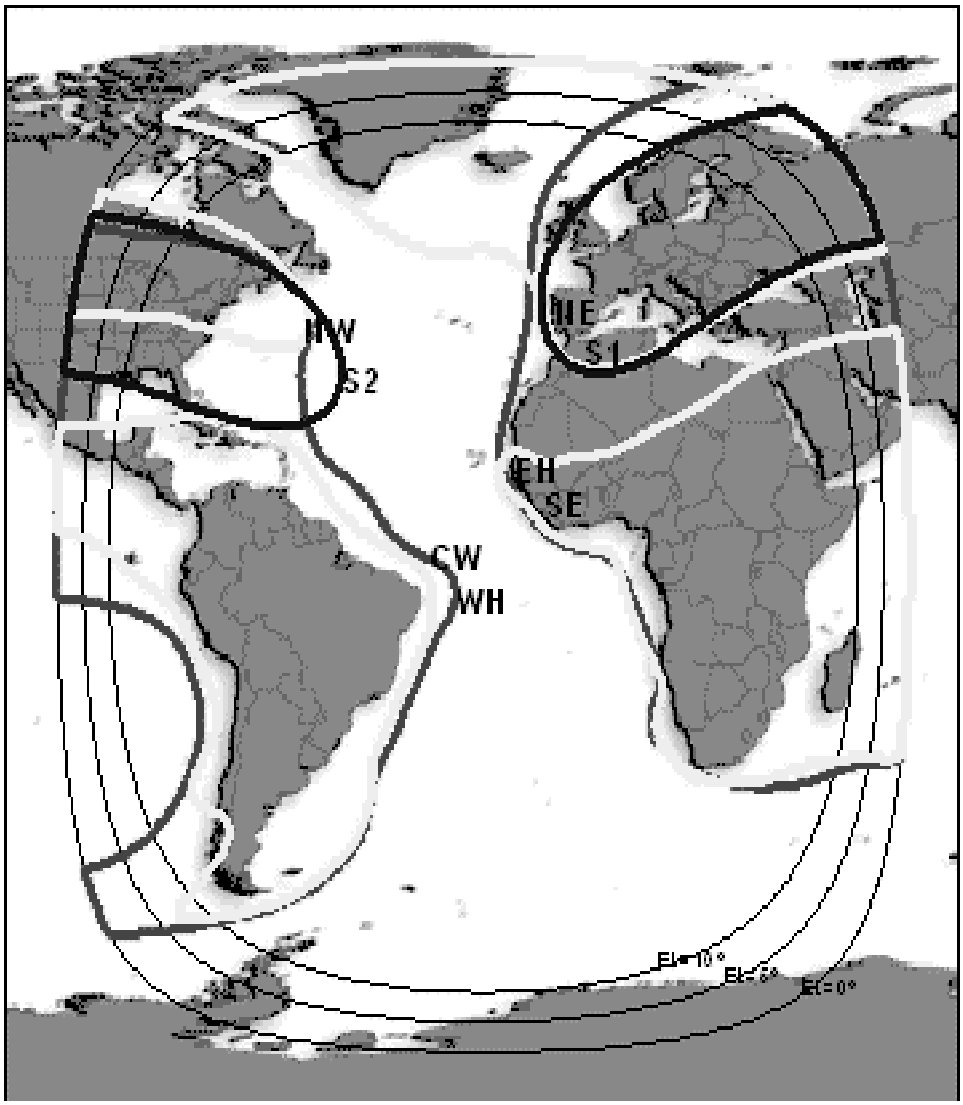
c) take note on the different of available space bandwidth reservation in the service provider, described in the section 4 of this working paper, considering that the contractor must be who determine, through an appropriate study, the best option for the implementation of the SAM digital network (REDDIG);

d) take into consideration the possible recurrent cost of space segment for the REDDIG, described in section 5 of this working paper, complying with the established requirements of Appendix B of the Technical specifications document.

e) Consider the convenience of using schemes of modulation and algorithms of amendment of more frequent mistakes, in order to optimize the use of space segment.

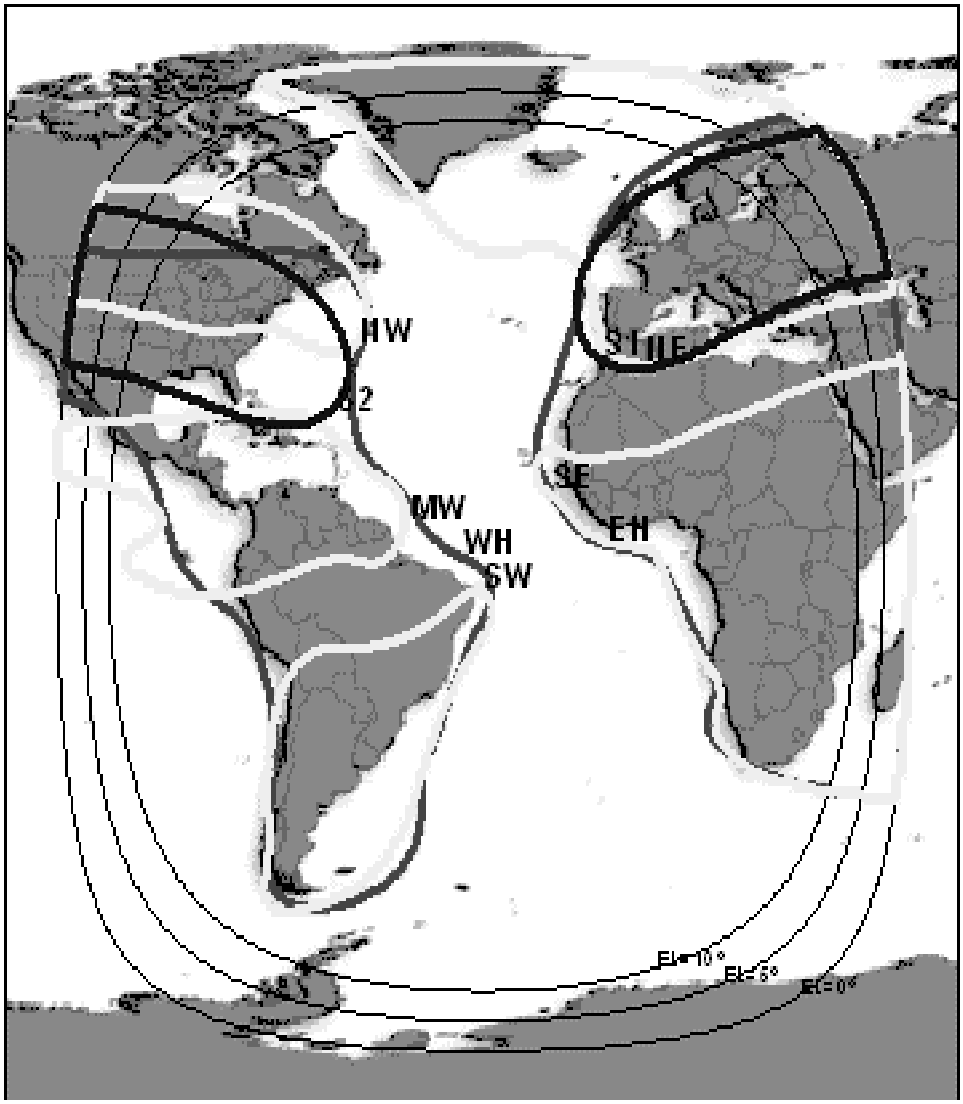
APÉNDICE A

Map of satellite coverage: **INTELSAT IS-903 @ 335.5 °E**
Date of commissioning: April 2001
Date of end of operation: + 14 years



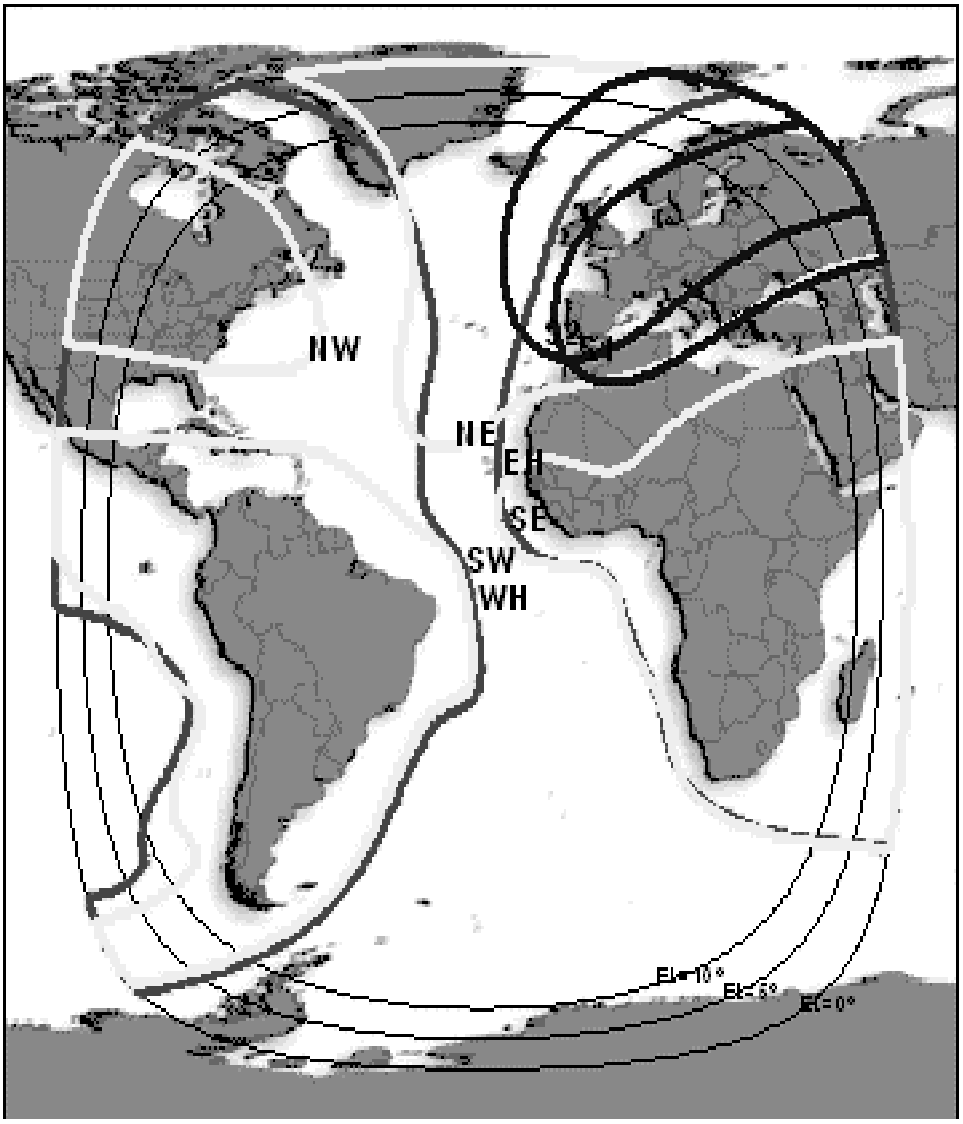
APPENDIX A

Map of satellite coverage: **INTELSAT IS-904 @ 325.5 °E**
Date of commissioning: June 2001
Date of end of operation: + 14 years



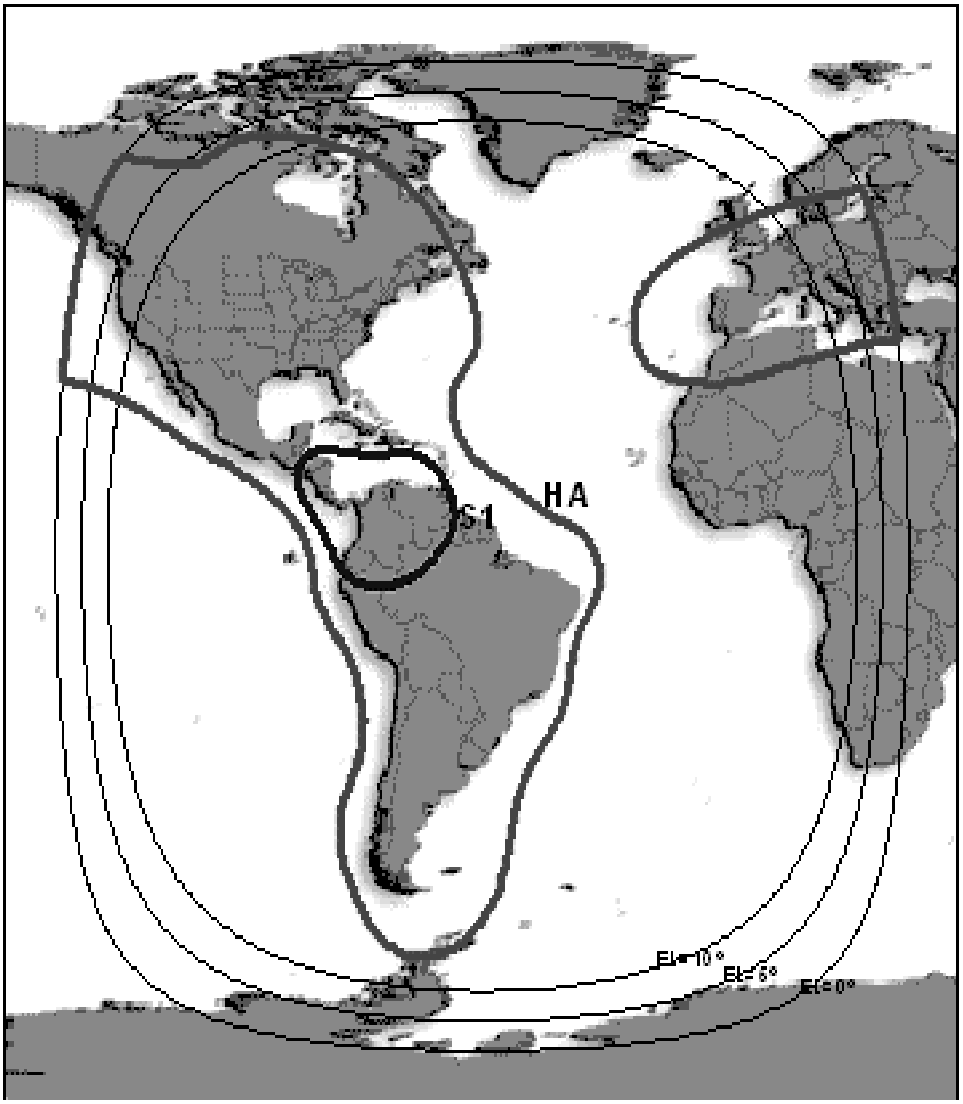
APPENDIX A

Map of satellite coverage: **INTELSAT IS-905 @ 332.5 °E**
Date of commissioning: January 2002
Date of end of operation: + 14 years



APPENDIX A

Map of satellite coverage: **INTELSAT IS-805 @ 304.5 °E**
Date of commissioning: June 1998
Date of end of operation: + 14 years



APPENDIX A

Map of satellite coverage: **INTELSAT IS-801 @ 328.5 °E**
Date of commissioning: November 1997
Date of end of operation: + 14 years