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ACCESS

ATN Compliant Communications

European Strategy Study

Third Party Service Provision

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Executive Summary

Increasingly, there is a general trend for businesses to increase efficiency by identifying those “non core services/functions” which may be “contracted out” to a third party provider. In the case of an ATSO the core service is clearly the provision of the operational Air Traffic Services which requires a number of “support” services (e.g. data communications between ATCCs). In today’s environment such support services are typically provided by the ATSOs themselves, i.e. “in-house” provision. However, as the aeronautical community moves towards the implementation of the CNS/ATM system it is necessary for the users (ATSOs and Airlines) to consider the issues involved in the provision of the support services required by the future ATM environment. A major issue is whether users should provide these services themselves, i.e. “in-house” or contract them out to a third party service provider.

The arguments applicable to contracting out non-safety services clearly need to be re-visited for their applicability to safety critical related services involved in ATM in order to assess the associated risks. The ATN is clearly considered as a support service to the future ATM system and elements of it, may either be provided “in house” by the end user or may be contracted out to a Third Party Communications Service provider (TPCSP). A TPCSP being defined as a commercial organisation (e.g. ARINC, British Telecom) that offers ATN compliant communications services to the aviation community. The purpose of this report is to address and provide guidance to ATSOs on the issues concerned with contracting the provision of elements of an ATN service to a TPSP.

Following an in-depth analysis of related ACCESS WPs, other related studies and taking into account of practical trials and operational experience acquired during the ADS Europe trial ([8], [9]) and FANS 1/A South Pacific Experiences [6] the report:

- identifies the of points/segments in the end-to-end ATN communications service/architecture at which a user (e.g. ATSO) may elect to contract a TPCSP;

- provides detailed guidance on the means by which a TPCSP may be managed, i.e. via a strict Service Level Agreement (SLA) and provides detailed guidance on the issues that such SLAs need to address/define.

The report concludes that though the SLA concept is in theory a means to specify communications service requirements it must be understood that the community (users and providers alike) have limited experience with the use/enforcement of SLAs for ATS based data link. Consequently the report recommends that:

a. A representative group of of ATSOs, Airlines and TPCSPs should work together to develop and validate a SLA for ATN Services in Europe taking into account the issues raised in this report. Such a group could either be based on an existing european ATN implementation group or be constituted through a CEC-sponsored initiative;

b. That the ATSOs establish the means to monitor the performance of the contracted communications service in order to develop and maintain confidence in the ability of the TPCSPs to provide the required level of service.

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1. Introduction

The general trend in business these days is, supported by convincing arguments, for businesses to contract out the provision of "non core" services thereby allowing it to focus on provision of its core service, which in the case of an ATSO is the provision of the operational Air Traffic Services. However, the arguments applicable to contracting out non-safety services clearly need to be revisited in light of the safety critical nature of ATS communications in order to assess the associated risks. The provision of an ATN service, or elements thereof, may either be provided "in house" by the end user or may be contracted out to a Third Party Communications Service provider (TPCSP). A TPCSP being defined as a commercial organisation (e.g. ARINC, British Telecom) that offers ATN compliant communications services to the aviation community. The purpose of this report is to address and provide guidance to ATSOs on the issues concerned with contracting the provision of elements of an ATN service to a TPSP.

This guidance is based on analysis of the following:

- other ACCESS work packages (WP240, Transition [1], WP223, Safety and Certification [2], WP220a and Deployment Scenarios for air/ground subnetworks[3]);
- previous related studies (e.g. COMT ST15 [9]);
- experiences with service providers in the context of trials (e.g. ADS Europe [8]);
- experiences with service providers in the context of FANS/1 operations in the South Pacific [6];

Three "Service" levels at which elements of an ATN service may be **realistically** contracted are identified, i.e. at the "application", "Internet" and "subnetwork" level. Taking these into account this document provides guidance on the content and nature of a "Service Level Agreement" (SLA) which is recommended as the contract vehicle by which the user defines his requirements for third party communications service provision. The SLA will provide the user (i.e. ATSO) with a benchmark against which he may define the means to monitor the actual level of service being provided. Guidance on the issues to be addressed in the SLA is provided, again based on experiences acquired in previous trials and operational experiences and knowledge of the issues specific to the ATN.

1.1 Objectives of WP

The main objective of this report is, taking into account related studies, trials and operational services, to identify and provide guidance to ATSOs on issues surrounding the use of Third Party Communication Service Providers for providing an ATN service or elements thereof.

Specifically:

- to identify those elements of the end-to-end ATN service which are suitable to be contracted to be provided by a Third Party Communications Service Provider;
- to provide guidance on the nature and content of a service level agreements.

1.2 Acronyms

AOC	Aeronautical Operational Control

AOR	Atlantic Ocean Region
APQP	ATS AIRCOM Performance Quality Plan
ATCC	Air Traffic Control Centre
ATSO	Air Traffic Services Organisation
ATSU	Air Traffic Services Unit
CLNP	Connectionless Network Protocol
CLTP	Connectionless Transport Protocol
CRA	Central Reporting Agency
FIT	FANS Interoperability Team
IOR	Indian Ocean Region
SLA	Service Level Agreement
SNDCF	Subnetwork Dependence Convergence Facility
SRC	Safety Regulation Commission
TPCSP	Third Party Communications Service Provider

1.3 References

1	ACCESS WP240, Transition Planing & Future Evolution of the European ATN, Draft 0.3, 17th September 1998
2	ACCESS WP223, Safety Assessment & Certification, Issue 2.0, 14th January 1999
3	ACCESS WP220a, Deployment Scenarios for Air/Ground Subnetworks - Issue 1.0, 2nd November 1998
4	Data Link Servers in Europe, ATNP/WG3-RIO, EUROCONTROL, 27-Feb-98
5	The Introduction of Data Link Technology in ATC Centres, EUROCONTROL, Version 0.A, 20th August 1998
6	FANS Interoperability Team Report/2, 3rd August 1998
7	Scenarios for the ATN, Non-technical Implementation Issues, Revision 1.2, 28th August 1998, ATNI2
8	ADS Europe, Final Trials Results Report, December 1996
9	ADS Europe 97, Final Trials Results Report and Recommendations for

	Further Work, Issue 2.0, March 1998
10	COM.ET2.ST15:Analyse Options for Initial A/G Data Networks, Phase 3 Report: Part 1, Tentative Implementation Plan by Horizon 2000 (ACARS DataLink)
11	RTCA SC-189/EUROCAE WG-53 Position Paper P/SG3/12, Datalink Performances, 9th June 1998
12	European Commission, Deliverable 2, The Introduction of ATN in Europe: A Regulatory Framework, Issue 1.1, 15/12/98.
13	Satellite Communications and Ground Earth Station Institutional Issues Study - Volume 1: Executive Summary - Doc,1AK7-FR-01-GES, Version 1.0 12 December 1995
14	Satellite Communications and Ground Earth Station Institutional Issues Study - Volume 2: Final Report - Doc 1AK7-FR-01-GES, Version 1.0 12 December 1995

2. General Considerations

When planning to provide an operational ATS service based on an ATN infrastructure an ATSO needs to consider the optimal means for the provision of this infrastructure. The options ranging from building and operating its own infrastructure versus contracting a third party communications service provider to provide the required service. This service may be provided at different levels within the ATN architecture, these levels being referred to as “Service” levels. For each Service Level the factors that need to be considered as to determine which way to proceed include:

- the business objectives of the ATSO, e.g. whether it intends to focus on purely providing an ATS service or whether it considers itself in the business of offering CNS services based on its infrastructure to third parties;
- an assessment of the confidence in and the feasibility of a typical TPCSP to provide the communications service to the required level;
- an assessment of the safety and economic implications on the ATS service in the event the TPCSP failed to provide the required level of service for short, medium and extended periods of duration;
- fall back procedures in the event the contract with the TPCSP was terminated by either party;
- an assessment of the liability/accountability issues when contracting a TPSP to handle safety critical ATS messages including the extent to which a TPSP would be willing to accept liability/accountability;
- an assessment of the consequences of having no direct monitoring & control over the infrastructure;
- an assessment of the costs of installing, operating and maintaining own infrastructure versus costs of using a TPCSP over equivalent periods of time;
- an assessment of the long term implications on staff in terms of knowledge and experience in ATS related data communications;

- an assessment of the safety, technical, economic and organisational risks associated with contracting out the service provision versus providing it in house;
- the issues involved in and means by which an SLA may be forced in practice;
- previous experience that the ATSO may have acquired in using a TPCSP for ATS communications.

3. Relevant Issues Arising out of Related Access WP's

3.1 WP 220A - Deployment Scenarios for Air/Ground Subnetworks

The objective of WP220A [3] was *"to identify and describe the most probable deployment scenarios for VDL Mode 2 and AMSS in terms of location of ground stations and the connectivity of these ground stations to ATN routers*." The following sub-sections highlight the key points and issues identified in WP220A that are considered relevant to and need to be taken into account in WP220.

3.1.1 AMSS

The following list of key points and issues were identified by WP220A and are considered relevant to WP220:

- The AMSS is unlikely to be the primary air/ground subnetwork in core Europe due to the availability of VDL Mode 2 coverage and possible Mode S data link, both of which are expected to be cheaper to use. However, the use of AMSS as a secondary back-up to the VDL Mode 2 service in the core area of Europe is considered likely especially in the event that a Mode S data link service is not deployed;
- The AMSS is likely to be the primary air/ground subnetwork in the fringe areas of Europe (e.g. Mediterranean, Eastern Europe and the NAT) in the event that there is no VDL Mode 2 or Mode S coverage;
- AMSS equipped aircraft are typically of the long haul type. Short haul aircraft types operating within Europe are unlikely to be AMSS equipped;
- The AMSS service is offered by organisations referred to as "INMARSAT Signatories". Access to AMSS services is via Ground Earth Stations' (GES) which are typically owned & operated by these Signatories.
- The INMARSAT Signatories have formed consortia referred to as "Satellite Service Providers" in order to provide global service coverage. Currently there are three such consortia:
  - **Satellite Aircom** (France Telecom, SITA, Teleglobe Canada, Telstra (Australia))
  - **Skyphone** (British Telecom, Telenor, Singapore Telecom)
  - **Skyways Alliance** (Comsat, KDD, Communication Authority of Thailand, Korea Telecom, Telecom Italia)
- The satellite service "Users" (e.g. airlines for AOC type services) select their satellite service provider on purely commercial reasons e.g. data communications costs;
- It is the airlines that will select which of the satellite service providers which they will use for the provision of ATC;

- For ATS purposes it will be necessary to make arrangements with all consortia in order to ensure that it is possible for ATC to communicate with all SATCOM equipped aircraft. This implies that connections to the GESs of all three service providers will be required which provide access to the required satellites. *Note: An alternative scenario could be one whereby a single service provider is mandated for ATS by an ATSO for operations in its airspace. However, this is unlikely to be popular with those airlines that have selected an alternative service provider for their AOC communications and indeed the alternative service providers themselves who may claim that such a situation would be anti-competitive and discriminatory*;

- AMSS coverage for the European area will require access to Atlantic Ocean Region (East) and Indian Ocean Region (IOR) satellites. Access to Atlantic Ocean Region (W) may also be required;

- In the case of ATS trials, ground/ground connectivity between the trials ATC Systems and the GES has been based on the use of public X.25 networks. For example, the ADS Europe trial [7] used the British Telecom Global Network Service (GNS) and the TRANSPAC service to access the required GESs in the UK and France respectively.

- Three possible AMSS deployment/access options were outlined, though no specific option is recommended:

- **Scenario 1** (*Complete Connectivity*) whereby each ATSO provides its own ATN A/G BIS and access to GESs of all three satellite service providers the for AOR(E), IOR & AOR(W);

- **Scenario 2** (*A/G BIS per GES*): whereby those ASTOs where the GES is located would provide ATN A/G BIS service to all other states requiring access - e.g. NATS would provide ATN BIS access to Goonhilly for all States);

- **Scenario 3** (*A/G BIS per AMSS operator*): whereby the AMSS operators themselves provide A/G BIS access to their satellite services.

3.1.2 VDL Mode 2

The following list of key points and issues were identified by WP220A and are considered relevant to WP220:

- The need to replace the existing ACARS service in Europe has been recognised by the community due to increasingly demanding AOC application requirements and increasing numbers of airline users. The VDL Mode 2 system has been accepted as the technology to replace ACARS;

- Two proposed solutions to migrate to VDL Mode 2 have been presented to the AEEC and are summarised. The “SITA” proposal is based on an ACARS/X.25 conversion. The “ARINC” proposal includes the CLNP, CLTP and mobile SNDCF functionality with the objective of providing a transition path to ATS services over the ATN. *WP220 assumes that the latter solution, i.e. the “ATN-1” is the one that will be implemented*;

- In terms of deployment, two strategies are presented. An “Communications Service Provider” (CSP) driven strategy whereby the infrastructure is owned, deployed and operated by service providers such as SITA and its scope, coverage and schedule initially driven by AOC requirements. An “Air Traffic Service Provider” (ATSP) driven strategy whereby the ATSO requires to own and operate the infrastructure so as to exercise maximum monitoring and control over the system;

- It is concluded that the CSP driven strategy will probably prevail and that an ATSP is considered to be a longer-term possibility;

- The following parameters are identified as means to define/monitor a communications service, irrespective of technology: availability, reliability, temporary loss of communications service, maximum service outage, transit delay, residual error rate (RER), throughput and coverage;

- The VDL Mode 2 service (irrespective of whether it is contracted out or provided in-house) has to be regulated to ensure required QoS can be provided and maintained.

3.2 WP 223 - Safety Assessment & Certification

The following list of key points and issues were identified by WP223 and are considered relevant to WP220:

- Third Party Communications Service providers offering their service to support operational ATS services will require that their service offered and means to maintain it be "certified" for use by an appropriate aviation safety regulation body (It is expected that the requirements for such a body will be defined by the Safety Regulation Commission (SRC) which has recently been constituted along-side EUROCONTROL);

- In submitting its certification application to the safety regulation body, the TPCSP will need to provide evidence supporting the basis upon which the service to be offered will be provided and maintained. For example the results of a risk analysis, test results from a test facility such as the Common American European Reference ATN Facility (CAERAF);

- The Safety Management (i.e. use of system/safety cases) methodology has, to date, focused on ATS provider systems and avionics. Safety management issues related to TPCSPs has not yet been addressed. However, it is expected that the procedures/requirements imposed on for TPCSPs will be no different to those applicable to the ATS providers and/or their suppliers;

- The means by which an ATSO would procure the services of a TPCSP is through a formal contract that would include a Service Level Agreement (SLA);

- Even though an ATSO may have contracted a TPCSP for service provision, the ATSO remains "accountable" for any incident arising out of a failure of the contracted service. The TPCSP, however, would in such a case be liable. The extent of the liability being subject to agreement in the SLA;

- The QoS parameters that may be used to define/monitor an ATN Internet Service are: availability, continuity, integrity, reliability, throughput and transit delay. Any definition of QoS and the associated parameters will need to be validated. The "end-to-end" delay budget that is expected to be assigned to the end-to-end service is quoted as 90% of the "operational" end-to-end delay;

- The TPCSP will notify all Users and all parties in the "end-to-end" chain of any modifications (software, hardware and system changes) to the TPCSP infrastructure that may affect the QoS of the data link service. This should be done prior to the introduction of the modification. Any modifications that have the potential to affect the QoS must be tested, subject to user satisfaction, prior to their introduction into the operational service. The SLA should define the right of the ATSO to witness the testing of and/or review the test approach and results of any modifications made to the TPCSPs infrastructure;

3.3 WP240 - Transition Planning

The following list of key points and issues were identified by WP240 and are considered relevant to WP220:

- The transition plan focuses on transition to the "initial" ACCESS ATN, i.e. the infrastructure envisaged to be deployed in the 2000 – 2005 time frame. The transition from the initial to the "target" ATN is not addressed due to uncertainty.

- The concept of "Data Link Server" (DLS) as being developed by the community in the context of ATNP and the EUR AGDL project ([4], [5]) is expected to be implemented in the initial ACCESS ATN. The DLS being proposed as a server that is a focal point within an ACC for all communications aspects of data links.

4. Related Studies, Trials and Initiatives

4.1 ST15 Study – Analyse Options for Initial Air/Ground Data Networks

The EATCHIP COMT ST15 Study, "Analyse Options for Initial Air/Ground Data Networks, Phase 3, Part 1 Report) [10], provides guidance on the types of issues that need to be addressed in a SLA for simple ATS applications operating over ACARS. Much of the guidance is also relevant to an ATN environment and has been taken into account in section 6 of this document which is devoted to guidance on issues that need to be addressed in an SLA.

4.2 ATNI2 Study

The European Commission (DG7) has commissioned a study whose objective is to: "analyse the non technical obstacles which could affect the operational implementation of the Aeronautical Telecommunication Network (ATN) and to develop organisational, regulatory and institutional configurations capable of facilitating the implementation of the ATN." The first stage of the study has been completed with the delivery of a report titled "Scenarios for the ATN, Non-technical Implementation Issues" [7]. The report reviewed and discussed the roles of the various players in the aeronautical environment (e.g. industry, airlines, ATSOs), their changing roles (e.g. ATSO privatisation), and the various legal and institutional issues that the introduction of the ATN in Europe will face. The report concluded with two scenarios for the deployment of the ATN referred to as the "Market Driven" (i.e. ATN deployment driven by commercial requirements) and "Public Volunteerism" (i.e. ATN deployment driven by public entities and funding). The second deliverable of the study has, in order to avoid a limited number of powerful "players" from steering ATN deployment in their favour, focused its attention on the definition of a "Regulatory Framework" for aeronautical telecommunications. Such a framework is intended to establish the "rules of the game" related to ATN deployment and would be intended to ensure a fair relationship between the players.

The framework proposed has been based on experiences gained in the telecommunications domain as well as from parts of air transport regulation. The report goes on to discuss at length the various issues that need to be defined within the context of a Regulatory framework, the most significant points being:

- **Harmonised Service Provision (HSP) Principles**: based on the need to respect "essential requirements" (which ensure optimal safety conditions in transport) and ensuring the freedom to services in order to make the best technical and economic solution.

- **Safety Rules**: Related to the management of the safety requirement focusing on:

  The certification of systems and services**;**

  The civil liability of service providers;

The nature of contracts.

- **Interconnection Rules**: Firstly, to ensure the effective "opening" of networks, their interoperability and the economic conditions to ensure that it is effective. Secondly to create a neutral entity which is responsible for providing the services of common interest. The study proposes that the stakeholders create an initial entity, the "European ATN Administrator" (EATNA). The EATNA would be responsible for contracting a second neutral entity, the "European ATN Co-ordinating Entity" (EACE) with the task of providing all common services, e.g. provision of route servers.

- **Congestion Rules**: Given the forecast congestion in European airspace in the event that the ATM infrastructure does not adequately evolve, this element of the regulatory framework is concerned with defining rules to facilitate the economic emergence of the ATN. "They consist, according to different modalities, in favouring the users which use the ATN, by "taxing" those which do not."

- **Authorisation/Licensing Rules**: In order to put into practice all of the measures mentioned above, the need to define an authorisation policy is proposed. Two types of policy are addressed. These being, licences (authorisations granted individually upon submission of a dossier, when they are limited in number), or general authorisations (granted automatically after verification of criteria).

- **The Regulator**: Finally the question of issues surrounding the regulator are addressed. The need for independence from service provision is stressed plus the fact that a regulator would be more efficient at an European level than a national one. EUROCONTROL is considered as a likely candidate with the proviso that there can be a clear distinction and separation between its regulatory and operational service functions.

4.3 ADS Europe Trial

The ADS Europe trial [7], [8] made extensive use of the AMSS service offered by the Skyphone and Satellite Aircom consortia. The trial acquired a significant amount of experience and learnt some key lessons in the area if AMSS service provision. The key areas relevant to the subject of TPCSP are presented below:

- **GES Software changes**: As a result of software changes (without notification to the users) introduced into the GES the AMSS service level degraded to a level where the ADS Europe message delivery success rate dropped from 97% to 93.6%. Following joint investigations with the service providers and INMARSAT it was concluded that the cause of degradation resulted from loss of data uplinked to aircraft. This loss of data resulting in X.25 resets which ultimately resulted in the degraded delivery success rate. This fault also affected the Data-2 as well as the Data-3 service and consequently impacted the FANS 1/A operations in the South Pacific. These being based on the Data-2 service. Having developed a solution for the problem it has been observed that the changes are being introduced into GESs sequentially.

- **GES Testing**: As highlighted by the above, it is necessary that the means are provided whereby the users are satisfied with the procedures to test new GES software releases. The introduction of any new software release into the operational environment must be co-ordinated with all parties involved in the supply and use of the end-to-end service.

- **QoS Monitoring**: As a result of experience gained the project concluded that when a TPCSP is being used to support the transmission of safety critical ATS communications there is a need to monitor the QoS being provided. It is necessary to investigate those parameters that are required to be monitored in real time and to assess the technical feasibility of doing so.

- **Ground Network Priority Support**: The ATN SARPs define a priority scheme whereby

application priority is mapped through to transport and network layer (CLNP) priority as a mandatory requirement. The SARPs state that where a subnetwork supports priority it shall be invoked by the SNDCF. The trial exposed the fact that whilst the GESs supported the AMSS SARPs defined priority scheme the BT GNS (like many public X.25 networks) was compliant with the 1984 version of CCITT X.25 standard which did not require the support of priority. Consequently data arriving at the GES with no priority level was being sent over the AMSS link with at no assigned priority. Given the maturity of X.25 technology it is questionable whether the service providers will upgrade their networks to support priority.

- **Support of X.25 Fast Select Facility:** In the context of routing initiation, the ATN SARPs require that where the subnetwork supports the X.25 Fast Select facility it shall be used. Specifically it is used to encode the Intermediate System Hello (ISH) packet in the Call Request packet or the user data of the Call Accept in order to minimise the amount of data transferred over the limited bandwidth mobile subnetworks. The trial observed the fact that a number of public X.25 networks do not support the facility and in some situations it has been intentionally disabled due to the inability of the operator to being able to charge for its use when crossing international gateways. The possibility could occur whereby the receiver receives and digests data received in the call request but always rejects the call which would prove difficult to bill. The trial managed to have the facility enabled for access to GESs located in Norway, France and Singapore.

- **Configuration Control:** The trial realised the need for configuration control of the software of all elements of the end-to-end chain. This would enable consistent testing and re-testing of the various elements in a reproducible manner. Furthermore it would enable roll-back to previous working configurations in the event that new software releases resulted in a faulty service.

- **Network Maintenance:** It was observed that the BT GNS service was suspended on a weekly basis for 30 minutes in the early hours for maintenance purposes.

- **Ground/Ground, AMSS Service Provision:** The ground/ground and AMSS service is not offered as a single end-to-end service. In the UK case, NATS had to separately contract the ground/ground service with GNS and the air/ground AMSS service with Skyphone.

- **Charging/Billing Mechanism:** Due to the fact that the ground/ground and AMSS services had to be contracted separately there were two sets of bills to be consolidated and settled by the users. The charges, for both ground/ground and AMSS services, were solely based on the amount of data transferred. There were no charges related to duration of virtual circuit establishment. (*It needs to be determined whether the AMSS charges are dependent on type of antennae – i.e. low gain, high gain.*)

- **Aircraft Loading**: The fact that the QoS requirements defined in an SLA should take into account a realistic number of equipped aircraft, i.e. the required QoS should be based on an assumed number of participating aircraft;

- **GES Software Testing**: The GES Data-3 software has not been stress tested in the trial. Due to the limited numbers of aircraft simultaneously logged onto a single GES the trial was unable to stress test the service;

- **GES Direct Connection**: It may be desirable for an ATSO to directly connect its own private X.25 network to a GES. In the case of the UK it has been suggested that this may be possible with the Skyphone service.

- **Help Desk**: The GNS service included a comprehensive Help Desk facility. The AMSS service, however, did not have a formal contracted Help Desk (*To be confirmed*).

- **Problem Reporting**: Users should be, as early as possible, informed of any potential,

planned or unplanned service outage.

- **Performance Assessment**: The trial concluded that a 15 second ADS reporting rate can be technically achieved as well as a 12 second downlink time. These figures need to be interpreted in the context of the trial, i.e. limited numbers of aircraft simultaneously exercising the communications infrastructure.

4.4 FANS/1 South Pacific Experience

The FANS Interoperability Team (FIT) was formed in 1996 with the objective of gathering, analysing and resolving problems associated with the operation of the FANS 1/A system in the South Pacific Region. Based on an analysis of the FANS Interoperability Team Report/2 [6] the following points are considered relevant for the subject of TPCSP:

- **FIT Objective:** FIT established to oversee the monitoring process which ensures that the FANS 1/A system continues to meet its performance and interoperability requirements and that operations and procedures are working as planned;

- **Central Reporting Agency**: The FIT established a Central Reporting Agency (CRA) which acts as a clearing house for FANS related problem reports and monthly trend data. All information released by the CRA is de-identified;

- **System Performance Consolidation and Publication**: The FIT achieves its purpose by receiving from members monthly status reports that include system performance indicators and anomalies. The FIT consolidates reports produced and publishes the consolidated set of system performance indicators on the FIT web site;

- **Performance Requirement**: The original FANS 1/A performance requirement against which the FIT publishes its report is for an end-to-end delay of 60 seconds or less for 95% of downlink messages delivered. For uplink messages, a 120 second round trip delay on 95% of occasions is the requirement. These requirements have recently been tightened as the users were dissatisfied with the system when it was performing within the stated requirements. This implies that the original requirements were not tight enough.

- **System Integrity**: The FANS 1/A system integrity is provided through implementation of the Cyclic Redundancy Check (CRC) as described in ARINC Specification 622-2. Analysis has show that the CRC provides for a probability of 1 in 10^{-6} of an undetected error bit. This implies that the probability of an undetected error occurring is one per million hours of service in the South Pacific region given foreseen operational scenarios [6].

- **System Availability:** The FIT collates data related to system availability in order to publish overall system availability figures as a part of the routine monthly reporting process. System unavailability is only included when flight operations are affected, i.e. planned outages for maintenance are not counted against overall system availability. The FIT is currently working towards a better definition of system availability.

- **Performance Responsibility:** FIT recognises that system availability requirements will become more critical as traffic separation is reduced and intends to ensure that all participants accept responsibility for the performance of their element of the end-to-end chain.

- **Open Issues**: Current open issues include (1) effect of system timers on message delivery and (2) effects of receipt of duplicate messages both by aircraft and ATS providers when transmission media switch between VHF and SATCOM.

- **Communications Service Provider QA Plan**: In the context of FANS 1/A operations

SITA has developed a "Quality Plan" for the CAA's. The "ATS AIRCOM Performance Quality Plan" report (APQP) measures performance with regard to a predefined set of indicators. The report is produced on a monthly basis and ARINC has implemented a similar plan.

- **System Outage Notification**: There is a strong need for timely, effective system outage notification. Such notification should be in a form easily understandable by all recipients and notification reception must be assured. The notification should outline the problem in terms that are practical for the recipient (i.e. what the operational effect is and where it will have/is having an effect). Unaffected aircraft should not be informed but Airline Operational Control centres and ATSUs should receive all the data in order to make their own assessments of relevance.

- **GES Software Changes**: The "X.25 Reset" problem experienced by the ADS Europe trial similarly affected FANS 1/A operations. As a result the FIT is requiring that the communications service providers accept (1) responsibility for the performance of the elements of the end-to-end chain that only they control, (2) to ensure that all parties involved in the provision and use of the end-to-end service are aware of the effects of configuration changes on the performance of their element and (3) to inform all parties of any such change prior to their introduction in the operational system.

- **Configuration Control**: Primarily as a result of the above the FIT has introduced a configuration control system. This will enable roll back to previous well known configurations in the event of problems with new software releases.

- **Performance Monitoring/Problem Resolution Procedures**: FIT is starting to enforce established procedures for problem resolution. Communications service providers are required to monitor their system performance and react to reductions in performance rather than to wait for users to complain.

- **Certified Communications Service:** A view has been expressed in the FANS 1/A environment that the service provided by communications service providers is "certified". This becomes more likely as the requirements on the communications service become more stringent in order to enable tangible operational benefits such as reduced separation.

4.5 RTCA SC-189/EUROCAE WG-53

The RTCA SC-189/EUROCAE WG 53 is developing ATS safety and interoperability requirements and related material in order to facilitate the safety assessment, certification and operational deployment of data link based systems. SG3 (Performance) is currently in the process of developing a position paper on the subject of "Datalink Performances" [11]. The purpose of the paper is to provide basic information on datalink performances of the current VHF and SATCOM ACARS based technology and those of ATN based systems, i.e. AMSS DATA-3 and VDL subnetworks. Of particular relevance to WP220 is the following data/information provided in [11] with respect to transit delay:

- **Airborne I/O processing** time between 100 milliseconds for modern dedicated processors up to 2 seconds for some older non-dedicated processors (e.g. FMC) retrofitted to provide datalink I/O processing;

- **Airborne End System processing** – the ATN ES is assumed to include Application Service Elements, Upper Layers communications service and internetworking function. Transit delay assumed for airborne ES processing is 50 milliseconds.

- **Airborne Subnetworks** – existing ARINC 429/Williamsburg connection oriented protocol not well suited for use where a short overall end-to-end transit delay is required. The planned connectionless version of the Williamsburg protocol appears to be better

suited. Transit delays assuming the use of this version of the protocol for a 256 byte message is assumed to be 100 milliseconds.

- **Airborne Intermediate Systems** – transit delay assumed is in the order of 25 milliseconds.

- **Air/Ground Subnetworks** – major contributor to the overall end-to-end delay:

  - **AMSS –** for the 10.5 Kbps service a transit delay of 8.5 seconds is quoted;

  - **Mode S Subnetwork** – for the Mode S subnetwork a transit delay of 6.18 seconds is quoted;

  - **VDL Mode 2** – based on simulations in an en-route environment with 600 aircraft a transit delay of 5 seconds was quoted.

- **Ground Intermediate System** - transit delay assumed is in the order of 25 milliseconds.

- **Ground Networks** – Current version of FAA NADIN Network (based on 56 Kbps trunk circuits) transit delay is quoted as 147 milliseconds with a 4 node hop. Based on upgraded FAA NADIN network (using T1 circuits for the backbone) a figure of 17 milliseconds quoted for a 4 node hop.

- **Ground End System** – the transit delay for a packet going through the communications service within the ES is assumed to be in the order of 50 milliseconds.

- **Ground I/O Processing** – the I/O processing time required by ground ATC automation systems may vary between 500 milliseconds for modern systems optimised for datalink services up to as much as 5 seconds for systems where a datalink capability has been retrofitted.

4.6 INMARSAT Safety Case

Recognising the future role of satellite communications in the ATS environment it is understood that INMARSAT are in the process of developing a Safety Case for their system. Other than that it is being modelled on the typical approach adopted for Safety case development by ATS providers there is little that can be currently be reported due to the early phase of the work.

4.7 Satellite Communications and GES Institutional Issues Study

The primary objective of the Satellite Communications and GES Institutional Issues study ([13], [14]) was to survey the institutional issues which will affect the provision and operation of a satellite communications service for ATS purposes within Europe. In particular, the study shall analyse how GESs supporting ATS services in the European airspace could be best organised, operated and managed and which requirements would be placed on the GES operator and the aeronautical satellite communications service provider. The study focused on the institutional, regulatory, and operational aspects and only subsequently on the procurement and implementation of such satellite ground earth stations. The study provided a an outline (Appendix A) of the contents of a typical SLA that would be used in the case of a user, such as an ATSO, contracting a satellite service provider for their service.

5. Service Provision Framework

5.1 Service Levels

The overall end-to end ATN service is provided by a number of elements in a chain. Figure 1 illustrates the elements that comprise the end to end chain and identifies the points in the chain where service provision may be contracted to a third party communications service provider.

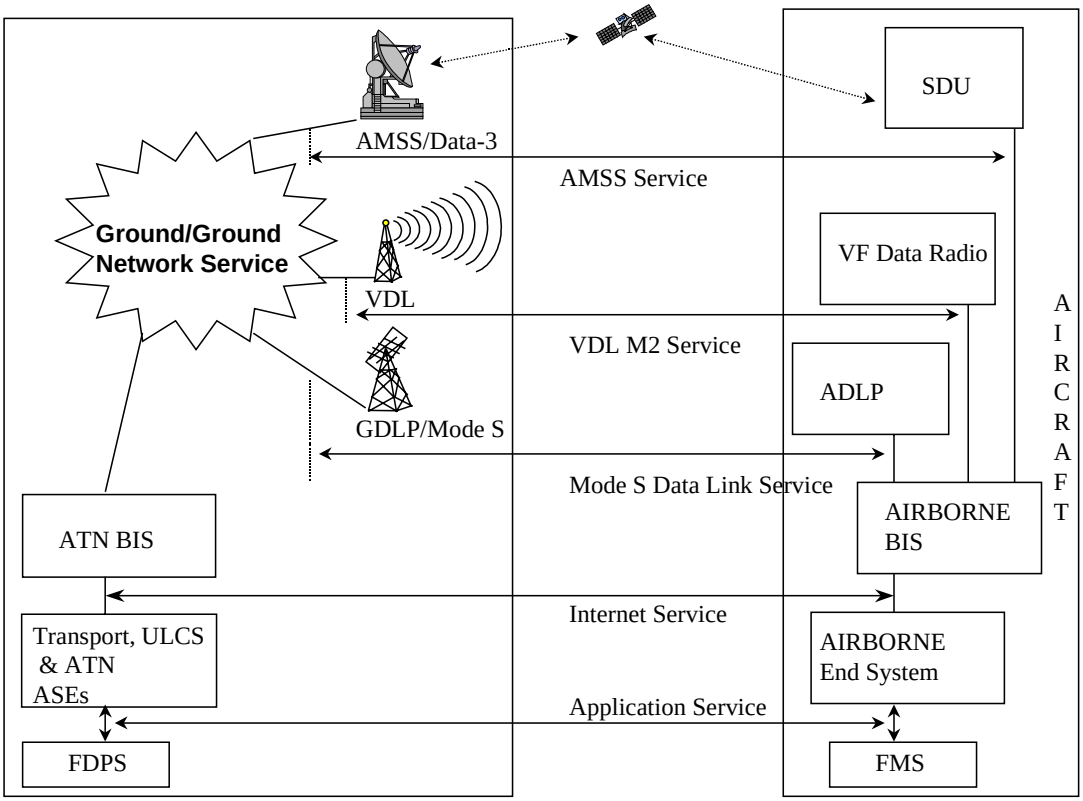

Figure 1 - ATN Service Levels

From the figure it can be seen that the points within the framework where an ATSO may consider contracting a TPSP are at the:

- "**Application Service**";
- "**Internet Service**";
- "**Air/Ground Subnetwork Service**";
- "**Ground/Ground Network Service**".

5.2 Application Service

The Application Service would provide a communications service at the application service interface and below. This would most likely involve the provision of a "server" by the TPCSP to be co-located with the host system (e.g. FDPS) to which it will be required to provide a data link service. The concept of a Data Link Server (DLS) has been proposed in the context

of ICAO ATNP ([4], [5]) and the CEC EUR AGDL project. Such a server is being proposed as the "*focal point for the provision of all the functionality associated with handling the communications aspects of datalinks, and would present a process oriented interface to other centre components such as the Flight Data Processing System and/or the Human/Machine interface*." Essentially the DLS is may be viewed as adding an 8th layer to the communications model. This layer being responsible for implementing common generic functions such as setting up application connections, managing CPDLC dialogues, routing CDPLC messages to the datalink service applications (e.g. ACM, DCL etc). Such an approach to developing this common software is being adopted by the EOLIA project. On the other hand, the approach being used to provide datalink services at Maastricht UAC is to upgrade the existing FDP system to achieve this same functionality. The implementation choice of using a DLS is, to an extent, determined by the existing ATC infrastructure. Whilst the concept of the DLS has yet to be accepted by the community it is understood that industry products based on this concept may be developed.

With respect to Figure 1, the Application Service that an ATSO would contract would extend from the service provided to the ATSOs host system (e.g. FDPS) up to the service provided to the avionics host system, i.e. it will be the complete "end-to-end" service. It will therefore be required to include, in a transparent manner, the provision and use of Routers, ground/ground and air/ground subnetworks necessary to satisfy the ATSOs performance/QoS requirements as defined in the SLA.

5.3 Internet Service

The Internet Service would be provided to the ATSO by means of local or remote access to a BIS of the TPCSP. The service, subject to physical realisation of the avionics, would extend from the ground interface to the BIS up to the BIS interface provided to the airborne End System. The Internet service will be required to ensure, in a transparent manner, the available ground/ground and air/ground networks to satisfy the performance/QoS requirements as defined in the SLA.

5.4 Air/Ground Subnetwork Service

Based on the WP220A report [3], the only realistic means by which an ATSO may use a VDL or AMSS service is to contract a TPCSP, there is unlikely to be an alternative option possible in the short term.

5.4.1 AMSS

As indicated in WP220A there are currently three communications service providers offering AMSS services. Given that the airlines will contract one of these service providers (based on commercial reasons) to support their AOC applications then this will dictate the service provider for ATS communications. The main reason being that an Aircraft Earth Station (AES) can only log on to one GES at a time. Consequently, in the event it is decided that AMSS support is required for the airspace of the ATSO in question, then that ATSO will need to establish contracts with all three satellite communications service providers (providing that each of these providers confirm to the "Minimum Performance Standards" discussed in section 6).

The AMSS service would be accessed from the GES Data-3 interface and extend up to the avionics user interface to the AES. An ATSO may use a TPCSP for the ground/ground network connection to the GES or make use of its own private connection direct to the GES.

5.4.2 VDL

Based on WP220A it maybe concluded that both ARINC and SITA will offer an overlapping VDL Mode 2 service. As in the case of AMSS, airlines will select one or other of these providers to satisfy their AOC requirements and will naturally prefer (if not dictate) that their

selected service provider be used for ATS data communications. Consequently, and as in the AMSS case, the ATSO will need to establish contracts with both ARINC and SITA for the VDL service.

5.5 Ground/Ground Network Service

The ground/ground Network service would be used to provide connectivity between the user (e.g. ATSO systems) and the access points to one or more of the air/ground subnetworks. It is understood that many ATSOs today make use of third party networks for their ground/ground data communications services. When using a TPSP for ground/ground services it is important to assess the providers compliance with applicable provisions in the SARPs with respect to support of the X.25 priority and Fast Select optional facilities.

6. Service Level Agreements

Having:

- considered all issues relevant to Third Party Communications Service Provision from the applicable ACCESS WP reports;
- reviewed the results and conclusions relevant to communications service provision from related studies, reports and trials;
- identified the points within the ATN architecture at which an ATN service, or elements thereof, may be contracted;

this section provides guidance to ATSOs in the sort and types of issues that need to be addressed in a Service Level Agreement for the provision of an ATN service.

- **Performance/Quality of Service Requirements**: The ATSO should ensure that the performance/QoS requirements placed on the communications service are sufficient to meet its objectives, i.e. delivery of operational benefits. Where appropriate, these requirements should be defined in the context of maximum numbers of ground based and airborne users simultaneously using the system. The following parameters should be used as the basis for defining the system performance/QoS requirements:
  - **Availability:** (*ADSP Manual Definition) – "The ability of the system to perform its required function at the initiation of the intended function. It is quantified as the time that the system is available to the time that the system is planned to be available"*.)
  - **Reliability: (***ADSP Manual Definition) – "The probability that a system will deliver a particular message without errors"***.)**
  - **Integrity:** (*ADSP Manual Definition) – "The probability that errors will be mis-detected. This may be when a correct message is indicated as containing one or more errors, or when a message containing one or more errors is indicated as being correct. Note. Integrity relates to the trust which can be placed in the correctness of the information provided".)*
  - **Continuity: (***ADSP Manual Definition) - "The probability of a system to perform its required function without unscheduled interruptions during the intended period of operations"***.)**
  - **Throughput:** *The rate at which data, typically expressed in bits/second or kilobits/second, will be transmitted by the system.*
  - **Transit Delay: (***ATNP SARPs Definition***) –** *"In packet data systems, the elapsed*

time between a request to transmit an assembled data packet and an indication at the receiving end that the corresponding packet has been received and is ready to be used or forwarded."

- **Maximum service outage:** *The maximum period of time acceptable to the user for which there is no service available as a result of a malfunction.*

- **Geographical/Volume coverage:** *The combination of the geographical region and volume of airspace (expressed in Latitude, Longitude and altitude) where the communications service is required to be available.*

- **SLA Performance Indicators**: Based on the performance/QoS requirements defined in the SLA, the SLA should identify a set of "Performance Indicators" which are used by both parties as part of the assessment to ensure that the SLA is being satisfied.

- **Minimum Performance Requirements for AMSS Service Providers**: It was stated in WP220A that it is the airlines that will determine which service provider they will use of AOC and therefore ATS communications. The ATSOs should publish a set of "minimum performance requirements" for the satellite service providers who, as a minimum, must be satisfied by any provider proposed by an airline, or otherwise, to be used for ATS communications.

- **Service Communications Profile**: The SLA should define a communications profile for the service being contracted which must tie down all options and recommendations defined in the applicable ATN and industry standards, e.g. use of Fast Select. Note: In the case of the AMSS it may be possible for an ATSO to access the GES via its own private network. In this case some of the constraints experienced with commercial ground services (e.g. support of priority) may not be applicable.

- **Service Access/Interconnection Requirements**: The SLA should define the physical means by which to access the communications service.

- **Certification**: As recommended by WP223 (Safety and Certification) and currently being considered by the FANS 1/A community, the communications service used to support ATS communications (be it in provided "in house" by the ATSO or contracted to a TPCSP) may required to be "certified" by the appropriate safety regulatory body(ies). This certification is expected to be based on current practices whereby the applicant develops a safety case for the system in question. The SLA should (1) require that the service offered has been certified and (2) that any changes to the infrastructure enabling the provision of the service require that it be re-certified based on an accordingly updated safety case.

- **Performance/QoS Monitoring**: The SLA should define the requirements on the TPCSP to monitor the performance of the service in real time. The methods and means by which the service will be monitored should be defined. In the case of AMSS this should include the monitoring of the GES operation. For initial operations and in order to acquire confidence in the service, ATSOs should consider the need for themselves to monitor the performance of the communications service. The SLA should include a requirement on the TPCSP to publish (in the public domain) data related to the performance of the SLA Performance Indicators on a periodic basis, i.e. weekly, daily and monthly.

- **TPCSP Quality Plan**: Based on the SITA "ATS AIRCOM Performance Quality Plan" produced for the FANS 1/A environment, the SLA should require the TPCSP to develop a Quality Plan that defines the procedures to be followed by the TPCSP to ensure compliance with the SLA.

- **Right to Audit**: The SLA should ensure the ATSOs right to conduct an audit of the TPCSP's methods and means by which it ensures compliance with the requirements of

its Quality plan and those defined in the SLA itself. The user should additionally have the right to verify the published SLA Performance Indicator data.

- **Problem Reporting and Resolution**: The SLA should define the procedures to be followed in the event there are problems identified in the service either as a result of the performance monitoring function or feedback received from the service users. These should include a requirement on the TPCSP to immediately initiate actions to resolve the problem. The TPCSP should additionally be required to notify all other parties involved in the provision of other elements of the end-to-end chain as well as users of the end-to-end chain (1) as soon as the problem has been detected, (2) how long it is expected that the problem will exist, (3) the expected/actual impact on the operational service and (4) when the problem has finally been resolved.

- **TPCSP Infrastructure Enhancements**: Both the ADS Europe trial and FANS 1/A operations suffered from a degraded communications service as a result of the software upgrade introduced into the GES. These experiences highlight and reinforce the need for well defined and end User accepted procedures for:

  - Notifying all parties involved in the provision of elements of the end-to-end chain and users of (1) the type of change to be introduced, (2) the benefits of the change, (3) the date on which the change is to be introduced into the operational system and (4) the procedures to be followed in the event there is an adverse effect on the performance of the system following introduction of the change;

  - Prior to operational introduction the testing of the change in an “off-line” environment (e.g. CAERAF) to ensure that (1) the system operates as specified and (2) there is no adverse affect on the communications service;

  - Managing the introduction of changes into the infrastructure, e.g. in the case of AMSS the order of GES upgrades;

  - Following introduction of the change into the operational system the testing of it and monitoring of the communications service to ensure its correct operation;

  - The means to “roll-back” to previous versions of the infrastructure in the event of system malfunction and/or performance degradation following the introduction of a change.

- **Configuration Management**: As identified in both the FANS 1/A and ADS Europe environment it is essential to implement an effective configuration management system for all elements of the end-to-end chain. The SLA should define a requirement for the TPCSP to implement a configuration management system which should, as a minimum, be capable of archiving all versions of the system so that it may be possible to roll back to any previous version if required. The CM system should additionally include all standards, design, development and test documentation that defines the functionality of the system.

- **ATN Service User Forum**: Based on experiences in the FANS 1/A environment it is expected, and recommended, that a User Forum of ATN service users will be established. The SLA should include requirements on the TPCSP to support such a forum in order to (1) present data related to the performance of its service and (2) to receive collective feedback from its customers so that it may improve elements of its service.

- **Liability**: The SLA will clearly need to address the subject of liability and the extent, in financial terms, the TPCSP would be liable for in the event that it was demonstrated that it (i.e. the TPCSP) was negligent in providing the required communications service as specified in the SLA.

- **Charging Mechanism**: The SLA needs to define the methods and means by which the user will be charged for communications services used. In the case of NATS in the ADS Europe trial, NATS were billed for both the GNS and AMSS services based on the amount of data that was (1) originated by the NATS ground End System and (2) the downlink data that was addressed to the NATS End System.

- **Billing**: The SLA needs to define issues related to billing in terms of frequency, breakdown of costs, information to be provided etc. Unlike the NATS experience in ADS Europe where NATS were presented with separate bills for the ground (GNS) and air/ground service the SLA should require that a single bill is presented in the event that the same TPCSP is contracted for provision of both segments. The SLA should require that the bills are sufficiently detailed so as to allow the user to determine the elements attributable to airlines, specific aircraft, and flight phase (i.e. pre-departure, terminal, en-route, descent, post-arrival).

- **Help Desk**: The SLA should include a requirement whereby there is a continuous (24 hours a day, 365 days a year) help desk service available manned by experienced personnel.

- **Maintenance**: The SLA should define the periodicity, times and duration of any planned maintenance to be performed on any element of the TPCSPs infrastructure that is used in the provision of its contracted communications service.

7. Conclusions and Recommendations

Based on the relevant contents of the related ACCESS Work Packages, and as a result of the experiences gained in the ADS Europe trial and FANS 1/A operations it has been possible to develop a comprehensive list of issues that require to be addressed in a SLA for ATN service provision. Guidance on the specific details to be addressed has been provided.

Four levels at which an ATN service, or element thereof, have been identified as realistic options for contracting a TPCSP, these being the “application”, “internet”, “air/ground” and “ground/ground” services.

Though the SLA concept is in theory a means to specify requirements it must be understood that even the TPCSPs have limited experience with ATS based data link. Consequently it is recommended that:

a. A representative group of of ATSOs, Airlines and TPCSPs should work together to develop and validate a SLA for ATN Services in Europe taking into account the issues raised in Section 6 and relevant elements of Appendix A of this paper. Such a group could either be based on an existing european ATN implementation group or be constituted through a CEC-sponsored initiative;

b. That the ATSOs establish the means to monitor the performance of the contracted communications service in order to develop and maintain confidence in the ability of the TPCSPs to provide the required level of service.

Appendix A – Example SLA

The following outline SLA was proposed by the Satellite Communications and Ground Earth Station Institutional Issues Study [13] for the case where a user (e.g. an ATSO) would contract a satellite service provider (e.g. BT Skyphone) for the provision of satellite communications services.

A. PURPOSE OF THE SYSTEM - NARRATIVE DESCRIPTION OF THE APPLICATION

B. DEFINITION OF TERMS

C. OVERALL FACILITIES

1. Grounds diagrams
2. Floor plans
3. Description of all services provided from the GES facility outside those used by the customer
4. Expansion capacity for future system growth
5. Visitor facilities and conference rooms

D. UPLINK SERVICES DESCRIPTION

1. Organisation of facilities
2. Diagram of facilities
3. System specifications and subvendors utilised
4. Satellite usage specification
5. Operation and Maintenance
6. Earth Station technical specifications
7. IF interface (between high frequency and baseband frequency equipment)
8. Power control of up link path
9. Local monitoring and control
10. Remote monitoring and control
11. Test equipment utilised
12. System testing procedures

E. HISTORICAL SYSTEM PERFORMANCE

1. Uplink service availability (for existing services)

F. LICENSING

G. ORGANISATION OF STAFFING

1. Contact persons and methods of contact
2. New user on-line procedures
3. Training levels, qualifications, and training plan of personnel

H. INSTALLATION/MAINTENANCE SCHEDULE, PLAN, AND PROCEDURES

1. Planned maintenance schedule
2. Preventive maintenance
3. New hub equipment (if required) installation plan
4. Network fault isolation
5. Network fault rectification
6. Start-up procedures
7. Spare parts stock and plan

I. NETWORK OPERATIONS

1. Network administration
2. Operations response to problem inquiries
3. Trouble ticketing systems and procedures
4. Problem escalation
5. Reporting procedures normal and emergency
6. History of maintenance
7. History of operating performance
8. Pilot and demonstration facilities
9. Software updating activities

J. PERFORMANCE MONITORING FOR SLA COMPLIANCE

1. Availability measurement
2. Signal quality measurement
3. Response time measurement

K. TERRESTRIAL CONNECTIONS AND BACKUP SYSTEMS

1. Diverse routing capability
2. Digital and analog capacity

3. Recovery from failures
4. Circuit ordering procedures and lead times
5. Cost of service from GES

L. POWER SUPPLY AND BACKUP SYSTEMS

1. Power distribution plan
2. Short term backup
3. Long term backup

M. DISASTER PLAN

1. Fall over plan
2. Recovery plan

N. SECURITY SYSTEMS AND PROCEDURES

1. Employee screening
2. Change management procedures
3. Fire protection system
4. HVAC systems

O. DATA PROCESSING FACILITIES

1. Key document storage
2. Software backup procedures

P. QUALITY CONTROL, ISO 9001 COMPLIANCE

1. Penalties for non-performance

Q. PRICING OF SERVICES

R. OTHER CONTACT TERMS AND CONDITIONS