MAEVA

A Master ATM European VAlidation Plan

D2.4: Platform Identification and Development Programme

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Executive Summary

A major objective of the MAEVA project is to provide guidelines for the overall 5th Framework Programme Validation Process. This includes guidelines for the required validation environment for the individual validation exercises and especially for the components to be integrated, their functionality and their required configuration within this environment. The present deliverable D2.4, which concludes the work performed in Work Item WP2.4, fulfils this purpose.

The work undertaken in Work Package 1 has established an understanding of the way by which the validation processes should be implemented in the 5th FP. In particular, Work Item WP1.1 has identified the basic steps to be undertaken when conducting a Validation Exercise in support of the 5th FP, and Work item WP1.2 has proposed the process through which requirements should be placed on the validation platforms. These elements were further consolidated in the MAEVA Validation Guidelines Handbook (VGH). As such, the VGH provides a methodological framework for WP2.4 work. Work Package 2 has developed, in parallel with Work Package 1, the ideas to provide the details required for use in the development of the Initial Validation Plan to be undertaken in WP3. The expected result of work package 2 is an initial, clear understanding of the type of work to be conducted under the 5th FP, the methods by which it is to be conducted and the tools with which it will be conducted. Within Work Package 2, Work Item WP2.4 is particularly dedicated to the "platform identification and development programme", thus logically focusing, on the requirements that should support the identification of the validation platforms to be used in the overall validation process addressed by the MAEVA Master Validation Plan. These recommendations are discussed to serve both the European Commission and the validation projects.

To take maximum benefit of the different expertise brought by the expert services involved in this work and considering the wide scope of the VMP validation process, these recommendations were developed against the following perspectives:

- **Validation environment**, taking into consideration data preparation, data recording, on line and off line data analysis including traffic generation, use of live traffic data and highlighting the use of software tools for experimental design;
- **Fast-time platforms**, taking into account their application to validating the TORCH operational concept elements;
- **Real-time platforms**, in the following areas:
  - **En-Route/TMA platforms**, taking into consideration possible system components as well as the basic steps in the validation exercise framework;
  - **Airport platforms**, considering the Gate to Gate dimension of the 5th Framework Programme Validation Process;
  - **Airborne components**, covering air traffic generators and cockpit simulators as well as research aircraft or aircraft in use by airlines and highlighting the necessary certification issues;
  - **Platform architecture**, highlighting complementary requirements regarding previous work such as AVENUE for example;
  - **Multi-site Experiments**, covering requirements for simulator interconnection but also connection with operational systems as well as requirements for distributed data collection.

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0.2	M. Estienne	05/01/01	Section 1.2, 1.3 and 1.5 completion Chapter 2 development: context and proposed approach to WP2.4 work
0.3	M. Estienne	19/01/01	Integration of various step 1 contributions. Consolidation through comments
0.4	M. Estienne	19/02/01	New Chapter 6 with DFS contribution
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1.2	M. Estienne & Jean-R. Velten	18/10/01	Mainly Chapter 5 with updated contributions from related ES
1.3	M. Estienne & Jean-R. Velten	12/11/01	Various editorial changes and comments from NATS
1.4	R S Eveleigh	08/02/02	Amended in response to review document 24RJ0101, but does not address NATS comments in 24RJ0101_N1

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1. Introduction

1.1. Purpose

This document corresponds to deliverable D2.4 of the MAEVA project, the deliverable for Work Item WP2.4. The MAEVA project aims at developing a Master ATM European Validation Plan. The main objective of Work Item WP 2.4 is to address the requirements on validation platforms to support the MAEVA validation process and to therefore ease platform identification and the related development programmes in the frame of the validation activities.

1.2. Background

The work undertaken in Work Package 1 has established the framework within which the MAEVA Validation Plan will operate. This includes gaining the agreement of objectives for trials and the characteristics of the ATM scenarios, a methodology for assessing the requirements for the validation platforms and the production and dissemination of the first issue of the MAEVA Validation Guideline Handbook (VGH). Work Package 2 developed the ideas, in parallel with Work Package 1, to provide the details required for use in the development of the Initial Validation Plan to be undertaken in WP3.

Work Package 2 therefore has four tasks:

- Work programme identification and mapping;
- Validation methodology;
- Scenario description;
- Validation platform requirements.

The expected result of work package 2 is an initial, clear understanding of the types of validation activities to be conducted within the 5th FP, and the methods and tools with which they will be conducted. Within Work Package 2, Work Item WP2.4 is particularly dedicated to the "platform identification and development programme", thus logically focusing on the requirements that should support the identification of the validation platforms to be used in the overall validation process addressed by the MAEVA Validation Master Plan (VMP).

1.3. Document Structure

Chapter 1 provides an introduction to the document.

Chapter 2 introduces the context to this work item in the frame of the MAEVA project and the suggested working approach.

Chapters 3 to 5 present the main outcomes of this work item in term of requirements and recommendations about the validation platforms, respectively in the following areas:

- Validation Environment;
- Fast-time platforms;
- Real-time platforms encompassing:
  - En-Route/TMA platforms;
  - Airport Platforms;
  - Airborne Components;
  - Platform Architecture;
  - Multi-site Experiments.

Chapter 6 in conclusion, summarises the main outcomes of this work item.

1.4. Glossary

Term:	***Description:***
ACAS	Airborne Collision Avoidance System.
ACC	Air traffic Control Centre.
ADEXP	Automatic Data Exchange Protocol.
ADS	Automatic Dependant Surveillance.
AEEC	Airlines Electronic Engineering Committee.
AFAS	Aircraft in the Future ATM System.
AMAN	Arrival MANager.
AO	Airline Operation.
AOC	Airline Operation Centre.
APW	Area Proximity Warning.
ARINC	Aeronautical Radio INCorporated (USA).
ASAS	Airborne Separation Assurance System.
ASM	Air Space Management.
A-SMGCS	Advanced Surface Movement Ground Control System.
ATFM	Air Traffic Flow Management.
ATC	Air Traffic Control.
ATG	Air Traffic Generator.
ATIS	Air Traffic Information System.
ATM	Air Traffic Management.
ATN	Aeronautical Telecommunication Network.
AVENUE	An ATM Validation Environment to be Used for EATMP.
A/G	Air To Ground.
CAA	Civil Aviation Authority.
CAVA	Concerted Action on Validation of ATM Systems.
CDM	Cooperative Decision Making.
CORA	COnflict Resolution and Advisory.
CP	Centre Planner.
CPDLC	Controller Pilot Data Link Communication.
CWP	Controller Working Position.
DEVAM	Development of an EATMP Validation Methodology.
D/L	Datalink.
DMAN	Departure MANager.
DOP	Daily Operational Plan.
EATCHIP	European ATC Harmonisation and Integration Programme.
EATMP	European Air Traffic Management Programme.
EC	European Commission.
ECAC	European Civil Aviation Council.

Term:	*Description:*
EOLIA	European pre Operational dataLInk Applications.
FAA	Federal Aviation Administration.
FBS	Fixed Based (aircraft) Simulator.
FFS	Full Flight Simulator.
FIR	Flight Information Region.
FMS	Flight Management System.
FP	Framework Programme.
FUA	Flexible Use of Airspace.
HITL	Human In The Loop.
HMI	Human Machine Interface.
ICAO	International Civil Aviation Organisation.
JAA	Join Airworthiness Authority.
LoA	Letter Of Agreement.
MAEVA	A Master ATM European Validation Plan.
MASS	Multi Aircraft Simplified Simulator.
MAW	Minimum Altitude Warning.
MCP	Multi-Centre Planner.
MSP	Multi-Sector Planning.
MTCD	Medium Term Conflict Detection.
NOTAM	NOtice To Air Men.
NUP	NEAP Update Programme.
OCD	Operational Concept Document.
OLDI	On Line Data Interchange.
PD3	PHARE Demonstration 3.
PHARE	Programme for Harmonised Research in EUROCONTROL.
RNAV	aRea NAVigation.
RVSM	Reduced Vertical Separation Minimum.
R&D	Research and Development.
SID	Standard Instrument Departure procedure.
SSR	Secondary Surveillance Radar.
STCA	Short Term Conflict Alert.
STAR	STandard ARrival procedure.
TLM	Traffic Load Monitoring.
TLS	Traffic Load Smoother.
TMA	Terminal Manoeuvring Area.
TORCH	Technical, Economical and Operational Assessment of an ATM Concept Achievable from the Year 2005.
VGH	Validation Guidelines Handbook.
VMP	Validation Master Plan.
WI	Work Item.
WP	Work Package.
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R&D	Research and Development.
SID	Standard Instrument Departure procedure.
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VGH	Validation Guidelines Handbook.
VMP	Validation Master Plan.
WI	Work Item.
WP	Work Package.

1.5. Reference Documents

LIST OF REFERENCE DOCUMENTS	
Reference	**Author / Organisation, Title, Edition and Date**
20WN__13.doc [1]	R. Eveleigh/NATS, WP2 Work Package Plan, V1.3, 08/10/00.
11DL__10.doc [2]	R. Eveleigh/NATS, D1.1: Framework for Validation Exercises, V1.0, 20/12/00.
12DN__10.doc [3]	R. Eveleigh/NATS, D1.2: Generic Mapping to Determine Validation Platform Requirements, V1.0, 02/01/01.
TOR/ISD/WP0/ 01MI__03.doc [4]	N. Suarez/Isdefe, TORCH Description, V0.3, 17/01/00.

2. Validation Platforms Context within MAEVA

2.1. Objectives

The objective of WP2.4 is to prepare for WP 3 by identifying requirements on the validation platforms which will be suitable and available for MAEVA validation exercises, thus supporting platform identification and the related development programmes in the frame of these validation activities.

WP1.2 has provided the framework for setting validation platform requirements and WP2.2 has identified the types of validation platforms required to conduct the work – concentrating on both fast-time and real-time simulation techniques. Given these requirements, recommendations will be made as to the development required to fulfil the overall 5th FP validation process. This work will act as a pre-cursor for WP 3. To take maximum benefit of the varied expertise brought by the expert services involved in this work and considering the wide scope of the VMP validation process, this task has developed the validation platform requirements against the following perspectives:

- **Validation environment**, taking into consideration data preparation, data recording, on line and off line data analysis including traffic generation, use of live traffic data;
- **Fast-time platforms**, taking into account their application to validating the TORCH operational concept elements;
- **Real-time platforms** covering the following areas:
  - **En-Route/TMA platforms**;
  - **Airport platforms**;
  - **Airborne Components**, covering ATG and cockpit simulators and research aircraft or aircraft in use by airlines;
  - **Platform architecture**, highlighting complementary requirements regarding previous work such as AVENUE for example;
  - **Multi-site Experiments**, covering requirements for simulator interconnection but also connection with operational systems as well as requirements for distributed data collection.

2.2. Background

A major objective of the MAEVA project is to provide guidelines for the required validation environment for the individual 5th FP validation exercises and especially for the components to be integrated, their functionality and their required configuration within this environment. As a contribution to this high level objective, the main expected result of Work Item WP2.4 is to identify the requirements on the validation platforms to be used in the overall validation process addressed by the MAEVA Master Validation Plan and to discuss recommendations for the validations platforms to be used in this validation process. These recommendations are elaborated to serve both the European Commission and the validation projects. The MAEVA consortium recognised the need for the commission to have a decision-making tool for the management of all the 5th FP validation projects as well as for the necessary co-ordination actions with EUROCONTROL and Member States in the framework of a consistent and global European validation initiative. As a result, information is provided that will support this decision making process.

Prior to this Work Item, Work Package 1 has worked on identifying how the validation processes should be implemented in the 5th FP. In particular, Work Item WP1.1 has identified the basic steps to be undertaken when conducting a Validation Exercise in support of the 5th FP, and Work item WP1.2 has proposed the process through which requirements should be placed on the validation platforms. These elements were further consolidated in the MAEVA Validation Guidelines Handbook (VGH). As such, the VGH provides a methodological framework for WP2.4 work, as summarised in Appendix 2. Work item WP1.2 highlighted the need to properly understand the ATM operational concept before the validation platform requirements can be developed. As the TORCH operational concept is the basis for the 5th FP validation process, a synthesis is provided in Appendix 1 for those not familiar with it. These Appendixes were initially provided as a common starting point for those undertaking the work and are included to ensure a self contained document.

2.3. Working Approach to WP2.4 Work

In the frame of the 5th FP overall validation process, WP2.4 aims at providing guidelines to support, on the one hand, the identification and the selection of the adequate validation platforms and, on the other hand, the identification of the necessary related development programmes. These guidelines will have to be refined later on by the related validation projects. WP2.4 also provides recommendations for the selection of ATM components to be used. As stated earlier, these recommendations shall serve the European Commission as well as the validation projects. These requirements and recommendations were developed in the light of the guidelines and framework provided by WP1, taking into account the TORCH scope as well as any additional information partners were aware of and which were deemed relevant for this work. Considering the low level of effort on this task, the various perspectives against which these requirements and any recommendations were to be developed, have been derived from the typical area of expertise generally found in the validation platform field. They have been allocated to the expert services involved, according to their specific area of expertise.

3. Validation Environment

This chapter develops the validation platform requirements and recommendations on Validation Environment, taking into consideration data preparation, data recording, on line and off line data analysis, including traffic generation, and the use of live traffic data.

3.1. Overview

The Validation Environment describes those aspects of the identified platform specifically associated with its use for validation exercises. Thus Validation Environment covers:

- Data Preparation Facilities: - any system for generating the inputs that the experimenter wishes to control. This includes traffic and airspace data preparation tools;
- Experimental Design Utilities: - for experimental design and exercise planning;
- Data Analysis Facilities: - utilities for managing and analysing both input and output data;
- Observation Facilities: - aids to system observation, such as on-line "analysis".

The types of platform considered here are fast-time simulators, and human-in-the-loop (HITL) experiments such as real-time simulation, shadow-mode trials and live (operational) trials. The requirements identified below apply to all these types unless otherwise stated. Clearly, data preparation requirements and run management requirements are not relevant in the case of live-trials, although many of the recommendations for data analysis, experimental design and observation are also applicable to this type of validation exercise.

Most of the requirements identified here have already been met in one form or another within existing simulation facilities. There are, however, two requirements that have an even greater importance in the context of a validation environment. The first covers the need of the experimenter to create specific scenarios to ensure that the ATM component under validation is tested under a broad range of conditions. The second is the more general requirement for reproducibility of results. These two requirements are discussed in the appropriate sections below.

3.2. Data Preparation Requirements

Good data preparation facilities are a vital component of any platform used for validation exercises. A well-designed preparation tool will allow the experimenter to create the scenarios required within an acceptable timescale.

The Data Preparation requirements of a validation platform are, in general, the same as those for simulators used for other purposes (training / demonstration). In both cases the systems should be able to accept and edit data from many sources as well as allowing the experimenter the possibility of creating new data.

The Data Preparation environment should be able to cope with the complexity of the airspace design in the context of TORCH concept, that is, not only the standard definition of routes, sectors and areas, but it should also be able to cope with dynamic sectorisation, FUA and different airspace regimes. This is particularly important because it is expected that the designer of the validation exercise should consider the ability of the tools to generate the traffic samples and patterns in terms of sector loading, traffic flow, procedures (RVSM, RNAV etc) and different separation standards (such as en-route and TMA).

For validation work there is also a need to be able to create more specific scenarios. This might entail constructing a particular conflict situation or converting an entire traffic sample from fixed-route to free-route. It is important to ensure that the data model behind the preparation tool is adapted to the ATM concepts under consideration.

Although specific local scenarios may be created, there is usually a need to maintain an overall level of consistency or realism in the traffic sample. The preparation system should possess a certain number of validity checks, e.g. minimum turnaround time, allocation of call signs.

As mentioned previously, validation work also requires reproducibility of results. To obtain this it is usually necessary to perform several repetitions of a validation run. For real-time simulations this can lead to controllers 'learning' the traffic samples. For fast-time simulation the repetitions are meaningless unless some variation of the inputs is used. In both cases the solution is to use statistically equivalent traffic samples. These are samples for which the overall descriptive statistics are the same but whose individual flight detail is different. A simple way to achieve this is to apply a random delay of +/- n minutes to the start time of each flight but other changes such as call sign and aircraft type could also be used. The data preparation system should be capable of applying these perturbations to create sets of equivalent traffic samples. In general the system should use realistic perturbations.

There is usually a requirement for the data preparation system to generate augmented traffic samples based on some future traffic level prediction. Clearly for validation work the ability to look at future scenarios is of the utmost importance. The augmentation facility should be capable of increasing traffic on specific flows (rather than applying a global percentage increase), taking due consideration of restrictions to increase in traffic such as airport capacity limitations. It should allow the user to define the fleet type and equipage for future scenarios.

The level of detail in the traffic sample descriptions should reflect any requirements due to the introduction and use of specific metrics for measuring ATM system performance in areas such as Safety, Efficiency and Environmental Impact.

Traffic Generation facilities should be adapted to the type of traffic samples which will be required for the validation exercises. In general this requires that the generator has the following properties:

- Accepts data from multiple sources;
- Produce samples that are realistic in terms of likely flow management processing and call sign allocation;
- Is able to generate statistically similar versions of the same sample;
- Is able to generate augmented samples consistent with predictions of traffic growth;
- Is able to create specific traffic patterns within a sample.

3.3. Experimental Design

The key to the validation process is the successful mapping of objectives to results through experimental design. Only through the correct planning of the number and type of experimental runs can the appropriate level of confidence in the results be achieved. Good planning of the experimentation is the responsibility of the project team but there are several tools available to help in optimising the experimental design.

Any validation experiment, both fast and real-time, has the disadvantage of time-limitation. In the case of real-time, HITL experiments, controller and pilot time is an expensive and rare commodity. Experimental design tools can help in minimising the number of experimental runs needed to meet the objectives (or conversely, maximising what can be achieved from the number of experimental runs available).

In brief the experimental design provides a record of all the variables considered in the validation experimental (dependent variables, independent variables and sources of error). The experimental design tool can also be used to generate the analysis database, which will eventually be populated with the results of the planned experimental runs.

The use of software tools for experimental design can be particularly advantageous if experimental runs are lost due to technical reasons. The experimental plan will provide a clear indication of how to restore the design and the software may be able to propose ways to minimise the impact on the overall results.

For HITL experiments, especially large-scale studies involving many controllers, tools to construct and manage seating plans can be useful.

3.4. Data Analysis Requirements

Data analysis requirements are relatively simple and can be considered in three components: data recording, data management and tools for qualitative and quantitative analysis. The descriptions below do not specifically consider the various sources of data recording that may be used. There are potentially many of these and the data recording system must be adaptable to new sources of data.

3.4.1. Data Recording

Most experimental platforms produce a large number of recordings files covering the different elements of the ATM system (e.g. air, ground, telephone etc.). In addition there may be recordings from experimental elements e.g. eye-tracker, video cameras or observers. Usually there will be one of each of these files per actor per exercise. The primary requirement of the data recording system is to ensure that each file is uniquely identified and safely stored.

Because the subsequent analyses will require data to be brought together from different files it is also important that the files be synchronised. Thus, recording to all files should be initiated by the supervision system and each record should be time-stamped.

3.4.2. Data Management

The recorded data needs to be stored in a database allowing easy access to all data for analysis. The data model will need to represent both the time-stamped data recorded during the exercise but also post-exercise recordings such as questionnaire responses. Depending on the format of the raw data files, it may be desirable to post-process the data before storing them. Post-processing can be used to reduce the amount of data that needs to be stored and also to compute the variables of interest for subsequent statistical analysis.

Standard data management functions for data checking and data cleaning should be available. Results obtained from the statistical analysis should also be written to the database along with any details of how the analysis was performed. It would be useful to store a summary-level view of the experiment, which could be used to feed a validation repository if appropriate.

3.4.3. Quantitative Analysis

The role of the analysis system is to process the objective, normally quantitative, measures and the qualitative, normally subjective, measures of the system under test. In the case of real-time HITL exercises, both types of data will be generated, whereas fast-time modelling will normally only produce quantitative data. The object of the analysis will generally be to determine whether a given operational improvement brings a measurable improvement in the performance of the system.

Therefore, apart from the appropriate statistical software, the main requirement of the analysis system is for a set of metrics to measure the performance of the system. These metrics should be identified in the experimental design as the dependent variables of interest and computed during data storage.

Standard statistical software packages are widely available containing all the inferential tests and descriptive functions that would be required. Most also contain the necessary facilities to access data stored in a database.

3.4.4. Qualitative Analysis

Any platform designed for HITL experimentation should contain facilities for obtaining direct feedback from the participants. This should include a debriefing room (ideally with appropriate equipment for replaying periods of the simulated exercises). It is also useful to have separate debriefing areas for one-to-one interviewing.

Questionnaire production and analysis can be supported by the use of a good software package, of which there are many now available. The use of scanners and voting-boxes can also facilitate the acquisition of data from questionnaires.

3.5. System Observation Requirements

System observation describes the capacity to observe the states of the system (both machine and human) in real-time. It does not necessarily imply the recording of these observations, although it is normal to expect that the system observations will be recorded for subsequent analysis.

It is a common feature of many validation exercises to observe the human operator at work. A validation platform should allow for observation to occur without unnecessary disruption to the participants. In facilities where groups of visitors are often invited to see the experiments, the use of a one-way glass screen plus demonstration CWP should be considered.

Observation of the human, whether formal or informal, is an essential element of any HITL experiment. Formal observation will involve a subject-matter-expert watching the controller throughout the experiment, looking for particular behaviours or actions. Informal observation can simply imply witnessing the controllers at work to get an understanding of their attitude during the experiment.

System observation is sometimes referred to as on-line analysis. It is useful for the experimenter to be able to see the load on the various system components in real-time, although only in extreme cases would any intervention be expected, e.g. on-line analysis would identify any problems with the recording system or errors in the room configuration. Video recording equipment is a useful aid to observation of both the controller and their working position.

In addition to the video facility, it is also very useful to be able to replay exercises during a controller debriefing. Such a facility should be able to recreate the controller working position exactly as it was at any point during the experimental run.

4. Fast-Time Platforms

4.1. The Approach

To determine the requirements for a fast-time validation platform, the logical starting point is to consider them in relation to the purpose of individual simulation projects. The purpose of a simulation will establish, to a large extent, what measurements are to be made, the size and detail of the geographic area being modelled, the ATC environment to be modelled and the time-based constraints imposed (in terms of traffic growth and technological advances). Other possible requirements to consider are the need for randomisation elements within the platform's traffic model and a visual playback facility for the purpose of verification. These requirements are firstly discussed in general terms, and secondly in relation to specific TORCH ATM Elements. The aim of relating the requirements to the TORCH ATM Elements is to try to identify those areas in which fast-time validation can contribute now and those to which fast-time might contribute in the future. Any developments required in terms of modelling will be identified as specifically as possible.

4.2. Requirements in General Term

Measurements

Some potential fast-time simulation measures are controller workload, traffic density, number and type of conflicts, sector capacity, airport capacity, and sector counts (throughput). Those used in a study will largely depend on the type of study being undertaken. For instance a study designed to highlight potential flow problems in some high-level en-route sectors may involve illustrating traffic density and measuring sector counts. In contrast a study which examines capacity in a small, highly procedural section of TMA airspace, may need to provide a quantitative measure of controller workload. Fast-time simulators can also be used for more qualitative judgements, for instance, assessing possible design concepts for new SIDs or STARs. Obviously a visual representation of these features is extremely useful.

Geographic scope

It is likely that the requirement for the size of area to be modelled will have a great deal of impact on the fidelity at which the model works. For instance a model of a single sector is likely to require highly detailed representation of ATC procedures and controller workload elements, whereas a model of a complete ACC may be much more concerned with accurately representing the general flow of traffic through airspace.

Operational scope

The types of functions to be modelled are highly dependent on the airspace operation under examination. For instance the mix and type of controller tasks will differ significantly depending on the type of operation being modelled (en-route, TMA, airport, Oceanic, Military). Each of these operations in turn will also differ slightly according to geographic location and service provider. For example, controllers operating en-route traffic in Europe will essentially have the same tasks to perform as those in North America, but the details of how the traffic is handled may be very different. Also, one may wish to model different surrounding airspace at a fairly crude level (or not at all).

Temporal scope

Consideration needs to be given to whether the model requires traffic growth and how far into the future the study is examining. If looking at future operations, consideration needs to be given to whether the model needs to cope with probable ATC and / or aircraft developments, aircraft mixes, flight plan and route changes.

Further, consideration needs to be given to the length of elapsed time a platform will have to cope with (e.g. a day, a week, a month).

Randomisation elements

Thought must be given to whether it is statistically desirable to use a number of samples to test a particular hypothesis. If it is desirable, two further questions need to be answered:

- Which elements need to be randomised (e.g. aircraft entry times)?.
- Should this operation be performed within the simulator or as a separate operation?.

Verification

All fast-time simulations require an element of verification for the credibility of results. This may range from a quick review of the simulation to a much more detailed examination. Usually the review process will be conducted by controller(s) with the aim of providing comments, recommendations and suggestions for improving the realism of the model. Some models lend themselves more readily to this form of verification than do others, and visual playback features are highly desirable for this task.

4.3. Requirements in Relation to TORCH

The fast-time platform requirements in relation to the Torch ATM Elements are discussed below.

E1 Airspace Plan Development and Implementation

Projects within this domain will address issues such as assessing possible operational concepts and airspace designs with a view to developing the overall airspace plan and route network structure. Fast-time validation is an ideal tool for making an initial assessment of which concepts or designs are worth developing further.

ATM Scope

The broad requirement is a fast-time platform with the ability to model the en-route airspace environment including

TMA where appropriate, as reflected in the Invariant Processes demands:

Airspace Organisation and Management

With reference to airspace organisation and management, the platform must have:

- the capability of modelling high-level airspace including standard airways/routes;
- the capability of modelling standard methods of en-route operation such as standing agreements, standard acceptance levels and specific entry and exit points.

To model future airspace design, the platform would have to handle emerging concepts such as free-routing, R-NAV, multi-sector planning controllers and FUA.

Sequence Optimisation and Management

The platform must be able to model the en-route sequencing techniques employed by controllers involved in co-ordination with adjacent ACCs and FIRs.

Separation Assurance

For future operations the platform will need to be able to model separation assurance as the responsibility of flight deck crew. If this is introduced it is likely to be introduced in en-route airspace first.

Information Management

The ability to model new information management concepts such as CDM and CPDLC will be important in the near future. Given platforms with configurable rule bases it may be possible to model the impact of these concepts and technologies now, but it is not possible to determine the detailed platform requirements until more is known about the way in which they will be used.

Aircraft Operations

Studies in the E1 domain will be concerned with future traffic flows. Therefore traffic samples will have to reflect future aircraft fleet mixes, aircraft operations and mixes of aircraft equipage. All of these factors will impact on the results of a fast-time study, but would almost certainly be better-handled external to the fast-time platform. As long as the platform can simulate new aircraft type performances this should be sufficient to meet requirements in this area.

Airport Operations

As airspace plan and route network development will primarily concern en-route operations, the platform's airport modelling capabilities could be basic or not modelled at all.

Flow and Capacity Management

F&CM is complementary to the study of en-route airspace and procedural design but specific study of flow and system capacity is best handled separately to ensure the models remain manageable in terms of size and complexity. Hence the representation of flow and capacity management within the fast-time platform could be limited or non-existent depending on the ATM concept being tested.

External Agencies Operations

It is not important that a fast-time platform suitable for addressing issues connected with E1 be capable of modelling the sort of details involved in external agencies operations. These would be best dealt with separately.

Geographic Scope

The nature of en-route airspace demands that the platform be capable of coping with large geographical areas.

Temporal Scope

Airspace and route network development studies will often require modelling of both current and future air traffic environments in order to compare the benefits of new concepts or tools with what currently exists. There is, therefore, a requirement that the platform be able to cope with emerging technologies. However, it is very difficult to predict what impact technological advances in ATC and the flight deck beyond 10 years in the future. Even concepts and technologies likely to be introduced in the near future, such as CDM and CPDLC, are presently not very precisely defined. As a consequence, the further into the future a study looks the more general the conclusions must be.

In terms of elapsed time, the platform would need to be able to model times ranging from one hour to one day or even one week.

Operational Scope

Useful information on the performance of this TORCH element could be obtained if the operational scope is limited to en-route airspace. If the concepts based on this element had to be assessed within the context of the Gate to Gate operation of the system, additional processes, for example TMA and airports, would need to be represented.

Measurements

Measures likely to complement airspace development and route network structure studies include:

- sector counts (i.e. throughput of aircraft per timed period);
- controller workload;
- traffic density measures;
- traffic event analysis (of events such as conflict generation).

Obviously the fast-time platform would be required to report sufficient details to allow these measures to be made.

Requirements for Verification

In studies designed to assist in developing airspace and route network structures, verification would usually be provided by controllers examining the model to determine:

- whether aircraft behave as they should in terms of performance;
- whether all desired control procedures are present and correctly modelled;
- whether controller workload is represented sufficiently accurately within the model.

For the first two of these tasks, a platform with a visual playback facility, or which has the ability to interface with a visual playback system, is desirable. For the third task, the platform needs to either model and report on controller workload directly or interface with a post-processing mechanism which can process workload information from the recorded data. Modelling controller workload requires a platform with a configurable controller rule base.

Note that controller input is also valuable when developing future traffic samples. Controllers can provide advice in terms of the technology likely to be available, the mix of aircraft equipage and the likely growth in routes, all of which may affect the requirements for the rule bases within the proposed platform.

Inputs

A platform suitable for modelling airspace and route network design requires:

- a traffic sample;
- airspace (including sectors);
- a set of rules and procedures;
- aircraft performance data.

It is also worth considering whether studies require traffic growth. It is likely that most in the E1 domain would, so consideration should be given as to whether the traffic growth mechanism should form an integral part of the platform to be used, or if it is best managed as an independent function.

Other Issues

- Is there a statistical need to be able to randomise certain elements of the simulation, for example, the times aircraft enter the simulation?.
- Should this be a platform operation?.
- Is it achievable as a separate operation?

E2 Demand and Capacity Determination

Projects within this domain will attempt to assess traffic demand and airspace and airport capacity, and improve forecasting of these two elements. Currently fast-time simulators exist which can determine capacity measurements for both airspace sectors and airports using physical limitations, separation standards and controller workload models. Demand can be modelled indirectly through the relationship of demand to traffic growth algorithms. Improving forecasting would require a separate monitoring function to assess the accuracy of model output.

ATM Scope

There is the potential to use different platforms in different study scenarios in this area, as demand and capacity studies can conceivably cover all types of airspace and airport operations. Therefore, it is necessary to consider meeting the Invariant Processes demands in terms of either a single platform or a suite of different platforms:

Airspace Organisation and Management

With reference to airspace organisation and management to cope with all potential problems, the platform (or suite of platforms) requires the following capabilities:

- the capability of modelling high-level airspace including standard airways/routes;
- the capability of modelling TMA airspace including standard airways/routes;
- the capability of modelling standard methods of en-route, TMA and airport operations such as standing agreements, standard acceptance levels, the TMA/airport interface and runway/taxiway operations.

To calculate capacity with reference to future airspace design studies, the platform would have to model emerging concepts such as free-routing, multi-sector planning controllers and flexible use of airspace. Currently, using fast-time simulation to measure the impact of such concepts as free-routing and multi-sector planning on capacity would be difficult as the way in which they will work has not been precisely defined.

Sequence Optimisation and Management

Sequencing is critical to the efficient operation of airports, runway usage and TMA/airport interaction. The platform needs to model sequencing in these areas in a great deal of detail which, in turn, means modelling stack management, vectoring of aircraft and ground controller functions. At en-route level, sequencing techniques are very different and tend to be constrained by standing agreements with neighbouring ACCs and FIRs. A configurable controller decision rule base would be required to model the sequencing techniques employed by these controllers.

Separation Assurance

Separation standards are a prime factor in determining capacity in relation to final approach airspace and runway usage operations. Standards change as an aircraft transit from ground movement, to runway, approach, TMA and en-route control (they can also change from country to country). The platform would have to cope with these different standards, or different platforms would have to be used in different studies. Again the future concept of separation assurance as a responsibility of flight deck crew would impact on modelling separation assurance, and initially it may only apply in en-route airspace – so yet another variation on modelling separation standards may be required.

Information Management

In the future, new information management concepts such as CDM and CPDLC will impact on ATC at all levels – from en-route to push-back clearance and hence on capacity issues. Given platforms with configurable rule bases it may be possible to model the impact of these concepts and technologies now, but it is not possible to determine the detailed platform requirements until more is known about the way in which the information management technologies will be used.

Aircraft Operations

Traffic samples used in studies concerned with future capacity and demand will have to reflect future aircraft fleet mixes and mixes of aircraft equipage. These factors will impact particularly on capacity. Demand may well grow or fall independent of aircraft operations. As long as the platform can simulate new aircraft type performances and the impact of future ATC communication advances, this should be sufficient to meet requirements in this area.

Airport Operations

The platform(s) will have to be capable of modelling current and future airport operations in great detail in order to measure runway capacity and taxiway usage issues. Furthermore, fast-time simulation is an ideal way to test initial concepts for additional runways, new taxiways (or taxiway operations) or even a completely new airport. The platform(s) will need such a capability.

Flow and Capacity Management

The outputs from modelling capacity and demand issues should ultimately feed into flow and capacity management decisions. To provide input at a strategic level requires a gate-to-gate type simulator capable of coping with a lot of data and a large geographical area. Some simulators may be capable of such a task at the moment, but it requires a significant amount of time to set up and access to large amounts of data.

External Agencies Operations

Capacity in en-route sectors may be determined to some extent by the impact of co-ordination at adjacent ATM boundaries on controller workload or by restrictions to traffic numbers applied in adjacent FIRs. Therefore, the platform would have to model the co-ordination functions.

Geographic Scope

Demand and capacity determination can require platform(s) which cope with the very small (e.g. airport) to the very large (e.g. FIRs or even larger areas such as Europe).

Temporal Scope

Demand and capacity studies will, by their nature, require modelling of both current and future air traffic environments. There is, therefore, a requirement that the platform be able to cope with emerging technologies; however, it is very difficult to predict what impact technological advances will have on ATC and the flight deck beyond 10 years from now. Even concepts and technologies likely to be introduced in the near future, such as CDM and CPDLC, are presently not very precisely defined. As a consequence, the further into the future a study looks the more general the conclusions must be.

In terms of elapsed time, the platform would need to be able to model times ranging from one hour to one day or even one week.

Operational Scope

To assess demand and capacity issues over a large geographic area, by implication, the platform would have to have the ability to model in a Gate-to-Gate manner.

Measurements

Possible measures likely to complement demand and capacity determination include:

- sector counts (i.e. throughput of aircraft per timed period);
- controller workload;
- traffic density measures;
- traffic event analysis (of events such as conflict generation);
- runway delays;
- taxiway delays.

The fast-time platform(s) used would have to be capable of reporting sufficient details to allow the appropriate measures to be made.

Requirements for Verification

In terms of modelling airspace, the platform has the same verification requirements as for E1 previously:

- whether aircraft behave as they should in terms of performance;
- whether all desired control procedures are present and correctly modelled;
- whether controller workload is represented sufficiently accurately within the model.

Additionally, should airport operations be modelled, ground movement procedures and sequencing would need to be verified. Again a platform with a visual playback facility, or which has the ability to interface with a visual playback system, is desirable.

Inputs

The platform would require the same standard inputs as for E1:

- a traffic sample;

- airspace;
- a set of rules and procedures specific to the operation being modelled (i.e. en-route airspace, TMA airspace, ground movement);
- aircraft performance data.

Other Issues

- Is there a statistical need to be able to randomise certain elements of the simulation, for example, the times aircraft enter the simulation?.
- Should this be a platform operation?.
- Is it achievable as a separate operation?.

E3 Operational Plan Development and Implementation

This element develops and implements the daily operational plan. The short event horizon makes application of fast-time simulation in this area impractical.

E4 Real Time Operational Plan Optimisation

This element updates and implements changes to the daily operational plan, and again has a sufficiently short event horizon to make application of fast-time simulation in this area impractical.

E5 En-route planning

En-route planning acting on the basis of the daily operational plan analyses the current and predicted traffic situation up to two hours ahead. This timescale is much too short to make fast-time simulation of use in this area.

E6 Terminal Area Sequencing

Projects within this domain will be concerned with assessing arrival, departure and ground movement management to produce an optimal flow of traffic in the TMA environment. Terminal area sequencing functions can already be modelled on a number of different simulators, an area that lends itself readily to fast-time simulation – particularly with reference to procedure and airspace design.

ATM Scope

Platforms will need to cope with ground movement, runway and TMA operations as reflected in the Invariant Processes.

Airspace Organisation and Management

In relation to airspace, the following requirements should be applied to the platform:

- the capability of modelling TMA airspace including standard airways/routes;
- the capability of modelling airport operations and runway usage;
- the capability of the interface between TMA and airport operations.

Particular attention would have to be paid to modelling standard TMA concepts such as SIDs, STARs and hold stacks.

Sequence Optimisation and Management

The platform needs to model sequencing in a number of areas;

- sequencing aircraft arriving in the TMA into and out of hold stacks;
- vectoring of aircraft (possibly from hold stacks) into a final approach sequence for landing;
- ground movement modelling should reflect a controller's ability to organise aircraft into an efficient departure sequence considering wake vortex limitations and slot allocation;
- sequencing arrivals with departures if the airport operation is single runway or dependent multiple runways".

Separation Assurance

As mentioned previously in relation to E2, separation standards are critical in determining capacity in relation to final approach airspace and runway usage operations. Further, separation standards change from ground operations to approaches airspace and TMA and en-route airspace. The platform would have to cope with these different standards, or different platforms would have to be used in different studies. Again the concept of separation assurance as a responsibility of flight deck crew would impact on modelling separation assurance, but initially it is likely to only apply in en-route airspace, so it may be possible to ignore this concept in relation to Terminal Area Sequencing for the foreseeable future.

Information Management

In the future, new information management concepts such as CDM and CPDLC will impact on TMA operations and hence probably on sequencing issues. Given platforms with configurable rule bases it may be possible to model the impact of these concepts and technologies now, but it is not possible to determine the detailed platform requirements until more is known about the way in which these technologies will be used.

Aircraft Operations

Changes in aircraft technologies may have an impact on areas such as SID and STAR design and final approach routes (for instance curved final approaches to airports may be possible). However, this impact may be sufficiently well modelled using route information only. The most obvious impact of aircraft on TMA operations may come in terms of their performance (particularly climb rates), as it may be possible to hand aircraft off to en-route airspace sooner than is currently possible. Therefore, as long as the platform can simulate new aircraft type performances, this should be sufficient to meet requirements in this area.

Airport Operations

The platform will have to be capable of modelling current and future airport operations in great detail in order to simulate sufficiently the interface between TMA and airport operations. Further, fast-time simulation is an ideal way to test features which would affect TMA sequencing – such as initial concepts for additional runways (or even a completely new airport), hold stack placement/design and SID and STAR design. The platform will therefore clearly need to be capable of modelling these features. The ability to simulate taxiway usage and ground movement beyond the runway will depend on the fidelity requirements of the model, although usually taxiway usage would be considered separately from this TORCH element.

Flow and Capacity Management

The outputs from modelling capacity and demand issues should ultimately feed into F&CM decisions. To provide input at a strategic level requires a gate-to-gate type simulator capable of coping with a lot of data and a large geographical area. Some simulators may be capable of such a task at the moment, but it requires a significant amount of time to set up and access to large amounts of data.

External Agencies Operations

Fast-time simulation may be a good tool to test concepts for coping with emergency situations, for instance closure of one airport forcing aircraft to divert to others.

Geographic Scope

Generally studies in this area will be concerned with airspace immediately around an airport or clutch of airports, so the area modelled will be small.

Temporal Scope

Terminal sequencing studies are likely to look at both current and future air traffic environments. Therefore the platform must be able to cope with modelling emerging technologies; however, it is very difficult to predict what impact technological advances will have on ATC and the flight deck beyond 10 years from now. Even concepts and technologies likely to be introduced in the near future, such as CDM and CPDLC, are presently not very precisely defined. As a consequence the further into the future a study looks the more general the conclusions must be.

In terms of elapsed time, the platform would need to be able to model times ranging from one hour to one day or even one week.

Operational Scope

Useful information on the performance of this TORCH element could be obtained if the operational scope is limited to TMA airspace. If the concepts based on this element had to be assessed within the context of the Gate to Gate operation of the system, additional processes, for example en-route, would need to be represented.

Measurements

Possible measures likely to complement TMA sequencing studies include controller workload, traffic event analysis (of events such as conflict generation) and runway delays (and possibly taxiway delays if modelled to this granularity). The fast-time platform used would have to be capable of reporting sufficient details to allow the appropriate measures to be made.

Requirements for Verification

Modelling TMA airspace requires the same basic verification procedures as for en-route airspace:

- whether aircraft behave correctly in terms of performance;
- whether all desired control procedures (including ground movement, if necessary) are present and correctly modelled;
- whether controller workload is represented sufficiently accurately within the model.

Again, a method of visual playback is desirable for the first two of these tasks. For the third task the platform needs to either model and report on controller workload directly, or interface with a post-processing mechanism which can process workload information from the events reported. Modelling controller workload requires a platform with a configurable controller rule base.

Inputs

The platform would require the following as standard inputs:

- a traffic sample;
- airspace;
- a set of rules and procedures specific to the operation being modelled (i.e. en-route airspace, TMA airspace, ground movement);
- aircraft performance data.

Other Issues

- Is there a statistical need to be able to randomise certain elements of the simulation, for example, the times aircraft enter the simulation?.
- Should this be a platform operation?.
- Is it achievable as a separate operation?.

E7 Separation Assurance

In future, separation assurance may be affected by both new technologies and new concepts of operation. For instance, separation standards may be reduced given accurate satellite surveillance techniques, or separation assurance may be partially delegated to aircrews. These advances will obviously impact on the way in which aircraft are controlled and modelling them in fast-time for conceptual development may become a requirement. Fast-time platforms may require additions to their rule bases to model these features, but until it is known how they will operate and under what conditions, it is not feasible to assess fast-time platform requirements in this area.

E8 Hazard Assessment

There is insufficient data available to the writers of this section to provide an authoritative statement on the requirements for a fast-time platform for hazard assessment within the effort available. This is a complex area affecting all parts of the ATM system and expert advice in the assessment and modelling of hazards should be sought.

E9 Airline Operation Planning

Some fast-time simulators currently allow a degree of representation of airline operations by allowing aircraft performance to be altered to represent the way individual airlines fly their aircraft. Simulations can provide information of interest to operators such as fuel burn and departure and arrival delay information. The major concepts of interest in this area – decision support tools for airlines and the use of CDM – require further development and much more precise definition before fast-time simulation tools can model their impact.

E10 Aircraft Flight Management from Gate-to-Gate

This issue is most directly impacted by those issues mentioned in E9 and so no further comments are made in relation to fast-time platform requirements here.

E11 AO Flight Control

This issue is most directly impacted by those issues mentioned in E9 and so no further comments are made in relation to fast-time platform requirements here.

E12 Airport Strategic Planning

Fast-time simulation lends itself readily to assessing the impact of concepts involving the introduction of new airports or significant changes in airport infrastructure such as new runways and taxiways.

ATM Scope

Platforms will be concerned principally with modelling ground movement and runway operations, which is reflected in the Invariant Processes as follows:

<u>Airspace Organisation and Management</u>

Studies examining airport strategic planning would require limited airspace modelling capabilities. The airspace constraints imposed on ATM would be addressed separately. The platform needs to model only a limited portion of the TMA airspace.

<u>Sequence Optimisation and Management</u>

The sequence of aircraft into the modelled TMA airspace (if any) would need to be pre-determined. Beyond this, the platform needs to model sequencing in a number of other areas:

- ground movement modelling should reflect a controller's ability to organise aircraft into an efficient departure sequence considering wake vortex limitations and slot allocation;
- sequencing arrivals with departures in a sensible manner if the airport operation is single runway or inter-dependent multiple runways.

<u>Separation Assurance</u>

The platform will need to be able to model the separation standards that exist on final approach into the airport, and those determined by wake vortex for aircraft taking off.

<u>Information Management</u>

In the future, new information management concepts such as CDM and CPDLC will impact on TMA operations and hence probably on sequencing issues. Given platforms with configurable rule bases it may be possible to model the impact of these concepts and technologies now, but it is not possible to determine the detailed platform requirements until more is known about the way in which they will be used.

<u>Aircraft Operations</u>

CDM may have a major impact on the way aircraft and airports interact but again until more is known about the way in which it will operate it is hard to define requirements for a fast-time platform to model it.

<u>Airport Operations</u>

Again the most likely influence on airport operations is likely to be a change in concept and culture to CDM.

<u>Flow and Capacity Management</u>

The model may require an element that considers capacity in some limited form at a runway usage level (for example, to measure how runway delays may be affected by alternative taxiway operations), but beyond this a separate platform would be required.

<u>External Agencies Operations</u>

Fast-time simulators that are commonly used within ATM research, would be of limited use in simulating the impact of external agency operations in relation to airport strategic planning.

Geographic Scope

Generally studies in this area will be concerned with airspace immediately around an airport or clutch of airports, so the area modelled will be small.

Temporal Scope

It is likely that the interaction between airport operators, airlines and airport ATC will be significantly affected by CDM, and this is one of the principle concepts which will need to be modelled in this environment in the near future. However, as has been stated previously, the precise nature of this interaction needs to be more precisely defined before it can be modelled. Again, at a more general level it is very difficult to predict what impact technological advances may have beyond 10 years from now and so only very general conclusions can be drawn from studies looking at the very long-term future.

The platform would need to be able to model elapsed times ranging from one hour to one day and perhaps one week.

Operational Scope

Useful information on the performance of this TORCH element could be obtained if the operational scope is limited to airport airspace. If the concepts based on this element had to be assessed within the context of the Gate to Gate operation of the system, additional processes, for example TMA, would need to be represented.

Measurements

Possible measures likely to complement airport strategic planning are:

- runway delays;
- taxiway delays;
- runway movement counts;
- controller workload.

The fast-time platform used would have to be capable of reporting sufficient details to allow the appropriate measures to be made.

Requirements for Verification

Modelling strategic airport planning issues will require a slightly different emphasis to verification of airspace operations:

- whether all desired ground movement procedures are present and correctly modelled;

- whether wake vortex and final approach separation rules are adhered to;

- whether controller workload is represented sufficiently accurately within the model.

Again, a method of visual playback is beneficial for the first two of these tasks. For the third task the platform needs to either model and report on controller workload directly, or interface with a post-processing mechanism which can process workload information from the events reported. Modelling controller workload requires a platform with a configurable controller rule base.

Inputs

The platform would require some standard inputs:

- a traffic sample;

- a set of rules and procedures specific to ground movement and runway operations;

- aircraft performance data (possibly lower fidelity than for other simulations);

- limited TMA airspace.

Other Issues

- Is there a statistical need to be able to randomise certain elements of the simulation, for example, the times aircraft enter the simulation?.

- Should this be a platform operation?.

- Is it achievable as a separate operation?

E13 Airport Operations Management and Control

There are fast-time simulators currently which model aspects of airport operations. However, this concept is essentially one of monitoring the Daily Operational Plan and conformance to it and, as such, is not something which can readily be modelled using fast-time simulation. Developments which will affect airport operations management in the foreseeable future, such as the use of CDM, could possibly be modelled using fast-time simulation, but before the requirements can be defined the concepts require further development and much more precise definition. In the area of CDM, E13 is inextricably linked to E9 – Airline Operation Planning.

E14 Adjacent ATM Areas

Fast-time platforms could be configured to model and assess the problems associated with co-ordination of traffic between adjacent ATM areas. For instance, if aircraft are moving from an area of RVSM airspace to an area of non-RVSM airspace there will be particular difficulties at the boundary regions. Fast-time platforms could be used to model and assess such scenarios.

ATM Scope

Generally, models in this domain will be concerned with en-route airspace and this is reflected in the following Invariant Processes demands.

<u>Airspace Organisation and Management</u>

The platform must have:

- the capability of modelling high-level airspace including standard airways/routes;

- the capability of modelling standard methods of en-route operation such as standing agreements, standard acceptance levels and specific entry and exit points to adjacent FIRs and ATM areas.

To model future airspace design studies, the platform would have to manage emerging concepts such as free-routing, multi-sector planning controllers and flexible use of airspace.

Sequence Optimisation and Management

The platform must be able to model the en-route sequencing techniques employed by controllers involved in co-ordination with adjacent ACCs and FIRs in some detail.

Separation Assurance

For future operations, the platform will need to be able to model separation assurance as the responsibility of flight deck crew. It is likely to be introduced in en-route airspace first.

Information Management

For studies looking at ATM several years from now, the ability to model new information management concepts such as CDM and CPDLC will be important. Given platforms with configurable rule bases it may be possible to model the impact of these concepts and technologies now, but it is not possible to determine the detailed platform requirements until more is known about the way in which these technologies will be used.

Aircraft Operations

Studies in this domain will be concerned with current and future traffic flows. Grown traffic samples will have to reflect future aircraft fleet mixes, aircraft operations and mixes of aircraft equipage. All of these factors will impact on the results of a fast-time study, but may be better-handled external to the fast-time platform. As long as the platform can simulate new aircraft type performances, this should be sufficient to meet requirements in this area.

Airport Operations

As co-ordination with adjacent ATM areas will primarily be concerned with en-route operations, the platform's airport modelling capabilities could be basic or even non-existent. There may be some areas where co-ordination between different agencies takes place in TMA airspace. For studies of these areas a different simulator will be required.

Flow and Capacity Management

F&CM is complementary to the study of co-ordination between adjacent control areas, but specific study of flow and system capacity is best handled separately to ensure the models remain manageable in terms of size and complexity. Hence the representation of flow and capacity management within this platform could be limited or non-existent, depending on the ATM concept being tested.

External Agencies Operations

The principle of this whole sphere of work is based on how co-ordination between adjacent ATC works. Therefore any fast-time platform will have to model how this occurs particularly with reference to controller workload. For instance, there would be a requirement to model and record events such as telephone co-ordination of traffic hand-over.

Geographic Scope

The nature of en-route airspace and co-ordination between adjacent ATM areas demands that the platform be capable of coping with large geographical areas.

Temporal Scope

The platform would need to be able to model elapsed times ranging from one hour to one day or even one week.

Operational Scope

Useful information on the performance of this TORCH element could be obtained if the operational scope is limited to en-route airspace. If the concepts based on this element had to be assessed within the context of the Gate to Gate operation of the system, additional processes, for example TMA and airports, would need to be represented.

Measurements

Measures likely to complement airspace development and route network structure studies include:

- sector counts (i.e. throughput of aircraft per timed period);
- controller workload;
- traffic density measures;
- traffic event analysis (of events such as conflict manoeuvres). Obviously the fast-time platform would be required to report sufficient details to allow these measures to be made.

Requirements for Verification

Modelling any area of airspace requires some mechanism of verification. In studies designed to assist in developing airspace and route network structures, this would usually be provided by controllers examining the model to determine:

- whether aircraft behave as they should in terms of performance;
- whether all desired control procedures are present and correctly modelled;
- whether controller workload is represented sufficiently accurately within the model.

For the first two of these tasks, a platform with a visual playback facility, or which has the ability to interface with a visual playback system, is desirable. For the third task, the platform needs to either model and report on controller workload directly or interface with a post-processing mechanism which can process workload information from what is reported. Modelling controller workload requires a platform with a configurable controller rule base.

Note that controller input is also valuable when developing future traffic samples. Controllers can provide advice in terms of the technology likely to be available, the mix of aircraft equipage and the likely growth in routes, all of which may affect the requirements for the rulebases within the proposed platform.

Inputs

To model an airspace and route network design concept, a platform requires some standard inputs:

- a traffic sample;
- airspace;
- a set of rules and procedures;
- aircraft performance data.

It is also worth considering whether studies requires traffic growth. Some almost certainly would, so consideration should be given as to whether the traffic growth mechanism should form an integral part of the platform to be used, or if it is best managed as an independent function.

Other Issues

- Is there a statistical need to be able to randomise certain elements of the simulation, for example, the times aircraft enter the simulation?.
- Should this be a platform operation?.
- Is it achievable as a separate operation?.

E15 Military Operations

At the moment some fast-time platforms can be configured to model co-ordination between civil and military operators, and related issues such as Flexible Use of Airspace. However, there are no platforms specifically designed to deal with the issue of military operations within ATM.

E16 Meteorological Agencies, E17 Performance Monitoring, E18 Information Management

The assessment of concepts related to these TORCH elements is not suitable for modelling using fast-time simulation.

5. Real-Time Platforms

This chapter develops the validation platform requirements and recommendations for real-time time validation platforms.

The following table gives a global indication regarding the potential use of real-time platforms in validation projects for TORCH concept elements validation.

TE	Title	Use of real-time validation platform
E1	**Airspace Plan Development and Implementation**	These elements are related to flow and capacity management. Validation projects on these elements do not need real-time validation platform, because there is no need to make real-time simulation to validate these concepts. Results of these projects can be used to support preparation of real-time simulations.
E2	**Demand and Capacity Determination**	
E3	**Operational Plan Development and Implementation**	
E4	**Real-time Operational Plan Optimisation**	
E5	**En-route planning & multi-sector planning**	Use real-time validation platform for projects related to ATC functions such as multi-sector planning.
E6	**Terminal Area Sequencing**	Use of real-time validation platform for projects related to departure/arrival and surface movement management platform.
E7	**Separation Assurance**	Use of real-time validation platform for projects related to traffic monitoring, conflict detection, conflict resolution and conflict resolution negotiation between the air and the ground.
E8	**Hazard Assessment**	Use of real-time validation platform for projects related to conflict between aircraft predicted trajectories and ground obstacles, between trajectories and prohibited airspace or between aircraft trajectories.
E9	**Airline Operation Planning**	Use of real-time validation platform for projects related to a greater involvement of the airline operators in the planning process (negotiation etc).
E10	**Aircraft Flight Management from Gate-to-Gate**	Use of real-time validation platform for projects related to navigation accuracy improvement (4D FMS systems, report of the aircraft intentions to the controllers).
E11	**AO Flight Control**	Use of real-time validation platform for projects related to aircraft monitoring.
E12	**Airport Strategic Planning**	This concept element is not relative to the execution phase of the DOP (see E13), but to the planning phase in a time horizon scope of years in advance. There is no need of real-time validation platform for projects on this element.
E13	**Airport Operations Management and Control**	Use of real-time validation platform for projects related to the functions related to the airport operations (real-time resource allocation, aircraft movement management).
E14	**Adjacent ATM Areas**	Use of real-time validation platform for projects related to the co-ordination with units of adjacent areas outside of the ECAC.
E15	**Military Operations**	Use of real-time validation platform for projects related to the co-ordination between military and civil operators.
E16	**Meteorological Agencies**	No need for real-time validation platform.
E17	**Performance Monitoring**	No need for real-time validation platform.
E18	**Information Management**	No need for real-time validation platform.

-Table 5-1 Application of Real-Time Techniques in Relation to TORCH Elements

The following sections give a more detailed view of real-time platforms requirements and recommendations related to:

- En-route/TMA platforms;
- Airport platforms;
- Airborne Components;
- Platform architecture;
- Multi-site experiments.

Potential relation with TORCH elements will be highlighted when considered of interest for validation projects. They should, nevertheless, be considered with caution in view of the level of description and the granularity of some of the TORCH elements.

5.1. En-Route/TMA Platforms

This chapter develops the validation platform requirements and recommendations for en-Route/TMA real-time simulation platforms, taking into consideration possible system components as well as the basic steps in the validation exercise framework.

According to the procedure established in WP1.2, the validation platform requirements and recommendations for en-route/TMA platforms are structured in the scope of the ATM, the life cycle stage and other issues.

5.1.1. Overview

Most important for a real-time en-route/TMA platform is a good balance between providing a realistic validation environment with the human operator (and not a model, whatever kind it may be) inside the system boundaries and a reasonable relation to other platforms like fast-time simulators or information flow models.

5.1.2. Scope of the ATM

5.1.2.1. High Level Functionality

According to the dynamics of the development of future systems and tools – in contrast to the evolving operational concepts – an en-route/TMA platform has to be flexible in terms of integrating new functionality or new ATM systems [E3, E4, E5, E6, E7, E8, E9, E13, E14, E15, E17, E18]. Due to that, two basic principles have to be established:

1. The platform has to utilise standard ATC interfaces for input, output and even internal communication in terms of communication between different components of the platform. [E3, E4, E5, E6, E7, E8, E9, E13, E14, E15, E17, E18].

2. The platform has to establish a rigid separation between the airborne modelling of a flight (track or plot generation) and the ground-based data handling of a flight (flight data processing). [E3, E4, E5, E6, E7, E8, E9, E13, E14, E15, E17, E18].

Basically, the minimum operational functionality for the platform is as follows:

- Surveillance information (Radar or ADS) generation;

- Modification of surveillance information at runtime;

- Flight data processing;

- Human machine interface [E3, E4, E5, E6, E7, E8, E9, E13, E14, E15, E17, E18].

In addition, some supporting functionality is needed as follows:

- Data preparation;
- Data Analysis;
- Data Recording;
- Data Management;
- Quantitative analysis;
- Qualitative analysis;
- System observation.

Other functionality like future tools or new systems may be integrated via the standard communication processes. [E3, E4, E5, E6, E7, E8, E9, E13, E14, E15, E17, E18] This functionality may comprise, among others:

- 4D trajectories;
- Safety nets (STCA, MAW, APW);
- MTCD;
- Flight path monitor;
- Inter-centre communication;
- CORA;
- MSP, CP, MCP;
- AMAN/DMAN;
- Data link applications;
- Other planning tools (TLM, TLS).

5.1.2.2. Scope of Inputs and Outputs

5.1.2.2.1. Input Data

With regard to the high level functionality, it is necessary to establish two separate data preparation procedures, one for the airborne simulation and one for the ground-based simulation. Especially, the airborne simulation shall not be a mirror of the ground based – FDPS related – simulation process. [E2, E3, E4, E5, E6, E7, E8, E9, E12].

The data preparation should be based on flight plans plus additional information. It needs to be open for additional information needed by new components. [E3, E4, E5, E6, E7, E8, E9, E13, E14, E15, E17, E18] For that purpose, a mechanism is needed to parse the relevant parts of the information.

For the ground based simulation process, rules and regulations – especially letters of agreement – should be easy to prepare for later use in the simulation. [E2, E3, E4, E5, E6, E7, E8, E9, E12, E14, E15].

At runtime, live data or recorded live data needs to be integrated if necessary for the validation process. [E1-E18] Simulated data needs to be manipulated by the supervisor or simulation pilots. [E3, E4, E5, E6, E7, E8, E9, E13, E14, E15, E17, E18] .

Modelling of the aircraft should be based on the best performance model available for the objectives of the validation process (i.e. for UAC one model may be best, for TMA another one). [E6, E7, E8, E14, E15, E17].

A mechanism has to be established to assure the quality of data preparation throughout the life cycle.

5.1.2.2.2. Internal Communication

Internal communication between different components of the platform should be based on established ATC standards. [E3, E4, E5, E6, E7, E8, E9, E13, E14, E15, E17, E18] Especially, radar data communication should use the ASTERIX standards, flight plan data communication should use the ICAO, OLDI and the ADEXP standards. In case of doubt, communication should be established as close as possible to operational world. [E3, E4, E5, E6, E7, E8, E9, E13, E14, E15, E17, E18]

5.1.2.2.3. Output Data

Any data communication on any network inside the platform is considered as output data. A facility for recording output data is needed. [E1-E18] It may be helpful to be able to select the types of data recorded to reduce the amount of data gathered.

5.1.2.3. Operational Scope

The platform should not restrict the operational scope of a validation exercise, E5, E6, E7, E8, E9, E13, E14, E15, E17, E18]. Especially, the platform should be capable of supporting investigations on future operational concepts – even beyond TORCH.

The platform should be capable of simulating neighbouring sectors or facilities as co-ordination partners to the simulated sectors. [E3, E4, E5, E6, E7, E8, E14, E15, E17, E18]

The platform should be capable of simulating operational concepts dealing with non-sector oriented procedures. [E3, E4, E5, E6, E7, E8, E14, E15, E17, E18]

5.1.3. Life Cycle Stage

5.1.3.1. Fidelity and Resolution Scope

The platform needs to be scalable from one single controller working position (CWP) up to at least the size of one facility. [E3, E4, E5, E6, E7, E8, E9, E13, E14, E15, E17, E18] Co-operation with other facilities or other units (i.e. for example tower, military airfields) may be handled inside the platform or via means of multi-site experiments where appropriate. [E3, E4, E5, E6, E7, E8, E14, E15, E17, E18]. From a service providers point of view, a link between an en-route/TMA platform and a tower platform can be of interest. From an overall point of view, other components like AO or airport authorities may come in place as well.

5.1.3.2. Geographic Scope

The geographical scope of the platform should be restricted to about 1000 x 1000 nautical miles. [E3, E4, E5, E6, E7, E8, E9, E13, E14, E15, E17, E18] Inside this area it should be possible to implement any structure of facilities and sectors (even sub-structures of sectors). [E3, E4, E5, E6, E7, E8, E14, E15, E17, E18].

5.1.3.3. Temporal Scope

Since investigations on shift work and problems in that context are not envisaged, the platform needs to cover a time horizon of up to two hours. [E3, E4, E5, E6, E7, E8, E9, E13, E14, E15, E17, E18] With regard to future concepts like TORCH, mechanisms to integrate broader time horizons, i.e. for example a daily operational plan and its life throughout the day, are needed [E3, E4, E5, E6, E7, E8, E9, E13, E14, E15, E17, E18]. These mechanisms may be established with systems or organisational means.

5.2. Real-Time Airport Platforms

This chapter develops the validation platform requirements and recommendations for real-time airports platforms as well as airport related research and development.

Airport platform requirements and recommendations are structured in high level requirements and other issues.

5.2.1. Overview

Airports are becoming the capacity-limiting factor in the air traffic management infrastructure. Airport capacity constraints under adverse meteorological conditions, such as reduced visibility, are becoming a major bottleneck in the gate-to-gate flight cycle. Besides capacity, environmental issues and noise regulations are becoming more and more important.

Simulations (real-time) and validations of airport developments in the ATM system can be broken down into the following applications/areas:

- Current and future ground operations;
- Airport capacity studies;
- Design and analysis of TMA procedures;
- Controller workload analysis;
- Role of the human controller (i.e.: automated environment);
- Airspace redesign;
- Current/future airport and airspace infrastructures;
- Environmental constraints;
- Apron Control.

The airport real-time simulation platform's main objective is to evaluate planned improvements, in order to provide recommendations to enhance existing airport and airspace capacity, accommodate future forecasted traffic demand, decrease delays improve overall airport efficiency and improve environmental issues.

5.2.2. High Level Requirements

The types of functions to be modelled are highly dependent on the TMA and airport operation under examination. Each of these operations will in turn also differ slightly according to the geographic location and service airport provider, but considering the dynamics of the development of future systems such as A-SMGCS and new operational concepts such as gate-to-gate, airport platforms must be flexible in terms of integrating new functionality. Using this as a basis, the following principles have been established:

- The airport platform must have an open system architecture, which will enable future extensions.

- Linked with TORCH element E13 (Airport Operations Management and Control) the airport platform should be capable of monitoring the information from Daily Operational Plan processes to verify the conformance with the Operational Plan or to identify required modifications.

- Linked with TORCH element E17 (Performance Management) the airport platform should include a performance management module, which can establish continuous monitoring, and evaluation methods to ensure the achievements of the airport objectives in terms of effectiveness, safety, quality of the service and capacity.

- The platform has to utilise standard interfaces for input, output and internal communication among different components of the platform. This requirements is clearly linked with TORCH elements E18 (Information Management) where an information management is required which can support improved decision making by all stakeholders during their strategic, pre-tactical and tactical planning process, including real-time operations and post flight activities.

Basically, the minimum operational functionality for the airport platforms is as follows:

- Surveillance, guidance, planning and control of aircraft on and around the airport (SMAN). Considering TORCH element E7 (Separation Assurance), the platform should have the following capabilities: situation assessment, traffic monitoring, conflict detection and conflict resolution.

- AMAN/DMAN. Considering TORCH element E5 (en-route planning), the platform would need to analyse the current and predicted overall traffic with a time of horizon of up to about two hours. Moreover the platform should support integration of arrival management, departure management and ground movement management to produce an optimal flow of traffic in the TMA areas (see requirement for TORCH element E6 Terminal Area Sequencing).

- Flight and Aircraft Data Processing. The platform would need to process changes in flight and aircraft data in order to update the Daily Operational Plan. It would be necessary to agree common rules for the Collaborative Decision Making process. This functionality is linked with TORCH element E4 (Real-time Operational Plan Optimisation).

- Human machine interface. There are no explicit TORCH requirements regarding this functionality but the platform should consider an human centred approach.

- Simulation of future airports and airspace infrastructures. There are no TORCH requirements regarding this functionality but infrastructure simulation regarding future airports and airspace should be necessary for the platform.

- When considering the modelling of CDM in the airport, it should be possible to assess the use of information from sources such as handling agents, whose input can be important for the sequencing of departures.

- Airport Surface Detection functionality. Linked with TORCH element E7 (Separation assurance) the platform should allow representation of: situation assessment, traffic monitoring, conflict detection and conflict resolution tools.

- Runway Incursion functionality. Linked with TORCH element E7 (Separation assurance) the platform should allow representation of: situation assessment, traffic monitoring, conflict detection and conflict resolution tools.

- Design and analysis of TMA procedures. Considering TORCH element E1 (Airspace Plan Development and Implementation), the platform should have the capability to produce and develop airspace plan plus route network in TMA.

- Environmental impact assessment. There are no TORCH requirements regarding this functionality but the platform should have the capability to perform environmental assessment.

In general the platform should have the following supporting capability, as described in Section 3:

- Data preparation;
- Data Analysis;
- Data Recording;
- Data Management;
- Quantitative analysis;
- Qualitative analysis;
- System observation.

5.3. Airborne Components

This chapter looks at the requirements and recommendations on the different platforms when validating the airborne components.

5.3.1. Overview

To simulate or validate an airborne component (the airborne end user/aircraft with pilot) in the ATM system, two different types of platforms can effectively be used:

- Simplified target generator with low cost implementation;

- Aircraft and/or Full Flight Simulators.

The validation of an operational concept such as TORCH necessitates that additional new requirements on the Airborne Platforms be specified, not only within the TORCH elements E10 Flight Management Gate-to-Gate, E11 AO Flight Control, Flight Scheduling Gate-to-Gate Planning but also on:

- Aircraft parameters downlink capabilities, trajectory negotiation (ground trajectory prediction in E5 En-route

Planning, or trajectory negotiation in E9 Airline Operation Planning);

- Air-air interactions such as ASAS, ACAS and also Air-Ground or Ground-Ground in ASMGCS operations (E7 Separation assurance and E8 Hazard assessment);
- Gate to Gate management with taxi routing and stand capabilities (E6 Terminal Area Sequencing) or even with advanced FMS capabilities (E10 Flight Management Gate-to-Gate);
- Meteorological information processing (E16 Meteorological Agencies Operations) notably for air trajectory computation in simulated air system.

When an airborne component is to be evaluated, it is vital to use global standards as much as possible on equipment (symbols, colours, connectors, etc) and on operational procedures. The component must be operational and be evaluated in a realistic operative environment, have interoperability with ground systems and have the necessary redundancy, reliability and availability.

The first category of Airborne Component platform, a simplified low-cost target generator, corresponds to experiments where only the interaction between a ground system and a simulated airborne component are evaluated. The first category also corresponds to the use of airborne components (mainly Air Traffic Generator) for the evaluation of ground system components (ATG is the provider of air data handled by the ground system: plots, aircraft intentions, etc.). The second category, Aircraft and/or Full Flight Simulator, corresponds to the use of airborne components for evaluating onboard systems and using real aircraft in an operational environment. In such a case a ground infrastructure need only be simulated the same way as mentioned for the first category.

5.3.2. Simulated Aircraft Interaction with a Ground System

When talking of future interaction between a ground system and an airborne component, the data generated from the aircraft will come from the FMS, which the pilot is controlling. When evaluating elements in the TORCH concept with new procedures for the first time, based on the above-mentioned interaction, it is not necessary to have a full realistic cockpit environment. The important issue is to have realistic, correct and standardised output data from an airborne platform to the ground system.

This can be achieved by using a target generator simulating, in a very simplified way, a set of aircraft, or an FMS, based on a low-cost platform.

The Target Generator (E5, E6, E7, E8, E10, E11, E13)

The Target Generator platform will require no, or very limited, interaction from a pilot, therefore the requirements on the interface to this platform will vary and the most important will be the easiness to handle the system. The airborne target will be generated from a low-cost platform and displayed to a ground system. Several targets can be generated or displayed at the same time. The generated output data has to be in a standard FMS format or when non FMS aircraft will be simulated ordinary aircraft parameters (speed, vertical speed, heading etc).

The low-cost target generator (E5, E6, E7, E8, E9, E10, E11, E13, E15)

The low-cost platform will generate FMS data from simulated aircraft but with the same format and standardized output as from real aircraft (ARINC 429, optimum flight path etc). The data will be sent to a simulated ground system. The pilot can touch a screen and interact with the FMS system, as (s)he would do in a real cockpit environment with ordinary operational procedures. Therefore the interface requirements (symbols, colours, procedures etc) will be as the same as for an airborne FMS. With this platform the interaction between the controller and the pilot can be tested and evaluated, but most importantly procedures and operations based on aircraft generated data can be studied, developed and validated. The number of platforms that can be used at the same time can vary and depends on the scenario to be evaluated.

Fixed Base Simulators, FBS (E5, E6, E7, E8, E9, E10, E11, E13, E15)

FBS are aircraft flight simulators with engineering capability, i.e. there is a lower level of certification, and pilot training for real operations is limited; however, changes can be made to the interface, form and functionality of the system to develop HMI procedures and operations. They must have the flexibility to incorporate new systems, but still deliver the output data in a standard FMS or A/C format (ARINC 429 etc)

These platforms will be of lower fidelity than the Full Flight Simulator, Research Aircraft, Test flights with airline aircraft, and Airline aircraft in revenue flights platforms, described in section 5.3.3 "On-board Evaluation".

5.3.3. On-board Evaluation

When a new system is installed in an aircraft for test and trial purposes, the general requirements are that the equipment has to meet all of the various airborne requirements: ARINC standards, JAA and FAA requirements, Airlines Electronic Engineering Committee (AEEC) "form fit and functions", etc.

When making installations in an aircraft the cost for down-time and maintenance are extremely high. It is therefore very important that, prior to the start of a trial, the aircraft is/are available for possible installations. It is very important to involve maintenance personnel at all levels in the very beginning of the trial, since in almost every installation there are constraints (antenna positions, wiring, enough space in cockpit, connection to other systems, etc) that can be addressed by maintenance personnel who have the proven knowledge and/or the contacts with Aircraft Manufacturers.

The same is also true for FFS, e.g. Level D certified simulators where pilots are able to go straight to fly different types of line aircraft with fare-paying passengers after the simulator training.

Full Flight Simulators, FFS (E5, E6, E7, E8, E9, E10, E11, E13, E15, E16)

In this section we have not specified the different FFS, due to the fact there are so many. Therefore the requirements below are more general requirements and recommendation on the FFS. The FFS platform is used mainly for recurrent pilot training, however it can be used to test ATM system components as well. Together with a low-cost target generator and a ground system it can be used to verify and evaluate that the ATM system can handle such events or procedures developed and/or based on other platforms. The FFS can also work independently. The ordinary FFS is costly to use and difficult to modify since it is CAA certified, however there are also several experimental FFS where this issue will be of less importance. Some engineering simulators (Fixed Base Simulators, FBS) are available in Europe and elsewhere for more comprehensive validation exercises. FBS are described in section 5.3.1 "Simulated Aircraft Interaction with a Ground System". As described earlier on the other airborne platforms the output data has to be on a standard FMS format or A/C parameters. The functionality on the FFS will be to behave the similar way, as an aircraft will do when operated in different modes.

When using real aircraft, especially in shadow and operational trials, which tend to last for a longer period and for several flights, it is very important to have the maintenance personnel involved at an early stage in the design of the system so that it can be easily maintained. This also ensures that acceptable procedures are established regarding how to collect the recorded data from the onboard systems. In this way, the new system becomes a part of ordinary maintenance operations and not a limitation.

Because there are always certification issues in any installation, it is very important that the CAA Flight Safety Department takes part in the early stages of the trial planning and installation.

If a new cockpit system is to be tested and evaluated and real aircraft are to be the platform, three different types of aircraft may be used: research aircraft, airline/operational aircraft on test flights and aircraft on revenue flights.

Research aircraft: (E5, E6, E7, E8, E9, E10, E11, E13, E15, E16)

This type of aircraft is like a flying laboratory and can have different installations for different purposes. Various tests and evaluations can be made and analysed both on humans and the installed systems. Research aircraft are usually used individually or in a small fleet.

Test flights with airline aircraft: (E5, E6, E7, E8, E9, E10, E11, E13, E15, E16)

When conducting flights in test flight conditions, the aircraft and systems can be tested in more extreme circumstances than is possible when passengers are on board. This type of platform will often be used to verify that a newly installed system or the operation of an extended system can be used in revenue flights without any abnormalities. Test flights with airline aircraft are usually performed individually or in a small fleet.

Aircraft in revenue flights: (E5, E6, E7, E8, E9, E10, E11, E13, E15, E16)

This platform is used with a larger number of aircraft. The ordinary airline pilots control and use the system.

5.3.4. Data Recording/Collecting

Low cost target generator:

The generated data can easily be logged and collected for later analysis or repeated simulations.

Aircraft/FFS:

If a new installation with additional equipment for logging of data is to be made in an aircraft/FFS, the procedure to collect the data must be a part of the ordinary maintenance procedure. Because this procedure must not be a burden for maintenance personnel, the new equipment must also meet all the airborne requirements (ARINC standards, JAA and FAA requirements, Airline Electronic Engineering Committee (AEEC) "form fit and functions", etc).

5.3.5. Training

Low cost target generator:

When executing/verifying new procedures using a low cost target generator, training pilots is not an issue. The training can vary from individual study to classroom lessons.

Aircraft/FFS:

Pilot training becomes an issue when using real aircraft as opposed to the low cost platform. Often a dialogue must be initiated between the project and the respective Flight Safety Department how, what and how much training the pilot will need to complete before using the new equipment/procedures. Pilots doing trials with research or test flights, are often more familiar with new systems/procedures and are trained to handle the aircraft in the event of any abnormality, which can reduce the scope of the necessary training.

5.3.6. Life Cycle Stage

5.3.6.1. Geographical Scope

Today, aircraft are operated on a worldwide basis and hence must meet international as well as local requirements. The platforms inherently have no geographical limitations.

5.3.6.2. Fidelity and Resolution Scope

Low cost target generator:

The fidelity achieved with a low cost platform will be less than is possible with aircraft or flight simulators. The fidelity needs to be consistent with the objectives of the validation, which is more likely to be at an early stage in the life cycle of the concept.

Aircraft/FFS:

The fidelity of the FFS is very high and naturally, the aircraft offers complete fidelity to the operational aircraft. The relationship with other aircraft or the ground system may however not be completely realistic. The cost of installation will be high, only a few aircraft in the fleet will be fitted and this will also limit the fidelity of the exercise.

5.3.6.3. Temporal Scope

Low-cost target generators, aircraft and FFS have no limitations in the temporal scope that can be covered.

5.3.7. Other Issues

Naturally, most constraints lie in the aircraft platform. As mentioned earlier the cost for downtime, maintenance and in some cases training of pilots, can be very high. Also if new equipment needs to be installed or new procedures need to be established, there will be certification issues. Therefore, it is strongly advisable to have close contact with the respective Flight Safety Department and Maintenance organisation from the very beginning of the project.

5.4. Platform Architecture

This chapter develops the real time validation platform requirements and recommendations on architecture, highlighting complementary requirements regarding previous work such as AVENUE for example.

These requirements and recommendations can be presented according to the following point of views:

- facilities helping the integration of components provided by various partners;
- technical supervision of a simulation (not operational supervision);
- facilities for the simulation of degraded modes;
- impact of the use of operational components on the architecture.

5.4.1. Multi-partners Developments

This section does not focus on multi-site experiments, but on the impact of multi-partner developments on the architecture of the platform.

A platform (for example the AVENUE platform) may be composed of components provided by several partners. These components are then integrated on the platform. The architecture of the platform should be designed to help this work breakdown and the integration.

For that, it should separate:

- the infrastructure, which is in charge of the technical aspects, such as component communication;
- the components plugged on this infrastructure which are in charge of the ATC functionalities.

To achieve the integration and the deployment of such platform, the partners should share a common configuration management to exchange both the components themselves, and the infrastructure parts needed for the component adaptation or development.

In case of multiple experimentation sites, the on-site deployment should also be managed defining:

- the hardware and software requirements;
- the software licenses policy;
- the delivery (under a shared configuration management) and the installation (users guide, installation guides) of the components and the infrastructure.

5.4.2. Simulation Execution and Technical Supervision

A platform running a TORCH simulation should be able to manage exercises that correspond to the evolution of the traffic in the next years (2005 for ground trajectory prediction using down-linked parameters [E5] for example).

The operation of such platform can be very heavy in term of computational resources. For example, the trajectory prediction functionality can be very resource consuming and is critical for the simulation (studies on the trajectory negotiation concepts [E9], or trajectory prediction using down linked aircraft parameters [E5] for example). Another example is the safety net function [E8].

Furthermore, re-launching a run can be a long process (for multi-site simulations for example), or even impossible (for simulations involving an experimental aircraft for example). For these reasons, it shall be possible to individually supervise components during a run.

The validation platform should have technical supervision that allow the distribution of the components on the various hosts computers, in case of multiple host simulation:

- statically at the beginning of a simulation (for example, allocation of the components on hosts);
- dynamically during a run (for example: component duplication, or warm restart of a component on the same or on another host).

The architecture of the platform should allow component design, which is independent of the host on which they will run. Nevertheless some components associated with specific hardware cannot be "host independent".

The architecture of the platform should provide time functions that allow the design of components that run in accelerated/decelerated (faster/slower than real-time) mode.

It should be pointed out that this can impact components based on real-time clock or simulations connected with real components.

The architecture of the platform should provide supervision functions that allow the design of a component, which can be stopped/removed/restarted.

5.4.3. Degraded Mode Simulation

A validation platform can also be required to validate degraded modes functions. The infrastructure should provide support to simulate these degraded modes. It should be possible to dynamically trigger a component while inhibiting other components, for example providing data filtering (e.g. suppress some radar tracks between a surveillance component and safety nets).

5.4.4. Support for Testing and Integration

The goal of this section is to provide requirements and recommendations to assist in a successful integration of a multi-component validation platform. The more the partners have facilities to test and pre-integrate their own components on their own development site, the easier is the final integration on the simulation platform.

The validation platform should provide test harness capabilities for "component level" validation.

A "light" platform (for example with a simplified infrastructure and component stubs) could also be considered for pre-integration and pre-validation of components on the providers' sites (especially when it is not intended to deploy the validation platform on these sites).

The test harnesses and light platforms should provide facilities to support functional testing (such as recording and linking with test generator software).

5.4.5. Operational Components

A validation platform can contain components based on operational systems. Such components can be operational components (software/hardware) directly plugged onto the platform (such as data fusion processing from ARTAS into an experimental platform). They can also be external systems such as an external ATC centre (see section 5.5). Another example is the use of a component linked with an ATN stack connected to a real aircraft (such as the BAC1-11 experimental aircraft in the PHARE/PD3 demonstration) or an external simulator (such as the MASS Target Generator). This kind of component will be present in TORCH platforms (see [E5] ground trajectory using down linked parameters, or [E9] trajectory negotiation)

The goal of this section is to provide requirements and recommendations related to the interconnection with real systems, but not to discuss data-exchange for multi-site experiments (which is the aim of section 5.5).

The platform should be able to be connected and triggered (slave mode) by an external time generator. For example, this can be the case of a platform receiving flight plans and radar information from an operational centre.

A platform can be connected to a real system, mixing real data (for example position of a real aircraft) and simulated data (for example traffic coming from a traffic generator). In that case, it should be possible to shift dynamically the simulated data, in order to place them correctly regarding the real data (for example, if the real aircraft is delayed, the simulated data should be shifted to place the real aircraft in the correct environment regarding the generated traffic).

To facilitate the connection with real systems, the validation platform should support existing standards (Eolia D/L application and OLDI messages for example) for communication with operational systems.

5.5. Multi-site Experiments

This chapter develops the validation platform requirements and recommendations for multi-site experiments covering requirements for simulator interconnection and connection with operational systems as well as requirements for distributed data collection.

Taking into account TORCH concept elements, requirements and recommendations for multi-site experiments can be approached from four points of view:

- the stakeholders of the whole simulation;
- a description of data exchange among the stakeholders;
- the data distribution among the stakeholders;
- a description of data semantics for a common understanding of the data exchange and correct inter-operability.

5.5.1. Stakeholders of the Whole Simulation

The analysis of TORCH concept highlights the needs of several sources of traffic which should be mixed:

- air traffic generator (i.e. multi-aircraft simulator);
- cockpit simulator for accurate simulation;
- real traffic source (operational source and/or real aircraft (which should involve a change of referential));
- recorded traffic (from a former simulation) (E18);
- airport vehicle (i.e. fireman truck, follow-me car etc) for airport simulation.

Moreover, one or several components should be able to provide flight plans to the whole simulation. This component should also be able to negotiate the trajectory (E9).

Besides, the whole simulation should include ground simulated system:

- airport simulators;
- TMA simulators;
- En-route simulators;
- Initial Flight Plan System.

Simulation processing raises the matter of supervision:

- time management (basic orders, time reference and clock synchronisation);
- technical supervision (failure detection, warm launch of components, lost of component simulation);
- data exchange recording (in order to analyse and/or replay the simulation).

Lastly, remote simulated or real components should provide meteorological information to the whole simulation.

5.5.2. Data Exchange

This paragraph aims to present a first approach of the data, which should be exchanged among a TORCH simulation. The data could fall into eight parts.

Firstly, flight information should be exchanged including:

- flight plan for flight processing (E9 to E11);
- position, speed report, etc (E10 & E11);
- aircraft intentions (E10);
- flight attitude and aircraft feature (for visual simulation) (E13).

These data should be exchanged between air and ground simulations and also between air simulations for ASAS or ACAS functions (E7 & E8).

Then, airport vehicles features/data should be exchanged with airport simulation (E13).

ATC centres operational configuration should be modelled to supply a means to exchange information about:

- flow and capacity management (E2);
- operational organisation (e.g. control unit, LoA etc) (E3 to E6);
- runway configuration for airport cluster (E12).

Air Flight Information should be exchanged in order to allow aircraft flight management (E10 & E13). It includes for example ATIS information, NOTAM or airlines information to manage the arrival of a flight (gate of arrival).

Meteorological information should be dispatched through the whole simulation to improve the information necessary for the operational plan development (E16).

Such data operational configuration, airspace configuration including open or closed military area should be managed and then distributed to the interested components (E1 & E15).

In a multi-site simulation, including several ATC centres, there should be a means to allow ATC centres or military centres to communicate information about flight planning, co-ordination or emergency situations (E2 to E6 & E12 & E14 & E15).

Lastly, the flight planning involves the simulation must provide a trajectory negotiation process for strategic (E9) or tactical (E10 & E11) planning and also between air-air simulators (E7).

Another aspect of data exchange should be examined. Actually, a cockpit simulator can be considered as complementary to a global traffic generator. Hence, the flight ownership management should be discussed. It aims to dynamically handover the simulator responsible of a given flight (for a more accurate position report for example).

Moreover, from a global point of view, the content of the data exchange should be more or less detailed, depending of the capacity of each system. Accordingly, each component should be able to adapt its processing to the level of detail of received data.

5.5.3. Data Distribution

Multi-site simulation implies data distribution among remote components (E18). We have to consider several types of data distribution.

Firstly, named recipient communication should be possible. Indeed, a communication to a named recipient should be necessary for trajectory negotiation, co-ordination etc.

Then, broadcast addressing should be possible even if the nature of the components gathered in the whole simulation is different.

Data distribution should be considered depending on criteria to be defined. It aims to prevent an overloaded network and to preserve the fidelity of the simulation (i.e. an ATC centre should not be informed of a flight it is not interested in). The criterion should be for example:

- the ATC centre name;
- geographical 3D spaces;
- criterions relative to the flight plan, the trajectory;
- the radio frequency;
- the SSR code.

Lastly, all of these data distribution types should be managed by a component for technical supervision in order to record all the transmitted data.

5.5.4. Data Semantics

A general issue in multi-site simulation lies in the semantics of exchanged data (e.g. a fixed based Aircraft Simulator interconnected with a ground ATC simulator for an experiment on Trajectory Negotiation but working with different interpretation of the Trajectory Object semantic). A prior goal should be the construction of a means to provide a common understanding of the data.

As to the level of details of the data, which should be variable, a minimum level should be defined. Some fields of the data are mandatory for the data processing, depending of the type of the data, therefore these execution constraints should be documented.

6. Conclusions

The objective of Work Item WP2.4 is to prepare for WP 3 by identifying requirements on the validation platforms for MAEVA validation exercises and thus supporting platform identification and any related development programmes in the frame of these validation activities.

To take maximum benefit of the varied expertise brought by the expert services involved in this work item and considering the wide scope of the VMP validation process, these requirements were developed against the following perspectives:

- **Validation environment**, taking into consideration data preparation, data recording, on line and off line data analysis but also traffic generation, use of live traffic data and highlighting the use of software tools for experimental design;
- **Fast-time platforms**, taking into account their application to validating the TORCH operational concept elements;
- **Real-time platforms**, themselves were developed in the following areas:
  - **En-Route/TMA platforms**, taking into consideration possible system components as well as the basic steps in the validation exercise framework;
  - **Airport platforms**, considering the Gate to Gate dimension of the 5th Framework Programme Validation Process;
  - **Airborne components**, covering ATG and cockpit simulators as well as research aircraft or aircraft in use by airlines and highlighting the necessary certification issues;
  - **Platform architecture**, highlighting complementary requirements regarding previous work such as AVENUE for example;
  - **Multi-site Experiments**, covering requirements for simulator interconnection but also connection with operational systems as well as requirements for distributed data collection.

The validation environment requirements were developed respectively for Data Preparation, Experimental Design, Data Analysis and System Observation. Data Analysis requirements were analysed respectively for Data Preparation, Data Management, Quantitative Analysis and Qualitative Analysis. This section strongly recommends the use of software tools for experimental design, which is a key to the validation activity.

The fast-time platforms requirements were first discussed in general terms regarding the 5th FP validation process and secondly in relation to the TORCH concept elements. The objective of analysing TORCH was to identify those areas in which fast-time validation can contribute now and those to which fast-time might contribute in the future. This helped to identify those areas of TORCH which were too uncertain for fast-time validations and those where fast-time platforms may require additions to their rule bases to model advances features.

The real-time platforms requirements were further decomposed. Platform architecture requirements were focused on those requirements not yet addressed by previous projects and especially AVENUE. En-route/TMA requirements considered the ATM Scope and the life cycle stages. The section on airport platform requirements specified the minimum operational functionality for validating the airport-related TORCH elements and considered both the high level capabilities and the lower level enablers to support such concepts. Airborne Components requirements took into account the different nature of the airborne components while multi-site experiments requirements highlighted the outstanding needs in that particular area.

Appendix 1. A Summary of the Torch Concept.

This appendix summarises the TORCH concept elements that define the TORCH Operational Concept. A brief description of each element is provided in the following subsections, based on the EATMS OCD, the ATM 2000+ Strategy and the analysis performed by TORCH.

E1: Airspace Plan Development and Implementation

Description: Production, development and implementation of the Airspace Plan plus the Route Network structure, which will be optimised and harmonised in the entire ECAC airspace, in co-ordination with users, through established CDM procedures based on agreed options. These functions will be integrated into the process of Operational Plan Development (E3) and Operational Plan Optimisation (E4), which will use these functions as instruments to balance demand to capacity.

Feasibility of the element: After the analysis performed , for this element, further investigation about which schedules are required before giving a conclusion about how the required enablers to implement this element are felt to become available within TORCH timeframe.

E2: Demand and Capacity Determination

Description: Production of an accurate forecast of demand and capacity as basis for the layered planning process. The element will monitor the evolution of demand and capacity over time as basis for the development and optimisation of the Daily Operational Plan (E3 and E4). The basic principle is that demand and capacity forecasts are permanently improved whenever new or improved data become available, and they are made available to all interested parties by distributing them according to their needs.

Feasibility of the element: Main technical requirements (availability of algorithms for integration of demand data and availability of capacity models which can be used easily for short-term assessment) have to be met, but there should not be major problems if looked at quickly. Main problems are likely to be caused by the availability of data required from various organisations:

- Access to **all** sources of data about demand.
- Access to **accurate** data for capacity estimation.

These requirements need the involvement of all parts, and the agreement about the basic principles to calculate capacities, which is difficult to predict.

About the required socio-economical enablers an issue considered is the establishment of the legal framework, at the ECAC level, to support these procedures, and also to describe the procedures common for all States. This requires political agreements, which may add time to the process of getting operational procedures implemented.

E3: Operational Plan Development and Implementation

Description: This element develops and implements (sets into force) the Daily Operational Plan. The plan is presented to the ATM providers and the airspace users at the day before operations. The plan will be updated whenever changes to the demand or capacity are announced from authorised system users. This DOP is characterised by a higher accuracy and an active involvement of users in the decision loop by using their own planning and decision tools.

Feasibility of the element: The main technical problem lies in the availability of decision support tools to assist the process of negotiation among stakeholders, given the very short-term horizon and the complexity of the problems raised by the development of the DOP.

CDM and the central character of decision required to implement this element appear as major issues. Practically, this may mean a central organisation alone, a central organisation with local participation to decision making, or no central organisation, but algorithms leading to a common decision. This has important consequences on feasibility issues.

E4: Real-time Operational Plan Optimisation

Description: The processing of tactical changes in airspace status and ATM/airport capacity will result in updated information within the DOP. The DOP is used as the basis to supervise its conduction and implementation during the day of operation, applying refinements to the planning (re-planning) as reactions to unforeseen events by a CDM process in which the airspace users are involved. The re-planning is not a central function but a local optimisation of available resources. All parties (ATM providers, Airports, users, ...) are informed of the updated DOP.

Feasibility of the element: The required technical enablers can be in place during the TORCH timeframe. The implementation of technical requirements and the solution of human factor issues are challenging tasks for the stakeholders concerned, but can be solved in time. Operational problems can be solved, if tasks and responsibilities are clearly defined and rules and procedures are agreed by the affected stakeholders.

An important factor is the willingness of all stakeholders to:

- Make data available for a system wide situational awareness (for competitors as well as for partners).
- Agree on common rules for the CDM process.
- Make available the required investment and manpower.
- However, it should be possible to resolve these issues in the
- next years, before the TORCH timeframe.

E5: En-route Planning

Description: En-route planning acts on the basis of the agreed DOP. It analyses the current and predicted overall traffic situation with a time horizon of up to about 2 hours in advance and a smaller area of responsibility. This element will create a bridge between Flow and Capacity Management (E1 to E4) and tactical ATC (E6 & E7). Multi-sector Planning will be a new function in ATC which will be able to plan traffic and solve potential conflicts ahead.

Feasibility of the element: A significant number of enablers are required for the introduction of these functions. Supporting tools must be specified, developed and validated (although some are already on the way). An economic facilitator would be agreements on common developments to reduce costs.

Specific problems are expected in developing the required advanced controller tools for a free route environment in combination with the flexible, demand-oriented sectorisation within the centre envisaged by TORCH operational concept. New roles and responsibilities of participating operational staff, procedures and regulations, safety cases, have to be evaluated and approved for the new concept. The staff, mainly controllers, has to participate in this process and training has to be organised.

The implementation of functions such as multi-sector planning involves a significant amount of work (including validation) and need much time to be agreed by the ATM community and implemented. However, it could be done in time.

A phased implementation approach needs to be considered starting with improvements in ground-based algorithm for trajectory prediction using down-linked aircraft parameters in 2005 and continuing with the integration of the transmitted flight intent. This integration of transmitted flight intent is considered as a critical item which needs further evaluation.

E6: Terminal Area Sequencing

Description: Integration of arrival management, departure management and ground movement management to produce an optimal flow of traffic in TMA areas which will assure the optimum use of the available airport and airspace resources and closer to user needs.

Feasibility of the element: Implementation of arrival and departure management in itself is not a problem (this kind of management is already operational at some airports). The problem mainly comes from things which are new in this management, especially technical and organisational issues raised by collaboration decision making involving not only departure and arrival management, but also other functions (such as taxi routing management, stand management, etc.).

Integration between departure and arrival managers and ground management tools through CDM is needed, and that may be a problem within the timeframe.

E7: Separation Assurance

Description: During the TORCH timeframe the responsibility for separation assurance may be partially delegated to the aircrews of suitable equipped aircraft, by ASAS implementation such as Station Keeping. This element includes functions such as situation assessment, traffic monitoring, conflict detection and conflict resolution functions, characterised by an increase of automated tools, human ultimate responsibility for separation assurance, and possibility of negotiation for conflict resolution with pilots.

Feasibility of the element: This element is deemed to be available for the TORCH time frame, as the required technologies have been already experimented. The main problem is the installation of common or compatible communication technologies for datalink or ADS purposes, both on the ground and in the air. The compatibility issue extends beyond Europe.

There are a number of questions on what data needs to be exchanged between ground and air, the suitability of tools in all situations and whether additional computer assistance tools are required. Assuming these issues can be resolved with a positive outcome, the tools should be available within the TORCH timeframe, but it may take longer to integrate them into an operational system. The major concerns are economical (if ASAS is made mandatory) and operational: The change in responsibilities and the role of ground controllers in FFAS raise difficult human factors issues. Controller confidence in the computer assistance tools needs to be established and resulting decrease in controller workload proven in order that capacity can be increased.

E8: Hazard Assessment

Description: The safety net functions calculate possible conflicts between aircraft trajectories, or between aircraft trajectories and defined areas within the airspace, or between the trajectory and the ground, within the near future of the flight (last minute safety layer). They shall operate independent from other system functions.

Feasibility of the element: It is inconceivable to set up a control service coping with more traffic if the last resort systems against hazards are not enhanced up to a level guaranteeing at least the same safety standards as today. This element is not a direct contributor to capacity increases, but the capacity gains will somehow depend on the level of performance it can achieve.

The decision to mandate ACAS II over the ECAC airspace is an important step. There are a lot of uncertainties about ACAS III because of technological issues and lack of proactive R&D. It is however likely the ACAS II standard will be sufficient to meet the needs within the TORCH time frame.

Successful implementation of ACAS will rely, among other things, on an ECAC widespread training of controllers to the future ACAS environment.

Regarding ground safety nets, enhancements in quality are expected by use of more accurate surveillance data and new data (like aircraft intents) derived from parameters generated onboard aircraft. The air/ground datalink medium could therefore become an essential enabler.

E9: Airline Operation Planning

Description: The role of airline 6 operations will move towards more involvement in the planning processes. CDM will provide airline operators with the ability to negotiate their plans during the planning phase. Airlines Operators will develop the operation plan which includes the revised airline schedule and the flight plan information including gate-to-gate trajectories. Gate-to-gate planning conducts those navigational, flight guidance and trajectory planning activities necessary for the successful conduct of the entire flight. Flight planning includes all business processes involved in route planning decisions and evaluations supporting both operational and cost-wise assessments e.g. the flexible setting of flight planning parameters by speeds/procedures, altitudes, different routes, variable cost index and point-to-point calculations

Feasibility of the element: Major issues are:

- the availability of decision-support tools for airlines;
- all issues linked to CDM and interconnection of systems: the difficulty makes it likely that changes will be step by step, and therefore will take time.

Generally speaking, a stronger involvement of AOC is one of the fundamental enablers of the TORCH operational concept.

E10: Aircraft Flight Management from Gate to Gate

Description: Flight Management on board will be supported by FMS Systems which keeps the aircraft in a 4-dimensional cell, provides a high navigation accuracy in 3 dimensions, or advanced systems in 4 dimensions (lateral, longitudinal, vertical and time). The AOC will use its real-time data to optimise fleet operations and supply its aircraft with directives and environment data updates. In return, AOCs will be notified of changing intentions that are proposed or decided by the flight crew

Feasibility of the element: The required technical enablers are based on already existing technologies, but require further development and communication means (for communication with ground) with sufficient capacity and performance.

The main operational enablers are approved new regulations and procedures, for all changes in pilot's activities (including those due to AOC directives, and associated safety cases and training).

The socio-economic enabler is the decision of all major airlines to invest in required changes (which should ultimately save money).

E11: AO Flight Control

Description: AO Flight Control will have two complementary functions: to monitor the aircraft during the flight, co-ordinating the necessary changes and evaluating trajectory change requirements and to optimise fleet operations

Feasibility of the element: The required technical enablers are based on already existing technologies, but require further development. This element assumes that AOC will get a more important role for monitoring the flight and determining its route. Thus some responsibility would be transferred from controllers to AOC.

This is a major change, requiring new organisations in AOCs and ATC centres. It is difficult to evaluate time necessary to produce appropriate and safe procedures and rules, acceptable to all people involved.

E12: Airport Strategic Planning

Description: The objective of airport strategic planning is to plan and optimise the operation of a single airport or groups of airports (airport cluster) in accordance with the business/mission objectives. Airport Strategic Planning starts years in advance if big infrastructure changes are concerned (e.g. new runways, terminals, etc.). Resource management will be performed in a collaborative decision making process involving all actors being part of airport planning

Feasibility of the element: The major difficulty is the introduction of co-operation between different organisations: adjacent airports, other public transport means (although it sometimes happens that a single organisation manages adjacent airports).

This is made the more difficult since some of these organisations consider themselves as competitors.

E13: Airport Operations Management And Control

Description: Airport management is characterised by a Monitoring function which will control the development of the Daily Operational Plan processes information to verify conformance with the Operational Plan or identify required modifications. The other defined functions such as Surface Movement Management, Airport Operations Support and Real-time Resource Allocation aim to make aircraft handling and movement faster and more efficient, thereby increasing passenger satisfaction by minimising delays and expediting aircraft turn-around

Feasibility of the element: The main problem is not technical, as enough time is available in the TORCH time frame to develop required missing products (although time should not be wasted).

Major difficulties are related to:

- the major changes in work organisation.
- the number of stakeholders at airports and the complexity and variety of organisations involved and of decision-taking processes. This makes CDM especially necessary, but also especially difficult, at airports. A step by step approach seems necessary, but takes time.

E14: Adjacent ATM Areas

Description: Co-ordination with units of adjacent ATM areas outside ECAC airspace is necessary for the strategic, planning and real-time operational phases to manage traffic flows across boundary areas. This will permit to avoid internal capacity constraints due to the external airspace and traffic

Feasibility of the element: Feasibility during the TORCH time frame depends on the states involved. Generally speaking:

- problems are the same as internally, but decisions required to solve them are likely to be more difficult to take;
- any internal moves towards harmonisation are likely to facilitate these discussions and decisions.

E15: Military Operations

Description: Co-ordination between civil and military Operators, involving exchange of flight plan and airspace use information, will benefit to both civil airspace users and military air traffic. An effective and efficient co-ordination will enable the mentioned actors to get user preferred trajectories, improve flexibility and flight efficiency and furthermore, assure the integrity of national airspace (air defence tasks).

Feasibility of the element: It is difficult to assess at what time this element can be fully implemented, as it depends on the willingness of military and ATM organisations to collaborate.

E16: Meteorological Agencies

Description: The availability of more accurate meteorological information for an entire area/time-window of interest (e.g. airports), including better forecasts from long-medium to short term, will improve the information necessary for the Operational Plan Development from its strategic level to its implementation, increasing the accuracy of the DOP.

Feasibility of the element: It should be checked to what extent meteorological forecasts can be improved by considering new weather data captured and down-linked from aircraft.

E17: Performance Management

Description: Performance Management establishes a continuous monitoring and evaluation method to ensure the achievement of the ATM objectives in terms of effectiveness, safety, quality of service and capacity.

Feasibility of the element: The major uncertainty about this element is the possibility to agree on common indicators, and that actual values of these indicators are published by all organisations involved (states, ATC centres, airports, airlines, etc.) This may sometimes be difficult, due to the reluctance of many organisations to publish some information they consider confidential. However, public information already made available is sufficient to implement this element to some extent.

E18: Information Management

Description: Information management involves the acquisition, management (filtering and maintenance) and distribution of the information needed to perform all ATM functions. The best possible integrated picture of the past, present and (planned) future state of the ATM situation will be used as a basis for improved decision making by all ATM stakeholders during their strategic, pre-tactical and tactical planning processes, including real-time operations and post flight activities

Feasibility of the element: The major issue here is access of all stakeholders to common, accurate and consistent information. This is progressing well at airports (common central databases are used in more and more airports). However, the number of stakeholders and legacy systems makes a quick progress difficult Fully implementing all characteristics of this element will probably be impossible in the TORCH time frame, due to the number and difficulty of technical problems raised, as well as the organisational problems. But implementing enough of it to make possible the implementation of other elements should be possible.

Appendix 2. Generic Mapping to Requirements.

The MAEVA Validation Framework for Validation Exercise [2]

One of the objectives of MAEVA, is to identify the basic steps that have to be undertaken to perform a successful validation exercise, in particular in the context of the 5th FP. This validation framework shall form the basis for a common understanding on ATM validation amongst all participants in the 5th FP validation activities - answering the question "What do I have to do to perform a validation exercise that suits the aim(s) and objective(s) of my customer and that delivers the desired results?" -. Adoption of a common approach will go some way towards allowing a better comparison of results between different validation exercises on similar subjects.

In the WP1.1 report (deliverable D1.1), the basic steps for performing a validation exercise were discussed. It was proposed that every validation exercise can be defined in terms of the following five basic steps.

- Step 1: Define the validation aims, objectives and hypotheses;
- Step 2: Prepare the validation plan & prepare for exercise runs;
- Step 3: Execute exercise runs and make measurements;
- Step 4: Analyse results;
- Step 5: Develop conclusions and disseminate.

The relationships between the above five steps is illustrated in the following Figure.

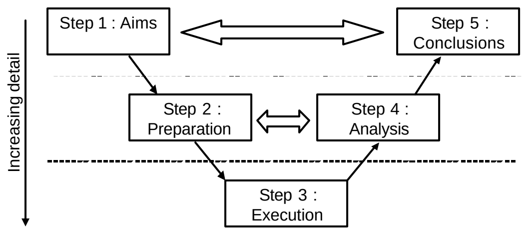

Figure 2-1 Relationship between the Basic Steps in the Validation Exercise Framework

These steps were derived from the EUROCONTROL DEVAM (Development of EATCHIP/EATMP Validation Methodologies) work programme.

The first step in a validation exercise is to obtain an understanding of the ATM problem that needs to be solved and the operational concept to address this problem. This will set the context for the aim(s) of the validation exercise – usually developed in close co-operation with the customer (to whom validation may well be considered as something of a “black art”). Establishing validation platform requirements is part of this first step.

Identification of the validation aim is effectively a prerequisite to establishing the requirements of the validation platform. In addition, an understanding of the ATM problem and the operational concept directly affect decisions made at this point.

The statement of requirements for the validation platform will identify options for the validation techniques (fast-time, real-time, ...) that may be used for the exercise. Normally only one technique is used within an exercise, but there may be circumstances where the use of two or more techniques (and therefore platforms) will provide the most cost effective solution.

The specification of the validation platform requirements was further detailed in WP1.2.

Generic Mapping to Determine Validation Platform Requirements [3]

The objective of WP1.2 was to develop the framework for a methodology applicable to the process of defining a set of achievable requirements for the validation platform to be used for a validation exercise. A validation platform should be capable of representing the components of the ATM environment that will enable a particular ATM concept to be validated.

Work Item WP1.2 has developed and presented a process for determining the requirements to be placed on a validation platform. The OCD Invariant Processes and the MAEVA definition for Validation Scope were used as a basis for the analysis.

The platform required for a particular validation exercise may take a variety of forms. It is most usually a set of computer tools; these tools may be:

- a set of high level models;
- a fully simulated environment;
- or a set of tools to support an operational trial, where much of the ATM environment is represented by the ‘real’ operational systems (for example aircraft, controllers and their supporting ground systems).

The decision on platform selection will be determined by the Validation Platform requirements. These requirements will cover:

- Scope of the ATM aspects as follows:
  - High Level Functionalities - which and what type of functions in the complete ATM process need to be represented;
  - Requirements for inputs and outputs;
  - Operational Scope – what part of the complete ATM process needs to be represented (en route, en route plus TMA and/or Gate-to-Gate);
- Life cycle stage – indicating the resolution/fidelity of representation;

- Geographic scope (location and physical size of the area to be represented if a global representation is not feasible or of relevance, ie one sector, complete ACC, Europe or world wide);

- Time based scope (future timeframe and time period for runs, hours or months).

A clear logical process for determining these requirements will ensure an objective approach to the selection of the Validation Platform. The requirements for the platform will be driven by the nature of the ATM operational concept and the ATM problem it is intended to address, but constrained by practical considerations such as cost, resource availability and technical feasibility. The platform requirements also need to be consistent with the scope of the validation aims.

The factors influencing the requirements placed on a validation platform can be divided into two types:

- drivers for the requirements which are:
  - ATM problem context which typically relates to one or more of the ATM 2000+ Strategy Objectives. These objectives are:
    - Safety;
    - Capacity;
    - Economy;
    - Environment;
    - National Security and Defence Requirements;
    - Uniformity;
    - Quality;
    - Human Commitment and Involvement.
  - ATM Operational concept, the scope of which can be clarified by going through the following points:
    - The ATM scope needs to be clearly defined and understood.
    - It is useful to know whether the concept has been validated previously.
    - It is important to know how dynamic or interactive the concept is.
    - It is also important to establish the fidelity of any modelling required.
    - The resolution of the modelling also needs to be established.
    - The maturity of the concept needs to be considered.
    - If there is a requirement for results to be assessed to a certain level of accuracy or resolution or a certain level of confidence in the results is required.
    - The primary and secondary objectives of the exercise need to be examined.
    - Finally, there may be an assumption by the customer that a particular validation platform will be used.
- constraints on the requirements:
  - Resources, which relates to:
    - Financial aspects.
    - Availability of resources.
    - Timescales.
  - Feasibility relating to:
    - Ensuring the safety of participants.
    - Operational considerations.
    - Practicalities.

In the process to be used to determine the requirements for the platform, the proposed steps to be taken are:

- Step 1: Identify the scope of the ATM to be incorporated within the platform:
  - ATM Problem and ATM Concept components and Validation Aims;
  - Scope of inputs;
  - Measurement Requirements;
  - Operational Scope;
  - Collate the scope of the ATM to be incorporated on the platform;
- Step 2: Decide on fidelity/resolution requirements, related to life cycle phase;
- Step 3: Define geographic requirements;
- Step 4: Define time-based requirements;
- Step 5: Balance requirements with constraints;
- Step 6: Consider options.

Deliverable <D2.4>

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