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WORKING GROUP 3 (APPLICATIONS AND UPPER LAYERS)

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Trials End System Project

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SUMMARY

This paper describes the Trials End System (TES) currently being developed by Eurocontrol. One objective of the TES is to assist in validating the CNS/ATM-1 Package draft SARPs for the Air-Ground ATM applications and Upper Layers.

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1. INTRODUCTION

The Aeronautical Telecommunication Network (ATN) was specified by the SICAS Panel of ICAO in the second edition of the ATN Manual, and continues to be developed and validated by the ICAO ATN Panel (ATNP). The ATNP has defined an initial package consisting of selected Air Traffic Management (ATM) applications and a supporting ATN infrastructure - the CNS/ATM-1 Package - for early standardisation. The aim of ATNP Working Groups is to specify and fully validate Standards and Recommended Practices (SARPs) for the CNS/ATM-1 Package before the next meeting of the ATNP in 1996.

To assist in these efforts, Eurocontrol is developing the Trials End System (TES). The objectives of the TES project are: the validation of the ATN Air-Ground applications and Upper Layer SARPs, the production of corresponding prototypes and simulation models, and free issue of the software to member Administrations. The TES is currently being procured by Eurocontrol for the ATN End System task (FCO.ET3.STO4).

2. ARCHITECTURE

The TES is a set of capabilities; hardware, base software and custom software, which will be used initially primarily for the validation of the ICAO draft SARPs for the ATN Upper Layers and Air-Ground ATM applications. The TES environment consists of two major components, the air-based end system and the ground-based end system. The ATN Upper Layers rely on the services provided by the ATN Internet, and provide communication services to the ATM applications. The ATN Upper Layers ensure the end-to-end communication between the two end systems over a number of ATN routers connected via ATN compatible subnetworks as illustrated in Figure 1.

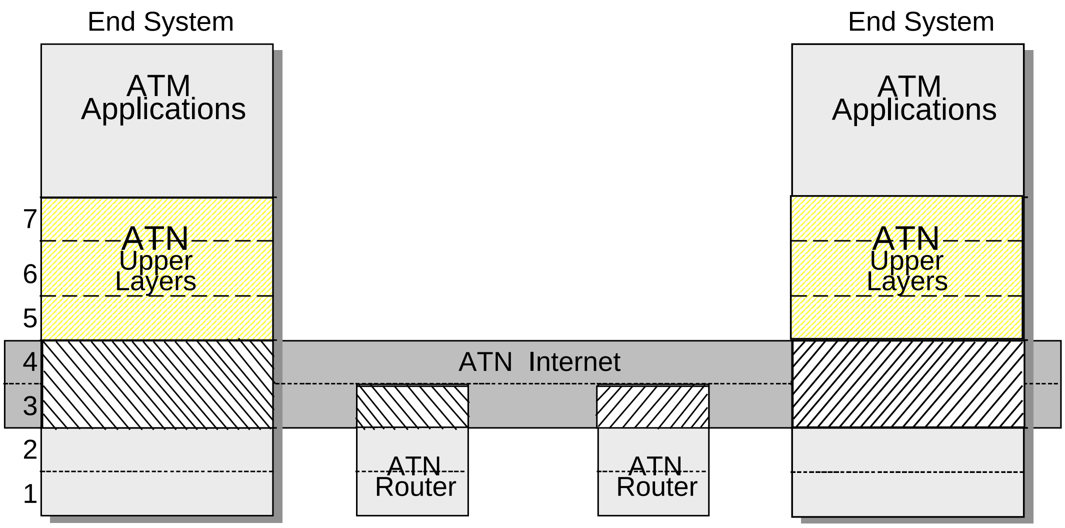

Figure 1: ATN End Systems Model

For the TES, these two systems shall communicate by a lower layer protocol stack which can be used in a variety of configurations, in place of the ATN Internet. This latter point is important since the objective of the TES is to validate the SARPs for ATM applications and ATN upper layers and not the ATN Internet.

The TES prototype software shall use the transport layer interface, to provide access to ATN Internet, which will be replaced with a connection-oriented Class 4 transport protocol to the communication infrastructure. For the TES, different communications infrastructure configurations can be "plugged in" beneath the transport interface, including at least the following:

- inter-process communication (single machine);
- TCP/IP communication;
- ATN simulation (i.e. software which simulates the anticipated behaviour of the various subnetworks of the ATN Internet);
- in the future, complete CNS/ATM-1 Package ATN Internet protocol stack;
- commercial off-the-shelf (COTS) lower layers.

Each of the different TES communication infrastructure configurations will be accessible from the TES platform, an HP-725 running a POSIX and XPG/4 conformant environment.

3. SARPS VALIDATION

The TES validation procedure will consist of a number of phases, which will identify different types of errors or omissions from the draft SARPs. These phases include:

- analysis of the draft SARPs requirements;
- production of functional specifications;
- production of design specifications;
- implementation;
- stand-alone tests;
- interoperability tests (using defined simulation scenarios).

Each of these TES phases will include documented evidence in the form of reports on the completeness and accuracy of the draft SARPs, including any assumptions and interpretations which it was necessary to make.

These phases are covered by three activities; the validation database, the TES prototype and the simulations.

3.1. Validation Database

The validation database is a tool which provides a means to trace requirements and track the progress of the validation exercise. The validation database initially acts as a paper validation of the SARPs. The draft SARPs are processed to identify the requirements, both mandatory and optional, and the dependencies between the requirements. These requirements and dependencies are then loaded into the validation database. This results in the draft SARPs being analysed for completeness, consistency and implementation issues.

Once the draft SARPs requirements have been loaded into the validation database, this can be used as a mechanism to track the validity of the draft SARPs by recording the issues raised and validated by the subsequent TES prototype and simulation activities.

3.2. Trials End System Prototype

The TES prototype will include software implementations of the following ATM SARPs:

- Automatic Dependent Surveillance (ADS);
- Context Management (CM) Application;
- Controller-Pilot datalink communication (CPDLC);
- Common Upper Layer Architecture and protocols.

Each of the TES prototype software implementations of the ATM applications will include the air and the ground based end system components. The TES does not include the validation of the Flight Information Services SARPs, which is also part of the CNS/ATM-1 Package.

The TES prototype will be developed by the contractor, selected to supply the TES, who will independently analyse the draft SARPs, produce functional and design specifications based on the draft SARPs and implement the software realisations. The TES prototype will then be used to test the functionality, interoperability and performance of the draft SARPs

The TES prototype will use the defined End System Interfaces (see Appendix A). The End System Interfaces provide a common interface which will allow simulation and test tools to be developed separately from the TES prototype.

The TES prototype will include a user interface simulation to allow data to be input into the prototype applications individually or concurrently. The TES prototype user interface simulation will be used to test and record the behaviour of the ATN components developed using the draft SARPs. The general model for the TES is illustrated in Figure 2.

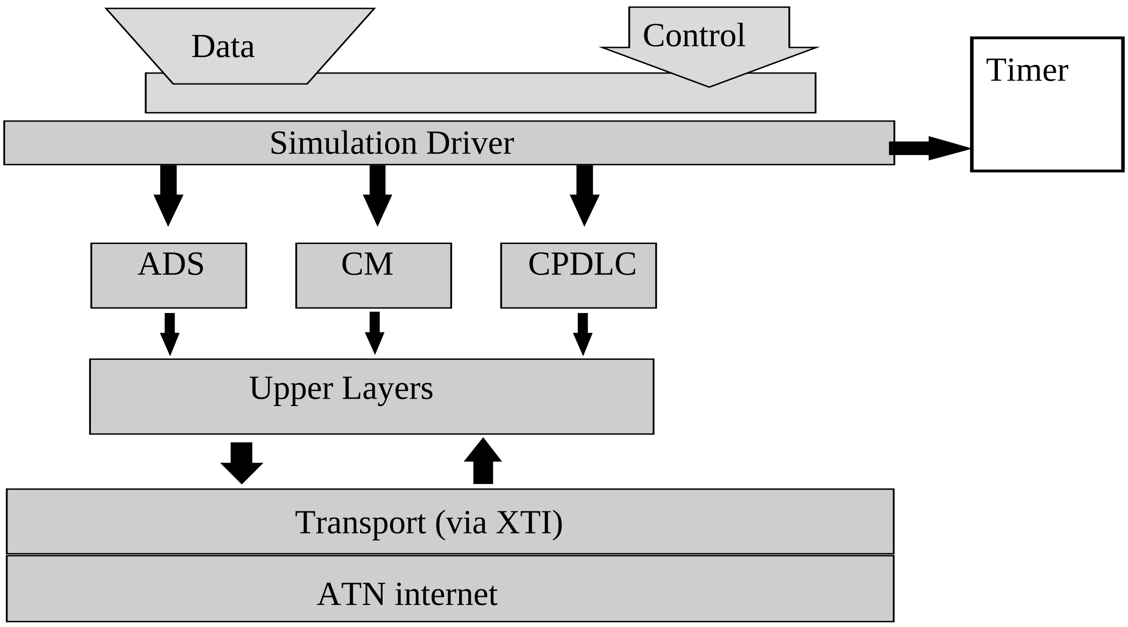

Figure 2: Trials End System ATN SARPs validation model

The TES prototype user interface simulation will use tables as a source of data, which where possible will be based on samples of real data, and control sequences which can utilise the tabular data to produce what-if scenarios.

The TES prototype user interface simulation will be used to test both normal and abnormal events into the TES prototype through the End System Interfaces. The test scenarios will be based upon real-life situations, including time based events, single instance of a flight and summation of all flights. These will be used to check the behaviour of the TES prototype and the draft SARPs.

Both the TES prototype user interface simulation and End System interfaces are aimed at the validation of the SARPs and would not necessarily be used in an operational environment.

3.3. Simulation Activities

The simulation activities are intended to model the behaviour of certain aspects of the draft SARPs which would be difficult and costly to reproduce in the TES prototype. There are currently two main aspects of the draft SARPs for which simulation models are to be developed; the protocol simulation and the system simulation.

The protocol simulation is intended to validate the protocol state machines, the protocol definitions and the events at the service interface defined in the draft SARPs. To achieve this protocol simulation activity, it is proposed that a simulation tool called “GEODE” is used. This will allow the applications to be modelled and scripts to be developed to exercise the protocol model in all likely and unlikely modes of operation, including error conditions. The simulation script results will identify any omissions or errors in the protocol definition of the draft SARPs.

The system simulation is intended to validate whether the draft SARPs have adequately defined procedures which will apply to the ATN on the macroscopic scale. To achieve this activity, it is proposed that a simulation tool called “OPNET” is used. This will allow the behavioural implementation characteristics of the SARPs to be modelled and scenarios to be developed, considering aspects such as traffic load, locations, and mobility. The system simulation is intended to validate the draft SARPs and provide a macroscopic study of the traffic flows between end systems based on assumptions for the topology and ATM automation in Europe.

4. BEYOND VALIDATION

The TES and its components shall support a number of configurations on the user side or Human Computer Interface (HCI), which will allow it to be used beyond the initial SARPs validation. These user configurations shall include:

- the validation environment;
- a demonstration environment, with user interfaces possibly based on Eurocontrol Bretigny HCIs;
- future ADS Europe experiments based on CNS/ATM-1 Package SARPs;
- ADS Mediterranean Trials based on CNS/ATM-1 Package SARPs.

The Trials End System will initially be used to host prototypes of the CNS/ATM-1 Package applications and ATN upper layers. At a later stage, the TES system and its host applications will evolve into an ATN Application Reference System, providing a stable implementation of the CNS/ATM-1 Package SARPs once validation is complete, against which other implementations can be tested.

APPENDIX A - END SYSTEM INTERFACES

The CNS/ATM-1 Package Standards and Recommend Practices (SARPs) need to be validated prior to the Aeronautical Telecommunication Network (ATN) Panel meeting at the end of 1996. To validate the ATN SARPs, prototypes will need to be built based on the SARPs and then tested. The Trials End System (TES) is intended to accomplish this validation by implementing prototype applications. The ATN End System interfaces provide convenient points to examine the behaviour of the prototype applications and simulate the actions of the ATN application user.

The ATN application SARPs provide the Abstract Service Interface (ASI) Definitions and the Abstract Syntax Notation (ASN.1) for messages exchanged between the applications. These can be used to define Application Program Interfaces (APIs) for the prototype applications. ATN End System APIs have been defined to validate the ATN application SARPs, although in an operational system the APIs may not be implemented in this way.

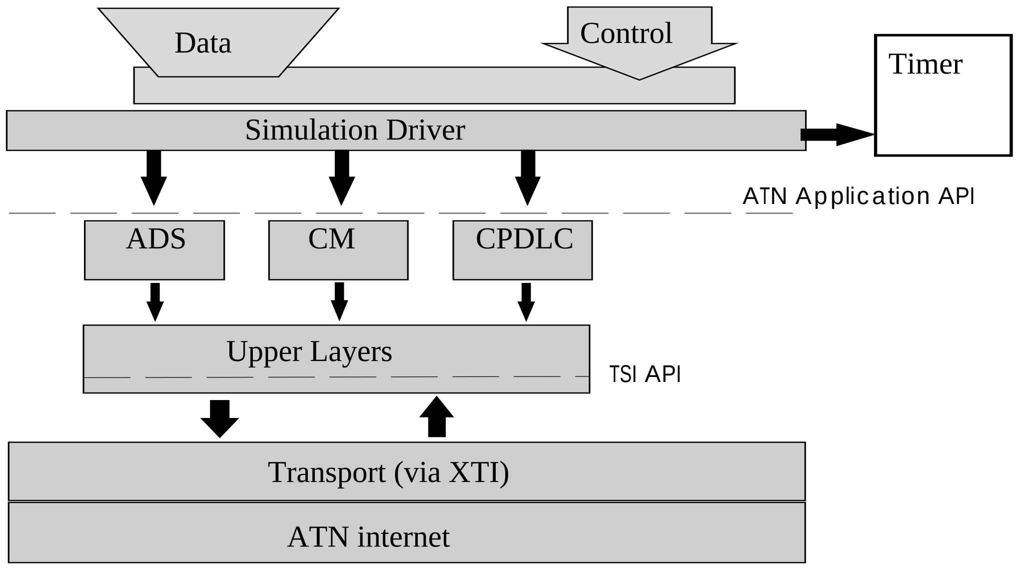

Figure 1: Trials End System

Figure 1 illustrates the TES including the ATN End System APIs which have been specified for the development of the applications to validate the SARPs. Each of the ATN air-ground applications illustrated, has an API specified in the “ATN End System Interfaces for SARPs Validation” document (TC3/DEL/T32/DO1). In addition, to support the use of commercial of the shelf XTI products, a Transport Service Interface (TSI) has been specified. This TSI will intercept ATN communication options, if these are not supported in the XTI product. XTI is the lower external interface and TSI is an internal interface allowing the ATN applications to operate transparently with XTI products whether or not they support the ATN communication options.

The X/Open XTI specification is a widely accepted interface to transport services which allows management options to be negotiated. The option level for ATN and options, Traffic Type and Network Priority, are not currently supported in commercial of the shelf XTI implementations. The TSI functions will directly call XTI functions in most instances except where ATN option level and options are negotiated, such as in a t_connect. The XTI structures and definitions are used by the TSI, including the option management structure for the ATN options.

For the Automatic Dependent Surveillance (ADS) API, the ADS-ground-user uses the ADS_snd<contract> to request a contract; demand, event or periodic, and the ADS-air-user uses ADS_listen to listen for the receipt of contract requests. The contract requests will be responded to by the ADS-air-user with a ADS_sndResult, which is used to deliver all response types to the ADS-ground-user. The ADS-ground-user will listen for responses with ADS_rcvResult. When events occur that are not part of the normal flow the function ADS_look can be used to identify the event and allow the ADS user to invoke a function to handle the event. In Figure 2, the ADS API is demonstrated using a demand contract as an example.

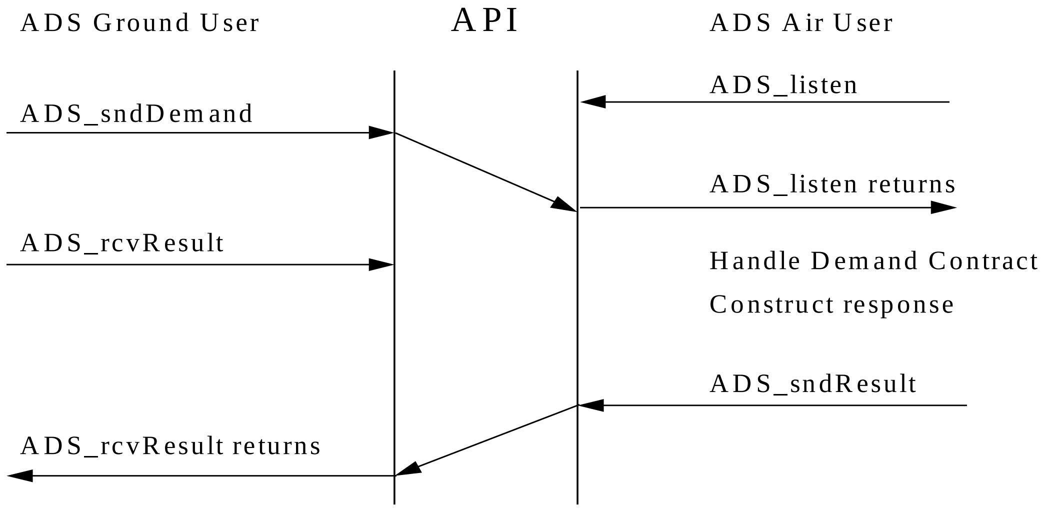

Figure 2: ADS API for demand contracts

For Controller Pilot Data Link Communication (CPDLC) API, the CPDLC_sndMessage is used to construct the message for communication with the remote party, either the CPDLC-air-user or CPDLC-ground-user. This includes the definition of data in structures to convey the message parameters to the intended recipient. There are two receive functions which allow the CPDLC user to receive messages from the message queue held below the API. The CPDLC_rcvMessage function returns the next message from the message queue. The CPDLC_Alert function can be made to poll or monitor the message queue for the arrival of messages conforming to the selection criteria. Both functions assume that messages are placed in urgency and then time order within the message queue.

For the Context Management (CM) API, both the CM-ground-user and the CM-air-user use CM_listen to detect events. The detected events are then used to call the relevant CM_rcv<function>. The CM-ground-user can respond to CM_rcvLogonReq with CM_sndLogonRsp to indicate the applications names and addresses available. The CM-air-user can respond to the CM_rcvContactReq with a CMsndContactRsp when the CM_rcvLogonRsp has been returned by the new flight information region air traffic control system. The CM-ground-user can send CM_sndUpdate to the CM-air-user to update the application names and addresses held when aircraft information is transferred by ground links.

The API descriptions above describe the normal behaviour. Abnormal behaviour is also included to handle aborts and emergency situations. Although the ATN End System interfaces are aimed at the TES to validate the SARPs these can be provided to other interested parties as a basis for further work. For example User Interface application developers may find the ATN End System APIs useful to test against the TES.