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WORKING GROUP 3 (APPLICATIONS AND UPPER LAYERS)

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Approach to Validation of CNS/ATM-1 Package SARPs (Revised)

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SUMMARY

The draft SARPs for air/ground applications for the CNS/ATM-1 package are nearing completion, and a number of major investments to achieve validation are in hand. This paper reports on work undertaken in Eurocontrol to develop a "Requirements Database", and to build various simulations of the behaviour of SARPs implementations. It reports on progress in the Agency towards building a prototype implementation of the draft SARPs, and looks in greater detail at the steps which are now necessary to validate the draft SARPs. Finally it identifies what decisions are required of ATNP WG3 at its October 1995 meeting to progress this validation.

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1. INTRODUCTION

ATNP WG3 has the task of presenting validated draft SARPs for the applications and ATN upper layers of the CNS/ATM-1 Package, to the ATN Panel meeting in 1996. It is expected that not only will the SARPs text be presented, but also justification for the claims that the text has been validated. This paper proposes how ICAO member bodies can contribute to the validation process, and proposes that WG3 set a target level of validation that is practicable to achieve in the timescale.

2. OBJECTIVES

A SARPs is considered to be "validated" when each requirement ("shall" statement) has been validated. An individual requirement is considered to be validated when it has been examined and tested to determine that it is a true and accurate requirement, unambiguous and not in conflict with any other requirement.

The objectives of SARPs validation are to ensure that the draft SARPs are:-

- complete and self consistent
- unambiguous
- mutually consistent (within a set)
- achieve the declared user requirement

The proposed approaches to validating these aspects are:-

- paper analysis
- simulation - at the protocol or system levels
- prototype implementation
- standalone testing
- Interworking testing

It is also vital that the level of validation is documented as the various validation methods are applied. To this end, a "Requirements Database" is proposed, which documents the mandatory and guidance statements in the SARPs, and against which the results of individual validation exercises can be recorded.

3. REQUIREMENTS DATABASE

3.1 Purpose

A “requirements database” is a means to establish a reference point to the requirements defined in the text of a SARPs. A requirements database modelled on that developed by ATNP WG2 for the validation of the ATN internet SARPs has been developed within Eurocontrol, and populated with a subset of the ADS SARPs to prove its viability. This will be made available on request to other ICAO members as a basis for co-ordinating validation exercises. The requirements database is described in a separate paper.

3.2 Development

In developing the database, it was necessary to go through the draft SARPs document extracting every statement which contained a “shall” (mandatory requirement) or every statement that represented a recommended practice. A two-way relationship between the SARPs text and the database has been retained, to minimise the risk of failing to incorporate changes required during validation.

The database has already been used in the first step of validation, the paper analysis for consistency and completeness. A hierarchical structure has been applied through the database to determine the related functionality requirements. For example, a requirement stating that “the position report shall be encoded as ....” is dependent on a superior requirement “the avionics shall provide periodic position reports”.

3.3 Traceability

All requirements are traceable through the hierarchy to the top of the requirements tree: “The avionics and ground systems shall comply with the requirements set down in ... SARPs”. In some cases a “hanging requirement” was identified, indicating that at some level in the hierarchy there is an unstated or implied requirement that needs to be stated. These observations have been fed through to the ADS SARPs editor.

The database is similarly to be used to ensure that the guidance material relates to existing mandatory requirements, and is not in itself introducing new concepts which should be mandatory.

Following the stabilisation of the draft SARPs as defined by WG3, the full texts will be entered into the database as a means both of picking up initial inconsistencies, and of tracking validation exercises.

3.4 Validation Classification

The following validation classification can be used in the requirements database. The classification can be used to identify how each SARPs requirement may be validated (if possible):

- paper validation - when a requirement can be judged to be valid or invalid based on a paper analysis of the SARPs
- dependent validation - when all the subordinate requirements are validated, this SARPs requirement can be deemed to have been validated
- validation by implementation - the process of designing and writing the software for an implementation will also validate or invalidate this requirement
- validation by functional testing - the requirement can be validated by tests carried out on a single prototype implementation, for example using a test harness, or back to back testing

- interoperability trials - the requirement can be validated by interoperability trials with another implementation over a dummy or real network
- flight trials - the requirement can only be validated by trials between an airborne implementation and a ground implementation
- cannot be validated by any of the above. Requirements which can only be validated on a fully operational implementation may fall into this category. For example, requirements relating to the layout of the Human/Computer Interface, or machine to machine communications within an aircraft. Few requirements should fall into this category.

4. SIMULATION

Simulation exercises allow a model of some aspect of the SARPs to be created (at a much lower cost than a prototype implementation). These models are constructed to exhibit some aspects of the behaviour of a SARPs implementation, and allow limited scale experiments which indicate the likely behaviour of full scale implementations. Two levels of simulation are considered, protocol simulation and system simulation.

4.1 Protocol Simulation

Protocol simulation models the behaviour of the protocol state machine, the emission and reception of PDUs and the events at the service interface.

The Agency is proposing to carry out protocol simulation initially of the ADS SARPs and the Upper Layers SARPs, using the “GEODE” protocol simulation tool. The tool requires that the protocol definitions are transcribed from the SARPs into the protocol definition language understood by the simulator. Scripts are then developed to exercise the protocol model in all likely and unlikely modes of operation, including error conditions. The tool identifies potential lockup conditions, unresolved error conditions, and behaviour under exceptional conditions.

4.2 System Simulation

System simulation is used to determine the likely behaviour of an unbounded number of individual SARPs implementations, operating over networks of varying quality and with varying traffic patterns.

The Agency is proposing to carry out system simulation of ADS using the “OPNET” simulation tool. The tool requires that behavioural characteristics of SARPs implementations are defined, and that scenarios for their location and mobility (for mobiles) are developed. The scenarios can then be run on the simulator and the behaviour of the systems under changing loads, and with mobility of components, can be observed.

5. PROTOTYPE IMPLEMENTATION

A prototype implementation is a complete software package, based on the implementable aspects of the SARPs. Prototype implementations will be used for the undertaking of a set of validation activities, including:-

- local functionality testing
- interoperability (with another remote implementation)
- performance testing over “real” or simulated communications links

It is proposed that prototype implementations of the draft SARPs be made, using a prototyping methodology which ensures that every aspect of the SARPs is addressed by

the prototype, and that any ambiguities or omissions detected during implementation are recorded.

Eurocontrol proposes to build prototypes of ADS, CM and CPDLC, with the supporting upper layers embedded. This is the "Trials End System" as described in a separate paper. (WP ....)

6. VALIDATION BY MEANS OF PROTOTYPES

6.1 General

A series of tests of varying complexity needs to be defined to be carried out on prototype implementations. Tests on a single prototype may be defined and devised by the organisation responsible for that prototype. Tests requiring interworking between prototypes need to be collaboratively agreed between the partners.

It has already been recognised that there will not be a one-for-one correspondence of tests to SARPs requirements. With several hundred "shall" statements in a typical ATN Application SARPs, such an approach would probably still be in test in 1999! Instead, an approach using a small number of more complex "scenarios" is proposed, each of which, on successful completion, should give a high degree of confidence in a large number of requirements. A separate paper (WP ....) describes some initial proposals for scenarios.

6.2 Functional Tests

Functional Tests can be carried out on a single implementation of the SARPs in an individual end system (Airborne or ground). These tests should not be confused with implementation tests carried out by the prototype implementor to ensure he has implemented the specification.

6.3 Interoperability Tests

Interoperability tests are specified to ensure that the exchange of information between implementations meets SARPs requirements. A test method similar to that used for OSI interoperability testing may be appropriate, either back-to-back with the same implementation, or testing with an independent implementation.

Performance tests are needed to validate performance aspects of the SARPs, e.g. is it feasible to achieve the required round trip time with current network technology? These tests are likely to be carried out over a real ATN internet and subnetworks, or else over a network simulator.

6.4 Flight Trials

Flight trials are needed to validate that the operational concept is correctly reflected in the SARPs. Such trials can be carried out with real aircraft and ATC centres, or with simulators.

7. TIMESCALE

The ADS and Upper Layer draft SARPs are expected to be stable by the beginning of 1996, and these are used as the basis for the following table. The CM and CPDLC are hoped to be in the same time frame.

The validation objective should therefore be to achieve the following end dates:

- Incorporate and categorise SARPs requirements - 15-12-95

- Design validation exercises and tests - 15-12-95
- Carry out validation - start TBD
- Complete validation - TBD

8. CHANGE CONTROL

ATNP WG3 should set up a mechanism for propagating information on defects in the draft SARPs, as these are identified by validation participants, together with the proposed solutions. A "Change Control Board", probably populated by the SG that produced the draft SARPs, should review the proposed solutions and recommend their acceptance or rejection. This should be done on an electronic communication basis, and should not be dependent on meetings. The draft SARPs editors should be required to undertake maintenance of the text (on the basis of minor revisions) between SG and /or WG meetings.

9. RECOMMENDATIONS

WG3 is invited to adopt the following proposals:

1. Create a change control board (CCB) as the means by which change control is to be applied to the ATN applications draft SARPs
2. Adopt the Eurocontrol requirements database as the means by which defects, proposed changes and CCB-ratified changes are tracked
3. Ensure SARPs editors and appropriate SGs are empowered to maintain and update draft SARPs material in the light of CCB-ratified changes
4. Plan the structure and content of a validation report to be passed to ATNP2 with respect to each draft SARPs
5. Propose a validation target (typically 95%) which represents the target coverage of validation
6. Determine a realistic timescale target for validation exercises to that level
7. Encourage member states and organisations to participate in the validation activities.
8. Consider the scenarios identified in WP .... as a basis for interworking testing