<u>AERONAUTICAL TELECOMMUNICATION NETWORK PANEL</u>

Working Group 2

Alexandria Virginia

U.S. Validation Report on the Aeronautical Telecommunication Network Sub Volume 5

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<u>SUMMARY</u>

This reports the results United Stated validation efforts on Sub Volume 5 of the Aeronautical Telecommunication Network. This is based on the agreed format at Munich. The United States for several years has been validating the ATN internet using a combination of analysis, simulation, prototyping, and flight trials.

REVISION HISTORY

Section	Date	Issue	Reason for Change
	September 30, 1996	Issue 1.0	Document Creation

U.S. Validation Report on the ATN Internet

1. Scope and Purpose of this Paper

This documents the results of the United States validation efforts on the CNS/ATM Package-1 Sub-Volume V Standards and Recommenced Practices (SARPs) which address the Internet Communication Service as produced by Working Group 2 of the ATN Panel. This paper is based on the validation objectives as defined in WG2/WP318.

2. References

This paper is based on many documents produced by MITRE/CAASD and WG2 of the ATN Panel.

3. Acronyms

4. Overview

4.1. Tools

The United States and in particular MITRE/CAASD has been using a variety of tools to aid in the validation of the CNS/ATM Package-1 Sub Volume V Standards and Recommended Practices. These include the extensive use of prototypes and simulations. A description of these two tools based on the form agreed in WG2 can be found in Appendix A. The following paragraphs give a overview description of the tools involved.

4.1.1. Prototyping

The Aeronautical Communications Engineering Testbed (ACET) laboratory is primary designed to support any area of investigation related to the use of internetworking technologies in a mobile environment. ACET consists of over 60 workstations configured as ATN routers and end systems. ACET is a complete end to end laboratory with the capability to emulate the flights of aircraft through various emulated air/ground subnetworks. Sufficient equipment exists to emulate the air traffic control air/ground communication grid for the eastern United Stated. The U.S. FAA is using the ACET to validate the proposed ICAO ATN draft standards. ACET is working with the FAATC in Atlantic City to perform various flight tests of ATN prototype software. This work includes rack mounting CAASD developed prototype work into FAATC aircraft and into prototypes of air/ground subnetworks (e.g., Mode-S and Satellite). ACET is used to investigate many aspects of the ATN including protocol specification correctness, protocol internaction, end to end delays, and robustness.

4.1.2. Simulation

The MITRE/CAASD simulation efforts are designed to investigate issues with respect to implementation, configuration, robustness, and scalability of the ATN internetwork, especially mobile routing. The following are examples of the types of issues being investigated 1) router performance requirements, connection establishment times, transport layer and upper layer delays, and scaling. The MITRE/CAASD high fidelity simulations are based on OPNET, a discrete-event simulation environment, marketed by MIL3. Model components consist of application traffic generators, TP4, CLNP, ES-IS, IDRP and the Mode S subnetwork. Although simulation models the complete United States ground topology and contains over 50,000 aircraft with up to 15,000 active at a given time, a reduced model consisting of five centers and 50 aircraft per center is used to gather results.

4.2. Documentation

Two documents form the based of the validation planning efforts. These consist of an overall validation plan which includes the roles and responsibilities, schedules, and the tools used in the validation efforts and a detailed validation plan which describes the validation objectives (which are based on the documentation produced in WG 2) and the validation experiments to be performed. The results of these experiments are described in many MITRE/CAASD briefings and are also documented in the CAASD validation report.

4.3. Results

The following is a list of the high level ATN validation objectives for the CNS/ATM Package-1 Internet SARPs and how they relate the U.S. validation efforts. These are based on WG2/318 which describes the results in terns of AVOs. Table 1 contains a list of the AVOs, their description, and the results of the U.S. validation efforts.

AVO Number	Description	Validated By U.S.	Comments
AVO_101	Verify that all ATN requirements pertaining to ground End Systems has been implemented and demonstrated to be SARPs compliant	YES	a
AVO_102	Verify that all ATN requirements pertaining to airborne End Systems have been demonstrated to be SARPs compliant	YES	a
AVO_103	Verify that all ATN requirements pertaining to ground-ground Boundary Intermediate Systems to be SARPs compliant	YES	a
AVO_104	Verify that all ATN requirements pertaining to air-ground Boundary Intermediate Systems have been implemented and demonstrated to be SARPs compliant	YES	a,h
AVO_105	Verify that all ATN requirements pertaining to airborne Systems supporting IDRP have been implemented and demonstrated to be SARPs compliant	YES	a,h
AVO_106	Verify that all ATN requirements pertaining to airborne Boundary Intermediate Systems Not supporting IDRP have been implemented and demonstrated to be SARPs compliant.	YES	a,h
AVO_108	Verify that ISO 8802-2 LAN subnetworks have been implemented for support of ATN communications and demonstrated to be SARPs compliant	YES	
AVO_109	Verify that ISO 8202 WAN subnetworks have been implemented for support of ATN communications and demonstrated to be SARPs compliant	YES	
AVO_110	Verify that ISO 8208 Point to Point subnetworks have been implemented for support of ATN communications and demonstrated to be SARPs	YES	

	compliant		
AVO_111	Verify that Mode S subnetworks have been implemented for support of ATN communications and demonstrated to be SARPs compliant	YES	
AVO_112	Verify that Satellite subnetworks have been implemented for support of ATN communications and demonstrated to be SARPS compliant	NO	Satellite system unstable
AVO_113	Verify that VHF subnetworks have been implemented for support of ATN communications and demonstrated to be SARPS compliant	NO	No VDL compliant system
AVO_114	Verify that CIDIN subnetworks have been implemented for support of ATN communications and demonstrated to be SARPS compliant	NO	
AVO_121	Verify that all ATN requirements pertaining to addressing have been implemented in ATN systems and demonstrated to be SARPs compliant	YES	
AVO_122	Verify that all ATN requirements pertaining to routing architecture and routing policy have been implemented and demonstrated to be SARPS compliant. This includes ATN systems aspects and associated procedures	YES	b,c
AVO_201	Verify that two compliant ATN End Systems interoperate and provide COTS to Transport Services for the default ATN profile.	YES	
AVO_202	Verify that two compliant ATN End Systems interoperate and provide simultaneous COTS to Transport service users.	YES	
AVO_203	Verify that two compliant ATN end Systems supporting different protocol profiles (support of ATN recommendation) interoperate and provide Transport Service.	YES	d
AVO_204	Verify that two compliant ATN End Systems interoperate and provide Transport Service across multiple subnetworks.	YES	
AVO_205	Verify that ground-ground BISs from different Routing domains with different IDRP/CLNP profiles stating compliance to the ATN Draft SARPs can internetwork at the function level	YES	b,d
AVO_206	Verify that ground-ground BISs belonging to the same Routing Domain with different IDRP/CLNP profiles can interwork at the functional level	YES	b,d
AVO_230	Verify the ground-ground BIS internetworking, as in the previously objective for various subnetwork adjacencies.	YES	b,d
AVO_231	Verify that air-ground and airborne BISs with	YES	b,d,e

	different IDRP/CLNP profiles stating compliance to the ATN Draft SARPs can internetwork at the function level for subnetworks providing event-driven routing initiation mechanisms.		
AVO_232	Verify that air-ground and airborne BISs with different IDRP/CLNP profiles can interwork at the functional level for subnetworks using polled-mode routing initiation mechanism.	NO	h
AVO_233	Verify that air-ground and airborne BISs supporting the non-use of IDRP option can internetwork the function level for subnetworks providing event-driven routing initiation mechanisms.	YES	
AVO_234	Verify that air-ground and airborne supporting the non-use of IDRP option can interwork at the functional level for subnetworks using polled-mode routing initiation mechanism.	NO	h
AVO_240	Verify that data packets follow alternative paths and maintain communication after failure of a network component.	YES	b
AVO_241	Verify that BISs can sustain BIS-BIS connection for a long period of time to support ‘typical’ routing information exchanges	YES	
AVO_242	Verify the ability of the IDRP protocol to choose the better route for a given criteria (minimal distance)	YES	b
AVO_243	Verify the stability of the IDRP: ability of IDRP to converge in the updating of the routing table insufficient time to avoid loss of transport connections, and to maintain end-to-end QoS	YES	b,c,e
AVO_244	Verify that routes to mobile domains are propagated in an ATN network in such a way that all aircraft remain reachable from ATN domain.	YES	b,c
AVO_245	Verify that in the case of multiple air-ground adjacencies, ground routers select appropriate routes to the aircraft in accordance with requested QoS/Security label.	YES	b,d
AVO_246	Verify that Routing policy Rules in the ground environment guarantee proper dissemination of routing information.	YES	b,c
AVO_247	Verify that Routing Policy Rules in the air/ground guarantee proper dissemination of routing information.	YES	b
AVO_248	Verify that Routing Policy Rules permit the definition of separate administrative domains in a given ATN topology	YES	b

AVO_249	Verify the Routing Policy rules guarantee proper dissemination of rout information for topologies involving Island.	YES	b
AVO_301	Verify that the ATN internet is transparent from the point of view of user applications.	YES	c,e
AVO_302	Verify that the ATN is capable of supporting the various types of user communications.	YES	
AVO_303	Verify the ability of the ATN service to ensure a fall back on another subnetwork in case of problems on the default subnetwork	YES	b
AVO_304	Verify that pertubated subnetworks has no impact for the ATN service except for the increase in average end-to-end transit delay.	YES	e
AVO_311	Verify the ATN can deliver homogeneous, continuous service to the user from take-off to landing.	YES	c
AVO_312	Verify the ATN can be designed to accommodate normal traffic and peak traffic.	YES	c,e
AVO_313	Verify that the ATN is able to support the various types as defined by the security type parameter.	YES	
AVO_406	Evaluate the IDRP update propagation time.		f
AVO_407	Evaluate the impact of IDRP timers on the Routing Propagation		f
AVO_408	Evaluate the impact of the policy for route distribution on Routing information propagation		b,c,e
AVO_409	Evaluate the reliability of the IDRP transport mechanism.	YES	f
AVO_420	Evaluate the inter-domain routing information exchange overhead for given ATN topologies and r policies when non use of IDRP is used over air-ground links		adequate for near term
AVO_431	Evaluate the inter-domain routing information exchange overhead for given ATN topologies and routing policies when IDRP is used over air-ground links		e
AVO_460	Evaluate the Transport/CLNP overhead.		f - compression should be used to lower overhead
AVO_421	Show that it is possible to maintain communication between any ground systems and an aircraft following a realistic flight path.	It is possible	
AVO_422	Show that when there is a change in the route to an aircraft, the time required between loss of communication and the establishment of a	It is possible	e,f

	replacement communication path neither results in the loss of a transport connection d aircraft, nor does the transit delay beyond an acceptable minimum QoS		
AVO_423	Show that the above holds with the simulation of many aircraft.	It is possible	e,f
AVO_424	Verify the reliability of the service during mobile subnetwork handover conditions	It is possible	e,f
AVO_426	Verify that in case of mobile handovers, ongoing transport connections are not terminated	It is possible	e,f
AVO_429	Evaluate the impact on IDRP of additional subnetwork connections between an air/ground and the handover from one air/ground router to another.		e,f
AVO_435	Verify that once the applied load on the ATN exceeds designed limits that network performance degrades gracefully.		depends on e,f,g
AVO_436	Verify that the number of routing updates is consistent with the router processing capacity	It is possible	
AVO_441	Evaluate end-to-end QoS		e,g
AVO_442	Evaluate the effects of the specific protocol options or implementation strategies on the end-to-end QoS		
AVO_443	Evaluate the impact of the traffic load on the QoS		
AVO_444	Evaluate the service characteristics in term of...		
AVO_445	Evaluate the impact on transport parameters tuning on the QoS and performances.		
AVO_446-473	Congestion Management.	YES	f
AVO_451	Verify that high priority date having a higher probability of achieving the expected QoS.	YES	e,f,g
AVO_452	Evaluate the QoS discrimination between high and low priority data under the various congestion management strategies	YES	e,f
AVO_454-a	Evaluate the compression ratio for LREF only	YES	reduces overhead considerably
AVO_454-b	Evaluate the compression ratio for LREF + ACA	YES	adds some benefit
AVO_454-c	Evaluate the compression ratio for LREF + V.42bis	NO	V.42bis not tested
AVO_454-d	Evaluate the compression ratio for LREF + ACA + V.42bis	NO	V.42bis not tested
AVO_455	Evaluate the impact on the SNDCF compression on the ATN service performance	YES	compression highly desired given

			air/ground bandwidth
AVO_456	Evaluate the probability of use of the cancellation procedure in Air-Ground Communications.	YES	should not be used in near term

Notes of comments

- a - Congestion management not implemented in end-to-end environment
- b - Policies should be universally consistent to ensure correct operation
- c - Result may vary because of network topology and size
- d - Options must be implemented and consistent
- e - Results will vary depending on subnetwork performance
- f - Results will vary depending on timer value settings
- g - Results will vary depending on type (amount, priority, security tag) of load
- h - Polling not implemented

5. Conclusion

The ATN as specified in the draft SARPs is a complex specification which involves the interaction of many different protocols. The environment which these protocols are placed in directly effects their behavior. Therefore in the timeframe required to validate the ATN it is impossible to perform a complete/exhaustive effort. The problems found in the MITRE/CAASD validation efforts to date, based on the ATN Validation Objectives defined by WG2, do not represent any technical defects in the ATN design. They do represent areas of concern and guidance material should emphasis implementation strategies and organizational coordination is required to avoid these problems.

APPENDIX A

Tool Identification	
Name	**ACET**
Full Name	Aeronautical Telecommunication Engineering Testbed (ACET)
Category	PROTOTYPE IMPLEMENTATION
Description	ACET is a prototype laboratory of over 40 machines consisting of End Systems and Intermediate systems with the ability to be configured in many scenarios and the ability to interconnect with various organisations around the world. ACET also contains many internetworking tools including subnetwork emulators and mobility emulation. ACET is developed by MITRE and funded by the US FAA
Contact Point and/or Supplier	MITRE Patrick D. Feighery Tel +1 703 883 3331 Fax +1 703 884 1251 Email feighery@mitre.org
Tool Version and Date	
Supporting Hardware	Intel 486 workstations
Supporting Operating System and/or Software	Mix of BSDI 1.1 Berkeley 4.4 with modification by MITRE
CNS/ATM-1 SARPs Scope	
ATN Systems	End Systems Ground-ground BIS Air-ground BIS Airborne BIS Access to Live Mode-S Subnetwork Access to Live Satellite Subnetwork

Protocols	ISO 8073 ISO 8602 ISO 8473 ISO 9542 ISO 8208 SNDCF ISO 8208 Mobile SNDCF ISO 8802 SNDCF AEEC-745 BASIC CMA Mobility Emulators Mode-S and Satellite Emulators
CNS/ATM-1 Specifics	ATN Addressing ATN Routing Policy Air-Ground Routing Initiation ATN Security End-to-End Transit Delay TP4 Timers

Connectivity Information

Type	**Connector Type and Number**	**Notes**
ISO 8802-3 LAN	As per workstation configuration	
X.25	As per workstation configuration	

Notes

Tool Identification

Name	**ACET**
Full Name	OPNET ATN Simulation Model
Category	SIMULATION MODEL
Description	The ATN simulation models the ATN environment from the physical layer to the application layer. The simulations models application traffic, the transport layer protocols, network layer protocols through the SNDCF, and a Mode–S subnetwork. The OPNET ATN simulation model is developed by MITRE/CAASD and funded by the US FAA.

Contact Point and/or Supplier	MITRE Edward G. Dillon Tel +1 703 883 5275 Fax +1 703 884 1251 Email edillon@mitre.org
Tool Version and Date	ATN simulation version 3.2 (November 1995)
Supporting Hardware	Sun 4 workstation (SPARC station 10)
Supporting Operating System and/or Software	Sun O/S release 4.1.3_U1 Simulation software: OPNET Release 2.5.B

CNS/ATM-1 SARPs Scope

ATN Systems	End Systems Ground-ground BIS Air-ground BIS Airborne BIS
Protocols	ISO 8073 ISO 8473 ISO 9542 ISO 10747 ISO 8208 SNDCF ISO 8208 Mobile SNDCF
CNS/ATM-1 Specifics	ATN Addressing ATN Routing Policy Air-Ground Route Initiation

Connectivity Information

Type	**Connector Type and Number**	**Notes**
Not Applicable		

Notes

The ATN simulation currently supports only the Mode–S air/ground subnetwork.