INTERNATIONAL CIVIL AVIATION ORGANIZATION
ASIA AND PACIFIC OFFICE

ASIA/PACIFIC REGIONAL AERONAUTICAL TELECOMMUNICATION NETWORK (ATN) GROUND-GROUND ROUTER DESCRIPTION

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1.0 Introduction

The Aeronautical Telecommunication Network (ATN) is a global inter-network that provides digital communications necessary for automated systems that include; air traffic service communication (ATSC), aeronautical operational control (AOC), aeronautical administrative communication (AAC), and aeronautical passenger communication (APC).

The ATN is composed of an ATN network infrastructure and ATN applications, and provides the global communication for ground-ground (G/G) and air-ground (A/G) services. The major components of the ATN network are routers (Intermediate Systems: IS), including G/G routers, A/G routers, and communication sub-networks including air-ground and ground-ground sub-networks. The ATN applications include among others, context management (CM), controller-pilot data link communication (CPDLC), and air traffic service message handling service (ATSMHS). Applications are hosted by the End Systems (ES).

This document describes ATN G/G BIS (Boundary Intermediate System) routers planned for the Asia/Pacific region.

1.1 Scope

This document describes the protocol, performance, and management requirements for the G/G BIS (Class 4) routers that form nodes of the Asia/Pacific regional network Backbone and/or have inter-State/inter-region connectivity within the Asia/Pacific region. It provides essential procurement guidance for G/G routers to assure the interoperability of the ATN network within in the Asia/Pacific Region.

This document should be used in conjunction with ICAO Doc 9705 "Manual of Technical Provisions for the Aeronautical Telecommunication Network", which specifies the ATN Standards and Recommended Practices (SARPs), the Asia/Pacific Regional Router Interface Control Document (ICD) for ATN G/G Router, and other applicable documents as highlighted in this document.

The router descriptions in this document include:

1. G/G router functional requirements associated with ATN Protocol Requirements Lists (APRLs) relevant to support layer 1 to layer 3 requirements, with reference to the Asia/Pacific Regional ATN Router ICD;

2. Guidelines on G/G router performance requirements to ensure the performance of the Asia/Pacific ATN network; and

3. Network management-related G/G router requirements needed to support local and Asia/Pacific regional ATN network management.

While the specifications of Intermediate Systems (whether IS or BIS) and End Systems (ES) within a domain is a local matter, parts of these guidelines may also be applicable to such systems.

1.2 SARPs Compliance

This document is applicable to ATN G/G routers that are defined as Class 4 routers in sub-volume V of the ICAO Doc 9705. ATN G/G routers must, as a minimum, conform to the mandatory ATN SARPs requirements for Class 4 routers.

While the current version of ICAO Doc 9705 is Edition 3, there are no significant differences between the mandatory requirements for Class 4 routers specified in Edition 2 and Edition 3, and it is further noted that the SARPs are generally backwards compatible between successive editions.

While Doc 9705 Edition 3 adds SARPs for ATN enhancements such as ATN Security, Directory Services and Systems Management, these enhancements are not mandatory for Class 4 routers, and the use of these enhancements for Class 4 routers is not currently planned in the Asia/Pacific region on a regional basis. Therefore, both SARPs Edition 2 compliant ATN routers and SARPs Edition 3 compliant ATN routers may satisfy the requirements of this document.

2.0 Documents

2.1 Applicable Documents

The following documents, with specific editions and/or versions, contain requirements, which, through reference in this text, constitute requirements of this document. The requirements for the ATN G/G router descriptions are specified in the following documents:

1) ICAO Doc. 9705-AN/956. Manual of Technical Provisions for the Aeronautical Telecommunication Network, Second Edition – 1999, Sub-Volume V.

2) ICAO Doc. 9705-AN/956. Manual of Technical Provisions for the Aeronautical Telecommunication Network, Third Edition – 2002, Sub-Volume V.

3) ISO/IEC 8208:1995. Information technology - Data communications - X.25 Packet Layer protocol for Data Terminal Equipment (Revision of ISO/IEC 8208:1990).

4) ISO/IEC 8473-1:1994. Information technology - Protocol for providing the connectionless-mode network service: Protocol specification.

5) ISO/IEC 8473-3:1995. Information technology - Protocol for providing the connectionless-mode network service - Part 3: Provision of the underlying service by an X.25 subnetwork.

6) ISO/IEC 8473-2:1994. Information technology - Protocol for providing the connectionless-mode network service - Part 2: Provision of the underlying service by an ISO/IEC 8802 subnetwork.

7) ISO/IEC 8802-3: 1989, Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements - Part 3: Carrier sense multiple access with collision detection - Access method and physical layer specifications.

8) ISO/IEC 8802-2: 1990, Telecommunications and information exchange between systems - Local and metropolitan area networks -Specific requirements - Part 2: Logical link control.

9) ISO/IEC 9542:1988**.** Information processing systems — Telecommunications and information exchange between systems — End system to Intermediate system routing exchange protocol for use in conjunction with the Protocol for providing the connectionless-mode network service (ISO/IEC 8473).

10) ISO/IEC 9542/DAM1: 1988. Information processing systems — Telecommunications and information exchange between systems — End system to Intermediate system routing exchange protocol for use in conjunction with the Protocol for providing the connectionless-mode network service (ISO/IEC 8473) —Amendment 1: Dynamic Discovery of OSI NSAP Addresses by End Systems.

11) ISO/IEC 10589:1992. Information technology — Telecommunications and information exchange between systems — Intermediate system to intermediate system intra-domain-routing routine information exchange protocol for use in conjunction with the protocol for providing the connectionless-mode Network Service (ISO/IEC 8473).

12) ISO/IEC 10747:1994. Information technology — Telecommunications and information exchange between systems — Protocol for exchange of inter-domain routing information among intermediate systems to support forwarding of ISO/IEC 8473 PDUs.

13) Asia/Pacific Regional Router Interface Control Document for Aeronautical Telecommunication Network Ground-Ground Router for the ISO/IEC 8208 Sub-Network, Issue 1.0.

14) Table CNS 1B "ATN Router Plan" of the ASIA/PAC FASID.

2.2 Reference Documents

The following documents are reference documents applicable to the ATN G/G router descriptions. These documents do not form a part of this document and are not referenced within the document.

1) ICAO Doc. 9739-AN/961 The Comprehensive Aeronautical Telecommunication Network Manual (CAMAL), First Edition.

2) ISO/IEC 8348:1993. Information technology - Open Systems Interconnection - Network Service Definition.

3.0 ATN Ground-Ground Router Requirements

3.1 Overview

The ATN system will provide an inter-network for the international aviation community replacing the point-to-point circuits and message-switch based services in use today for ground-ground Air Traffic Services communications. It will also introduce an air-ground mobile data service for aircraft worldwide. The ATN Network is based on the seven-layer ISO Open Systems Interconnect (OSI) model. Figure 3-1 shows the full seven-layer OSI model.

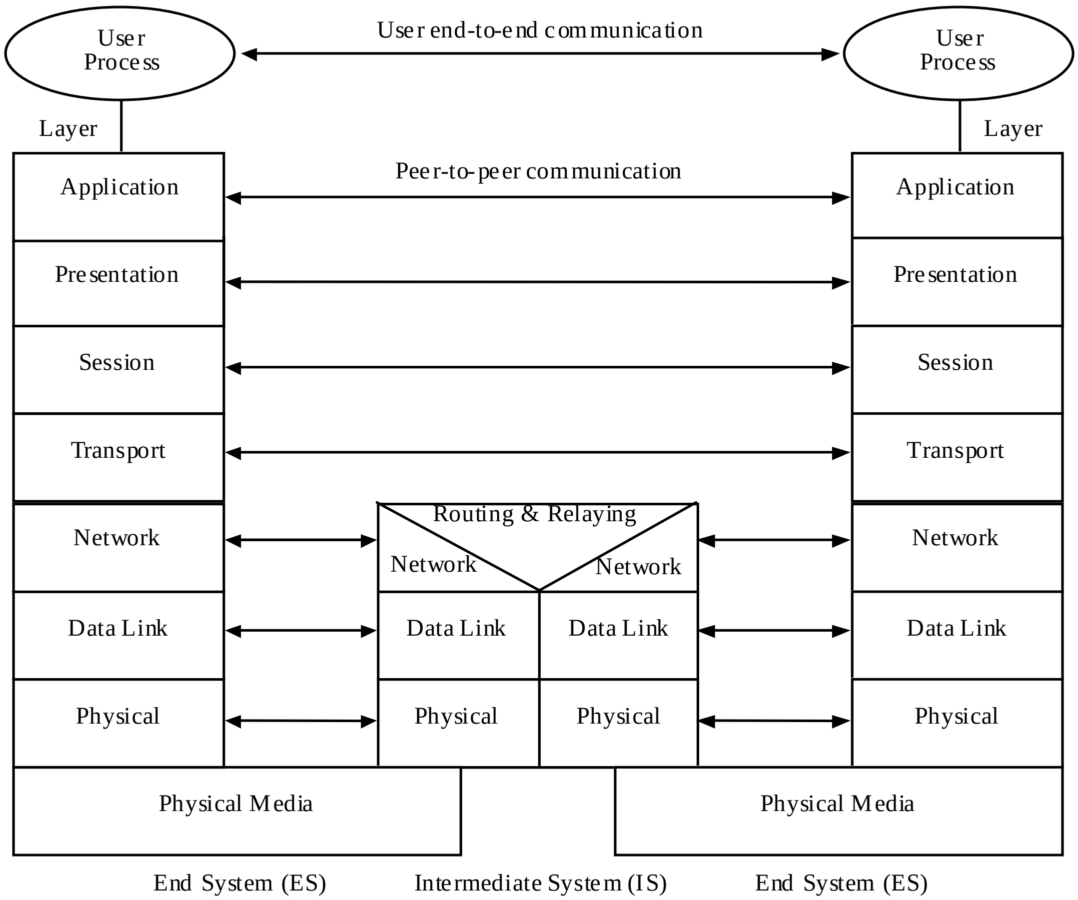


Figure 3-1 Open System Interconnection Reference Model

This document addresses the lower three layers of the OSI seven-layer model for the ATN Ground-Ground (G/G) routers in the Asia/Pacific regional ATN network.

The ATN uses the ISO/IEC8473 Connectionless Network Protocol (CLNP) as the network protocol. Data are transferred in the CLNP Protocol Data Units (PDUs) over sub-networks such as ISO/IEC 8802 Local Area Network (LAN) and ISO/IEC 8208 (“X.25”) point-to-point connections or packet switched networks. ATN routers bridge these sub-networks together to form an integrated ATN network, relaying data packets between LAN and WAN, and WAN and WAN.

Class 4 routers support dynamic routing using the following routing protocols:

1) End system to Intermediate System (ES-IS) routing protocol as specified in ISO/IEC 9542 (optional);
2) Intermediate System to Intermediate System (IS-IS) routing protocol as specified in ISO/IEC 10589 (optional); and
3) Inter-domain Routing Protocol (IDRP) as specified in ISO/IEC 10747.

3.1.1 ATN G/G Router Protocol Characteristics

3.1.1.1 Application Layer

Not applicable to the router.

3.1.1.2 Presentation Layer

Not applicable to the router.

3.1.1.3 Session Layer

Not applicable to the router.

3.1.1.4 Transport Layer

Not applicable to the router.

3.1.1.5 Network Layer

The network layer includes three sub-layers:

3.1.1.5.1 Sub-network Independent Function (SNICF)

The SNICF should include the following routing and routed protocol:

a) ISO/IEC 10747 — the Inter-Domain Routing Protocol (IDRP); and
b) ISO/IEC 8473-1 — the Connectionless Network Protocol (CLNP).

The SNICF may support the following two optional routing protocols:

1. ISO/IEC 9542 — the End-System to Intermediate-System (ES-IS) protocol; and
2. ISO/IEC 10589 — the Intermediate-System-to-Intermediate-System (IS-IS) Intra-domain routing information exchange protocol.

3.1.1.5.2 Sub-network Dependent Convergence Function (SNDCF)

The proper SNDCF should be implemented for underlying sub-network(s). The most commonly implemented SNDCFs are the following:

a) ISO/IEC 8473-2 — Sub-network Dependent Convergence Function (SNDCF) for Local Area Network (LAN); and
b) ISO/IEC 8473-3 — Sub-network Dependent Convergence Function (SNDCF) for X.25 network.

3.1.1.5.3 Sub-network Sub-layer

The sub-network sub-layer is determined by the underlying sub-network. When the data are communicated over X.25 sub-network, the sub-network should include X.25 Packet Layer Protocol (PLP) as specified in ISO/IEC 8208.

3.1.1.6 Data Link Layer

The ATN G/G router Data Link Layer for use within States is a local matter and could be X.25, LAN, etc. The Data Link Layer used between States is subject to bilateral agreement. To ensure regional interoperability, however, the data link layer requirements for ATN routers that connect to the Asia/Pacific ATN regional network are specified in the Asia/Pacific regional ATN router ICD.

3.1.1.7 Physical Layer

The ATN G/G router Physical Layer is a local or bilateral matter and could use the Physical Layer of X.25, LAN, etc.

3.2 Network Layer Requirements

The section defines the ATN G/G router network layer requirements.

3.2.1 Routing and Routed Protocols

3.2.1.1 End-System to Intermediate-System Protocol (ES-IS) (Optional)

According to ICAO Doc 9705, the ES-IS routing protocol is an optional protocol for ATN G/G routers. However, if ES-IS is supported, it is recommended that to ensure interoperability with End Systems, ATN G/G routers **should** comply with the requirements of ISO/IEC 9542 (ES-IS).

3.2.1.2 Intermediate-System to Intermediate-System Routing Protocol (IS-IS) (Optional)

According to ICAO Doc 9705, the IS-IS routing protocol is an optional protocol for ATN G/G routers. However, if IS-IS is supported, it is recommended that to ensure interoperability with IS routers, ATN G/G routers should comply with the requirements of ISO/IEC 10589 (IS-IS).

3.2.1.3 Inter-Domain Routing Protocol (IDRP)

The ATN G/G router should comply with the requirements in ISO/IEC 10747 (IDRP), section 5.8.3 of ICAO Doc 9705, and the IDRP APRLs specified in the Asia/Pacific regional Ground/Ground router ICD.

3.2.1.4 Connectionless Network Protocol (CLNP)

The ATN G/G router should comply with the requirements in ISO/IEC 8374-1, sections 5.6.2 and 5.6.3 of ICAO Doc 9705, and the CLNP APRLs specified in the Asia/Pacific regional Ground/Ground router ICD.

3.2.2 Sub-network Dependent Convergence Function (SNDCF)

Proper SNDCF should be implemented for the supported underlying sub-network(s). The following provides the requirements for SNDCFs supporting X.25 and LAN sub-networks, which are the most commonly implemented sub-networks.

3.2.2.1 X.25 SNDCF Requirements

For underlying X.25 sub-network, the ATN G/G router should comply with the requirements of ISO/IEC 8374-3 and with the APRLs specified in the Asia/Pacific regional Ground/Ground router ICD.

3.2.2.2 Local Area Network (LAN) SNDCF Requirements

The use of LAN sub-network is a local matter. However, if LAN sub-network is supported, to ensure interoperability with other systems/routers it is recommended that ATN G/G routers should comply with the requirements of ISO/IEC 8374-2.

3.2.3 Sub-Network Sub-layer

The sub-network sub-layer is based on the sub-network. When X.25 is used, the ATN router should support the X.25 Packet Layer Protocol (PLP) as specified in Asia/Pacific regional G/G router ICD.

3.3 Data Link Layer Requirements

The following are the Data Link Layer requirements for X.25 and LAN.

3.3.1 X.25 Data Link Layer

When X.25 is used, the ATN G/G router should support the X.25 Data Link Layer requirements as specified in the Asia/Pacific regional G/G router ICD.

3.3.2 LAN Data Link Layer

3.3.2.1 LAN Logical Link Control (LLC)

When LAN is used, the ATN G/G router should support Logical Link Control (LLC) Type 1 connectionless-mode operation requirements specified in ISO/IEC 8802-2.

3.3.2.2 LAN Media Access Control (MAC)

When LAN is used, the ATN G/G route should support the media access control (MAC) using carrier sense multiple access with collision detection (CSMA/CD) defined in ISO/IEC 8802-3.

3.4 Physical Layer Requirements

The Physical Layer is a local matter. The following Physical Layer requirements can be used as references for X.25 and LAN sub-networks.

3.4.1 X.25 Physical Layer

The physical layer requirements are a local matter.

3.4.2 LAN Physical Layer

LAN physical layer should comply with the following minimum requirements:

1. The physical layer should comply with ISO/IEC 8802-3.

2. The router should be capable of supporting 10Base-T physical medium.

3. The physical media dependent interface (MDI) connector should use RJ-45 connector.

4.0 Performance Recommendations

The ATN G/G router performance requirements depend on the ATN network traffic, network planning, services requirements and bilateral agreements.

The follows are the baseline ATN G/G performance recommendation and guidelines.

4.1 Communications Performance and Capacity

The required communication performance of the ATN router (circuit speeds, number of circuits, throughput etc.) should be first determined. This may be achieved by analysis of existing communications traffic levels and the bandwidth and latency requirements of current and future applications. The following are general guidelines for ATN Backbone BIS (BBIS) routers.

4.1.1 WAN Performance

A WAN connection over X.25 is implemented as Virtual Circuit (VC), where more than one VC can share a common physical circuit using logical channels. The router WAN connectivity capability can therefore be expressed in terms of number of VCs supported per physical circuit and number of supported physical circuits.

Where several WAN connections share a common physical circuit, the capacity of the circuit is divided amongst the logical channels and represents a single point of failure. It may be therefore advisable from a performance and failure point of view to distribute the WAN connections over several physical ports. In the case of a large number of WAN connections, it may be advisable to split the connections between more than one BIS.

During transition from AFTN to ATN/AMHS, the ATN link may share the same physical circuit as an existing AFTN link by using a separate logical channel.

4.1.1.1 Circuit Bandwidth

The minimum supported WAN bandwidth should be at least the maximum of the link speeds to the adjacent ATN BIS routers specified in Table CNS 1B of the ASIA/PAC FASID. However, in order to satisfy future network traffic growth, it is recommended that the minimum supported WAN speed should be 64 kbps.

4.1.1.2 Number of WAN Connections

The number of simultaneous WAN connections that must be supported by the BIS depends on the number of adjacent BIS, IS and ES that must be connected by WAN. It is recommended that the BIS router should be capable of supporting at least six physical circuits (assumed two diversified circuits for inter-domain IDRP, two diversified circuits for intra-domain ISIS, and two reserved for ESIS or future expansion), and at least one Virtual Circuit per physical circuit.

4.1.2 LAN Performance

The minimum LAN speed should be at least 10 Mbps.

Note: Most modern LAN devices are capable of supporting both 10Mbps and 100Mbps.

4.1.3 Router Throughput and Delay

4.1.3.1 Throughput

The ATN G/G router throughput should be determined base on the analysis of traffic through the node where ATN G/G router is located. The analysis should consider the current traffic, planned application traffic, and future growth projection.

The following is the example of a throughput calculation. Assuming,

1. CLNP NPDU payload size is minimum 38 bytes;
2. Out of six (6) WAN ports, three (3) ports are operating and fully loaded; and
3. During the normal operation, assuming less than 60% fully loaded.

Using the above assumption 1), the X.25 frame length should be 100 bytes minimum (NPDU payload plus the CLNP overhead: 57 bytes, X.25: 3 bytes, HDLC: 2 bytes).

Then with the assumption 2), the ATN G/G router throughput should be 240 NPDUs/sec (64Kbps*3/100/8) for fully loaded. Considering about 40% off, 150 NPDUs/sec is recommended.

4.1.3.2 Delay

The ATN G/G router delay requirement should be determined base on the analysis of node where ATN router shall be implemented.

According to the results of the example in 4.1.3.1 and assuming that only 50% of the router processing time is used for processing an NPDU, the processing time for each NPDU will be 3.33 milliseconds (0.5second/150NPDUs). Considering the queuing delay, the throughput delay time is assumed to be 5 milliseconds.

The ATN G/G router throughput delay should not exceed 5 milliseconds from the above example.

4.2 Availability and Reliability

The availability of routing service is determined based on Mean Time Between Failures (MTBF) of the routers and downtime. In the network design, availability requirements should first be determined and the network should then be designed to achieve this with given equipment reliability. Availability requirements are higher for BBIS routers that are in Transit Routing Domains and relay traffic for other States than for BIS routers in End Routing Domains, and also depend on the type of applications that use the network infrastructure.

1. For ATN Backbone BIS (BBIS) routers, a high level of availability of the routing service is required. This may be achieved either by using routers that have internal redundancy (e.g. dual-redundant systems) or by the use of multiple non-redundant routers, with automatic switchover capability in the event of failure.

   Where such high levels of availability are not required, use of multiple routers with manual switchover in the event of failure within a certain time period, or identification of faults and replacement of malfunctioning units within a certain time period, may be acceptable methods of meeting availability requirements.

2. The maximum allowed routing service downtime is determined based on maintenance contract. Use of multiple or redundant routers may help to maintain routing service availability during scheduled maintenance downtime.

An example of computation of MTBF for a dual-redundant router is given in Appendix A.

5.0 Network Management Capability

The ATN G/G router should provide a network management agent capable of supporting the network management provisions defined in ICAO Doc 9705 section 6.3.

The Common Management Information Protocol (CMIP) is the network management protocol specified for ATN in Edition 3 of ICAO Doc 9705. ATN network management sees the use of CMIP to allow direct access to network management information across domains in real-time. However, there are currently no requirements for such real-time inter-domain management information sharing within the ICAO Asia/Pacific region. Further, there are very few commercially available CMIP products at present. Implementation of ATN SARPs compliant CMIP agent in the router is therefore optional for Asia/Pacific region Class 4 routers at present.

For local management of the ATN routers within a domain, use of the Simple Network Management Protocol (SNMP) is recommended, given the widespread availability of commercial off-the-shelf SNMP server (network management) products.

It is recommended that the ATN router have a function to generate ECHO Request (ERQ) NPDUs for fault and performance investigation.

6.0 Security and System Integrity

6.1 System Integrity

Specific measures to ensure system integrity (e.g. prevention of unauthorized operation or use of resources) are a local matter, but overall policy for the Asia/Pacific region will be specified in the Asia/Pacific Systems Integrity Policy document currently under development. Generally, it is assumed that ATN routers operated by States for the Asia/Pacific ATN ground network will be in secure environments and connected to only private networks.

1. The ATN router should have functions that prevent unauthorized control of the router (e.g. user authentication).

6.2 ATN Security

Implementation of the technical provisions for ATN Security applicable to ATN routers specified in ICAO Doc. 9705 sub-volume V and sub-volume VIII, that is, Type 2 Authentication in IDRP, is not currently required in Asia/Pacific regional policy but may be required in future when the regional network has reached a level of maturity.

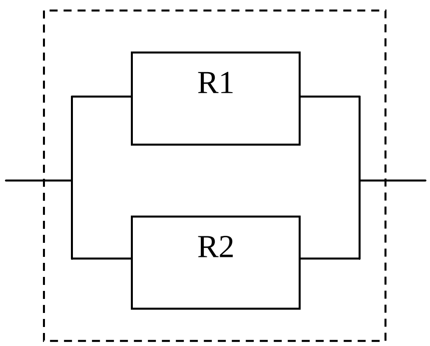
Routers should authenticate the router to which they are connected, either through simpler or strong (cryptographic) means. Use of additional security measures such as Type 2 Authentication is optional and may be use subject to bi-lateral agreement.

Note: Use of dedicated (private) circuit between two ATN routers is a possible means of simple authentication.

APPENDIX A REDUNDANT ROUTER MTBF CALCULATION

The MTBF of a redundant ATN router is analyzed under the assumption of no service loss during a single router switchover.

Considering a redundant system with two routers, the relation between redundant system MTBF and single router MTBF is derived as below.



Assumptions and definitions:

- Assume two routers are identical and have the same MTBF.
- Let router $MTBF_{R1}=MTBF_{R2}=MTBF_R$.
- Let redundant system MTBF be $MTBF_S$.
- Let router fail rate $\lambda_{R1} = \lambda_{R2} = \lambda_R = 1/MTBF_R$.
- Let redundant system fail rate $\lambda_S = 1/MTBF_S$.
- Assume reliability of each router is Poisson distribution: $R_{R1}(t) = R_{R2}(t) = R_R(t) = e^{-\lambda_R t}$.
- Assume reliability of the redundant system is Poisson distribution: $R_S(t) = e^{-\lambda_S t}$.

The reliability of redundant system:

$$\begin{aligned} R_S(t) &= 1-(1-R_{R1}(t))(1-R_{R2}(t)) \\ &= R_{R1}(t)+R_{R2}(t)-R_{R1}(t)R_{R2}(t) \\ &= 2e^{-\lambda_R t} - e^{-2\lambda_R t} \end{aligned}$$

Then $e^{-\lambda_S t} = 2e^{-\lambda_R t} - e^{-2\lambda_R t}$

Integrate the above equation form 0 to infinite

$$\int_0^\infty e^{-\lambda_S t} dt = \int_0^\infty 2e^{-\lambda_R t} dt - \int_0^\infty e^{-2\lambda_R t} dt$$

$$\frac{1}{-\lambda_S} e^{-\lambda_S t}\Big|_0^{\infty} = \frac{2}{-\lambda_R} e^{-\lambda_R t}\Big|_0^{\infty} - \frac{1}{-2\lambda_R} e^{-\lambda_R t}\Big|_0^{\infty}$$

$$\frac{1}{\lambda_S} = \frac{2}{\lambda_R} - \frac{1}{2\lambda_R} = \frac{3}{2\lambda_R}$$

Then $$MTBF_S = \frac{3}{2} MTBF_R$$

Based on industrial survey, the minimum of 40,000 hours MTBF for any server is supportable. According to the assumption of minimum of 40,000 hours MTBF for a single server (router), the redundant system MTBF can be calculated as 60,000 hours.

APPENDIX B ACRONYMS

A/G	(Air-Ground)
AMHS	(ATS message handling system)
APRL	(ATN profile requirement list)
ATC	(Air Traffic Control)
ATN	(Aeronautical Telecommunication Network)
ATS	(Air Traffic Service)
ATSMHS	(ATS Message Handling System)
BIS	(Boundary Intermediate System)
CLNP	(Connectionless Network Protocol)
CLNS	(Connectionless Network Service)
CMIP	(Common Management Information Protocol)
CSMA/CD	(Carrier Sense Multiple Access with Collision Detection)
ES	(End system)
ESs	(End Systems)
G/G	(Ground-Ground)
ICAO	(International Civil Aviation Organization)
ICD	(International Code Designator)
IDRP	(Inter-Domain Routing Protocol)
IEC	(International Electrotechnical Commission)
IEEE	(International Electrical and Electronics Engineering)
IS	(Intermediate system)
ISO	(International Standardization Organization)
ISs	(Intermediate Systems)
LLC	(Logical Link Control)
MAC	(Multiple Access Control)
MDI	(Medium Independent Interface)
NPDUs	(Network Protocol Data Units)
NSAP	(Network Service Access Point)
PUD	(Protocol Data Unit)
PLP	(Packet Layer Protocol)
QOS	(Quality of Service)
RD	(Routing domain)
RIB	(Routing Information Base)
SARPs	(Standard and Recommendation Practices)
RDs	(Routing Domains)
SNDCF	(Subnetwork Dependent Convergence Function)
SNICF	(Subnetwork Independent Convergence Function)
SNMP	(Simple Network Management Protocol)
TBD	(To Be Determined)
TBP	(To Be Proposed)