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Proposed Scenarios for CNS/ATM-1 Package Draft SARPs Validation

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SUMMARY

This document outlines a number of scenarios which are intended to form the basis of interoperability testing of prototype software implementation of ATM applications. This is part of the validation of draft SARPs for the CNS/ATM-1 Package. It is intended to apply these scenarios to the validation of draft SARPs using prototype applications produced under Eurocontrol's Trial End System (TES) project.

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Scope

This document outlines a number of scenarios which are intended to form the basis of interoperability testing of prototype software implementation of ATM applications. This is part of the validation of draft SARPs for the CNS/ATM-1 Package. It is intended to apply these scenarios to the validation of draft SARPs using prototype applications produced under Eurocontrol's Trial End System (TES) project.

This document restricts itself to the interoperability of applications based on the ADS[1], CM[2], CPDLC[3] and Upper Layer draft SARPs[4] as defined for the CNS/ATM-1 Package.

The objective is to define a small number of scenarios which will simulate operational use of ATN end systems. These scenarios include potential interoperability between:

a) TES air <-> TES ground components

b) TES air or ground with other implementations from other States.

The goal is to achieve about 90% coverage of SARPs requirements. Scenarios can be based on flight lifecycles and cover the operation of the CM, ADS and CPDLC applications. Each scenario will consist of one or more 'flights' (or tasks).

The number of tests specified has been kept to a reasonable number in order that the tests can be performed in a reasonable time whilst giving an assurance that the testing is comprehensive and meaningful.

1.2 Commentary

Interoperability testing is just one of a number of methods that can be used in validating draft SARPs. Other methods include the building of the Trial End System (TES), Simulation activities and the SARPs Requirements database.

The results from the interoperability tests will show up:

- deficiencies in particular implementations under test.
- incorrect or ambiguous specification of protocol in the draft SARPs.

1.3 Structure

Section 2 provides details on the scenarios.

Section 3 provides a background to the scenarios for interoperability testing.

Section 4 defines the basic entities that are used in the scenarios.

Section 5 proposes CM SARPs test messages.

Section 6 proposes the ADS SARPs test messages.

Section 7 proposes the CPDLC SARPs test messages.

Section 8 describes how a final assessment of the SARPs can be made.

1.4 Notation

Messages are transferred between end-systems and these are represented as:

End-System-Name ➔ SARPs[Message.MessageElement] ➔ End-System-Name

For example: Aircraft-1 ➔ CM.ContactResponse ➔ FIR-A

End-System-Names are defined in Section 3.6.

1.5 References

[1] Draft ADS SARPs dated 7th August 1995.

[2] ATNP CNS/ATM-1 CM Draft SARPs (Draft 4) dated 5th August 1995.

[3] ATNP CNS/ATM-1 CPDLC Draft SARPs (Post Silver Spring Meeting Version), dated 30th August 1995.

[4] Draft SARPs for ATN Upper Layers for the CNS/ATM-1 Package (Version 0.1) dated 5th May 1995.

2. THE SCENARIOS

2.1 Scenario Description Format

Each Scenario has an associated table with the following format:

Name: *Scenario identification.*
Brief Description : *A brief description of the scenario in plain English.* Number of FIR's involved : *A Number* Number of airports involved : *A Number* Number of TES (air) involved : *A Number* Detailed Description : *A detailed description of each event in the scenario.* ***Fixed Events** are listed in chronological order and given an event-identifier 'a)', 'b)', etc.* ***Period Events** are a special case of a fixed event that repeats itself every n minutes - it is identified as 'a)+n', 'b)+n', etc. These periodic events remain active until an end of periodic event identifier is specified as 'a)-', 'b)-', etc.* ***Random Events** (which are given the event-identifier '*') are specified after the fixed and periodic events and contain the start and end event-identifiers during which the random event can occur.*

2.2 Scenario-1

Name: Scenario-1

Brief Description :

In this scenario an aircraft remains in the same FIR from take-off to landing. This simple scenario includes some basic (ground initiated) CPDLC messages.

This scenario also assumes that the versions of ADS and CM used by the aircraft and the ground are the same.

The scenario can be extended to test demand and event contracts.

Note: It is assumed that an ADS Cancel Contract is issued just prior to landing.

Number of FIR's involved : 1

Number of airports involved : 2

Number of TES (air) involved : 1

Detailed Description :

a) Aircraft-1 departs Airport-A[1]
Aircraft-1 → CM.LogonRequest → FIR-A
FIR-A → CM.LogonResponse → Aircraft-1
FIR-A → ADS.PeriodicContract → Aircraft-1
Aircraft-1 → ADS.Response → FIR-A

b)+5 Aircraft-1 flies in FIR-A airspace
Aircraft-1 → ADS.PeriodicReport → FIR-A (every five minutes)

c) FIR-A → ADS.CancelContract → Aircraft-1
Aircraft-1 → ADS.Response → FIR-A

d) Aircraft-1 lands at Airport-A[2]

*) CPDLC communication during b)
FIR-A → ATCUplinkMessage → Aircraft-1
Aircraft-1 → ATCDownlinkMessage → FIR-A

2.3 Scenario-2

Name: Scenario-2

Brief Description :

In this scenario an aircraft enters an FIR from (from somewhere outside the scope of the scenario) and lands at an airport within the FIR. There is no CM logon in this scenario (it is assumed that Ground-Ground communications had already taken place prior to the aircraft entering FIR-A's airspace).

Note: It is assumed that an ADS Cancel Contract is issued just prior to landing.

Number of FIR's involved : 1

Number of airports involved : 1

Number of TES (air) involved : 1

Detailed Description :

a) Aircraft-1 enters FIR-A controlled airspace from Airport-X
FIR-A → ADS.PeriodicContract → Aircraft-1

b)+5 Aircraft-1 flies in FIR-A airspace
Aircraft-1 → ADS.PeriodicReport → FIR-A (every 5 minutes)

c) FIR-A → ADS.CancelContract → Aircraft-1
Aircraft-1 → ADS.Response → FIR-A

d) Aircraft-1 lands at Airport-A[1]

*) CPDLC communication during b)
FIR-A → ATCUplinkMessage → Aircraft-1
Aircraft-1 → ATCDownlinkMessage → FIR-A

2.4 Scenario-3

Name: Scenario-3

Brief Description :

In this scenario an aircraft takes-off from an airport (within the scope of the scenario) and proceeds to another airport (outside of the scope of the scenario).

Note-1: It is assumed that an ADS Cancel Contract is issued just prior to landing.

Note-2: It is assumed that the ADS Event Report is issued at an appropriate point (i.e. when the event happens).

Number of FIR's involved : 1

Number of airports involved : 1

Number of TES (air) involved : 1

Detailed Description :

a) Aircraft-1 takes off from Airport-1
Aircraft-1 → CM.LogonRequest → FIR-A
FIR-A → CM.LogonResponse → Aircraft-1
FIR-A → ADS.PeriodicContract → Aircraft-1

b)+5 Aircraft-1 flies in FIR-A airspace
Aircraft-1 → ADS.PeriodicReport → FIR-A (every 5 minutes)

c) FIR-A → ADS.CancelContract → Aircraft-1
Aircraft-1 → ADS.Response → FIR-A

d) FIR-A → ADS.DemandContract → Aircraft-1
Aircraft-1 → ADS.PosiveAck + DemandReport → FIR-A

e) FIR-A → ADS.EventContract → Aircraft-1
Aircraft-1 → ADS.PosiveAck + EventReport → FIR-A

f)+10 Aircraft-1 flies in FIR-A airspace
Aircraft-1 → ADS.PeriodicReport → FIR-A (every 5 minutes)

g) FIR-A → ADS.CancelContract → Aircraft-1
Aircraft-1 → ADS.Response → FIR-A

h) Aircraft-1 exits FIR-A enroute FIR-X bound for Airport-X

*) CPDLC communication during b)
FIR-A → ATCUplinkMessage → Aircraft-1
Aircraft-1 → ATCDownlinkMessage → FIR-A

2.5 Scenario-4

Name: Scenario-4

Brief Description :

In this scenario an aircraft enters an FIR from (from somewhere outside the scope of the scenario) proceeds through this and another FIR (again within the scope of the scenario) and enters yet another FIR (which is outside of the scope of the scenario).

The scenario can be extended to test ADS periodic reports with two FIRs simultaneously.

Number of FIR's involved : 2

Number of airports involved : 0

Number of TES (air) involved : 1

Detailed Description :

a) Aircraft-1 enters FIR-A
Aircraft-1 → CM.LogonRequest → FIR-A
FIR-A → CM.LogonResponse → Aircraft-1
FIR-A → ADS.PeriodicContract → Aircraft-1

b)+5 Aircraft-1 flies in FIR-A airspace
Aircraft-1 → ADS.PeriodicReport → FIR-A (every 5 minutes)

c) FIR-A → ADS.CancelContract → Aircraft-1
Aircraft-1 → ADS.Response → FIR-A

d) FIR-A to FIR-B transition
FIR-A → CM.ContactRequest → Aircraft-1
Aircraft-1 → CM.LogonRequest → FIR-B
FIR-B → CM.LogonResponse → Aircraft-1
Aircraft-1 → CM.ContactResponse → FIR-A
FIR-B → ADS.PeriodicContract → Aircraft-1

e)+5 Aircraft-1 flies in FIR-B airspace
Aircraft-1 → ADS.PeriodicReport → FIR-B (every 5 minutes)

f) Aircraft-1 exists FIR-B enroute FIR-X bound for Airport-X

*) CPDLC communication during b)
FIR-A → ATCUplinkMessage → Aircraft-1
Aircraft-1 → ATCDownlinkMessage → FIR-A

2.6 Scenario-5

Name: Scenario-5

Brief Description :

This is basically Scenario-1 with an inflight emergency initiated by the aircraft. Note that the transition to emergency mode should suspend the periodic ADS reporting until the emergency is cancelled. During the emergency, periodic reports will be sent at a time interval based on the reporting interval active at the time of the emergency (See FD5 in the ADS SARPs).

This scenario can be extended to support the cancellation of the emergency report and check that the periodic report resumes.

Number of FIR's involved : 1

Number of airports involved : 1

Number of TES (air) involved : 1

Detailed Description :

a) Aircraft-1 departs Airport-A
Aircraft-1 → CM.LogonRequest → FIR-A
FIR-A → CM.LogonResponse → Aircraft-1
FIR-A → ADS.PeriodicContract → Aircraft-1

b)+5 Aircraft-1 flies in FIR-A airspace
Aircraft-1 → ADS.PeriodicReport → FIR-A (every five minutes)

c) Aircraft-1 lands at Airport-A[2]

*) CPDLC communication during b)
FIR-A → ATCUplinkMessage → Aircraft-1
Aircraft-1 → ATCDownlinkMessage → FIR-A

*) Emergency between a) and c)
Aircraft-1 → ADS.EmergencyReport → FIR-A

2.7 Scenario-6

Name: Scenario-6

Brief Description :

This is basically Scenario-3 but using Aircraft-4 (i.e. no ADS but has CPDLC). The simulation aims to show how CPDLC communications can be used in place of ADS.

Number of FIR's involved : 1

Number of airports involved : 0

Number of TES (air) involved : 1

Detailed Description :

As for Scenario-3 but with Aircraft-4. All ADS uplinks and downlinks should be replaced with CPDLC equivalents.

2.8 Scenario-7

Name: Scenario-7

Brief Description :

This scenario involves Aircraft-1 and two FIR's (FIR-A and FIR-D). Aircraft-1 will communicate (like Scenario-3) with FIR-A, but use CPDLC with FIR-D (much like Scenario-6).

Number of FIR's involved : 2

Number of airports involved : 0

Number of TES (air) involved : 1

Detailed Description :

A mixture of Scenario-3 and Scenario-6.

2.9 Scenario-8

Name: Scenario-8

Brief Description :

This scenario involves all the Aircraft and FIR types defined in Sections 3.6.2 and 3.6.3 respectively. This scenario will check that an aircraft can maintain ADS communications with up to four FIR's. It should also include random emergencies (both ground and air initiated), ADS non-compliance's, and a temporary failure of key communication paths.

In addition to the above there will be a normal dialogue of CM, ADS (a mixture of Event, Demand and Periodic reporting) and CPDLC as appropriate to the aircraft and FIR's capabilities.

This scenario should mimic reality as closely as possible to exercise fully the communications protocols defined in the draft SARPs. The number of objects (FIRs and Aircraft) involved should be kept to a minimum as we are not interested in capacity limitations but we are interested in the functioning of the draft SARPs.

Number of FIR's involved : 5

Number of TES (ground) involved : 0

Number of TES (air) involved : 5

Detailed Description :

<<tbd>>

3. INTEROPERABILITY TESTING

3.1 Methodology

The approach to designing an Interoperability test suite will follow tried and tested practices. This will result in a series of matrices (implementation by implementation) for each scenario (or group of scenarios) that is implemented.

This interoperability test scheme can be briefly summarised as:

1. Define the initial state of the interoperability test environment (State-0). This basically says what files should exist and what they should contain. These files can be control files (the scripts that drive a particular scenario) or data files. It will also specify what connectivity is required, addresses, etc.

2. During the execution phase (State-1) each scenario is run in a pre-determined order. A scenario may consist of one or more flights (tasks), and each task will be made up of a series of tests.

3. After all the scenarios have been run the interoperability test environment will be in its final state (State-2). This will contain the files from State-0 which may have changed, plus other files which will contain the results of the executing the scenarios.

3.2 The Tests

Each interoperability test consists of events (See Section 2.1) which in turn consist of tests. These tests are designed to test one or more facets of a SARPs. These facets (the 'test level') may be:

'N' Basic operation of the protocol with 'normal' data values (and no Optional fields included).

'O' Basic operation of the protocol with 'normal' data values (with Optional fields included).

'X' Basic operation of the protocol with 'extreme' data values.

'E' Forcing an error condition.

Note-1: Care will be required when generating CPDLC messages because they contain nested choices and as a consequence a vast number of permutations can be generated.

Given that the ATN Upper Layer SARPs is used by the application SARPs (ADS, CM, and CPDLC) then this is sufficient to effectively test the Upper layers SARPs in situ (by virtue of the success or failure of the application SARPs), i.e. embedded testing.

Most of the tests verify the ability of one test partner to generate messages and the ability for another test partner to recognise these correctly.

3.3 Test Style

The test are presented in a style similar to that used by EurOSInet[1], i.e.:

- test name: YYY-XXXz (where YYY is one of ADS, CM, and CPDLC), XXX is a sequence number (001..999).
- category: "SARPs Validation".
- purpose: Brief description of the purpose of the test.
- procedure: Step-by-step instructions on how to perform the test. There will potentially be separate test for each test level.
- expected result: Brief description of the expected results from the test.

3.4 SARPs Confidence Set

A subset of all tests can be specified such that it gives reasonable confidence in the behaviour of the implementation. This may not be appropriate in safety-critical software applications.

3.5 General Identification

Associated with each test set there will need to be information supplied by the test partners concerning the software being used:

1. Implementation identification.
2. Software version identification, build identification , build date and time.
3. Platform (complete details of hardware and operating system).
4. Based on (draft SARPs details).
5. Incorporating defect reports (list of defect reports).

[1] EurOSInet - The European Interoperability Testing Association.

3.6 Airports, Aircraft and FIRs

The scenarios presented in this document make use of End Systems at Airports, Aircraft and FIRs and the messages that flow between them.

For the purposes of these scenarios the following naming and capability scheme is used.

3.6.1 Airports

Airports are named "Airport-R[n]", where the 'R' is the FIR Region (or set to 'X' if the originating or destination airport is outside of the FIRs used by scenarios) and the 'n' is an integer identifier starting at one which is used where an FIR contains more than one airport.

Airport
Airport-A
Airport-B
...
Airport-C

3.6.2 Aircraft

Aircraft are named "Aircraft-n", where the 'n' is an integer (capability) identifier starting at one, for example, different Scenarios may involve aircraft with different capabilities (in terms of CM, ADS and CPDLC.

Aircraft	CM onboard	ADS onboard	CPDLC onboard
Aircraft-1	Yes	Yes	Yes
Aircraft-2	Yes	Yes	No
Aircraft-3	Yes	No	No
Aircraft-4	Yes	No	Yes
Aircraft-5	No	No	No

3.6.3 FIRs

FIRs can be within in scope of these tests in which case they are named "FIR-R", where the 'R' is a alphabetic identifier starting at 'A' (but excluding 'X'). FIRs can also be outside of the scope of these tests in which case they are given the general name "FIR-X".

FIR	CM available	ADS available	CPDLC available
FIR-A	Yes	Yes	Yes
FIR-B	Yes	Yes	No
FIR-C	Yes	No	No
FIR-D	Yes	No	Yes
FIR-E	No	No	No

3.6.4 Messages

3.6.4.1 Notation

Messages are transferred between end-systems. These are represented as:

End-System-Name ➔ SARPs[Message.MessageElement] ➔ End-System-Name

For example: Aircraft-1[1] ➔ CM.ContactResponse ➔ FIR-A

3.6.4.2 CM Messages

There are a number of CM Messages:

- CM.LogonRequest
- CM.LogonResponse
- CM.ContactRequest
- CM.ContactResponse
- CM.UAbort
- CM.PAbort
- CM.UpDate

3.6.4.3 ADS Messages

There are a number of ADS messages with seven downlink (ADSD) and eight uplink (ADSU) messages defined:

- ADSU.CancelContract
- ADSU.CancelEmergencyAck
- ADSU.DemandContract
- ADSU.EventContract
- ADSU.GroundCancelEmergency
- ADSU.ModifyEmergencyContact
- ADSU.PeriodicContract
- ADSD.AirCancelEmergency
- ADSD.DemandReport (*)
- ADSD.EmergencyReport
- ADSD.EventReport (*)
- ADSD.NegativeAck
- ADSD.NoncomplianceNotification
- ADSD.PeriodicReport (*)
- ADSD.PositiveAck (*)

* These reports may also carry an ADSD.PositiveAck.

3.6.5 CPDLC Messages

There are a large number of CPDLC messages with 200 uplink messages and 88 downlink currently defined. For the purposes of scenario definition, and in order to add a degree of realism, these should be generated from real (VHF) voice communications. For the purposes of the scenarios, just two generic messages are defined:

- ATCDownlinkMessage
- ATCUplinkMessage

3.7 Overall Plan

The following test plan will be executed :

State	Comment
State-0	Set up filestore to known state, including all test files and scripts. Ensure basic connectivity etc. ...
State-1: Scenario-1	Execute Scenario-1
State-1: Scenario-2	Execute Scenario-2
...	...
State-1: Scenario-10	Execute Scenario-10
State-2	Test Completed
-	Produce report matrix

4. THE CM SARPS TEST MESSAGES

These are the test messages used by the scenarios.

4.1 Test CM-001

Category	SARPs validation
Purpose	To validate the CM Message 'CM Logon-on Request'. The test will request that certain information is returned, this returned information can be analysed for completeness and validity.
Procedure	1. CM Log-On Request to contain the following Field Value CMLogonRequest.CMVersion CMLogonRequest. CMLogonRequest.AircraftFlightIdentification "CM-001" I 2. Send Message 3. A Response is received.
Expected Results	The following fields must be returned: • CMLogonResponse.response and must contain valid data.

4.2 Test CM-002

Category	SARPs validation
Purpose	To validate the CM Message 'CM Logon Response'. The test will request that certain information is returned, this returned information can be analysed for completeness and validity.
Procedure	
Expected Results	

4.3 Test CM-003

Category	SARPs validation
Purpose	To validate the CM Message 'CM Contact Request'. The test will request that certain information is returned, this returned information can be analysed for completeness and validity.
Procedure	
Expected Results	

4.4 Test CM-004

Category	SARPs validation
Purpose	To validate the CM Message 'CM Contact Response'. The test will request that certain information is returned, this returned information can be analysed for completeness and validity.
Procedure	
Expected Results	

4.5 Test CM-005

Category	SARPs validation
Purpose	To validate the CM Message 'CMUAbort'. Note that no information is returned.
Procedure	
Expected Results	

4.6 Test CM-006

Category	SARPs validation
Purpose	To validate the CM Message 'CMPAbort'. The test will request that certain information is returned, this returned information can be analysed for completeness and validity.
Procedure	
Expected Results	

4.7 Test CM-007

Category	SARPs validation
Purpose	To validate the CM Message 'CMUpDate'. Note that no information is returned.
Procedure	
Expected Results	

4.8 Judging Success or Failure of a Test

In order to determine if a test has been successful, each test will use the appropriate field within the following valid responses:

- Success
- Parameter error
- Logon was not successful
- Contact not successful
- Avionics unsuitable

Any other response will be treated as a test failure.

4.9 Test Identification

In order to specify a test identifier *in situ* it is proposed that the field normally associated with the flight identification be used for the test number. In this way the test number forms part of the test message.

5. THE ADS SARPS TEST MESSAGES

These are the test messages used by the scenarios. The actual values associated with each test are currently undefined pending acceptance of the scenario descriptions.

5.1 Test ADS-001

Category	SARPs validation
Purpose	To validate the ADSUplinkMessage. The test will request that certain information is returned, this returned information can be analysed for completeness and validity.
Procedure	1.ADSUplinkMessage Request to contain the following Field Value 2.Send message 3.A Response is received.
Expected Results	The following fields must be returned: <<tbc>>

5.2 Test ADS-002

Category	SARPs validation
Purpose	To validate the ADSDownlinkMessage. The test will request that certain information is returned, this returned information can be analysed for completeness and validity.
Procedure	1.ADSUplinkMessage Request to contain the following Field Value 2.Send message 3.A Response is received.
Expected Results	The following fields must be returned: <<tbc>>

5.3 Judging Success or Failure of a Test

In order to determine if a test has been successful, each test will use one of the following valid responses:

- A valid report
- A negative acknowledgement
- A non-compliance notification

Any other response will be treated as a test failure.

5.4 Test Identification

In order to specify a test identifier *in situ* it is proposed that the field normally associated with the aircraft's identity (registration number) be used for the test number. In this way the test number forms part of the test message.

6. THE CPDLC SARPS TEST MESSAGES

These are the test messages used by the scenarios.

6.1 Test CPDLC-001

Category	SARPs validation
Purpose	To validate the ATCUplinkMessage. The test will request that certain information is returned, this returned information can be analysed for completeness and validity.
Procedure	
Expected Results	

6.2 Test CPDLC-002

Category	SARPs validation
Purpose	To validate the ATCDownlinkMessage. The test will request that certain information is returned, this returned information can be analysed for completeness and validity.
Procedure	
Expected Results	

6.3 Judging Success or Failure of a Test

In order to determine if a test has been successful, each test will use the "ErrorInformation" field for valid responses:

Any other response will be treated as a test failure.

6.4 Test Identification

For the purposes of the interoperability tests the aircraft's registration number shall be taken as the test number, in this way the test can be identified.

7. THE FINAL ASSESSMENT ANALYSIS

7.1 The Test Results Proforma

SARPs Validation Test Results Proforma
Implementation Identification
Software Version Identification
Software Build Identification
Software Build Date and Time
Platform
SARPs details
Incorporating defect reports
Assessments
Scenario-1
Scenario-2
Scenario-3
Scenario-4
Scenario-5
Scenario-6
Scenario-7
Scenario-8
Scenario-9
Scenario-10
SARPs Validation Assessment
CM
ADS
CPDLC
UL

8. RECOMMENDATIONS

ATNP WG3 is invited to adopt the concepts described in this paper as the basis for the interoperability aspects of validation for air and upper layer SARPs for CNS/ATM-1 package.