AERONAUTICAL TELECOMMUNICATIONS NETWORK PANEL (ATNP) WORKING GROUP 2

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Package 1 Requirements and Options Evaluation

SUMMARY

The basis for Package 1 SARPs definition are not currently defined and agreed to. Apparent differences between operational requirements of different states and organizations have slowed this process. This paper is written to state key U.S. operational requirements for near-term implementation of the ATN and based on those requirements and goals for Package 1, develops a set of criteria upon which solutions to various aspects of the Package 1 ATN can be evaluated. These criteria are then used to evaluate alternatives for the Package 1 air/ground routing information exchange solutions and identify a U.S. preference. A strategy for pursuing Package 1 validation is proposed.

REFERENCES

ATN Manual, second edition
ATNP WG2/WP13 Time Estimates for IDRP Initiation Sequence
ATNP WG2/WP25, “Requirements made by early Applications on the ATN Internet, and the consequent Transition Strategy” I. Valentine & T. Whyman.
ATNP WG2/WP35 Proposed Internet Architecture for CNS/ATM Package 1
ATNP WG2/WP27, “CNS/ATM-1 Package Policy Implementation Definition”, T. Signore

Package 1 Requirements and Options Evaluation

1.0 Introduction

1.1 The complete basis for Package 1 SARPs definition is not currently defined and agreed to. Apparent differences between operational requirements (vs. those supported in pre-operational trials) of different states and organizations have slowed this process. This paper is written to state key U.S. operational requirements for near-term implementation of the ATN and based on those requirements and goals for Package 1, develops a set of criteria upon which various solutions can be evaluated. These criteria are then used to evaluate alternatives for the Package 1 air/ground routing information exchange solutions.

2.0 U.S. Operational Requirements

2.1 The U.S. Operational Requirements which are not perceived as shared by all States and Organizations include the need to:

1) Separate safety related traffic from non-safety related traffic over ITU restricted subnetworks. This is a Federal Aviation Regulations (Part 1212) that no Airline Operations Communications should occur over an FAA-operated communications link, unless it is clearly safety related.

2) Allow information to be exchanged between aircraft and appropriate ground systems in all controlled airspace and during all phases of flight where data link communication is available.

2.2 The first operational requirement was discussed at some length in the Working Group 2 ad hoc meeting held in January 1995. In order to meet this requirement, mechanisms are required to differentiate between types of data traffic.

2.3 The second requirement addresses the extent to which mobile routing is needed in the Package 1 time frame. Specifically, this requirement applies to all ground systems in the facility currently providing air traffic services to an aircraft and to ground systems in facilities providing air traffic services to geographically adjacent airspace. This requirement allows air traffic services to be continuously provided to an aircraft as it transitions between adjacent controlling facilities where supporting network connectivity exists. As automation capabilities increase over time, requirements for additional ground systems to exchange information with aircraft in flight will exist and may evolve to require information to be exchanged between any ground system and any aircraft in flight where a valid data communication path exists.

2.4 U.S. validation activities have raised sufficient concerns to consider the mobile routing solution described in the draft ATN standards as a risk area. The second operational requirement indicates that a general solution for mobile routing is not required for Package 1 and therefore can be excluded from Package 1 if validation can not be completed in a timely fashion. The remainder of this paper will focus on routing exchange requirements between aircraft and ground routers.

3.0 Evaluation Criteria for Package 1

3.1 Criteria that the U.S. deems important in evaluating various alternatives for features of Package 1 are :

- meeting the operational requirement for traffic separation identified in section 2.0 (traffic separation requirement)

- the likelihood that a solution can be fielded in commercial aircraft in the operational time frame (avionics availability)
- the likelihood that a solution can be fielded in U.S. ground systems in the operational time frame (U.S. ground implementation availability)
- the extent to which COTS products can be used for general ground implementation (ground COTS)
- ease of transition to future ATN capabilities (transition)
- the likelihood that validation activities can be completed by early 1996 (validation risk)

3.2 Note that succesful validation requires both that validation activities can be conducted in the allotted time and that the validation results will prove that a solution performs adequately in expected operational environments. The U.S. has previously raised issues on air-ground routing exchange use of air-ground bandwidth in a detailed quantitative analysis at ATNP WG2/1.[1] This area requires additional investigation as part of validation activities to further quantify the performance through laboratory experimentation and simulation, and to determine the operational impact of the performance in expected operational scenarios. Never the less, based on the issues identified in the analysis, it is prudent to add the following evaluation criteria :

- performance issues related to inefficient use of air-ground bandwidth for routing exchange (bandwidth efficiency).

The issues described above will be used as evaluation criteria to compare alternative Package 1 proposals.

3.3 Sections 4.0, 6.0 and 7.0 describe and assess alternative proposals for air-ground routing exchange in Package 1. The alternatives analyzed are :

- no use of air-ground routing exchange between aircraft and ground routers
- a connectionless exchange of routing information between aircraft and ground routers that utilizes IDRP PDU formats
- use of IDRP between aircraft and ground routers without support for QOS and security parameters

Section 5.0 discusses alternative means within the last two options to meet the traffic separation requirement.

4.0 No Air-Ground Routing Exchange

4.1 The simplest alternative in terms of aircraft router complexity would be to have an aircraft router which does not support IDRP or any routing exchange with ground routers. Different versions of this have been described in ATNP WG2/WP25[2] and WG2/WP35[3]. These versions differed with respect to the use of the CLNP Security parameter. For purposes of this comparison, for this alternative it is assumed that CLNP packets do not carry and use the CLNP Security parameter in the Package 1 time frame, and that IDRP Security is not supported by ground implementations in this time frame. While this alternative does not require IDRP implementation on aircraft routers, ground routers are required to interoperate with airrcraft routers that both implement IDRP and have no air-ground routing exchange. The following paragraphs evaluate this alternative against the evaluation criteria.

4.2 Traffic Separation Requirement - With no routing exchange between aircraft and ground routers, no mechanism exists to ensure that the traffic separation requirement will be met.

4.3 Avionics Availability - By removing any requirement for avionics to support routing exchange, avionics complexity is kept minimal. Since this approach is being utilized for pre-operational ATN flight trials, there is high confidence that commerical avionics would be available in the Package 1 time frame.

4.4 U.S. Ground Implementation Availability - Focusing strictly on U.S. plans for implementation of a ground router to support Air Traffic Service communications, the Data Link Processor (DLP) Build 2 is well underway with software development largely complete. This implementation will support IDRP for aircraft-ground routing exchange, although neither QOS or security parameters are supported. By allowing aircraft implementations that don't support routing exchange, additional functionality recognizing aircraft routing exchange implementation is required in the DLP 2. Although this functionality may be conceptually simple, implementation and programmatic difficulties may make availability in the early part of the Package 1 time frame problematic.

4.5 Ground COTS - Looking at more general ground router availability, the key issue would be the extent to which deviations from COTS products are required. Since this alternative requires ground routers to interoperate with aircraft with IDRP and aircraft with no air-ground routing exchange, ground routers are required to implement IDRP and functionality recognizing aircraft routing exchange implementation. While both use of IDRP and no air-ground routing exchange are consistent with available COTS products, the additional functionality to recognize aircraft routing exchange implementations would have to be added.

4.6 Transition - Requiring ground routers to interoperate with both aircraft with IDRP and aircraft with no air-ground routing exchange, handles the transition to future ATN capabilities. Avionics implementations can be upgraded to use IDRP at the discretion of aircraft owners and operators with ground routers accomodating the mix of aircraft implementations

4.7 Validation Risk - Since this option requires use of IDRP over the air-ground link to be validated, the validation risk is comparable to the other alternatives.

4.8 Bandwidth Efficiency - With no routing exchange required between aircraft and ground routers, air-ground bandwidth usage can be minimized.

4.9 While this approach allows aircraft router complexity to be kept to a minimum, it clearly does not meet the traffic separation requirement and is not a viable option.

5.0 Alternate Means to Provide Traffic Separation

5.1 Separation of traffic in the ATN, also referred to as access control, requires that traffic type information be conveyed in each CLNP PDU. To meet U.S. operational requirements for traffic separation, a means of conveying this information is required. The ATN Manual specifies that traffic type information be carried in the CLNP security parameter.

5.2 At the WG2 ad hoc meeting to discuss package 1 alternatives, held in Paris in December 1994, it was suggested by some participants that the traffic type information be conveyed in the NSAP rather than the CLNP security parameter. Doing so would require the aircraft to support multiple administrative domains and may alter the NSAP allocations presently defined in the Manual; however, such a solution would allow for the use of off-the-shelf routers for ATN ground-ground applications. It should be noted that off-the-shelf routers do not today support routing based upon the CLNP security nor do those that support IDRP provide for routing decisions to be made based upon the security parameter. The U.S. has implemented various ATN solutions that include multiple domain support by the aircraft, as well as forwarding decisions based upon the CLNP security parameter, and presents the "security via NSAP" alternative as a feasible solution to traffic typing and separation in the ATN.

5.3 If traffic type is not conveyed in CLNP PDUs, no means exist to accomplish traffic separation on a dynamic basis. Schemes to filter (i.e., droping of unacceptable traffic types) based on source and destination NSAPs would have to be devised and topologies restricted to force hop count decisions and tie breaks to be made accordingly. Additionally, such a solution results in dropped packets as a means to ensure traffic separation over restricted links and presents scalability concerns in the growth of the ATN internetwork.

5.4 Traffic separation is most easily provided in package 1 via the assignment of multiple administrative domains to the aircraft (i.e., convey traffic type information in the NSAP itself). This scheme meets U.S. operational requirements and maximizes the use of off-the-shelf technology in the ATN. Additionally, transition is not required as this solution provides a solution for traffic separation in the end-state ATN. The traffic separation mechanisms and tradeoffs described here apply equally to the routing exchange schemes described below.

6.0 Connectionless Routing Exchange Using IDRP PDUs

6.1 At WG 2/2 the FAA put forth a proposed solution in ATNP WG2/WP72[4] that both meets it's operational requirements and avoids IDRP's intensive use of air-ground bandwidth. Referred to as the Routing Initiation and Policy (RIP) process, this solution has been implemented, so it is clear that it works and can potentially be made available. RIP supports reachability exchange and supports policy routing based on NSAP addresses. This solution could be modified to utilize IDRP PDU formats to allow reuse of portions of a full IDRP software implementation. The following paragraphs evaluate this alternative, using IDRP PDU formats, against the evaluation criteria.

6.2 Traffic Separation Requirement -This proposal would meet the traffic separation requirement through the use of the policy process based on NSAP addresses.

6.3 Avionics Availability - This approach requires more software complexity in the aircraft than the previous proposal, but is estimated to require less that one half the lines of software required to support a full IDRP implementation. The degree to which this effects the commercial availability of Package 1 avionics cannot be quantified. Discussions with U.S. avionics manufacturers have indicated that routing exchange using IDRP could be supported by avionics in the Package 1 time frame if sufficient market demand exists. Based on these discussions we estimate that this solution could be supported in avionics in the Package 1 time frame.

6.4 U.S Ground Implementation Availability - Again focusing on U.S. plans for implementation of a ground router, this option would require software changes to DLP 2. Although this functionality may be conceptually simple, implementation and programmatic difficulties may make implementation in the early part of the Package 1 time frame problematic.

6.5 Ground COTS - In looking at the impact this proposal has on the use of COTS products, the specified routing exchange is not available in COTS products and would require additional functionality. Since this functionality can be implemented in a separable software module that uses standard interfaces to network layer functions, implementation could be accomplished with minimal impact to COTS router software.

6.6 Transition - Since the connection-less routing exchange differs from the standard IDRP defined in the draft ATN standards, transition to future ATN capabilities will require ground routers to support an environment of mixed avionics capabilities.

6.7 Validation Risk - Since this proposal is based on a solution that has already been implemented as part of U.S. validation activities, the validation risk is low.

6.8 Bandwidth Efficiency -By avoiding the connection oriented operation of IDRP, this proposal would significantly reduce air-ground bandwidth usage. If validation results indicated air-ground difficulties in this area, the PDU formats in the original U.S. proposal could be used . These formats would allow more efficient use of the air-ground bandwidth.

6.9 This alternative meets the traffic separation requirement and has several positive attributes that make it a viable option. It's primary drawbacks are in transition to future ATN capabilities and the impact on U.S. ground router availability.

7.0 Air-Ground Routing Exchange Using IDRP Without Support for QOS and Security Parameters

7.1 This approach is most closely aligned with the material in the draft ATN standards and is well understood.

7.2 Traffic Separation Requirement -This proposal would meet the traffic separation requirement as discussed in section 5.0.

7.3 Avionics Availability - This approach requires the greatest software complexity in the aircraft of the alternatives considered. Here again, the degree to which this effects the commercial availability of Package 1 avionics cannot be quantified. Based on the previously mentioned discussions with U.S. avionics manufacturers we estimate that this solution could be supported in avionics in the Package 1 time frame, although clearly the risk of timely implementation is greatest with this alternative.

7.4 U.S. Ground Implementation Availability - This option would require no changes to DLP 2 and therefore carries the least risk.

7.5 Ground COTS - Since initial COTS implementation of IDRP are recently available, this alternative is consistent with a limited number of COTS products.

7.6 Transition - Since this alternative implements IDRP on both aircraft and ground routers, it most closely aligns with the draft ATN standards and minimizes transition concerns.

7.7 Validation Risk - The complexity associated with IDRP makes this the highest risk for completing validation in the required time period. Despite this, progress made to-date in validation activities by various states and initial availability of commercial products implementing IDRP would suggest an acceptable level of risk.

7.8 Bandwidth Efficiency -The connection oriented operation of IDRP, coupled with the inefficient PDU formats makes this alternative the least bandwidth efficient. While validation results have not conclusively shown this to be a problem in operational environments, the analysis presented in ATNP WG2/WP13 quantifies the impact.

7.9 This proposal meets the traffic separation requirement and provides the minimal transition risk. It's weakest features are bandwidth efficiency and validation risk. Though subject to validation, at this point, neither of these issues are considered to cause unacceptable levels of risk.

8.0 Evaluation Summary

8.1 Evaluation of the various options described above leads to the matrix below. Where appropriate, a rating for each evaluation criteria is provided on a scale of 1 to 10 with 10 being most desirable. The following paragraphs provide a short summary of the ratings for each evaluation criteria.

8.2 Traffic Separation - Any of the options which assume a routing information exchange protocol across the air/ground link will meet the traffic separation requirement, so this index is purely a binary "Yes/No" value.

8.3 Avionics Availability - The ability to have commercial avionics available for the Package 1 operational time frame was evaluated subjectively, taking into account feedback from U.S. avionics manufacturers. As the code size goes up the certification and general implementation concerns increase. The alternative with no air-ground routing exchange requires the least avionics code and will be available as part of pre-operational trials. The connectionless routing exchange is based on RIP which requires minimal code and has been implemented, so this has the next least risk. Risk increases with use of IDRP since no avionics implementations exist and IDRP requires the largest and most complex avionics software. Relative ratings take into account indications from U.S avionics manufacturers that even IDRP could be available in commercial avionics in the Package 1 time frame.

8.4 U.S. Ground Implementation Availability - Of the three alternatives, use of IDRP for air-ground routing exchange allows the least deviation from current U.S. ground router implementation plans. Either other alternative requires changes to the current specification and would introduce risk for programmatic and possibly implementation reasons.

8.5 Ground COTS - In looking at the alternatives impact on the ability to use COTS products for ground routers, here again, the use of IDRP minimizes deviations from COTS products. Either other alternative requires additional functionality to be added to COTS products, with the connectionless routing exchange being somewhat more complex.

8.6 Transition - Of the three alternatives, use of IDRP is most closely aligned with the current draft ATN standards and minimizes transition complexity. The remaining also have minimal transition complexity since ground routers would be required to support an environment of mixed avionics capabilities.

8.7 Validation Risk - Although IDRP is thought to have the highest risk for completing validation in the required time period, progress in validation activities by various states and initial availability of commercial products implementing IDRP would suggest an acceptable level of risk. Either of the remaining proposals would have a low level of validation risk, with no use of air-ground routing exchange being minimal.

8.8 Bandwidth Efficiency - Evaluating bandwidth in this paper was done subjectively in this paper, but it is clear that there is a continuum between no routing information exchange protocol and the use of full IDRP across air/ground links. The connectionless routing exchange using IDRP PDU's avoids the connection establishment use of bandwidth, and clearly falls between the two. Ratings between the three alternative should take into account the opertional impact of bandwidth usage. Since conclusive information on this is not currently available the ratings are clearly debatable.

	No Air-Ground Routing Exchange	**Connectionless Air-Ground Routing Exchange**	**IDRP Without Support for QOS or Security**
Traffic Separation	No	Yes	Yes
Avionics	10	8	5
U.S. Ground	5	5	10

Ground COTS	8	7	10
Transition	9	9	10
Validation Risk	10	8	6
Bandwidth	10	8	5

9.0 Proposals

9.1 The U.S. proposes that a decision be made at this meeting on air-ground routing exchange for Package 1. Based on the above comparison, the U.S. proposes that Package 1 routing exchange be defined to use IDRP without support for the QOS and security parameters. Of the alternatives considered, this option meets the requirement for traffic separation, aligns with planned COTS products, best aligns with U.S. ground router implementation plans and can be implemented in avionics in the Package 1 time frame, albeit with some risk.

9.2 Given this risk in avionics availability and with air-ground bandwidth usage, the U.S. further proposes that a risk mitigation plan be adopted by Working Group 2. This risk mitigation plan should identify a preferred alternative approach and a planned time frame for reconsidering the air-ground routing exchange solution. The U.S. proposes that the connectionless routing information exchange option be defined as the preferred alternate solution. This alternative meets the traffic separation requirement, reduces risk associated with both avionics complexity and bandwidth usage and is based on a solution currently implemented as part of U.S. validation activities. The U.S. proposes that progress be reviewed in September of 1995 to determine if the alternative approach should be pursued.

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[1] ATNP WG2/WP13, “Time Estimates for the IDRP Initiation Sequence”, T. Signore
[2] ATNP WG2/WP25, “Requirements made by early Applications on the ATN Internet, and the consequent Transition Strategy” I. Valentine & T. Whyman.
[3] ATNP WG2/WP35, “Proposed ATN Internet Architecture for CNS/ATM Package 1”, F. Colliver
[4] ATNP WG2/WP27, “CNS/ATM-1 Package Policy Implementation Definition”, T. Signore