International Civil Aviation Organization
CAR/SAM Regional Planning and Implementation Group (GREPECAS)
Fifteenth Meeting of the CAR/SAM Regional Planning and Implementation Group (GREPECAS/15)
Río de Janeiro, Brasil, 13 – 17 October 2008

Agenda Item 2 Global and inter-regional activities

2.1 Inter-regional and intra-regional CNS/ATM activities and coordination

COMMUNICATIONS PERFORMANCE IN OCEANIC AND REMOTE REGIONS AND THE WORK OF THE FUTURE AIR NAVIGATION SYSTEM SATCOM IMPROVEMENT TEAM (FANS SIT)

(Presented by the United States of America)

SUMMARY

This working paper presents the United States Federal Aviation Administration (FAA) perspective on satellite data communications service provision and data link performance problems that have impacted service. It summarizes the positive effect of the work of the FANS SIT over the last year and recommendations to achieve the targeted Required Communications Performance (RCP) for 30/30nm operations.

1. Introduction

1.1 The Future Air Navigation System (FANS-1) was developed by Boeing, Honeywell and ARINC in the early 1990's as a communications/surveillance enhancement for the 747-400 in oceanic and remote areas. Later introduced in the Airbus fleet in accordance with the Boeing-maintained FANS-1 document as FANS-A, it is now known as FANS1/A. Data communication services were introduced to South Pacific oceanic operations in 1995 using FANS 1/A data link technology.

1.2 Applications based on FANS 1/A include ATS Facilities Notification (AFN), Controller-Pilot Data Link Communications (CPDLC), and Automatic Dependent Surveillance-Contract (ADS-C). These applications enable greater air traffic control (ATC) flexibility along with reduced oceanic separation and provide the platform for the following emerging services:

i) ADS-C In Trail Procedures – Separation down to 15 nautical miles (nm) for climb and descent through a blocking aircraft;

ii) Tailored Arrivals – Optimized arrival profile up-linked to aircraft and loaded into FMS;

iii) Waypoint Management – Managed in-flight spacing using FANS for delivery of controlled times at strategic points; and,

iv) 4-D Trajectory Optimization – Frequent enhancements to flight profiles are up-linked via CPDLC.

1.3 Based on ICAO standards, the introduction of satellite data link service for communications and surveillance has allowed ATC units to introduce reduced oceanic separation standards (e.g. 50nm longitudinal and 30nm lateral/30nm longitudinal [30/30]) that require a minimum level of communications and surveillance performance. There are also other strategic imperatives (e.g. elimination of third-party high-frequency (HF) voice communications) that add demand to existing systems and require a minimum level of availability and consistent performance of the data communications system that is not being achieved currently.

2. Discussion

2.1 Outages and inconsistent performance in satellite data link service has reduced Air Navigation Service Provider (ANSP) and airline confidence in end-to-end service. From September 2006 to August 2007, Oakland Center (ZOA) experienced 38 unplanned communication service outages. Even though FANS SIT investigation reported that many of the outages in the satellite subnetwork were of very short duration, ATC reported thirty-one of those outages were equal to or greater than ten minutes. Outages of greater than ten minutes require application of larger separation standards which may necessitate the delivery of a considerable number of re-clearances via back-up communications. This has focused the work of the FANS SIT towards reducing the recoverability time of the satellite subnetwork in the event that large numbers of aircraft are forced to log-off and on again to the same Ground Earth Station (GES) – the achievable target considered to be 1000 aircraft within five minutes.

2.2 For over the past two years, 50nm longitudinal and 30/30 operational trials have been conducted by the Airways Corporation New Zealand, Airservices Australia and the FAA. In October 2005, Airservices Australia and Airways New Zealand suspended trials in the South Pacific for two months due to availability issues via the Perth GES.

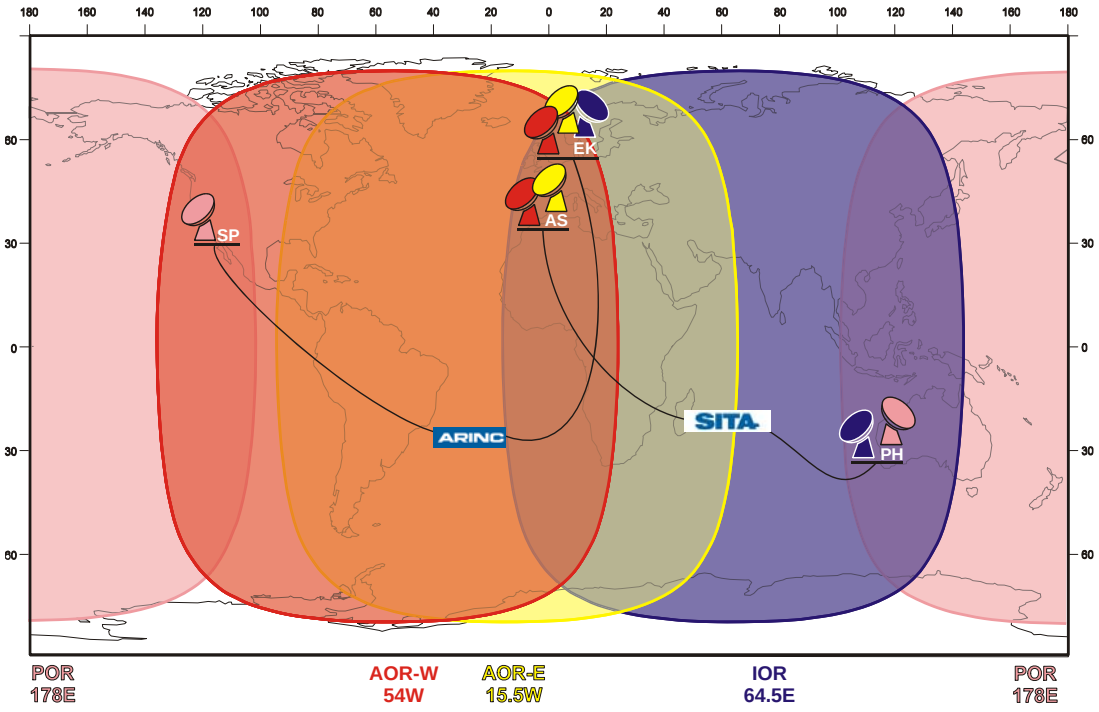
2.3 The FAA introduced 30/30 separation standard operational trials in Oakland Oceanic Control Sector 3 in December 2005. In March 2007, these operational trials were restricted to climb/descent due to Perth GES communications thread issues. In late March 2007, the FAA made the determination to expand the 30/30 trials to the entire Oakland Flight Information Region (FIR); however, the expansion remained restricted due to satellite data link problems. A pattern of inconsistent performance and periodic outages of the Perth GES resulted in substantial efficiency loss during the trials.

2.4 The closure of Goonhilly GES sharply reduced the capability of the satellite communications system to recover from single GES failures. This event raised concerns in the North Atlantic (NAT) region regarding the performance of the satellite services used for ATC communication. Furthermore, both satellite data link communications service providers (ARINC and SITA) indicated that neither service provider had sufficient means or capacity to act as a back up in the event of a catastrophic failure of the other GES'.

2.5 Service availability, via "alternate GES'" has been impacted by the following GES closures:

i) Sentosa located in Singapore, 2003;
ii) Yamaguchi located in Japan, March 2006;
iii) Goonhilly located in United Kingdom, February 2007; and,
iv) Southbury located in United States, March 2008 (when Atlantic Ocean Region, West [AORW] aero operations transferred from Southbury to the Eik ground station making it a three ocean region station).

2.5.1 The satellites now all link to only four GES' (Eik, Aussaguel, Santa Paula, and Perth), each connected either to SITA or ARINC. However, each ocean region is supported by two GES'.



I3 Constellation and Classic Aero Networks

Datalink service provision (March 27th 2008 onwards)

	LESO	CSP	AOR-E	AOR-W	POR	IOR
Eik	Vizada	Arinc	X	X		X
Santa Paula	Vizada	Arinc			X	
Aussaguel	Vizada	SITA	X	X		
Perth	Stratos	SITA			X	X

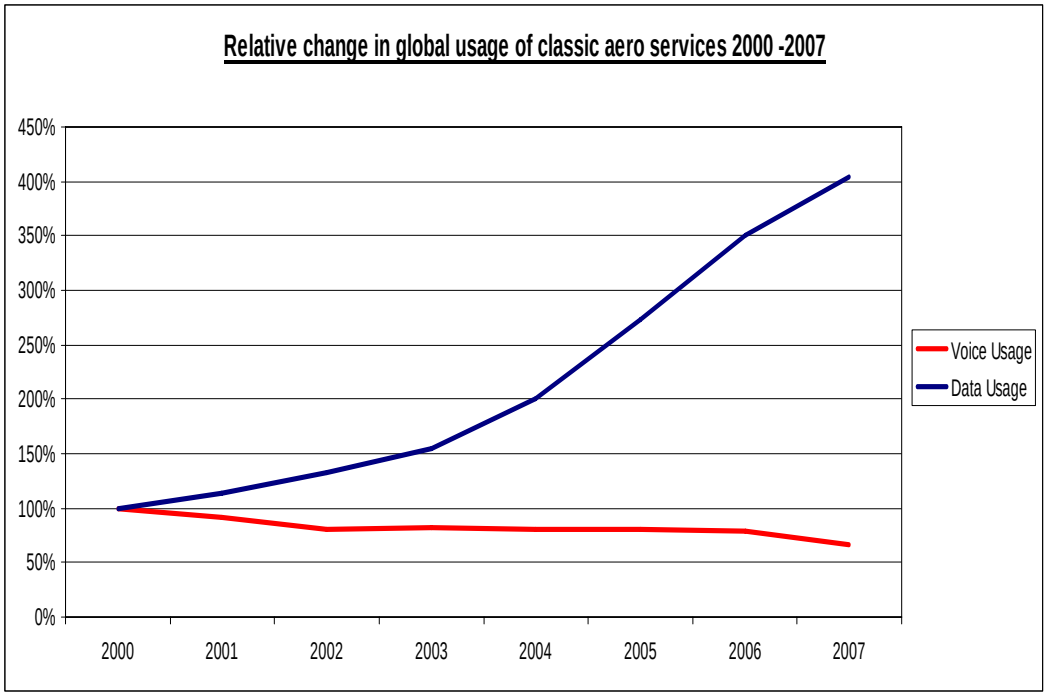
2.6 On November 15-16, 2007, a special meeting of the NAT Systems Planning Group Meeting (NAT SPG Special 2007) was convened to specifically address the loss of dual-GES redundancy in the NAT and elsewhere due to closures of GES'. NAT SPG Special 2007 considered the following issues:

i) Technical requirements to ensure GES redundancy;
ii) Cost to ensure GES redundancy;
iii) Communications requirements necessary to implement and improve the level and efficiency of services;
iv) Effects on the HF infrastructure;
v) Monitoring requirements;
vi) Cost of doing nothing taking account of forecasted increases in traffic and "Open Skies"; and,
vii) Incentives to meet the communications requirements such as the use of FANS with redundant GES only.

2.7 In addition to concerns about availability, there are equal concerns regarding capacity. The data link network is shared among messages carried for safety services and those for routine information. There is the prospect for booming demand for both safety service and routine messages. As reduced separations come online in various regions, ADS reporting rates will increase demand significantly.

2.8 Currently in the NAT, 55% of the fleet use Flight Management System (FMS) waypoint reporting (WPR) or FANS 1/A ADS-C. In the Pacific Region, 80% of the fleet in the South Pacific and 60% in the Central Pacific use CPDLC and ADS-C based on FANS 1/A.

2.9 Over the past three years, Aircraft Communication Addressing and Reporting Systems (ACARS) data traffic has grown yearly by 13%. With Open Skies and reduced separation minima, SITA estimates growth to become 20% yearly by the end of 2009. There are European mandates for data link services to enable increased ATC capacity. Historic trends and current plans suggest that service demands will continue to grow.



2.10 Only two GES' currently serve the NAT Region (Aussaguel and Eik), but neither of them has the capacity to carry all of the current NAT data link traffic. If one of them failed, a significant number of data link aircraft would need to revert to HF voice communications, or switch to the remaining GES. Although a proportion of the aircraft would be able to switch to the remaining GES, a continual stream of log-on requests would continue to load the operating GES. Under the current configuration, this could affect the efficiency of that GES service to the existing aircraft connections.

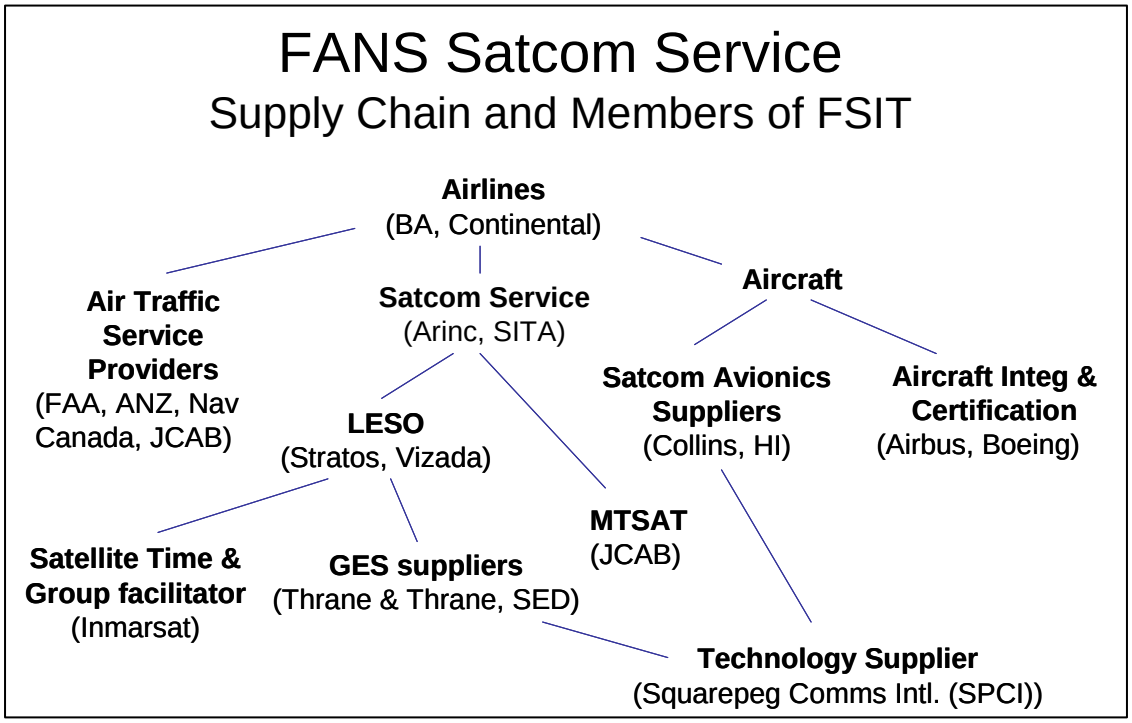
2.11 Lack of adequate aero backup capacity affects the ability of communications service providers to meet performance objectives specified in Service Level Agreements. System performance objectives were developed based on the ACARS network and GES that were already in place and this has been affected by GES closures. A GES technology "refresh" (described below) has mitigated performance issues associated with the original GES hardware but due to the costs associated with adding channel units, and in some cases changing the GES architecture to enable more fail-over capacity, a major blocking factor to the next stage of performance enhancement still exists.

2.12 Recent satellite network improvements include a development contract between Inmarsat and Nera, now Thrane & Thrane (T&T) for a new generation of channel units and other related GES computer improvements. A GES upgrade program (Change Notice "CN94") was procured from T&T by all GES operators to include station upgrades:

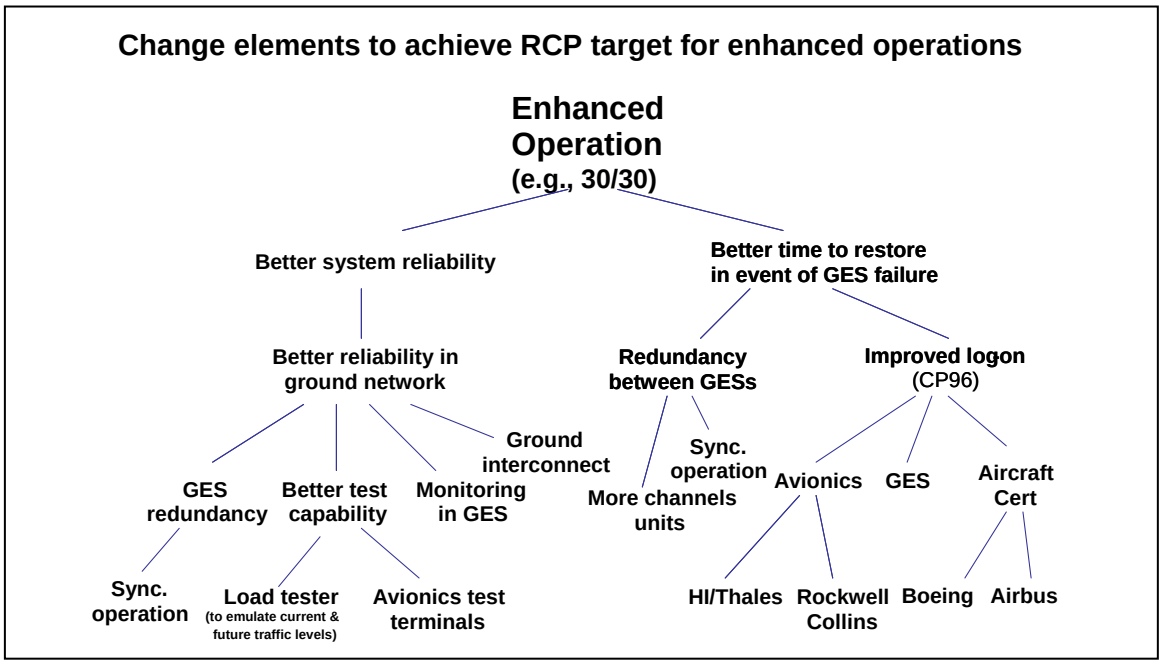
i) Aussaguel GES completed March 2007;
ii) Perth GES completed April 2007;
iii) Eik GES upgrade expected completed October 2007; and,
iv) Santa Paula GES upgrade completed November 2007.

2.12.1 In addition, the GES providers have installed or are in the process of installing backup connectivity to overcome any terrestrial network problems (in some instances three “tiers” of redundancy are now being provided). Aussaguel and Perth upgrades installed backup connectivity for terrestrial network problems and added redundancy to GES components; however, despite those upgrades, degradation of performance and outages of greater than ten minutes persist.

2.13 In response to continuing stakeholder concerns about SATCOM data link performance, Inmarsat instigated formation of the FANS SATCOM Improvements Team (FSIT). Government and industry stakeholders were invited to contribute to assessing viable short, medium and long-term changes to the system to improve both FANS and airline operations center (AOC) SATCOM data link network performance. Stakeholders represented at this group include (but have not been limited to) FAA, Inmarsat, ARINC, SITA, Continental, British Airways, Boeing, Airbus, Japan Civil Aviation Bureau (JCAB), T & T, SED, SPCI, Honeywell, Rockwell Collins, Stratos, Vizada, the International Air Transport Association (IATA), Airways New Zealand, Airservices Australia, NAV CANADA and ICAO.



2.14 FSIT/1 examined the general user needs and concerns with service and over the course of the second and third meetings, there were rapid advances in the definition of the Required Communications Performance (RCP) for Enhanced Operations (e.g. 30/30 and other separation reductions/service enhancements). The FSIT examined how improvements to each element of the system could contribute towards achieving the required RCP for separation reductions and service enhancements:



2.15 Four meetings have been held to date from May 2007 to June 2008. At the June 2-3, 2008 FSIT/4 meeting, key points discussed by the group were:

i) evolved performance requirements, including outages and latency;
ii) improved end-to-end monitoring; and,
iii) GES software upgrades, including availability through automated redundant architecture.

2.15.1 The FSIT also explored solutions to performance goals including redundancy between GES, improved reliability in GES/network and capacity planning.

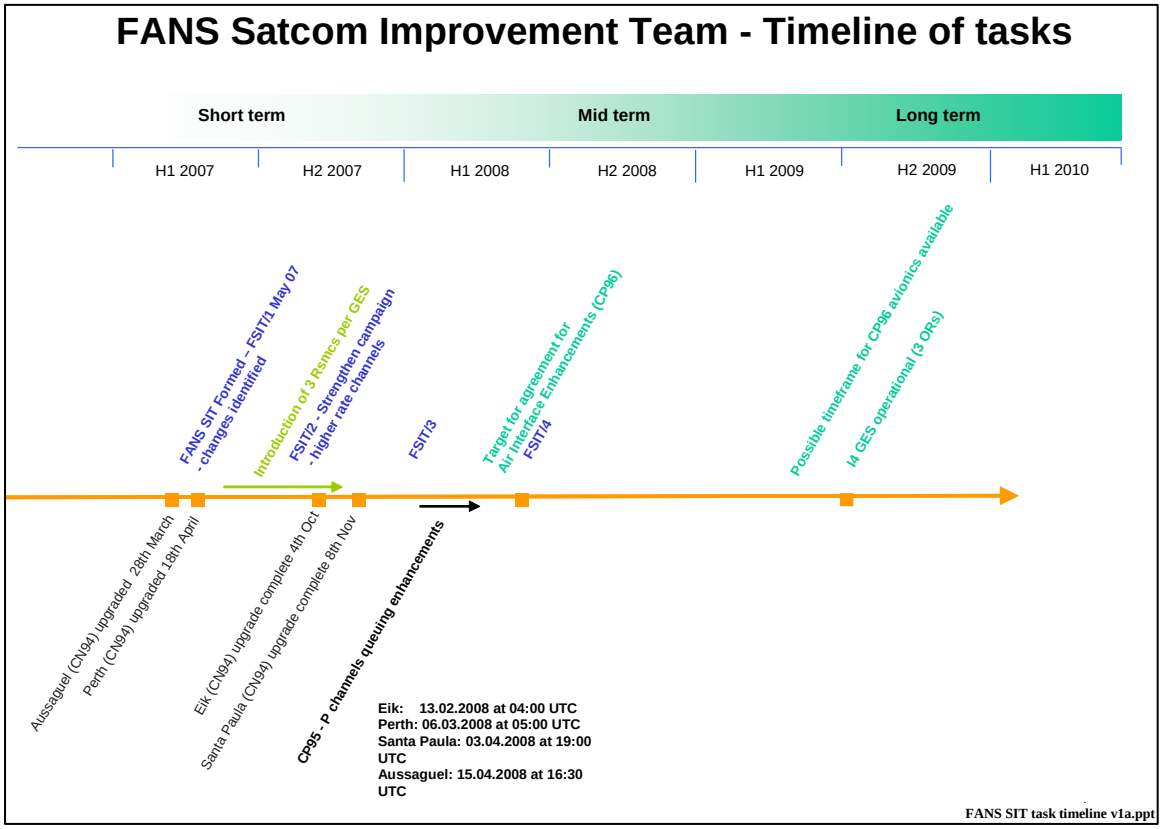
2.16 During the course of the year, the group has achieved its objective to assess the short, medium and long-term changes to the global system in support of advanced ATS applications and to implement the changes they were able to. Through partner contributions, the following has been achieved:

i) The implementation of CN94 upgrades at all remaining GESs;
ii) The introduction of additional log-on channels (with a new access/loading technique), speeding up the log-on process;
iii) Further tuning of the log-on sequence (reduction in retries, uplink channel signal unit management);
iv) Noticeable improvements in the latency of messaging following initiation of the campaign to move Airborne Earth Stations (AES) to higher rate channels;
v) Removal of the need for the AESs to send a second signal unit containing Flight ID in the log-on sequence and for the GES to not need this for successful log-on acknowledgement, again , speeding up the log-on sequence;
vi) SP analysis of and improvements to the redundancy of the terrestrial communications thread; and,

vii) Definition of an enhanced air interface change proposal (CP96) to achieve the target of 1000 aircraft logging-on in 5 minutes.

2.17 This is a enormous achievement resulting in overall system resilience. The implemented changes have resulted in at least halving the time taken to log aircraft back on following a GES outage.

2.18 The timeline for these improvements is shown below:



2.19 Through FSIT, Inmarsat has committed to implement three new GES' to provide datalink safety services (FANS-1/A) over the Inmarsat-4 satellites once they are repositioned to new locations. Dependent on the successful launch of the Inmarsat-4 F3 and redeployment of the Inmarsat-4 fleet, the intent, in collaboration with JCAB, is to increase the total number of satellites that are able to support datalink safety services to 8 (i.e."7+1"). The target for the availability of the new Inmarsat GES' is July 2009.

2.20 FSIT recognizes that the major outstanding issue the datalink partnership needs to address is the capability for the two GES' in each ocean region to be able to back each other up in the event of a catastrophic failure/prolonged outage of either. Key to this are architectural changes to the GES' supporting the existing Inmarsat-3 constellation. At FSIT/4, T&T presented information and costs on the development required to achieve these changes, as well as costs for GES to introduce a new advanced air interface change (currently originally designated as Change Proposal "CP96"). This will allow 1000 aircraft to log-on in five minutes. Integration testing for Software Release 15.0, as it is known, has started and will include all the improvements defined by the FANS SIT to date.

2.21 T&T also presented the estimated cost for implementation of the required GES architectural changes to achieve ocean region backup (i.e. the use of a Synchronous Data Computers architecture as opposed to the Asynchronous architecture that Santa Paula and Eik currently utilize).

Implementation of Sync Data Computers:

- Santa Paula (Pacific Ocean Region [POR]) – 0.45 million; and,
- Eik (Indian Ocean Region [IOR], Atlantic Ocean Region East, West [AORE, AORW]) – 1.38 million.

2.22 T&T explained that once all GESs can operate in Synchronous mode, there are three different levels of failover backup capability that can be introduced:

- Solution 1 or "full" – equal numbers of channels units in each of the two 'half TAD chains' of the GES
- Solution 2 or "one-sided" – one half (one TAD chain within the GES is sized much larger than the other)
- Solution 3 or "partial" – the ability to use the any spare capacity available in the backup TAD chain other half of the GES

2.22 The costs for these solutions are defined below:

i) Solution 1 – back-up channels available on both Data Computers;
ii) Solution 2 – back-up channels available on one Date Computer; and,
iii) Solution 3 – use spare capacity on passive Data Computer.

Solution 1		**Solution 2**		**Solution 3**	
POR	1.3 million	POR	0.95 million	POR	0.2 million
IOR	1.7 million	IOR	1.1 million	IOR	0.2 million
AORE/AORW	2.3 million	AORE/AORW	1.4 million	AORE/AORW	0.4 million
Total	5.3 million	Total	3.45 million	Total	0.8 million

2.23 As a result of the FANS SIT's work to define these costs and the previous costing of the advanced air interface "CP96," the group developed a spread sheet defining the cost options for all of the improvements – see Appendix A.

3. Conclusion

3.1 The implementation of enhanced monitoring, CP96 and Solution 1 will give the very best fail-over redundancy, fastest log-on performance and monitoring capability. If Solutions 2 or 3 are implemented, a failover capability is provided but is limited by degree. Since CP96 also involves AES change, it should be noted that avionics manufacturers wishing to implement the change would incur costs, and it is also assumed that there would be airframer costs for re-certification. The avionics and airframer costs are presently being sought, although some broad estimates have been included in the spreadsheet.

3.2 It should also be noted that the existing avionics would be backwards – compatible with the CP96 solution but for those AES not CP96-capable, the log-on performance would be markedly less (the overall effect on system capability is very difficult to assess since it will depend on a number of factors including; the balance of those AESs that have changed versus those that have not, the number and speed of the channel units available for log-on etc.)

3.3 FSIT/4 concluded that, with funding the targeted RCP for 30/30nm operations could be achieved subject to airlines implementing a no-cost software change in parallel with enhancements to the ground infrastructure. Inmarsat proposes renaming CP/CN 96 to "CN 30/30 – Satellite Data Unit (SDU) Changes to achieve 30/30nm FANS operations," thus making it clear what service change the software modification enables. The estimated total funding needed for all the improvements is between US $15-20 million to cover ground infrastructure changes and provision of service bulletin by Honeywell and Rockwell/Collins (and endorsed by Boeing and Airbus) for software upgrades to the satcom avionics. Cost estimates from all parties are solicited to confirm/refine the total.

3.4 Lastly, the FSIT/4 came to a consensus that without the necessary funding, work for the upgrades to meet RCP 30/30 performance requirements cannot proceed and as such, if unavailable, FSIT had no need to continue.

4. Action by the GREPECAS

4.1 States are invited to:

a) Note the use of satellite data link services for communications and surveillance is currently used for AFN, CPDLC, and ADS-C and has allowed ATC units to introduce reduced oceanic separation standards of 50NM longitudinal and 30/30 operational trials. In addition, satellite communication provides the platform for advanced ATM procedures including ADS-C In-Trail Procedures, Tailored Arrivals, Waypoint Management, and 4-D Trajectory Optimization.

b) Consider the use of satellite communications for CPDLC and ADS-C will continue to grow at an estimated rate of approximately 20% per year. New investments to provide the additional infrastructure in order to meet steadily increasing demand for data link services are required.

c) Recognize the urgent need to identify and provide a funding mechanism to provide required investments to modernize and maintain the satellite communication infrastructure to sustain the growth of aviation in the CAR/SAM region and support development and implementation of advanced ATM procedures.

APPENDIX A

INITIAL COST ASSESSMENT FOR ADVANCED AIR INTERFACE CHANGES, ENHANCED MONITORING AND OCEAN REGION FAIL-OVER BACKUP

FANS SIT#4 - Cost Estimates for FANS Improvements						
		000s				**Brief description of line item**
Synchronous TAD						TAD architecture is pre-requisite for recommended redundancy method
Santa Paula		$450				
Eik		$1,380				
		$1,830				
	Sol 1	**Sol 2**	**Sol 3**	**Sol 4**		
Backup				I4s		These are the sync-TAD options for backup and give varying degrees of capability (1 is best option)
POR	$1,300	$950	$200			
IOR	$1,700	$1,100	$200			Sol 4 - the option of using I4 GESs
AORE/W	$2,300	$1,400	$400			N.B. This is not fully costed.
	$5,300	$3,450	$800	0		
Release 15 (incl GES CP96)						Ensures that I-3 GES include all the FANS SIT improvements
Perth/Aussaguel	$1,000					
Eik/Santa Paula	$1,000					
	$2,000					
Misc						Enables sync-TAD operation for Sol 3 at Vizada GESs
Vizada/SITA/Arinc (additions for backup for sol 3)	$1,600					
	$1,600					
CP96						Enables 1000 a/c to log-on to a GES in 5 mins. 'ACARS 270' - refers to an avionics change to indicate to the pilot when the satcom link to the GES is available but ACARS is 'no-comm'. This is being considered for inclusion in CP96.
Collins ext cost	$0		Does not include ACARS 270 change and is time limited			
HI ext cost	$1,500		Inmarsat estimate			
Airbus recert		Large uncertainty - will be large if flight test needed				
Boeing recert		Large uncertainty - will be large if flight test needed				
	$1,500					
Better Test						Ensures that I-3 GES upgrades can be thoroughly tested at representative (high) operational loading levels, and that test terminals are available on the development site
Load tester	$500		Est			
Terminals x 2	$300		Est			
	$800					
Better Monitoring						Ensures that DP/SP monitoring utilises near real-time satellite subnetwork data
Inmarsat - INMS & UEP	$300		to be shared among participating ACSEs (nominally 8)			
T&T (incl rel 15)						
	$300					
	Sol1	Sol 2	Sol 3	Sol 4 - may not be suitable		
Est. Sum ex Airbus/Boeing recert	**$13,330**	**$11,480**	**$8,830**	**$6,430**		

- END -