EC DG-TREN
Transport Programme
(4.1.1.1/6)

Contract : AI-98-SC.3030

RESEARCH FOR
SUSTAINABLE
MOBILITY

TORCH

Technical, EcOnomical and OpeRational Assessment of an ATM Concept AcHievable from the year 2005

TN6 PROPOSED TORCH OPERATIONAL CONCEPT FOR VALIDATION

Document Change Log

Release	Author	Edition Date	Affected Sections / Comments
0.1	Isdefe	29/09/00	Creation
0.2	Isdefe	8/11/00	All. First Draft version including contributions from Aena, Airsys ATM, BPM, DFS and Isdefe.
0.3	Isdefe	30/11/00	Comments by DFS, BPM and AIRSYS ATM included.
1.0	Isdefe	15/12/00	Comment by DFS and Peer Review included.

Document Distribution

To/cc	Code	Organisation	Name
To		Project Manager	N. SUAREZ
cc.	AEN	Aena	J.M. DE PABLO
cc.	AER	Aerospatiale - Matra Airbus	P. SCHUSTER
cc.	AIR	Airsys ATM S.A.	D. EGRON, M. SOURIMANT
cc.	BPM	BPM	I. GIANNOULI
cc.	DER	DERA	D. BASELEY
cc.	DFS	DFS	M. POPPE, J. BRÖKER-WOLF, R. WEIDEMANN
cc.	EEC	EUROCONTROL Experimental Centre	N. MAKINS
cc.	IBE	Iberia	P. GOMEZ
cc.	ISD	Isdefe	A. RECUERO, E. FRAILE
cc.	LUF	Lufthansa	W. LAUF
cc.	SEX	Sextant	G. SAINTHUILE
cc.	SCA	Swedish Civil Aviation Authority	N. GUSTAVSSON
To	DG	DG-TREN	P. BERNARD
cc.	EUR	EUROCONTROL	J. VARELA, B. ORR

Review and Approval of the Document

Organisation Responsible for Review	Reference of comment documents	Date
Aena	TOR/AEN/WP6/64PA__10	15/12/00
Organisation Responsible for Approval	**Name of person approving the document**	**Date**
Project Manager	N. SUÁREZ	15/12/00
Work Package Leader	A. RECUERO	15/12/00
EC Official	P. BERNARD	

Executive Summary

Air Traffic Management (ATM) capacity is a scarce resource that needs careful management. To ensure that available capacity is managed as efficiently as possible, TORCH promotes to exchange more transparently available data to ensure that the distribution of information and decision making is located where it is most effective. The transparency and quality of data, plus a greater involvement of the ATM users, will ensure that available capacity is used with greater efficiency. The TORCH Operational Concept is based on two main pillars: an improvement in the planning phases by introduction of layered planning and CDM procedures, and on reducing the workload of the air traffic controller per aircraft by additionally introducing computer enhanced tools.

The main objective of the TORCH project - co-funded by the European Commission Directorate General for Transport and Energy - is to identify and assess a viable European ATM/CNS Concept for the medium term timeframe (fully implementable by 2010) that could be validated by the various validation exercises envisaged to be performed by projects in the European Commission 5th Framework Research Programme. The work is based on the EUROCONTROL EATMS OCD and the ATM 2000+ Strategy.

The first pillar of the Operational Concept (OC) proposes a continuous layered planning based on a more flexible use of airspace and a stronger involvement of the actors. The objective of the Concept is to optimise the management of the available resources instead of constraining the demand. Decisions will be shifted into non-time-critical phases through enhanced co-ordination among all stakeholders, therefore, the need for time critical “ad-hoc” decisions will be reduced.

These improvements will be achieved through the elaboration and usage of the Daily Operational Plan (DOP). The DOP enables monitoring of the relationship between capacity and demand from months in advance to the actual moment of operation. All interested parties will have access to the same data under the same rules, based on the assumption that the required data will be available.

Collaborative Planning and Decision-Making (CDM) will allow the Daily Operational Plan to be a dynamic process. Although the basis for the DOP is established early in advance, the introduction of real-time information in the decision-making loop results in a more accurate picture of what is happening and takes into account real-time changes that can affect the stakeholders’ expectations.

The other pillar of the Operational Concept deals with Re-Planning and Flight Phases. The DOP ensures an enlarged planning horizon on Air Traffic Control centre and on (multi-) sector level. Unforeseen events not yet contained in DOP will be taken into account by re-planning actions. This will be achieved with new tools like Traffic Load Analyser or Medium Term Conflict Detection being fed with more precise data updated in real time. There will be a shift of tasks and new roles will emerge around tactical flow planning. Ultimate goal is the reduction of the traffic complexity in the sector, thus reducing the workload of the air traffic controller. This will lead to improved sector throughput and an increase in capacity, including airport and TMA operations.

The feasibility of the OC was tested by performing three types of assessments: technical, operational and socio-economic. These assessments have shown the benefits and costs of the proposed OC.

Most of the TORCH OC seems to be technically feasible within the considered time frame 2005-2010.Three subsequent implementation steps have been identified. Nevertheless, stress should be put on prompt decisions to use these new tools and technologies. Another critical issue is a sufficient proportion of equipped aircraft in order to gain substantial benefits. This applies also for ATM ground systems.

The operational feasibility study shows that a Daily Operational Plan (DOP) can be developed by means of more accurate input data. The DOP is the first step in a layered planning and provides input data for the following activities on centre and sector level. It should not be seen as a rigid plan which will be put into operation. It is rather the base for re-planning at the day of operation. Airport, TMA and En-Route studies have shown potentials varying by the chosen concept of operations, i.e. Station Keeping, Free Routing and Multi Sector Planning.

The TORCH OC is more likely to be viable from a socio-economic point of view under a scenario of high traffic growth. All stakeholders have mutual benefits, i.e. a win-win situation. There are no trade-offs among the objectives and aspirations of the ATM system stakeholders. The costs of investments will be substantial as compared to the continuation of the existing system. The experts involved in the socio-economic assessment allocated most importance on system functionalities which increase peak hour capacity at airports, minimise the delay of flights and which reduce controller workload.

This concept proposes the introduction of new or enhanced ATM functionalities within ECAC. The assessment part of the study has shown that it is hardly possible to validate the entire concept. Further validation activities are required in the area of better collaboration between the stakeholders, i.e. by the concept of Layered Planning and Daily Operational Plan.

Table of Contents

Index of Figures

Index of Tables

1. Introduction

1.1. Purpose

This document is the final deliverable of the TORCH Project. It was generated as part of WP6 "Proposed TORCH Operational Concept for Validation". The main objectives of WP6 are:

- To analyse the tasks performed throughout the Project, by analysing results from previous work.

- To provide a consolidated Operational Concept (OC) together with conclusions and recommendations.

The main purposes of this document are to present the TORCH Operational Concept and to draw final conclusions and make recommendations in at least the following areas:

- Viability of the proposed concept, from an analysis of the assessment results.
- Transition guidelines from the current CNS/ATM system towards full implementation of the TORCH Operational Concept.
- Future actions, including further validation activities such as “live” trials within the European Commission (EC) framework.

1.2. Background

The current situation of Air Traffic Management (ATM) in Europe is characterised by a set of problems that cause safety, capacity and economic shortfalls in the ATM system. The high density of traffic in the core area, the fragmented Air Traffic Management (ATM) in the ECAC region (49 ATC centres with different levels of functionality) and the complex airspace structure, create delays in European ATM with an already unacceptable associated cost.

European air traffic demand is forecast to double within the next 10 years. If nothing is changed, this situation will cause safety and congestion problems.

Existing activities to find candidate solutions within the European Framework are long-term oriented work (such as the EUROCONTROL EATMS OCD or the ATM Strategy for 2000+), or sets of fragmented solutions to partial problems. The implementation of future concepts is followed by constraints, such as the need for standards, the required time to put products to market, aircraft retrofits and the selection and training of operators to new operational concepts. The target Operational Concept [OCD] is not planned to be implemented before 2015.

Anticipating these facts, the European Commission (EC) Directorate General of Transport and Energy decided to sponsor a study to elaborate a pre-assessed ATM Operational Concept which could be made operational, upon validations, by steps between 2005 and 2010, and fully operational, at least in some parts of Europe, in 2010: TORCH. The TORCH Project is a twenty-two month study co-ordinated by Isdefe (Spain) with the contribution of ten European organisations representative of the ATM domain stakeholders: Aena (Spain), Aerospatiale-Matra Airbus (France), Airsys ATM S.A. (France), BPM (Greece), DERA (UK), DFS (Germany), EEC, IBERIA (Spain), LUFTHANSA (Germany) and Sextant (France).

The TORCH project commenced its work at the beginning of 1999. The main objective of TORCH is to identify and to assess a viable European ATM/CNS Concept for the medium term timeframe (fully implementable by 2010), that could be used in the various validation exercises envisaged to be performed by projects in the EC's 5th Framework Research Programme. The work is based on Eurocontrol’s EATMS OCD [OCD] and ATM 2000+ Strategy [ATM 2000]. As a complement to the attainment of this objective, TORCH aims to facilitate the early implementation of the Operational Concept, identify the most promising parts of the concept which may improve ATM with a minimum CNS investment and produce an Operational Concept ready for validation.

1.3. Document Structure

The document consists of six sections, which present the results of the TORCH Project. It also includes five appendices, which provide additional information to the different parts included in the main body of the document:

- Section 1, Introduction: This section presents the purpose of the document, its background and structure. In addition, it contains a glossary of the acronyms used in the document and a list of reference documents.

- Section 2, Project Methodology: This section contains a summary of the methodological approach taken in the project. The three phases of the project are presented, describing their objectives and interrelationship.

- Section 3, TORCH Operational Concept: This section presents the Operational Concept proposed by TORCH. The first part describes the TORCH Flow Diagram, which presents the Operational Concept from the point of view of interrelated operational processes. Finally, the three main phases of the Operational Concept are described.

- Section 4, Operational Concept Assessment: This section presents a summary of the results of the assessment made of the Operational Concept and the analysis of these results, providing conclusions and recommendations.

- Section 5, Transition Guidelines: This section establishes the need of implementing the Operational Concept in transition steps. It provides a set of guidelines for the transitions from the current ATM/CNS system towards the Operational Concept implementation.

- Section 6, Conclusions and Recommendations: This section includes recommendations drawn from the Operational Concept assessment, the relevance of the project, future actions and the lessons learned.

The five appendices, which expand and complete the text in the body of the document, are:

- Appendix A, Stakeholders' Role in the TORCH Operational Concept: Description of the TORCH Operational Concept from the stakeholders' point of view. This appendix complements Section 3.
- Appendix B, Summary and Analysis of the Technical Assessment. This appendix complements Section 4.
- Appendix C, Summary and Analysis of the Operational Assessment. This appendix complements Section 4.
- Appendix D, Summary and Analysis of the Socio-Economical Assessment. This appendix complements Section 4.
- Appendix E, Transition Guidelines: Description of the three transition steps to implement the full Operational Concept, identifying the foreseen operational improvements for each period.

1.4. Glossary

Term:	**Description.**
4D:	Four Dimensional.
4D-FMS:	4D Flight Management System.
A/C:	Aircraft.
A/G:	Air/Ground.
AAC:	Aeronautical Administrative Communication.
ACAS:	Airborne Collision Avoidance System.
ACC:	Area Control centre.
ADS-B:	Automatic Dependent Surveillance Broadcast.
AHP:	Analytical Hierarchy Process.
AMAN:	Arrival Manager.
AO:	Aircraft Operator.
AOC:	Airline Operation Centre.
APO:	Airport Operators.
APW:	Area Proximity Warning.
ASAS:	Airborne Separation Assurance System.
ASM:	Air Space Management.
A-SMGCS:	Advanced Surface Movement Guidance and Control System.
ATC:	Air Traffic Control.
ATFM:	Air Traffic Flow Management.
ATM:	Air Traffic Management.
ATN:	Aeronautical Telecommunication Network.
ATS:	Air Traffic Services.
ATSP:	Air Traffic Service Providers.
C/D:	Capacity/Demand.
CAA:	Civil Aviation Authority.
CDM:	Collaborative Decision Making.
CDTI:	Cockpit Display of Traffic Information.
CFMU:	Central Flow Management Unit.
CNS/ATM:	Communication Navigation and Surveillance / Air Traffic Management.
Concept of Operation:	Solution to a partial ATM problem.
CORA:	Conflict Resolution Advisor.
CPDLC:	Controller/Pilot Data Link Communications.
DEVAM:	Development of EATCHIP/EATMP Validation Methodology.
DG:	Directorate General.
DMAN:	Departure Manager.
DMS:	Departure Management System.
DOP:	Daily Operational Plan.
EATMS:	European Air Traffic Management System.
EC:	European Commission.
ECAC:	European civil Aviation Conference.
Element:	Generic part of an Operational Concept with includes related functions and services.
Enabler:	An "enabler" of the operational concept, or of an element of the operational concept, is any technical, socio-economical or operational factor which contributes to making it feasible.
FDB:	Flight Database.
FDPS:	Flight Data Processing System.
FIR:	Flight Information Region.
FIS:	Flight Information Service.
FMP:	Flow Management Position.
FMS:	Flight Management System.
FPL:	Flight Plan.
FUA:	Flexible Use of Airspace.
GA:	General Aviation.
GAT:	General Air Traffic.
Gate-to-Gate:	Concept starting at the moment the user first interacts with ATM and ending with the switch-off of engines, including charges after completion of the flight.
GNSS:	Global Navigation Satellite System.
LDSS:	Local Decision Support System.
LDST:	Local Decision Support Tool.
MAS:	Managed Airspace.
MET:	Meteorology.
MSAW:	Minimum Safe Altitude Warning.
MSP:	Multi-Sector Planning.
MTCD:	Medium Term Conflict Detection.
OAT:	Operational Air Traffic.
OC:	Operational Concept.
OCD:	Operational Concept Document.
ODIAC:	Operational Development of Initial Air/ground data Communication Services.
OSI:	Open System Interconnection.
Product:	Implementation of a function, fulfilling a predefined set of technical services; this implementation may be a prototype (research or industry), a sub-system or function of a CNS/ATM/board sub-system in full operation, a software or hardware COTS.
PSR:	Primary Surveillance Radar.
R/T:	Radio Telecommunications.
RNAV:	Area Navigation.
RWY:	Runway.
SA:	Separation Assurance.
SID:	Standard Instrument Departure route.
SSR:	Secondary Surveillance Radar.
STAR:	Standard Terminal Arrival Route.
STCA:	Short Term Conflict Alert.
SUA:	Special Use Airspace.
TCAS:	Traffic Alert & Collision Avoidance System.
TMA:	Terminal Manoeuvring Area.
TSA:	Temporary Segregated Area.
VDL:	VHF Data Link.
WP:	Work Package.

1.5. Reference Documents

LIST OF REFERENCE DOCUMENTS	
Short Reference	**Author/Organisation, Title, Edition, Date and Reference**
[TA]	Technical Annex
[PMP]	Project Management Plan
[ATM2000]	EUROCONTROL, ATM strategy for 2000+, Proposed Issue Edition 4.0, Brussels 05/10/98, FCO.ET1.ST07.DEL02
[OCD]	EUROCONTROL, EATCHIP Operational Concept Document, Issue 1.1, 04/01/99, FCO.ET1.ST07.DEL01
[ATM INV]	EUROCONTROL, EATMS ATM Invariant Processes Model, ECTF/DP/012, Issue 1.0, 12/07/96.
[D1.1]	Isdefe, TORCH User Forum Information Package
[D 1.2]	Isdefe, TORCH User Forum Minutes, Edition 0.1, 20/06/00, TOR/ISD/WP1/01DI__01
[D2.1]	Isdefe, Functional Description of the Current European ATM System, Edition 1.0, 15/11/99, TOR/ISD/WP2/21DI__10
[D2.2]	Aena, Definition of the Operational Concept, Edition 2.2, 29/10/99, TOR/AEN/WP2/22DA__22
[D2.3]	DFS, Identification of the Operational Concept Components and Elements, Edition 1.0, 03/12/99, TOR/DFS/WP2/23DF__10
[D2.4]	Airsys ATM, Identification of Enablers, Edition 0.4, 26/11/99, TOR/AIR/WP2/24DT__04
[D2.5]	Isdefe, Operational Concept Definition and Breakdown for TORCH, Edition 1.0, 7/04/00, TOR/ISD/WP2/25DI__10
[D.3.1]	Airsys ATM, WP3.1: Method and Tool Selection for Technical Assessment, Edition 0.5, 12/09/00, TOR/AIR/WP3/31DT__05
[D3.2]	Airsys ATM, WP3 Technological Assessment Final Report, Edition 0.1, 7/09/00, TOR/AIR/WP3/34DT__01
[D.4.3]	DFS, Scenario for the Operational Assessment, Edition 1.0, 10/07/00, TOR/DFS/WP4/41DF__10
[D4.1]	DFS, D4.1Tool Selection for Modelling and Simulation, Edition 1.0, 9/03/00, TOR/DFS/WP4/42DF__10
[D4. 2]	Aena, TORCH Operational Concept Feasibility Studies, Edition 0.2, 12/09/00, TOR/AEN/WP4/43DA__02
[D.5.1]	Airsys ATM, WP5.1 First Cost Estimation, Edition 0.5, 7/09/00, TOR/AIR/WP5/51DT__05
[D5.2]	Aena, TN5 Socio-Economic Appraisal of the Operational Concept, Edition 0.4, 20/09/00, TOR/AEN/WP52DA__04

2. Project Methodology

The main objective of the TORCH Project is the delivery of a viable consolidated Operational Concept implementable by steps between 2005 and 2010 which is consistent with and complementary to the ATM 2000+ Strategy [ATM 2000]. To reach this objective the project defined a methodological framework consists of three phases [see Figure 2-1]:

- Phase One, **"Definition"** was the definition of a draft operational concept: The objective of this phase was to define a feasible Operational Concept in terms of the technical, operational and socio-economical activities and structures needed to implement it. The Operational Concept was based on the EATMS OCD [OCD] and was coherent with the ATM 2000+ strategy [ATM 2000]. TORCH has adopted the EUROCONTROL target concept [OCD] to derive feasible ideas, or concepts of operation [D.2.2] which could be implemented before the OCD Target Concept timeframe.

  Using the EATMS Invariant Process Model [ATM INV], TORCH has derived an Operational Concept that consists of a set of generic elements covering the full ATM system. These elements include new operational ATM services and functions that are described in [D2.3] and summarised in this document. The feasibility of these new added functions contained in the Operational Concept is presented in [D.2.4] from the technical, operational and socio-economical point of view, by identifying the required enablers.

  A process oriented flow diagram has been developed with ATM processes which cover all phases from strategic planning to real time operation [see Section 3.2]. The general applicability and integration of expected functions like Collaborative Decision Making and Layered Planning have been emphasised. Of course, the implementation of the underlying functions will differ significantly depending on the geographical zone, traffic density, complexity of the airspace, etc. Another advantage of the flow diagram is the possibility of hierarchical breakdown to the required level of detail. The processes have been analysed and described in terms of inputs, outputs, functionalities, resources and stakeholders involved.

- Phase Two, **"Assessment"** described in greater detail in Section 4, assessed of the selected Operational Concept. This assessment was performed from three points of view: technical, operational and socio-economic:

  - The Technical Assessment aimed at making clear whether, the TORCH operational concept is technically feasible, in practical terms, in its timeframe, i.e., to make sure that all technical products required by the TORCH operational concept can be made viable early enough to be put in operation within the TORCH time frame (2005-2010).

The very broad scope of the TORCH Operational Concept made it impossible to generate a low-detailed description of the Operational Concept, or to develop a complete list of all requirements. The approach for dealing with this difficulty was to derive functional and performance requirements from several TORCH technical documents, and to use discussions and bottom-up approaches when information was not available in identified critical areas.

Firstly, a complete list of all TORCH critical requirements was used to select the products for the technical assessment considered most critical, and to select the way and the schedule these products meet TORCH requirements [see D3.1 for details]; Next, the technical assessment produced a feasibility timeline (from now up to 2010) focused on the selected products. Implementation times were derived from available commercial information and past experience on comparable developments.

The <u>Operational Assessment</u> aimed at assessing the operational feasibility of the Operational Concept. The assessment quantified operational feasibility by providing values for delay, capacity, efficiency indicators and related metrics with respect to the selected scenarios. The scenarios were selected focusing on innovative ideas and new operational procedures in the core area (high level of traffic and delay).

Again, the very broad scope of the TORCH Operational Concept limited the scope of the operational assessments because of the non-existence of an appropriate set of tools. The adopted approach consisted of using available *Process Modelling and Simulation* (BONAPART), *Fast-time Simulation* (FATIMA and TAAM) and *Quality of Service Modelling* tools to assess the feasibility of DOP, airport and TMA improvements Multi-Sector Planning, Free-Routing and Station Keeping. This assessment was achieved, using these tools by modelling and simulating a set of selected scenarios.

– The objective of the <u>Socio-Economical Assessment</u> was to get preliminary ideas about the social and economic impacts of the TORCH Operational Concept. The assessment highlighted the problems associated with the estimation of the socio-economic impacts of a complex technological system such as TORCH, and suggested further steps that should be taken in the future in order to derive more accurate assessments for the new European ATM system.

The characteristics of the assessment of the TORCH Operational Concept led to the conclusion that a traditional cost-benefit or cost-effectiveness assessment of the new European ATM system, based on the monetary quantification of system impacts, would neither be feasible nor reliable due to the complexity and diversity of the current European ATM system. These findings led to the following proposed methodological approach, which was based on a qualitative assessment of the TORCH and the Baseline systems.

The proposed methodology combined quantitative measurements, where possible, with qualitative assessment based on expert judgements provided by a European panel of experts. The methodology took a double approach to quantify costs and benefits, in order to check one against the other in terms of the validity of the produced results. On the one hand, the expected costs of the system for all stakeholders were estimated (to a precision of an order of magnitude), independently of the expected benefits of the system, using a Delphi panel. On the other hand, an overall TORCH system cost-effectiveness assessment and social-impact analysis of the system, with appropriate changes, were also performed using the Analytical Hierarchy Process (AHP) technique.

- Phase three **“Summary and Analysis”** consolidated the Draft Operational Concept into a final proposed Operational Concept for Validation. This consolidation was based on the results obtained from the second phase. The analysis of the assessment results and the issues raised in the course of the Project have given rise to conclusions and recommendations (See Section 6) about the Operational Concept proposed for future validation and its implementation. This phase also produced transition guidelines (see Section 5).

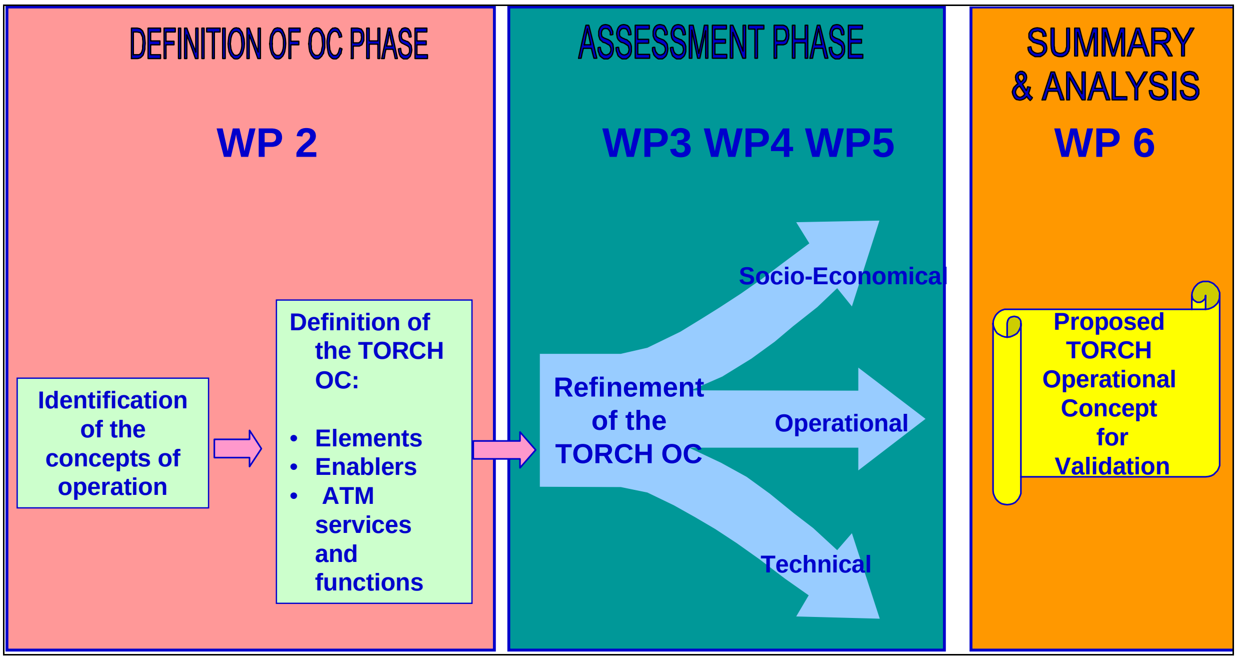

Figure 2-1 TORCH Methodological Approach

The main feature of the defined methodological approach is the provision of a functional description of a full ATM Operational Concept. The Concept has been derived from the need of new feasible solutions to address the current problems of the European ATM system. This approach has enabled the TORCH project to identify feasible non fragmented solutions.

Further information about the Methodological approach followed by the TORCH Project is provided in the following documents:

- [D2.2] for the identification of the concepts of operation.
- [D2.3] for the identification of Elements and ATM functions and services.
- [D2.4] for the identification of Enablers.
- [D2.5] for the definition of the Draft Operational Concept.
- [D3.1] for the Technical Assessment Methodology and Tool selection.
- [D4.1] for the Operational Assessment Methodology and Tool selection.
- [D5.2] for the Socio-Economical Assessment Methodology.

3. TORCH Operational Concept

This section includes a functional description of the TORCH Operational Concept, providing a general overview in Section 3.1, with the main concept statements. The TORCH flow-diagram is presented in Section 3.2. This diagram is intended to simplify the understanding of the concept elements with regard to flight phases, time horizon, information flows and interdependencies. The flow-diagram description is followed by a brief description of the TORCH Concept Elements (section 3.3) included in the diagram, which define the TORCH Operational Concept.

Finally, a more detailed description of the TORCH Operational Concept is provided in Section 3.4. The concept is divided into three phases placed in three different time horizons, from the strategic planning of a flight to the end of the flight execution.

3.1. TORCH Operational Concept Statement

The TORCH Operational Concept is based on two main pillars:

1. **An improvement in the planning phase by the introduction of a layered planning process[1] and**

---

[1] The concept of a layered planning process is introduced by the EATMS OCD in its target concept [OCD, Section 6].

Collaborative Decision Making (CDM) procedures. **2. The reduction of the workload of the air traffic controller per aircraft, by additionally introduced computer tools.**
The first pillar of the Operational Concept proposes a continuous **layered planning** based on a more flexible use of airspace and a stronger involvement of the actors. The objective of the Concept is to optimise the management of the available resources instead of constraining the demand. Decisions will be shifted into non-time-critical phases through enhanced co-ordination among all stakeholders, therefore, the need for time critical “ad-hoc” decisions will be reduced.
These improvements will be achieved through the elaboration and usage of the **Daily Operational Plan (DOP[2])**. The DOP enables monitoring of the relationship between capacity and demand from months in advance to the actual moment of operation. All interested parties will have access to the same data under the same rules, based on the assumption that the required data will be available.
Collaborative Planning and Decision-Making (CDM) will allow the Daily Operational Plan to be a dynamic process. Although the basis for the DOP is established early in advance, the introduction of real-time information in the decision-making loop results in a more accurate picture of what is happening and takes into account real-time changes that can affect the stakeholders’ expectations.
The second pillar of the Operational Concept deals with **Re-Planning and Flight Phases**. The DOP ensures an enlarged planning horizon on Air Traffic Control centre and on (multi-) sector level. Unforeseen events not yet contained in DOP will be taken into account by re-planning actions. This will be achieved with new tools like Traffic Load Analyser or Medium Term Conflict Detection being fed with more precise data updated in real time. There will be a shift of tasks and new roles will emerge around tactical flow planning. Ultimate goal is the reduction of the traffic complexity in the sector, thus reducing the workload of the air traffic controller. This will lead to improved sector throughput and an increase in capacity.
Progress towards a more autonomous aircraft is proposed. During the TORCH timeframe, responsibility for Separation Assurance may be partially delegated to the aircrews of suitably-equipped aircraft. Conflicts will be detected by the ground system, which will propose conflict resolution strategies. Hazard Assessment will be based on improved safety net functions (STCA, APW, MSAW and ACAS).
Aircraft operators will become more involved in planning and will make decisions together with ATC and the CFMU. They will negotiate their plans during the planning phase and exchange information with other stakeholders. Real-time data will be used to optimise fleet operations. Schedules and routes will be closer to user preferences, improving the overall predictability of the system.
Airport operations will be more integrated in the overall ATM process than at present. ATFM measures and airport capacities will be linked during all planning phases. Co-ordination with the en-route planning phase will support uninterrupted gate-to-gate operations.

3.2. The TORCH Flow-Diagram

Air Traffic Management is a very complex system of interacting processes and information flows involving many stakeholders in different periods of time. In order to achieve a manageable structure in the concept development process, TORCH has adopted the approach taken by EUROCONTROL in creating the "Invariant Processes" [ATM INV]. This view has the advantage of describing any operational concept by using the same, common, structure, thus facilitating comparison. Based on this idea TORCH has developed, modified and added Concept Elements derived from new ideas, mainly with regard to flight planning and collaborative decision-making activities. The 18 Operational Concept Elements[3] identified are placed in a flow diagram in Section 3.2 (Figure 3-7) and described in Section 3.3

To simplify the understanding of the TORCH concept ideas, the 18 Concept Elements have been assembled in a flow diagram (see Figure 3-7) grouped into flight phases, showing e.g. time horizon, information flows and interdependencies.

The flow diagram presents a process oriented view on the ATM systems. That means that each of the concept elements refers to a specific time horizon representing the evolvement of a flight within a Gate-to-Gate environment.

The purpose of this flow-diagram (Figure 3-7) is a visualisation of the TORCH concept in order to give a comprehensive overview and to explain and refer to the dependencies of the elements. For the sake of readability and clarity it shall not be interpreted as a complete picture of all information flows, inputs, outputs and other dimensions like time or optimisation objectives. The flow diagram only denotes the most important descriptions and connections.

3.2.1. Explanation of the Diagram

3.2.1.1. ATM Concept Element

Each Concept Element (Figure 3-1) stands for an ATM process with defined functionalities, input and output, involved stakeholders, and required resources. Below each concept element, an indication of the time horizon is given.

In general, an ATM process is characterised by a time distribution and requires physical or data resources. The process belongs to one or more stakeholders.

---

[2] The DOP contains comprehensive information regarding the airspace regime, detailed traffic demand (gate-to-gate trajectories) and required ATM capacity over time.

[3] . Further information can be found in [D2.3] and [D2.5].

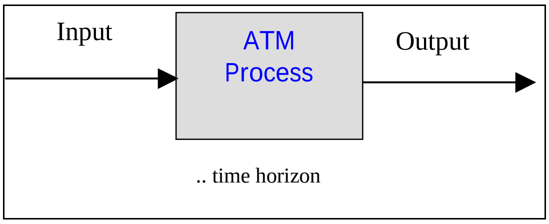

Figure 3-1 Concept Element

3.2.1.2. Time Reference

The elements are assigned to a specified time or to time intervals as shown in Figure 3-2. The time horizon starts with layered planning, months or even years in advance, and ends with the "last-minute" safety layer (e.g. TCAS) which acts within seconds. Also the desired precision of the output of an ATM process depends on the time horizon: the less the amount of reaction time available, the higher the required (data) quality.

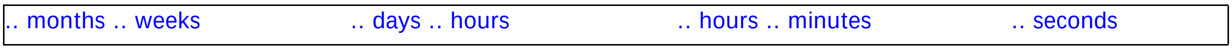

Figure 3-2 Time Reference

3.2.1.3. Planning/Re-planning, Execution Phases

The Planning/re-Planning and execution phases correspond to a time horizon. The Planning phase starts years in advance and overlaps with the execution phase. The execution phase encompasses the real-time operation of air traffic. Some processes (e.g., performance monitoring) continue beyond the end of the execution phase and continue as post- and pre-operational processes, thereby closing the control loop.

Re-Planning is as important as Planning because it enables due reaction to unexpected events. It will be carried out by CDM procedures.

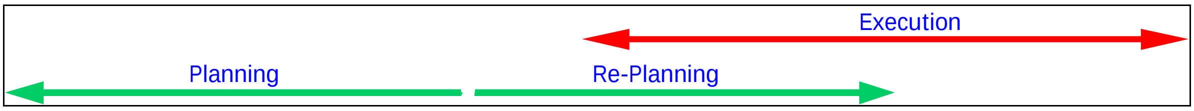

Figure 3-3 Planning/Re-planning, Execution Phases

3.2.1.4. Criticality level

The criticality level generally (see Figure 3-4) indicates the reaction time. A higher criticality level indicates less time to react. Criticality is not only related to safety. At a higher criticality level processes and their associated functionalities have more stringent requirements for e.g., processing times, safety aspects, reliability or availability.

Figure 3-4 Criticality Level

3.2.1.5. DOP Evolvement

To illustrate the layered planning idea within the TORCH concept, the status of the Daily Operational Plan (DOP) is shown. In the initial planning stages the DOP will be developed. In these stages, it is called the Evolving DOP. The tailored DOP is a subset of the approved DOP based on the information demand of the different stakeholders. Since the DOP is not static, common planning information updates will enable adaptation to unforeseen events which occur after the dissemination of the approved DOP. These adaptations give rise to an Updated DOP. This is illustrated in Figure 3-5.

Figure 3-5 DOP Evolvement

3.2.1.6. Optimisation Objectives

The optimisation objectives of the TORCH Operational Concept (Safety, Capacity, Economy as shown in Figure 3-6) are applicable to all elements. Nevertheless they can be identified within the Flow Diagram by areas of main effort.

- Economy/Efficiency are mainly addressed in the layered planning phase.
- Capacity/Throughput are mainly addressed in the re-planning phase and in the execution phase.
- Safety is mainly addressed in the execution phase.

Economy/Efficiency	Capacity/Throughput	Safety

Figure 3-6 Optimisation Objectives

3.2.2. Overview of the Operational Concept Illustrated in the Diagram

The TORCH Operational Concept proposes a layered planning process, based on flexible use of airspace and CDM procedures, in a context of gate-to-gate operations. The concept is composed of 18 concept elements, derived from the OCD's eight Invariant Processes.

TORCH Operational Concept Elements E1 to E13 have been placed in a flow chart (Figure 3-1) showing their dependencies and information flows. The idea behind this "process-oriented" presentation is that an aircraft with a specific flight leg is “activated” in several processes at the same time. For example an aircraft operating on the manoeuvring area of an airport may be treated within the Airport Operations, Arrival and Departure Management, Flight Management Gate-to-Gate, Separation Assurance, and Hazard Assessment elements at the same time.

Elements E14 to E18 contribute to all the other 13 elements and therefore have multiple interfaces (for the sake of simplicity indicated by only one single arrow). They are independent of a specific phase of flight and are related to both the Planning/Re-planning phase and the Execution phase.

3.2.2.1. Planning/Re-planning Phase

The gate-to-gate process illustrated in the flow diagram (Figure 3-1) starts with the strategic planning processes comprising elements E1 Airspace Plan Development, E9 AO Operations Planning and E12 Airport Strategic Planning. The time horizon is up to months or even years (for example, when contemplating construction of a new runway) before the actual flight.

Months ahead of the actual flight a Layered Planning [EATMS OCD] process is initiated. This means that a DOP evolves in subsequent steps through dynamic use of CDM activities with improving quality of service. Elements E2 Demand and Capacity Determination and E3 Demand and Capacity will continuously receive real-time updates to changing parameters (rolling planning). Airports, aircraft operators and ATS providers are actively involved in the DOP evaluation process for a better understanding of their needs and constraints, and to make use of available resources more efficiently. These CDM capabilities, expressed in E18 Information Management, are key enablers of the TORCH Operational Concept.

The planning cycle ends with the dissemination of the approved DOP, and of additional "tailored DOPs" containing information downsized to the individual user's need. In this phase the main optimisation objective involves efficiency and, in part capacity issues.

3.2.2.2. Execution Phase

On the day of operation, the DOP serves as a common reference for re-planning and decision-making. Planning inaccuracies and unforeseen events will affect the conduct of air traffic on the day of operations. Another central part of the TORCH Operational Concept takes place here, specifically the interaction between elements E4 Central Re-planning/ Local Optimisation, E5 En-Route Metering/ Multi-sector Planning and E6 Arrival and Departure Management. The current gap between planning and execution will be closed by a further re-planning layer. A feedback loop between real time operations and re-planning allows local optimisation actions when a central system reacts too slowly or does not provide accurate data in real time. Improved controller planning tools with a time horizon of up to 2 hours will enable to solve potential conflicts on (multi)-centre and multi-sector level already in the overlap between re-planning and execution phase.

Airport operator and AO flight control staff are actively involved in the re-planning and decision-making processes and rely on the same set of accurate data (which is currently not the case). This is visualised by including elements E11 AO Flight Control and E13 Airport Operations in the DOP loop.

Within elements E7 Separation Assurance, E8 Hazard Assessment and E10 Flight Management Gate-to-Gate the information-sharing between the flight deck and the ground via data link, and the introduction of autonomous aircraft operations will enable aircraft operators and ATS to further optimise their (4D-) trajectories.

3.2.3. Flow Diagram

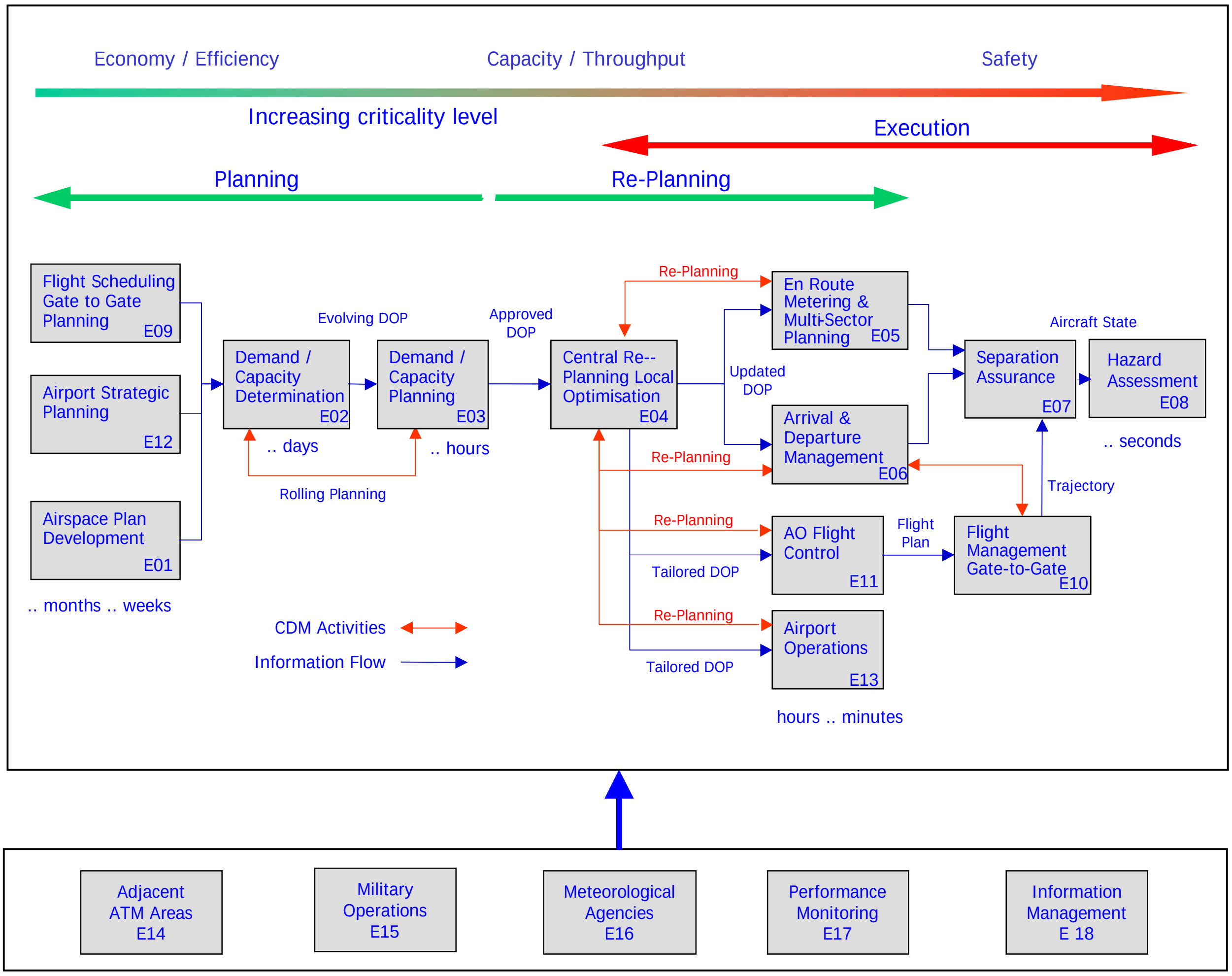

Figure 3-7 TORCH Flow Diagram

3.3. TORCH Operational Concept Elements

This section summarises the TORCH concept elements [D2.3], presented in Figure 3-1 and Figure 3-7, that define the TORCH Operational Concept. A brief description of each element is provided in the following subsections. The descriptions are based on the EATMS OCD [OCD], the ATM 2000+ Strategy [ATM 2000] and the analysis performed by TORCH in WP2.3 [D2.3]. Each description summarises the main ideas stated in [D2.3, Section 4]; further detail is provided in [D2.3].

E1 Airspace Plan Development and Implementation:

Element E1 consists of the production, development and implementation of the Airspace Plan including 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. [D2.3, Section 4.1].

E2 Demand and Capacity Determination:

Element E2 consists of the production of an accurate forecast of demand and capacity as a 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 continuously improved whenever new or improved data become available, and they are made available to all interested parties by distributing them according to their needs. [D2.3, Section 4.1].

E3 Operational Plan Development and Implementation:

Element E3 develops and implements the Daily Operational Plan. The plan is presented to the ATM providers and the airspace users the day before operations. The plan will be updated whenever changes to the demand or capacity are announced by authorised system users. The DOP is characterised by greater accuracy and the active involvement of users in the decision loop through the use of their own planning and decision tools. [D2.3, Section 4.1].

E4 Real-Time Operational Plan Optimisation:

The processing of tactical changes in airspace status and ATM/airport capacity in element E4 will result in updated information within the DOP. The purpose of this element is to supervise implementation of the DOP 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. Depending on the importance of the event (wide or local effect) the re-planning will be a central or local function. The re-planning is an optimisation of available resources. All parties (ATM providers, airports, users, ...) are informed of the updated DOP. [D2.3, Section 4.1].

E5 En-route Planning:

In element E5 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 two hours in advance and a smaller area of responsibility. This element will create a bridge between Flow and Capacity Management (Elements E1 to E4) and tactical ATC (Elements E6 and E7). Multi-sector Planning will be a new function in ATC which will be able to plan traffic and solve potential conflicts ahead. [D.2.3, Section 4.2].

E6 Terminal Area Sequencing:

Element E6 consists of the integration of arrival management, departure management and ground movement management to produce an optimal flow of traffic in TMA areas. This will ensure the optimum use of the available airport and airspace resources in closer compliance with user needs. [D2.3, Section 4.3].

E7 Separation Assurance:

During the TORCH timeframe the responsibility for separation assurance may be partially delegated to the aircrews of suitable equipped aircraft, by ASAS applications such as Station Keeping. Element E7 includes functions such as situation assessment, traffic monitoring, conflict detection and conflict resolution functions, characterised by an increase of automated tools, ultimate human responsibility for separation assurance, and the possibility of negotiation for conflict resolution with pilots. [D2.3, Section 4.4].

E8 Hazard Assessment:

In element E8, 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 operate independent from other system functions. [D2.3, Section 4.5].

E9 Airline Operation Planning:

In element E9, the role of airline[4] operations will move towards greater involvement in the planning processes. CDM will provide airline operators with the ability to negotiate their plans during the planning phase. Airline Operators will develop their operation plans, which include the revised airline schedule and the flight plan information including gate-to-gate trajectories. Gate-to-Gate planning performs 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-related assessments (e.g., the flexible setting of flight planning parameters by speeds/procedures, altitudes, different routes, variable cost index and point-to-point calculations [D2.3, Section 4.6.1]).

E10 Aircraft Flight Management from Gate to Gate:

In element E10, Flight Management on board will be supported by 4D FMS Systems, which keep the aircraft in a four-dimensional cell, provides a high navigation accuracy in three dimensions, or advanced systems in four 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 and ATC will be notified of changing intentions that are proposed or decided by the flight crew [D2.3, Section 4.6.2].

E11 AO Flight Control:

Element E11, 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 [D2.3, Section 4.6.3].

E12 Airport Strategic Planning:

The objective of airport strategic planning in Element E12 is to plan and optimise the operation of a single airport or groups of airports (airport cluster) in accordance with business/mission objectives. Airport Strategic Planning starts years in advance if large infrastructure changes are involved (e.g. new runways, terminals, etc.). Resource management will be performed in a collaborative decision making process involving all actors who are part of airport planning [D2.3, Section 4.7.1].

E13 Airport Operations Management And Control:

In Element E13, 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. This will increase passenger satisfaction by minimising delays and expediting aircraft turn-around [D2.3 Appendix III, Sections 14.1 & 14.2 & 14.3].

---

[4] Airline is used as synonym for all organisations or persons involved in planning and operations of aircraft.

E14 Adjacent ATM Areas:

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. Element E14 will enable internal capacity constraints, due to the external airspace and traffic [D2.3 Appendix III, Section 15.1], to be avoided.

E15 Military Operations:

In Element E15, co-ordination between civil and military operators, involving exchanges of flight plans and airspace use information, will benefit both civil airspace users and military air traffic. Effective and efficient co-ordination will enable the mentioned actors to obtain user-preferred trajectories, improve flexibility and flight efficiency, and assure the integrity of national airspace (air defence tasks) [D2.3 Appendix III, Section 16.1].

E16 Meteorological Agencies:

The availability of more accurate meteorological information for an entire area/time-window of interest (e.g. airports), including better forecasts from the long-medium to short terms, will improve the information necessary for developing the Operational Plan Development from the strategic level to its implementation. In this way, Element E16 will increase the accuracy of the DOP [D2.3 Appendix III, Section 17.3].

E17 Performance Management:

In Element E17, 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 [D2.3 Appendix III, Sections 18.1 & 18.2].

E18 Information Management:

In element E18, 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 [D2.3 Appendix III, Section 19].

3.4. Detailed Description of the TORCH Operational Concept

The TORCH Operational Concept was developed in the first phase of the project by functional descriptions [D2.3 and D2.5], identifying the TORCH functionalities and operational procedures. This section presents a more detailed description of the Operational Concept, taking into account not only the draft Concept presented in the first phase of the project, but also its refinement in the assessment phase. The concept is divided into three phases, placed in three different timeframes, from the strategic planning of the flight to the end of flight execution. The three phases considered are the following:

- Layered Planning Phase: Months, or even years, ahead of the actual flight, when strategic planning starts up, to the day of operations. It includes elements E1, E2, E3, E4, E9 and E12.
- Re-Planning Phase: During the day of operations, a short time before real-time operations, closing the gap between planning and execution by a further re-planning layer. It includes elements E5 and E6.
- Real-Time Operations (Flight Execution): During execution of the flight. It includes elements E7, E8, E10, E11 and E13.

They are described in detail in the following subsections. The rest of the elements are included in or affect all three defined phases.

Another view of the Operational Concept description is from the perspective of the stakeholders. A set of different stakeholders, such as central organisations, ATS providers, airspace users, regulators, etc., is involved in the operations and procedures considered by the TORCH Operational Concept. Appendix A includes a description of the roles and viewpoints of the main stakeholders.

3.4.1. Layered Planning Phase

3.4.1.1. Overview of the Phase

Current planning processes include shortcomings resulting in an ineffective use of airspace, airport and airline capacities. TORCH proposes to develop a Daily Operational Plan (DOP)[5] which contains the predicted airspace and traffic demand and the required and existing ATM system capacity for the day of operations. Months ahead, DOP establishes a Rolling Planning Paradigm at the ECAC level, among all involved stakeholders for a specific time window (i.e., day of operation). In this sense, demand and capacity forecasts are continually updated whenever new or improved data become available. Resulting forecasts are made available to all interested parties distributing them according to their needs. In the event of identified capacity shortfalls, it is anticipated that users will adjust their demand to avoid restrictions and delays in a CDM process. If capacity exceeds demand, system providers will adjust the capacity to improve the effectiveness of the system.

All stakeholders are expected to participate in the Collaborative Layered Planning process[6], which balances capacity and demand at an early stage (finished at least one day prior to operations). The complexity of the planning process will be shifted into a non-time-critical planning phase through improved co-ordination between all stakeholders, reducing "ad-hoc" decisions. Using synchronised data with common formats, DOP introduces a "look-ahead" planning function, transferring the decision-making process to a non-time-critical planning phase. The complexity of the planning phase will be solved in an earlier stage through improved co-ordination among all stakeholders.

---

[5] This process is currently under enhancements at European Level.

[6] See [D.2.5].

The idea of a **Layered Planning Process** (see Figure 3-8) is presented within the TORCH Operational Concept as an Enhanced Strategic Demand and Capacity Management process (Elements E2 and E3). It consists of pre-tactical Central Re-planning and Local Optimisation functions (Element E4) followed by tactical En-route Metering and Multi-Sector Planning functions (Element E5). [See D2.5].

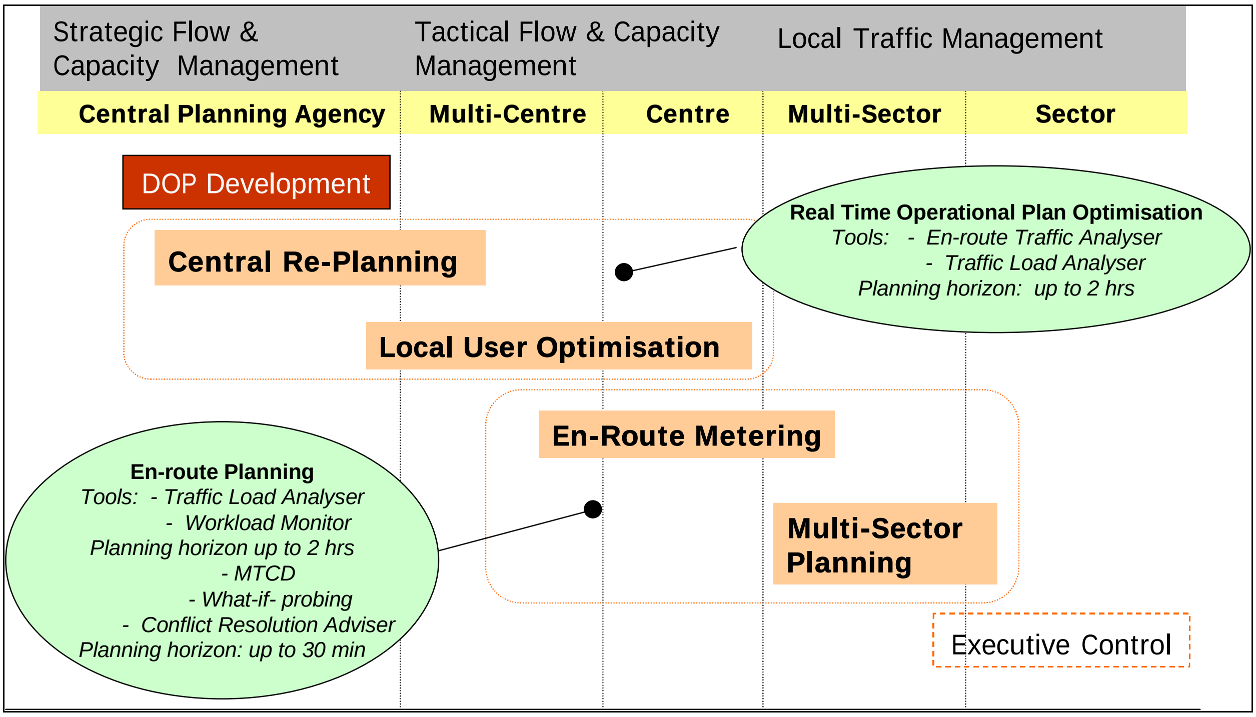

Figure 3-8 Layered Planning Process

Until the day of operation, the layered planning process will continuously receive real-time updates to changing parameters.[7] Rather than allowing a central instance to impact on user decisions, only situational awareness is provided to the stakeholders from the strategic planning point of view in order to help them in the decision-making process. This enables users to carry out "what-if" simulations if potential bottlenecks are predicted and helps them to decide whether or not to change their planning.

During the day of operation, planning inaccuracies and unforeseen events, (e.g., fast changing weather conditions or new flights not contained in the DOP) will require real-time re-planning by all involved stakeholders. The responsibility for decision-making between *Central Re-Planning and Local User Optimisation*[8] is related to the magnitude of the event and its consequences (local[9] or non-local). A wide area event may trigger either a DOP update; a local event may trigger a tailored DOP update or only a CDM action. Central Re-Planning and Local User Optimisation will take place between the time of distributing the DOP (prior to the day of operation) and the individual event. The level of the ATS-agencies/units involved ranges from individual planning carried out at the centre level to integrated planning carried out at a multi-centre for the Central Planning task; and from the Multi-Centre to Centre Level for Local User Optimisation (see Figure 3-8).

Through Local User Optimisation, all relevant ATM users will be able to assess re-routing options and optimise flight trajectories using their own planning and, if available, decision support and/or re-routing/"what-if" tools. All parties are informed of the updated DOP in real-time and may take advantage of changing conditions in a continuous process.

The underlying idea is that higher planning accuracy reduces unexpected changes in real-time operations. Decisions are made in a non-time-critical phase, taking user preferences into account through CDM processes. This is an improvement on the current situation, in which too many decisions are solved in a time-critical phase. "Ad hoc" decisions should be reduced to a minimum.

3.4.1.2. Development of the DOP

The main objectives of the DOP are:

- To enable layered planning process, with more accurate planning and balancing.
- To provide early balance of demand and capacity, since the DOP will be concluded one day prior to operations and will be updated during day of operations.
- To make better use of available capacity.
- To involve of all airspace users in its development, providing:

---

[7] Because of network effects, last minute changes can generate significant changes across the system.

[8] Under development at European ATC level.

[9] It must nevertheless be taken into account that all changes have a global effect. This is how the CFMU is currently arranged.

- Transparent decision making.
- Synchronisation of data.

Implementation of the DOP principle is intended to shift planning complexity into non-time-critical planning phases.

Figure 3-9 illustrates the development of the DOP. The development of the DOP distinguishes between “planned operations”, which result from the application of the layered planning process, and “unplanned events” which arise during the real-time operation of the system. "Planned Operations" are included in the DOP. "Unplanned events" include things such as runway closings, severe weather and any other events which are unforeseeable or which are not included in the DOP.

The standard development of the DOP (inner loop of Figure 3-9) includes determination of the Demand/Capacity, balance and allocation, and the optimisation of the individual plans. This continuous process is updated in real time with actual information from the system.

In the event of unplanned events (outer loop of Figure 3-9) the DOP development process enables local optimisation, which speeds-up changes, and enables the users to tailor the DOP to solve their local problems. These updates are then fed into the “standard” DOP development process for distribution and verification.

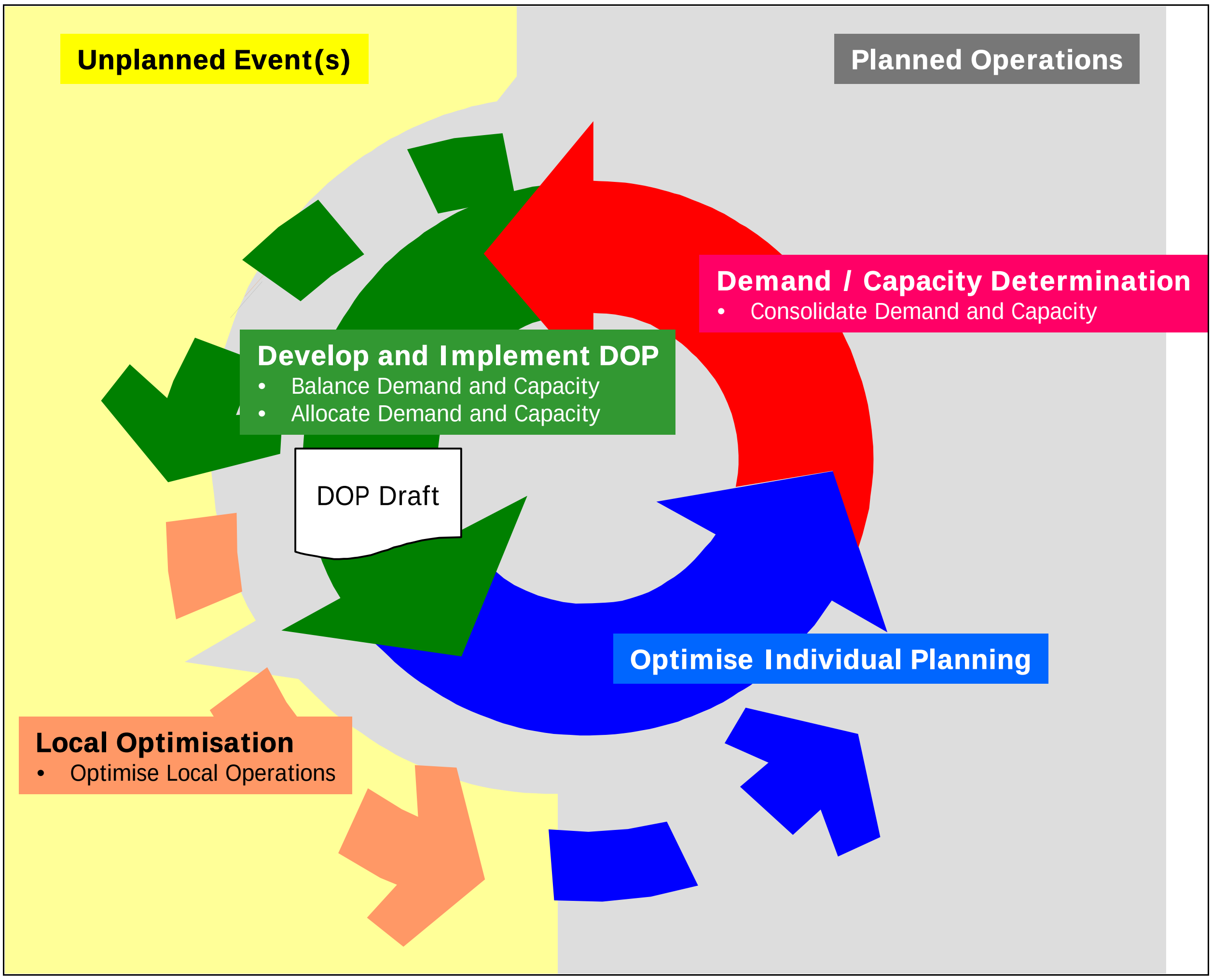

Figure 3-9 DOP Development as a permanently evolving Process

The Demand and Capacity Determination process contains parts of the current CFMU functionality. This process consists of two sub-processes[10]:

- Collect and prepare demand and capacity relevant information.
- Consolidate ATM system demand and capacity.

The system analyses the available capacity to define a series of configuration options for the allocation of resources in terms of geographic location, time, traffic mix and density. The anticipated capacity of the ATM system will be used as input for capacity management to meet demand. As compared with the current CFMU functionality, these processes extend the functionality, through the enlarged planning horizon, more information and the evolving DOPs.

---

[10] For a greater level of detail, see [D4.3].

The Develop and Implement Daily Operational Plan process consists of six main sub-processes:

- Simulate air traffic situation.
- Adjust capacity/ demand.
- Calculate Daily Operational Plan.
- Approve, tailor and distribute DOP.
- Re-plan central Daily Operational Plan at Ops Day.

The main differences from current practice include:

- Integration of stakeholder tools and processes for all stakeholders, e.g., airports.
- Transparency of the DOP development process through stakeholder access rights.
- Early detection of the bottlenecks, which can be worked on in a CDM process.
- More realistic trajectory calculation.

3.4.2. Re-planning Phase

The main objectives of the Re-planning phase are:

- To close the gap between Flow and Capacity Management (at the strategic and tactical levels) and real-time operations.
- To pave the way towards more autonomous aircraft and towards the more flexible use of airspace.

Local Tactical Planning encompasses En-Route Planning and Terminal Area Sequencing operations. These pre-tactical operations need to be implemented in all the ECAC area.

3.4.2.1. En-route planning

En-Route Planning consists of En-Route Metering and Multi-Sector Planning (MSP, see Figure 3-8). Both En-Route Metering and Multi-Sector Planning are new, planning functions (see Figure 3-8). They are deemed necessary to comply with the Gate-to-Gate Concept, especially the challenge of Hub-and-Spoke Operations, at most major airports within Europe. They include new functions that bridge Flow and Capacity Management (Elements 2-4) and Real-Time Operations (Elements E7 and E8).

3.4.2.1.1. En-route metering

En-Route Metering operates at the level of an ATS-Centre or a Multi-Centre environment (including Multi-Sector layout). The purpose of en-route metering is to analyse the planned (included in the DOP) and current air traffic, and the availability of resources, at the centre and multi-centre levels. A new working position is envisioned, the “ATS Centre Planner”, which will include the current local Flow Management Position (FMP) functionality. The function of the ATS Centre Planner will be to identify traffic overloads and congestion situations, determine optimum solutions, negotiate them with planners affecting the situation through automatic negotiation tools and distribute changes to the stakeholders involved. These functions are illustrated in Figure 3-10.

The ATS Centre Planner, as illustrated in Figure 3-10, will analyse the expected traffic about two hours in advance and will establish the needed flow regulations (multi-sector constraints) and the entry/exit conditions based on:

- Updated DOP.
- Terminal Area sequencing constraints.
- Next unit/adjacent ATM sequencing constraints; overload and congestion traffic situation and the agreed airspace centre/sector acceptance rates. These constraints aim to achieve workload balancing between sectors or to reduce the complexity of traffic patterns, rather than explicitly de-conflict trajectories, although this may be their effect.

To identify overloads and peak traffic situations the prediction time horizon should be about two hours. The algorithms and rules used within these tools will be quite similar to those used for the DOP development cycles[11]. Prediction results and solution proposals, however, will be much more precise and reliable due to the envisaged prediction time horizon. Furthermore the geographic prediction horizon will be extended beyond ATS centre boundaries enabling and forcing much closer co-operation and concerted actions between neighbouring ATS centres.

---

[11] E.g. by Fast-Time Simulations.

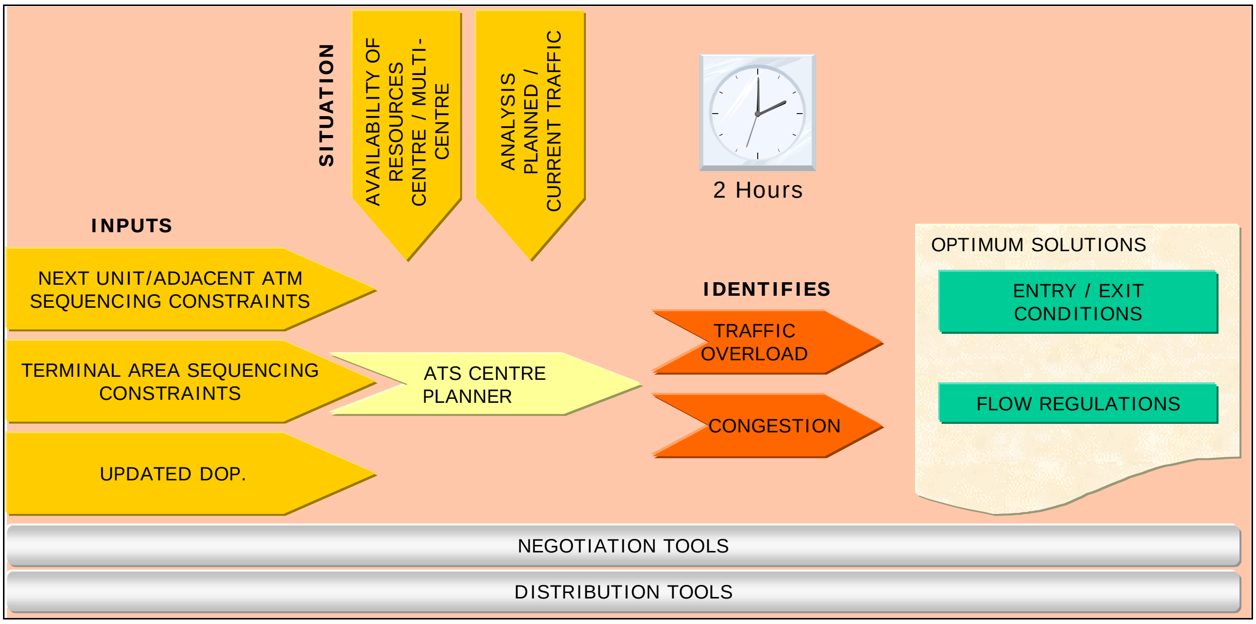

Figure 3-10 ATS Centre Planner functionality

3.4.2.1.2. Multi-Sector Planning

Multi-Sector Planning (MSP) can be seen as an extension of tactical control to a longer timescale. The Multi-Sector Planner is another new working position, who will carry out the planning task for an area comprising more than one tactical sector (Multi-Sector Area) and more in advance. MSP functions start 20-30 minutes before the moment that the aircraft crosses the boundary of the multi-sector responsibility area and end when the aircraft leaves the multi-sector area and the tactical control is transferred to the next sector. The multi-sector planning functions can be categorised in two types: conflict detection/resolution and trajectory negotiation. These functions, illustrated in Figure 3-11, can be defined as follows:

- **Conflict Detection and Resolution**: The time frame for conflict detection and resolution depend on the available tools. TORCH assumes the availability of the Medium Term Conflict Detection tool (MTCD), taking into account 4D FMS trajectories when available, and the Conflict Resolution Advisor (CORA). The conflict detection and resolution functions start 20-30 minutes before the moment that the aircraft crosses the boundary of the multi-sector responsibility area.

- **Trajectory**[12] **Change Request**: During the en-route phase, the multi-sector planner responsible for the area in which the aircraft is flying receives all change requests The multi-sector planner evaluates the trajectory change of the individual flight by appropriate tools and agrees the trajectory change, which is communicated to the sector-planning controller and to all affected down-stream sectors. Any trajectory constraints produced by the multi-sector planner will be stored in a Flight Database (FDB) and will be included in the next negotiation for that aircraft.

---

[12] The trajectories considered in TORCH are 4-D trajectories.

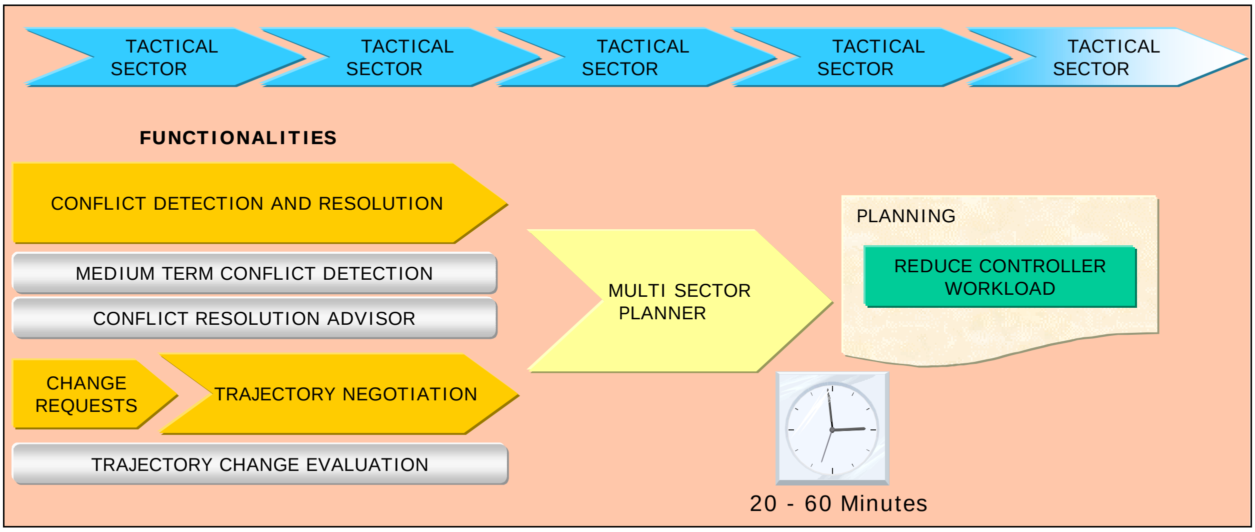

Figure 3-11 Multi-Sector Planning Functionality

3.4.2.2. Terminal Area Sequencing

Terminal Area Sequencing matches and optimises the planned approach and departure sequences such that arrivals and departures using the same or dependent[13] runways are interlaced using a defined set of management and/or priority rules. Terminal Area Sequencing provides a flow planning integrating arrival and departure management to assure an optimal flow of traffic to increase overall efficiency in airport operations and to maximise throughput and the use of the available airport and TMA resources. Information distribution systems (as basis for situational awareness - expanding the planning horizon - for all parties), arrival/departure/initial ground movement and data fusion with various airport resource management tools are envisaged to enhance co-ordination among ATC, airports and airline operators.

The arrival sequence is defined to optimise the inbound traffic flow by calculating arrival times for flights to the airport taking into account runway status, requested in-bound routings, and aircraft characteristics. The arrival sequence will allow departures to take off from the same or dependent runways.

The departure sequence has been calculated considering runway status, requested out-bound traffic flow, aircraft characteristics, flow control restrictions and other internal criteria (e.g., taxiway or gate area constraints). It will be modified such that take-off times for departing flights will be defined to fit into the sequence of arrivals.

Terminal Area Sequencing specifies the TMA entry conditions to achieve an optimum approach path and a landing at a specified arrival time.

3.4.3. Real-Time Operations (Flight Execution Phase)

Real-time operations (flight execution phase) can be broadly defined to include all operations from the time the engines of an aircraft are turned on until they are turned off. Nevertheless, for each specific actor within this phase, the actual beginning and end of real-time operations will be different. For example, real-time operations for en-route controllers include the time from when the aircraft first enters their sector to the time when the aircraft leaves their sector.

As envisioned by TORCH, the enhanced ATC system will support situation assessment, traffic monitoring, conflict detection and conflict resolution tasks with advanced tools (filtering, advanced detection tools, resolution proposals (co-operative tools) in order to reduce the controller workload. Medium term conflict resolution may be performed through air/ground trajectory negotiation, using the controller/pilot datalink communications (CPDLC). Responsibility for Separation Assurance (SA), both currently and in the near future will be retained by the ground systems. Ultimate responsibility for SA will nevertheless remain with the human in the TORCH timeframe (controllers + pilots).

During the TORCH timeframe, however, the responsibility for SA may be delegated to the aircrews of suitably equipped aircraft. The availability of this airborne function will greatly depend on relevant technical enablers (CDTI, conflict resolution tools).

As stated above, SA may be partially delegated to suitable equipped aircraft in Managed Airspace (MAS) by newly implemented ASAS functions such as Station Keeping. Station Keeping will allow aircraft on one track to maintain longitudinal separation in an in-trail stream [see D4.3 for complete description of envisaged ASAS applications and derived procedures]. These functions will be applied in suitable sectors (with an appropriate route structure without crossing routes) belonging to the Upper Airspace in high/medium density traffic zones (TORCH Zones 1 and 2). Further applications in the TMA with the objective of increasing capacity and safety could also be considered. Conflicts will be detected and displayed by the ground

---

[13] Dependent runways are not limited to the same airport. The runways of any airport linked to a particular airport (for example in a “hub and spoke” relationship) could be included within the integrated Terminal Area Sequencing manager.

system. While the ground ATC system will propose conflict resolution strategies, the controller will:

- Evaluate and give priority to traffic conflicts.
- Recover conflict detection responsibility for emergency cases in delegated SA operations.
- Receive and test trajectory change requests from the pilot (part of the trajectory negotiation process).
- Test resolution proposals and decide on resolution strategy.
- Negotiate the proposed trajectory with the pilot when feasible (medium term conflict).
- Implement de-conflicting solution through control instructions to involved aircraft.

Two important improvements within real-time operations introduced by TORCH are the enhanced safety nets and free routing operations. These improvements are described in the following subsections.

3.4.3.1. Safety nets

The safety net functions calculate possible conflicts between aircraft trajectories, 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 will, in principle, operate independent of other system functions.

The following functions will be available and enhanced throughout the TORCH timeframe:

- Short Term Conflict Alert.
- Area Proximity Warning (APW).
- Minimum Safe Altitude Warning.
- Airborne Collision Avoidance.

3.4.3.2. Free routing operations

The trend to use free routes and user-preferred trajectories is led by the introduction of RNAV capabilities and a desire to move away from the restrictions on flexibility and flight efficiency imposed on airspace users by route networks.

In Free-routing operations, the flight is allowed to take up direct routing as selected by the pilot. Free-routing enables aircraft to fly their own user-preferred trajectories (subject to any overriding airspace restrictions) outside the structured routes, in a “known” environment (MAS). This assumes that their identity, position and intentions are known. The controller is fully responsible for the aircraft, although aircraft, assisted by the AOC, may negotiate new trajectories with ATC.

Such operations are already supported to some extent by existing infrastructure and avionics. ATM intervention is by exception and utilises the principles of Collaborative Decision-Making to determine and agree the best course of action for flights. Any minor deviation from the initial trajectory is negotiated between the flight crew and the tactical controller. Initially neither the ATS Centre Planner (local flow management) nor the airline’s AOC become involved. For major deviations, the negotiation is undertaken also by the pilot, with the assistance of the AOC, and the multi-sector planner (plus the local flow management performed by the ATS Centre Planner). Its implementation is envisaged in the upper airspace of low/medium traffic density zones (TORCH Zones 3,4,5 and some areas in Zone 2) in order to increase the effectiveness of airline operations[14].

Free Routing may be requested by airlines before the flight or by pilots during the flight. It is expected that aircraft flying their own routes can save flight time or absorb delays. In the first case, when the aircraft has no delay free routing has to be planned in the event that an arrival is allocated at the destination airport. This will prevent aircraft from holding in a stack, waiting for an arrival slot, and to lose time saved during the free routing. Free routing should be planned as much as possible.

As will be discussed in Section 4 below free routing should be applied within sectors with low traffic density (because of the increased controller workload) and should not impose flight level changes because of negative effects in terms of fuel consumption. Free routing combined with Flexible Use of Airspace (FUA) presents big benefits for aircraft in terms of time and fuel savings.

The multi-sector planner's role, which acts on the basis of a greater planning horizon in time and distance, will be essential for developing the free routing concept. The Multi-sector planner will be assisted by MTCD and CORA which operate within a range of up to 20-30 minutes in a multi-sector environment. CDM processes manage the decision process among the Multi-sector Planner, ATS Centre Planner and Airport Operators in order to ensure that aircraft operating under free routing conditions do not give rise to any conflicts in any flight phase. New operational procedures, in addition to the technical improvements stated above, are to be developed and agreed on a common ECAC basis.

4. Operational Concept Assessment

In the second phase of the TORCH project, the Operational Concept derived in the first phase was assessed. Three assessments were made, in parallel: Technical, operational and socio-economic. These assessments evaluated the feasibility of the Operational Concept to determine the contribution it makes to the main objectives defined for it:

- Capacity.
- Safety.
- Economics.

---

[14] No specific new equipment will be required for entry into Managed Airspace, although new equipment would be necessary to fully benefit from the concept (e.g. Datalink for free routing).

This section presents the results of the assessment phase in two subsections, which respectively describe and discuss the following:

- The potential changes and expected benefits of implementing the TORCH Operational Concept.
- Second, the results of the assessments conducted, including conclusions and recommendations.

4.1. Expected Benefits of the Operational Concept

The main potential changes and benefits expected from implementation of the TORCH Operational Concept are stated in the following subsections, for each of the three phases of the Concept:

4.1.1. Layered Planning

The potential changes and expected benefits of the Layered Planning phase are as follows:

- Data will be tailored for different users and regions allowing early reactions to identified C/D imbalances.
- Capacity will be balanced according to the user demand. Planning accuracy will be higher than today. When capacity exceeds demand or the contrary system providers will adjust the capacity to improve cost-effectiveness. For example in case of lack of capacity additional staff could be allocated to an ATC centre to cope with the expected demand.
- Users and providers will have an improved picture of the predicted traffic situation to analyse business cases. Users will be actively involved in the decision-making process by using their own planning and decision tools.
- All parties will be informed about the updated DOP in real-time and may take advantage of changing conditions in a continuous process. The negotiation process will take user preferences into account.
- The higher expected accuracy of the DOP, as compared with current plans, will imply a reduction in unexpected changes in real-time operations, contributing to the reduction of costs generated by real-time operation changes.
- Re-routing potential for individual flights will be included within the optimisation process, allowing users to take advantage of DOP flexibility to improve efficiency.
- ATFM measures and airport capacity/resource planning will be coherent during all phases of planning. Planning slots will be made consistent with airport slots, allowing a better use of the available resources and capacity.
- Planning of adjacent airports resources (airport cluster) will be optimised through selected distribution of tasks and traffic.

4.1.2. Re-planning

The potential changes and expected benefits of the Re-planning phase are as follows:

- En-route metering, at least, at the centre level will fill the gap between ATFM and ATC and support gate-to-gate operations.
- Use of down-linked aircraft parameters or trajectories will produce a more accurate predicted situation.
- Multi-sector planning (MSP) will be a new function in ATC. Through the use of MTCD, controllers will be able to plan traffic and to solve potential conflicts well ahead of the flight.
- MSP and MTCD will make it possible to change from re-active to pro-active ATC.
- More accurate and complete planning of aircraft arrival times transparent for all system users may reduce delay situations.
- The certainty of flight schedules will be improved, contributing to the reduction of delays.
- Sequencing in Terminal Areas will take airspace user preferences into account.
- Optimum use will be made of airport and airspace resources.
- More satisfying conflict resolution strategies, considering user preferences and negotiation with the pilot, (if feasible), will be implemented.

4.1.3. Real-Time Operations

The potential changes and expected benefits of the Real-Time Operations phase are as follows:

- Integrated arrival, departure and ground movement management for one or more airports will increase capacity.
- System-supported monitoring will reduce controller workload.
- Delegation of separation responsibility will increase capacity in MAS by reducing controller workload.
- Safety will be increased through the reduction of collision risks by improved automated tools. The Concept includes a set of functions, which can be considered as a last minute safety net.
- Airlines will be more involved than today in decision taking if their flights are affected.
- Routes closer to user preferences will contribute to flight-efficiency.
- Gate-to-Gate trajectories will become part of the flight plan, improving capacity and flight efficiency.

- Datalink will enable automatic data exchange, (e.g., trajectories (synchronisation with FDPS)), reducing pilot and controller workload.

- The ability of AOC to make decisions or modifications to flights will improve flight efficiency.

- In airport operations, a local decision-support tool, accessible to all actors for "What-If" probing and communications of solutions, will improve punctuality and management of schedules.

4.2. Results of the TORCH Operational Concept Assessment

This section presents the results of the three parallel assessments, technical, operational and socio-economic. More information regarding the assessments and their methodology, tools, scenarios and results are included as appendices (Appendix B, C and D) to this document. For each of these assessments, a summary of the conclusions, an identification of shortcomings and uncertainties, and a list of recommendations are provided.

4.2.1. Technical Assessment

The technical assessment had two objectives. The first objective was to make clear whether the TORCH operational concept will be technically feasible, in practical terms, in its timeframe. The underlying idea was to make sure that all of the technical products required by the TORCH operational concept can be made viable early enough to be put in operations before the end of the TORCH time frame (2005-2010). The second objective was to try to determine how to proceed so that these technical products will actually be available early enough (production of a transition plan for technical products).

4.2.1.1. Summary of conclusions of individual technical assessments

Most of the TORCH Operational Concept seems to be technically feasible within the considered timeframe 2005-2010. This, however, does not imply that the Concept is achievable practically, which involves acceptance of the Concept by operational staff and all organisations involved, including airlines, validation of its operational and economic viability, and rapid decision making.

Table 4-1 shows the results of the technical assessment of the TORCH Operational Concept. The technical feasibility of the different component parts of the Concept is given for each of three transition steps, taking interdependencies into account.

	Possible use for 2005	**Possible use for 2007**	**Possible use for 2010**
Central organisations	Co-ordination tool for airspace status management	Demand prediction tool based on demand model	Central DOP production tool
	Fast-time simulation to ensure that the airspace plan is feasible	Capacity determination tool based on capacity model	Decision-support tool in case of an unexpected event with a wide effect
		ECAC-wide demand-capacity planning tool	
		Fast time simulation tools (for airspace plan development)	
ATS providers	En-route metering tools (some exist in the USA)	Ground "trajectory negotiation tool"	Decision-support tool in case of an unexpected event with limited local effect
	MTCD tool (using ground based trajectory information) Surveillance service system	MTCD tool (using 4D FMS trajectories when available)	Negotiation tool, with fast time simulation support, for negotiating with airlines, and with adjacent agencies
	Flight plan service system	Conflict resolution advisor	
	ATC automated system	Airlines/MSP trajectory negotiation tool Traffic Load Analyser	
	Automated controller agenda[15]	Demand-capacity planning tools (for ATS providers)	
	STCA, APW, MSAW	Negotiation tool with adjacent agencies (for local demand-capacity planning by ATS providers)	
	Conformance Monitoring		

---

[15] Display in a special window of particular tasks to be performed by the controller (especially conflict resolution), classified on a time line according to urgency. It uses inputs from conflict detection. The objective is to assist the controller in organising future work in high workload situations.

	Possible use for 2005	Possible use for 2007	Possible use for 2010
Airports	Arrival & departure managers	Airport conflict detection tool (taxiway conflict detection)	Various airport resources management tools (co-operative)
	Airport surveillance data fusion tool	Demand-capacity planning tools (for airports)	
	Airport conflict detection tool (runway incursion)	Negotiation tool with adjacent agencies (for local demand-capacity planning by airports	
	Central airport database		
Airlines		Airlines/MSP trajectory negotiation tool	Decision-support tools (for taking advantage of the DOP flexibility)
			Negotiation tool for changes in the DOP
Aircraft	VDL mode 2	ADS-B	ASAS
	ATN router	Airborne A/G trajectory negotiation tool	CDTI
	ODIAC applications		
	ACAS		

Table 4-1 Technical Feasibility Times for the TORCH Operational Concept

From this table, three technical transition steps can be defined:

(A) Operational concept technically feasible for 2005

This step is based on the current concept, with the following improvements:

- ASM-related improvements:
  - Improved, co-operative, airspace management.
- ATC-related improvements:
  - Introduction of en-route metering,
  - first data link applications,
  - New tools for improving controller's capacity (including ground based MTCD, conformance monitoring).
- Airport-related improvements:
  - Arrival and departure managers.
  - A-SMGCS (including airport surveillance data fusion, and runway incursion detection).
  - A central airport database.

(B) Operational concept technically feasible for 2007

This step is the same as the preceding step, with the following additional improvements:

- ASM and ATFM-related improvements:
  - Better demand prediction and capacity determination.
  - Better co-operative demand-capacity management.
- ATC-related improvements:
  - Better trajectory prediction through downlinking of 4D FMS trajectories (from equipped aircraft).
  - Adaptation of rules regarding control commands to facilitate the use of FMS.
  - Introduction of MTCD and associated conflict resolution advisory, based on enhanced trajectory prediction.
  - Introduction of A/G trajectory negotiation.
  - Introduction of multi-sector planning.
- Airport-related improvements:
  - Taxiway conflict detection
- Surveillance improvements:
  - ADS-B (for better surveillance and preparation of the next step).

(C) Operational concept technically feasible for 2010

This final TORCH step involves several major changes:

- Introduction of the DOP, and all co-operative processes related to the DOP.
- Introduction of areas with delegation of separation assurance responsibility.
- For airports, better, co-operative, airport resources management.

Some critical points regarding the technical feasibility of the TORCH Operational Concept are:

- In order for the schedules to be realistic, definitive decisions to begin the development of technical products required have to be taken without delay. As these decisions have to be taken by many stakeholders, and often have to be preceded by common decisions about co-operation, this is a difficult issue. If decisions are not taken early enough, the estimated dates will have to be shifted accordingly.
- The outfitting of a sufficient proportion of aircraft is sometimes a condition required for the concept to behave well (e.g., the more aircraft equipped with 4D-

FMS, the more acceptable MTCD tools are likely to be, due to more reliable future trajectories). This is also a difficult issue, given the number of different airlines, and especially small ones or airlines with old aircraft.

4.2.1.2. Shortcomings and uncertainties

The risks for the first transition step (up to 2005) are only minor risks, since this is a short term time frame. Much of this step is composed of items already operational in some places, or available as prototypes. Uncertainties for this first step are actually much lower than the uncertainties for the next steps, which are longer term. Nonetheless, estimating schedules for future ATM technical development is always difficult. Therefore, all times must be taken with much precaution.

The main uncertainty factor related to the time of operational use of a technical enabler is the fact that the assessment has been done on a technical feasibility basis. As long as final decisions on the operational concept, and decisions to launch associated technical activities are not taken, advances van be made towards the operational use of new technical means.

All decisions to be taken to make the first transition step operational in 2005 must be taken without delay. Most of these decisions have to be collective to be most effective. The main required decisions are:

- Decision to expedite implementation of the required communication infrastructures (both for ground-ground and air-ground communications); (ATS providers, airports, airlines, etc., each within its domain of responsibility);

- Decision to specify formats and protocols required for co-operation not yet available. This decision will include improved co-operative airspace management, and en-route metering. Several levels of functionality should be designed to make progressive implementation possible (if this is justified by the complexity level); (EUROCONTROL);

- Decision to develop requirement specifications for required products, when not available; in the case of en-route metering, the experience of other countries (such as USA) should be used as input (EUROCONTROL; ATS providers, airports, airlines, etc., each for their domain of responsibility; manufacturers);

- If these protocols and specifications are available, decision to develop an industrial product on this basis (EUROCONTROL; ATS providers, airports, airlines, etc., each for their domain of responsibility; manufacturers);

- Decision to be taken by authorities concerned (airport authorities, etc.) to use the various parts of the concept, and to schedule this use. Other decisions arise from this schedule (e.g. ordering required products, organising personnel training, etc.). (ATS providers, airports, airlines, etc., each for their domain of responsibility);

4.2.1.3. Recommendations

Based on the technical assessment conducted, it can be concluded that most of the TORCH operational concept seems to be technically feasible within the considered timeframe 2005-2010. Therefore, the following recommendations can be made:

- Emphasis should be placed on prompt decisions to use new concepts, and decisions on the associated development schedule for technical products required (decisions by ATS providers, by airports, by airlines, etc.). A mechanism should be designed to encourage these decisions and to make them less risky (e.g. an insurance scheme to protect against the risk that the decision eventually proves to have been a bad decision).

- Estimated schedules involve large risks. In some cases, risks may be reduced by organising necessary developments into several levels that can be made operational one after another, thus making gradual implementation of the new function possible. This should be done whenever possible.

4.2.2. Operational Assessment

The objective of the Operational Assessment of the TORCH Operational Concept was to prove the overall feasibility of defined scenarios by carrying out a process modelling of the various ATM processes. The Operational Assessment has been focused on:

- innovative ideas and new or not-yet-implemented operational procedures,

- core area with main traffic and high delay situation,

- provision of selected example solutions for all flight phases.

4.2.2.1. Summary of Conclusions of the Individual Assessments

The Operational Assessment has provided initial insights into the potential of the selected scenarios. These scenarios include new or innovative ideas such as the DOP or Layered Planning, and provide examples for all phases of flight. The results of the assessment will be summarised for the DOP, airport, TMA and en-route studies.

A) Daily Operational Plan

In principle, the CFMU currently generates an operational plan and simulates the anticipated air traffic situation. Nevertheless, there are several shortcomings which question the effectiveness of the current practice:

- At present no tools or models are available to support strategic ATFM.

- Unpredictable events may occur between the slot allocation time and departure time without an appropriate reaction (co-ordination between CFMU – ATCC/FMP – Aircraft Operator).

- The accuracy of data is insufficient or even deliberately wrong (“cheating”).

- Declared sector capacity is an average value but does not respect traffic complexity.

The feasibility study shows that a DOP can be developed by means of more accurate input data. The output data of existing planning and simulation tools (e.g., of airlines) should be integrated. An early balance of demand and capacity in a less time-critical phase can be achieved by involving all stakeholders. Fast-time simulations show potential bottlenecks several days before operation. Results should be made public in order to increase confidence in the balancing process.

The DOP is the first step in a layered planning and provides input data for the following activities at the centre and sector levels. It should not be seen as a rigid plan which will be put into operation. It is rather the base for re-planning at the day of operation.

Qualitative analysis shows that there is a high potential for introducing the DOP concept. This study was not intended to provide quantitative results to prove the advantages of a better planning and negotiation process in the strategic and pre-tactical phases. The main objective was to stimulate discussion and prepare further validation steps in order to utilise currently available resources and capacities more efficiently.

B) Airport and TMA studies

The airport and TMA simulations were conducted at Madrid Barajas (Fast-Time Simulations) and Frankfurt (Process Simulations) Airports. These simulations have shown that the forecast traffic for 2005 could be accommodated if several things are done. Accommodation could be achieved by means of better co-ordination through arrival and departure management by introducing new tools such as Local Decision Support System (enabling information exchange, new CDM procedures and decision support) or Wake Vortex Warning System (utilisation of minimum separation standards in all weather conditions).

The average capacity gain which could be achieved by these improvements is of a magnitude of 10% to 15%. This leads to the conclusion that further traffic increase until 2010 will cause further increase in delay if no other actions are taken (examples for further improvements are the introduction of A-SMGCS or optimised TMA procedures). Otherwise, airports may become significant bottlenecks in the TORCH timeframe.

A Quality of Service study was conducted on Station Keeping, which introduces the principle of using time as separation parameter, avoiding use of visual CDTI spacing of aircraft and using (3D/4D) FMS capabilities to navigate. The advantages and disadvantages of the selected concept cannot be fully understood from the analysis. More trials should be conducted to investigate the impact at an operational level. It is not fully clear how much Station Keeping will contribute to safety and capacity gains e.g. under bad weather conditions.

C) En-Route Studies

- *Re-Routing and Metering:* For the simulation of the en-route, re-routing and metering functions, it was assumed that tools like Traffic Analyser and Workload Predictor, with a prediction horizon of about two hours, will be available. They were used to identify overloaded sectors and to eliminate this overload by re-routing and metering aircraft. The simulation showed that it is possible within certain margins to eliminate overloads when alternatives for re-direction of traffic are available. Better use of the available capacity at the centre and multi-centre levels will minimise current central flow intervention.

- *Multi-Sector Planning:* A Multi-Sector Planner (MSP) was proposed in these simulations. The MSP was based on conflict detection and resolution at the planner level, having a planning window of up to 30, 40 or 60 minutes before the aircraft enters the area of responsibility. The reference case was based on advanced HMI, but even without MSP there was a significant workload reduction for the tactical and planner controller of a magnitude of 10% to 30%. Introducing several MSP strategies (additional MSP controller, data link for conflict resolution), no significant additional improvements or reduction in workload were obtained. A data link slightly reduced workload. The level of uncertainty associated with these MSP simulations is so high that it is not possible to quantify the MSP workload without further detailed development of the functions and roles. There are a number of possible concepts of operations which are currently under discussion in Europe.

- *Free Routing:* The Free Routing simulation conducted as part of the Operational Assessment focused on efficiency. The objective was to prove the benefits in terms of fuel consumption and flight time, taking into account factors such as sector density or crossed military areas. In the simulation area (Brest FIR) flight time reduction was obtained of a magnitude of 3%, fuel benefits are in the range of 2.5% to 3.5%. The higher the sector density the lower the benefits, because of the increasing number of potential conflicts. The opening of military areas in this region leads to time benefits of about 10%. Therefore, free routing should only be applied in low density sectors, and flight level changes should be avoided because these changes further reduce the rather small benefits in fuel and time. The most promising benefits could be obtained from opening military areas for civil traffic (applying the Flexible Use of Airspace concept). The free routing area should comprise more than one single FIR in order to obtain more significant fuel and time benefits.

4.2.2.2. Shortcomings and uncertainties

The operational assessment provided delay, capacity and efficiency indicators and related metrics with respect to the selected scenarios. The scope of these scenarios was usually limited to a dedicated FIR or airport because of current simulation tool capabilities. The ideal situation would have been a simulation of all ECAC airspace and airports including Air Traffic Flow Management (ATFM) with respect to all stakeholders involved. This kind of validation was not possible, not only because of the existing tools limitations, but also due to difficulties in applying overall simulation results to specific areas.

Some shortcomings and uncertainties of this assessment were identified, as follows:

- The concept covers the complete ECAC area. What is the expected accuracy (and credibility) if the individual assessment results are extrapolated to ECAC level ? What is the impact of the limited scope? Due to the different magnitude of the problems and different solutions (which support different stakeholders), each case has to be treated separately.

- Is the overall benefit of all individual assessments (e.g., in terms of capacity gain) the sum of each capacity gain? Or is it the arithmetical or geometrical average? There is no known scientific methodology known to answer this question. Estimates need to be justified by expert opinions.

- What is the quantitative planning impact on capacity? Improvements in central planning by introducing the concept of the DOP play an important role. There are no tools which allow a simulation of the impact of better planning or more accurate planning data on capacity or efficiency. Therefore, the TORCH process model showed the main processes and determined the required data from every stakeholder to show the qualitative feasibility.

- Considering uncertainty of results due to tools used, results should be understood as showing only a tendency.

4.2.2.3. Recommendations

Benefits in capacity gain in 2005 to 2010 will not be achieved by implementation of a single tool or new procedure. The operational assessment results show that of the ideas tested short-term benefits are more likely to be derived from improved planning. Improvements reviewed for the execution phases were dependent on the existence of new technologies and(Automation & prediction) tools, which will not be so readily available in the short term.

On the basis of the Operational Assessment of the TORCH Operational Concept, the following recommendations can be made:

- An overall improvement in the planning phases through the DOP will be beneficial and applicable to the entire ECAC airspace. It will improve efficiency while maintaining as much flexibility as possible (re-planning actions).

- There is an urgent need to improve the situation at Airports and TMAs in high and medium-density areas in order to decrease delays. Better planning related tasks have been identified within TORCH as a possible solution together with an integrated arrival and departure management (as a CDM implementation).

- The application of Station Keeping in TMAs gives the expectation of gains in efficiency and flexibility as a complementary solution for improving TMA management in general. Further emphasis should be put on investigation of the operational impacts of Station Keeping procedures. There is also a need to extend the technological analysis to ensure availability of technologies to support the supply of data, operational procedures and safety requirements.

- Further emphasis should be put on advanced controller tools like MTCD or CORA and the automation of tasks which alleviate the workload and could thus increase controller capacity. Other important research areas which are not covered in these feasibility studies include the change of route networks and sectorisation.

4.2.3. Socio-economic Assessment

The viability of a new ATM system in Europe does not depend only on the technical feasibility of the proposed system concept but also on its economic feasibility and social acceptability. More specifically it is important for decision-makers to know, before deployment the system:

- if the proposed system is cost-effective as compared to the existing baseline situation,

- how the different stakeholders are impacted by the introduction of the new system.

The objective of the Socio-Economical Assessment was to get preliminary ideas about the social and economic impacts of the TORCH Operational Concept. To reach this objective, the assessment has highlighted the problems associated with estimating the socio-economic impacts of a complex technological system like TORCH, and suggested further steps that should be taken in the future in order to obtain more accurate assessments of the new European ATM system.

4.2.3.1. Summary of Conclusions of the Individual Assessments

Two types of assessment were used. One was assessment by a panel of experts following the Delphi Method [see D5.2]. The second was an Analytical Hierarchical Process [also see D5.2]. The methodological approach taken was based on a qualitative assessment of the TORCH and the baseline system. It combined quantitative measurements, when possible, with qualitative assessment based on expert judgement provided by a European panel of experts. The analysis of the inherent costs and operational benefits of the TORCH Operational Concept obtained through the Delphi panel survey led to the following conclusions regarding economic viability:

- Substantial investments are needed by all relevant stakeholders for successful implementation of the TORCH OC.
- The expected investments are likely to pay-off under a scenario of high traffic increase.
- The expected benefits will be allocated to all relevant stakeholders in close relationship to their investments.

- The expected benefits of the ATM system proposed by TORCH will be derived from its positive impact on all performance metrics, i.e. safety, capacity, delays, cost-savings. This means that there are no trade-offs among the TORCH OC performance metrics.

The assessment of the overall cost-effectiveness and social impact of the TORCH as compared with the baseline system, based on AHP, suggests that:

- The cost of investments in the new European ATM system will be substantial as compared to the continuation of the existing system.
- The tangible benefits (direct economic benefits) and the intangible social benefits that will be generated by the implementation of the TORCH OC will exceed the investment cost.
- There is wide agreement with regard to the benefits and costs that will result from the implementation of the TORCH OC, as well as substantial consensus on the relative importance of the performance metrics involved in the assessment of the TORCH and the baseline systems.
- The evaluation results of both cost-effectiveness and social impact assessment are robust.
- The TORCH OC will be beneficial in terms of all performance metrics, especially the safety improvement of the ATM system.

Finally, a comparison of the results of the two parallel approaches used to evaluate the socio-economic performance of the TORCH OC shoes that they are in complete agreement. The two methods consequently provide a confirmation of the expected social acceptance and cost-effectiveness feasibility of the TORCH OC.

4.2.3.2. Shortcomings and Uncertainties

The Socio-economic Assessment of the TORCH Operational Concept differs from the classic impact assessment studies of new technological systems. The major features of the environment within which the new European ATM system was evaluated can be summarised as follows:

- The European ATM system is a rather complex technological system with numerous functionalities and strong interdependencies between its components.
- The European ATM system covers an extensive geographical area with substantial social, technological and economic differences.
- A new European ATM system like TORCH requires a rather long implementation time horizon.
- The European ATM system involves a substantial number of stakeholders with different and sometimes conflicting objectives.
- The impacts of the European ATM system relate to a multitude of performance objectives, i.e. cost, safety, controllers workload, level of service, delays, etc. which are difficult to quantify in monetary terms.
- While certain cost items of the TORCH OC can be calculated fairly accurately (e.g., acquisition cost of the various system components), other categories of costs and benefits can be assessed only in a comparative sense, (if they are larger or smaller than those for the existing baseline system.

Based on these factors the TORCH Socio-economic and Cost-effectiveness Assessment can be described as a problem with:

- high uncertainty in the estimation of the magnitude of the relevant impacts,
- high subjectivity in converting non-monetary to monetary impacts, and
- high uncertainty in projecting the macroeconomic environment of the countries impacted by the European ATM system for an extensive planning horizon, i.e. 2010-215.

The characteristics of the TORCH assessment led to the conclusion that a traditional cost-benefit or cost-effectiveness assessment of the new European ATM system based on monetary quantification of system impacts was neither feasible nor reliable.

4.2.3.3. Recommendations

On the basis of the Socio-economic Assessment of the TORCH Operational Concept as compared with the baseline systems the following recommendations for TORCH OC implementation can be made:

- From a socio-economic point of view, the TORCH Operational Concept should be implemented as a priority in areas of high traffic density.
- All stakeholders have mutual benefits, i.e. a win-win situation. There are no trade-offs among the objectives and aspirations of the ATM system stakeholders. This makes it possible to establish an effective stakeholder coalition to achieve the common goals.
- During the implementation process, priority should be given to those features of the TORCH OC that have the highest bearing on system safety.
- Considerable importance should be also given during system implementation to the TORCH system functionalities, contributing the most to the increase of the peak hour airport capacity and to features securing the minimisation the deviation between scheduled and actual time of the aircraft.
- System implementation issues related to controller workload should be also taken into serious consideration, since they have a positive impact on both system acceptability and system safety.

4.2.4. Recommendations derived from the Assessment

The combined results of the technical, operational and socio-economic assessments described in the preceding subsections have given rise to a set of recommendations. These recommendations are based on the following assumptions:

- The TORCH system is more likely to be socio-economically feasible in a scenario with high traffic growth, because the costs for implementing TORCH will be substantial as compared with the costs of continuing with the current systems.

- Safety is a fundamental and indispensable objective. This means that introducing new procedures or functionalities and their associated tools must never affect safety. Since a high traffic scenario has been assumed, priority must be given to the features which most greatly affect the safety of the system.

Based on these assumptions and the results of the three assessments of the TORCH Operational Concept, TORCH recommends the early implementation of system functionalities which meet three objectives:

- Increasing peak-hour capacity at airports.
- Minimising flight delays.
- Reducing controller workload.

The recommended functionalities for each of these objectives within the considered framework are described in the following subsections. All of the enablers and tools should be available for these functionalities before the year 2010 (see Table 4-1).

A) *Increased Peak-Hour Airport Capacity*

The recommended functionalities to increase peak hour airport capacity are:

- Integrated arrival and departure management.

- Ground movement guidance, monitoring and control Airport capacity/demand planning and resource management.

The results of the technical assessment show that arrival managers and departure managers will be available before 2005 [see Table 4-1]. These tools will be used to optimise the arrival and departure sequences, and to optimise the metering between successive arrivals. In a second step, arrival and departure managers should be combined with ground movement managers.

Advanced Surface Movement Guidance and Control Systems will optimise ground movement management and detect both runway intrusions and taxiway conflicts. The components of these systems will be ready for implementation before the year 2007 [see Table 4-1]. Major hub airports, which have complex runway and taxiway systems, should increase capacity by optimising the streams of taxiing aircraft and the sequence of departing aircraft. Safety will increase due to automated conflict detection.

Airport capacity/demand planning and the identification of capacity shortfalls will be assisted by Local Decision Support Systems. Airport resource management could be optimised by connecting and adjusting stakeholder databases (e.g., for airport, airline operators or ATC). Implementation of this functionality will lead to the co-ordinated actions of all relevant stakeholders which will, in turn, increase peak-hour capacity.

B) Minimised Flight Delays

The recommended functionalities to minimise flight delays are:

- Daily Operational Plan (DOP), based on capacity/demand planning at the overall ECAC level.

- Surveillance Data Fusion.

- Real-time capacity/demand optimisation at the overall ECAC and regional levels.

The results of the technical assessment indicate that fast-time simulation tools capacity/demand planning at the ECAC-wide level will be available before 2005 [see Table 4-1]. Capacity determination and demand prediction tools are expected to be operational by 2005-2007 [see Table 4-1]. A central DOP could be operational by 2007-2010 [see Table 4-1]. Implementation of the DOP is expected to increase the precision of capacity/demand planning. Capacity shortfalls will have been defined previously in the pre-tactical planning phase. Early reaction will enable the capacity to be adjusted to meet the demand, and not conversely as at present.

The networking effect, resulting from a combination of the surveillance data provided by all stakeholders. This will improve the quality of trajectory information.

Finally, as regards real-time capacity/demand optimisation, negotiation tools with adjacent agencies will be operational before 2005 [see Table 4-1]. These tools will enable airlines, airports and ATS providers to negotiate real capacity imbalances, at both the regional and ECAC-wide levels (real-time optimisation). The systematic, automated interaction of involved stakeholders could significantly improve capacity optimisation.

C) Reduced Controller Workload

The recommended functionalities to reduce controller workload are:

- Multi-sector planning and monitoring of traffic density.

- Airspace conflict detection and resolution.

- Airborne collision avoidance systems (ACAS) and airborne separation assurance systems (ASAS).

Multi-sector planning will be a new function in ATC. Controllers will be able to plan traffic and potential conflicts in advance. This is expected to significantly reduce controller workload.

Medium-term Conflict Detection (MTCD) tools using FMS trajectories will be available in 2007 [see Table 4-1]. “Ground-based“ versions of MTCD could be operational even earlier. In combination with traffic-load analyser tools, which will also be available around 2005, these tools could significantly modify the roles and tasks of the air traffic controller position. Conflict resolution advisor tools (CORA) could be operational by 2007 [see Table 4-1]. These tools increase safety by reducing the potential for human error. They will also decrease controller workload by supporting the decision-making process.

ACAS systems will be available before 2005, while ASAS may not be fully available until 2010 [see Table 4-1]. These tools will significantly increase safety and reduce the workload of the air traffic controller. ASAS applications make it possible, in certain circumstances, to transfer separation responsibility from the controller to the pilot, which increases capacity [D4.3].

5. Transition Guidelines

The implementation of a new operational concept such as TORCH is a complex process. This process involves:

- The need to evolve from a wide variety of different current CNS/ATM systems within the ECAC area, working with different levels of functionalities, towards the implementation of a wide set of proposed new functionalities that will involve the integration and improvement of current systems and the introduction of new ones.
- The set of involved stakeholders, who are the decision makers for the implementation of new systems. Stakeholders will need to adapt their philosophy, implement of new technologies, change their operational procedures and change their resources.
- Many political and institutional issues, such as the distribution and sharing of information, or the delegation of responsibility of separation assurance to pilots, which must be solved by Regulators and National Authorities, with the involvement of the affected stakeholders.
- The availability of the required technical products to develop the functionalities proposed by the TORCH Operational Concept.

Taking these factors into account, TORCH proposed a series of transition guidelines, to move from the current ATM/CNS system to full implementation of the TORCH Operational Concept in 2010. Three transition phases have been defined: until 2005, 2005-2007 and 2007-2010. The transition guidelines place the TORCH operational improvements within one of these phases.

The main criteria used to place the operational improvement in the transition phases were the feasibility and interdependency/interoperability of the technical products needed to implement the operational improvement. This information was obtained from the results of the Technical Assessment (see Appendix B).

The full set of transition guidelines is included in Appendix E. The guidelines for each of the three transition steps are briefly summarised in the following subsections.

5.1. First Transition Step (until 2005)

The first transition step takes in from the present time until 2005. During this period the current ATM/CNS system operating in Europe will, for the most part, continue to be in effect. This system consists of individual national systems, which are only interconnected for some CNS functionalities. There will nevertheless be the following significant improvements, listed for the layered planning, re-planning and real-time operations phases of flight.

In the layered planning phase, the following significant operational improvements should be incorporated until 2005:

- Improvements in airspace plan development process, which will require, among others, the introduction of a central organisation to prepare an ECAC-wide central airspace plan.
- Improvements in airspace status management by, among others, introducing fast-time simulation tools.
- Introduction of the Aeronautical Telecommunications Network.
- Introduction of a new airport capacity and demand determination tool.

In the re-planning phase, the following significant operational improvements should be incorporated until 2005:

- Introduction of the ATS Centre Planner position that will analyse the agreed DOP, current air traffic and current resources. This will involve, among others, the operational implementation of an en-route metering tool.
- Introduction of a local flow planning element, integrating arrival and departure management. Integration with the ground movement management tool will begin in this stage.
- Integration of datalink functionalities and a central airport database through the ATN infrastructure.

In the real-time operations phase, operational improvements to be incorporated until 2005 will depend on the new systems (both ground-based and airborne) to be implemented and the necessary infrastructure. These improvements should include the following:

- Improved surveillance functionality, which will involve implementation of a surveillance data fusion system at the level of control centres.
- Introduction of Reduced Vertical Separation Minima throughout European airspace.
- Improved hazard assessment functionality and wide-scale implementation of safety nets, involving implementation of the Short-Term Conflict Alert, Area Proximity Warning and Minimum Safe Altitude Warning tools and enhanced airborne ACAS systems throughout the ECAC airspace.
- Implementation of the central airport database.
- Introduction of data-fusion and runway conflict detection tools.
- Implementation of VDL Mode 2 and ATN routers on board to implement ODIAC applications.

5.2. Second Transition Step (2005-2007)

The second transition step takes in from 2005-2007. During this period, the most significant improvements are expected to be improved capacity determination and demand prediction, and improved co-operative capacity/demand planning management. Also, the Multi-Sector Planner should be introduced and ADS-B and air/ground trajectory negotiation should be implemented.

In the layered planning phase, the following significant operational improvements should be incorporated in the period from 2005-2007:

- Improvements in the airspace plan development process, which will require moving toward collaborative planning by all involved stakeholders.
- Improvements in the capacity/demand determination process, involving permanent capacity determination and demand prediction at all times through a capacity determination tool and a demand prediction tool.
- Improvements in the central capacity/demand planning process, involving an ECAC-wide capacity/demand planning tool, adaptable to airports, TMA and en-route sectors.

In the re-planning phase, the following significant operational improvement should be incorporated in the period from 2005-2007:

- Introduction of the Multi-Sector Planner, requiring air/ground data-link services, a 4D-trajectory negotiation tool (both ground-based and airborne, for negotiation between ATS providers and airlines), an MTCD tool and a conflict resolution advisor.

In the real-time operations phase, the following significant operational improvements should be incorporated in the period from 2005-2007:

- Enhanced surveillance system, through the introduction of ADS-B and its integration with the surveillance data fusion system.
- Introduction of conflict detection on the airport runway area, involving a conflict detection tool.

5.3. Third Transition Step (2007-2010)

The third transition step takes in from 2007-2010. During this period, the most significant improvements are expected to be implementation of the DOP development and the introduction of airspace areas with partial delegation of separation assurance responsibility. Other improvements should include full integration of airport resource management tools, station-keeping operations, through more accurate 4D flight profiles and areas of partial delegation of separation, and the introduction of free-route operations, in which the controller will be fully responsible for the aircraft.

In the layered planning phase, the following significant operational improvements should be incorporated in the period from 2007-2010:

- Implementation of the DOP development and optimisation process, which will require a central DOP production tool, a re-planning process and a decision-support tool.
- Introduction of airspace areas with partial delegation of separation assurance responsibility, which will require a significant number of aircraft equipped with ASAS.
- Introduction of Collaborative Decision-Making into the capacity/demand planning process.

In the re-planning phase, the following significant operational improvements should be incorporated in the period from 2007-2010:

- Full integration of airport resource management tools.
- Full implementation of the ATS Centre Planner, with a fast-time simulation-capable negotiation tool.
- Introduction of more accurate 4D flight profiles.
- Introduction of partial delegation of separation assurance.

Finally, in the real-time operations phase, the following significant operational improvements should be incorporated in the period from 2007-2010:

- Introduction of free-route airspace and operations, involving the need for aircraft to be equipped with specific airborne equipment (e.g., ASAS).
- Improved air resource management, involving the implementation at airports of co-operative resource management tools.
- Improved aircrew traffic situation awareness.
- Introduction of longitudinal station-keeping (en route an in the TMA) and closely-spaced parallel approaches (in the TMA).

6. Conclusions and Recommendations

This section presents the lessons learned and overall conclusions reached in the TORCH project, placing them into the perspective of the initial approach and limitations of the project. Also included in this section are recommendations for future work based on the results of the TORCH project.

6.1. Significance and Limitations of the Project

EUROCONTROL has proposed a Target Concept for the future ATM system in its Operational Concept Document (OCD). This concept will not be fully implemented until 2015, although the constraints on the ATM system will become critical before that date. The TORCH Operational Concept has been defined to be the transition from the current ATM system to the Target Concept.

TORCH is both consistent and complementary with EUROCONTROL's OCD and ATM 2000+ Strategy. It provides an Operational Concept achievable around the period 2005-2010 as an intermediate step to implement these strategies.

The TORCH Operational Concept will be validated through further validation activities within the 5th Framework Programme before launching implementation, and gives a rough estimation on expected benefits. However, there are some gaps in the level of detail regarding functional descriptions which should be filled by other projects within the 5th Framework Programme before the validation activities begin.

One of the main contributions of TORCH is its breakdown of the OC into operational elements and definition of the information flow between them, including most of stakeholder points of view. This makes it easy to identify how the OC, through its elements, behaves and affects the ATM system.

Furthermore, the functional description of the major functions proposed constitutes another added value of TORCH. The innovative functions proposed are:

- Introduction of the DOP, based on a layered planning process starting from the strategic planning phase until real time operation. The fundamental idea behind the DOP is to shift co-ordination processes to non-time-critical planning phases, involving all stakeholders in the decision-making process.
- Introduction of local decision support and local flow management, in order to close the gap between the flow capacity planning and real time operation. The main concepts involved are en-route planning (MSP and en-route metering), terminal area sequencing and free routing.
- Integration of enhanced aircraft planning and flight management capabilities to optimise arrivals, through the introduction of station keeping, in which the responsibility for separation is partially delegated to the aircrew using ASAS capabilities.

In analysing the overall conclusions and recommendations below, it should be taken into account that the level of detail of the functional descriptions contained gaps, due to the scope of the Operational Concept. In addition, the different kinds of assessments were performed with some restrictions so that their results should be considered carefully, paying attention to their specific context and assumptions considered. The assessment results give an indication of the possible benefits, but they should not be taken as consolidated results.

It should also be taken into account that the methodology used for analysis and assessment has not been fully tested, and that some assumptions were made which were not fully proven. The level, number, co-ordination and integration of the assessments was very ambitions and only selected parts of the concept were actually assessed due to the absence of a full set of tools.

Nevertheless, it must also be noted that despite these limitations, the TORCH assessments concentrated on identifying the most promising of the new operational ideas and related enablers, and on assessing the overall concept with respect to quantitative socio-economic benefits.

6.2. Challenges Faced and Lessons Learned

Four major challenges were faced during the carrying out of the project. The project methodology was adapted to meet these challenges. From these challenges and from the way they were managed some lessons were learned by the project team.

The Four major challenges faced by the TORCH Project were as follows:

- The very large scope adopted by the project. The stated scope of the project was to define a European Air Traffic Management Operational Concept comprising:
    - Planning and execution phases of a flight from layered planning to real-time operation.
    - All stakeholders (ATS Provider, ATFM, airports, aircraft operator, ...).
    - Different traffic densities and different geographical and political environment in Europe, which needed different solutions.
    - Poorly defined concepts of operations or magnitude of options (e.g., for Multi Sector Planning or use of ADS-B).
    - Short-term implementation (between 2005 and 2010).
- The assessment of an Operational Concept prior to its development: An operational concept of a highly complex technological system with numerous functionalities and strong interdependencies between components, prior to its development, can be assessed by establishing scenarios, which can be simulated by appropriate tools, it was extremely difficult to: (a) develop scenarios taking in all system variables and the interdependencies of the various components of the operational concept; and (b) to simulate these scenarios.

  The alternative approach taken by TORCH to assess the viability of the operational concept was to provide a high-level view of the concept and try to evaluate it. In this case the risk was to only obtain a very aggregate view of the system functions and operational procedures, without detailed evaluation of the system in absolute terms. Under these conditions only a comparative system assessment was possible.
- The parallel triple assessment that was conducted: The technical assessment identified technical products associated with each ATM process. Despite the lack of detailed operational requirements an attempt was made to estimate availability dates for all products. Following to a recommendation from the DEVAM project the operational assessment carried out feasibility studies with different methodologies and tools in selected areas. This also meant that there was no validation or assessment of the full Operational Concept.

- The socio-economic assessment took a parallel approach: on the one hand using the Analytical Hierarchy Process (AHP), an overall cost-effectiveness assessment and social impact analysis was carried out, on the other hand the Delphi method was used to estimate the expected costs as well as the expected benefits. Both approaches showed comparable results.

Nevertheless, in the course of the project some issues arose, which will be useful to know and to take into account in similar projects. In particular, TORCH learned the following lessons:

- Methodology: A Concept needs considerable translation in order to be able to identify functionality in different geographical zones. Therefore, scenarios have to be developed and prototypes should be defined. This requires a spiral iterative development model, not a parallel approach. The dependencies linking the three assessments were not clear at the beginning of the assessment phase. Later, due to time and resource constraints, iterative development was no longer possible. Assumptions had to be made in order to minimise risks. Additionally, new functionalities or even only modified tools and procedures identified in TORCH require flexible (fast-time) modelling tools to help assessment. This requires modifying existing tools. But it was only when the characteristics of concepts became clearer (e.g., in the area of ATFM), that the need for modified tools were identified.

- Short-term Implementation Time: This requires clear detailed functionality based on constraint analysis (e.g., legacy systems) and clear performance requirements on system and equipment level. Operational performance requirements are essential for deriving technical requirements thereby determining technologies at the system and equipment levels. This also impacts the cost of implementation. For economic analysis justification it is essential to describe benefits in terms of capacity, delay or workload reduction, among others, and also costs (e.g. for personnel or technologies). Again due to the complexity and scope of the Operational Concept, these issues could be solved only partly in TORCH. Today there is a large variety of different ATC control centres with different (legacy) systems, significantly different avionics and a dissimilar ATC route and network structure. Therefore, operational performance requirements are not the same all over Europe and many different cases have to be distinguished.

  The solution to this issue could be a number of projects with much more limited scopes. For example, a project specifying precisely the operational concept at a low level, a project with an overall view specifying very precisely the assessment activities to be performed and precise expected results, and several assessment projects with different scopes.

- Manner of Conducting Operational, Technical and Socio-Economical Assessments: Multiple assessments should carried out sequentially. The parallel approach caused problems because of unclear operational requirements and unclear operational benefits. The other difficulty was the scope of the operational assessment, which did not cover the entire concept. This was due to the lack of adequate tools. Therefore, in the beginning there should be an agreement about the scope and expected results of the operational assessment. Sequentially, the technical and socio-economic assessment can be carried out. Dependencies have to be identified and described.

- Safety Assessment: There is no formal way of assessing the safety impact of increased throughput and capacity. When the operational assessment indicated significant gains in throughput or capacity, the safety impact could not be estimated due to the lack of a clear, and acknowledged methodology. It could not be answered whether additional capacity provokes additional risks. Of course, a risk assessment needs much more detailed information and may also depend on the actual implementation of rules and procedures. As a consequence, TORCH was not able to state the safety impact of the proposed concept.

These lessons learned clearly indicate that it is not possible to reliably assess a broad, high-level operational concept like TORCH within a short timeframe. In addition to financial, time and manpower constraints, there were available no proven and commonly agreed or standardised assessment methodologies and tools.

Especially in the field of assessing capacity, there are no methods and validation tools for assessing for example, the idea of a future seamless or layered ATM system with CDM activities. Even though some tools are in the design phase, it seems to be presently impossible to assess, with an adequate guarantee, the ability of any future ATM system to accommodate the proposed traffic growth. Recognising that the envisaged TORCH concept timeframe starts around 2005 this fact should be taken into account.

It is also clear that the three assessments should not have been performed in parallel. This approach demanded strong co-ordination, but a major constraint was that the technical and socio-economic assessment had to begin using assumptions which could not be proven at that stage of the project by the operational assessment, thus reducing the reliability of the results.

6.3. Conclusions

As stated in the Technical Annex for the project, the objective of TORCH was to "define and assess the feasibility of a viable, consolidated concept that can be implemented from the year 2005 onwards" [TA]. This concept was to be based on the OCD target concept, but applicable in the short and medium term. The assessment was to include operational, technical and socio-economic assessments, through complementary modelling and simulations.

These objectives have, for the most part, been met. TORCH has defined a TORCH Operational Concept, which proposes the introduction of new or advanced ATM functionalities within the entire ECAC area. The realisation of this concept will pose a great challenge for all stakeholders of European aviation at the beginning of the third millennium.

The functions and services to be provided by the Operational Concept have been defined and described, even if only at a high level. The high-level view was complemented, in part, with low-level descriptions of operational procedures and required enablers. The technical assessment studied the technical feasibility of a group of products considered indispensable for implementation of the Operational Concept. The operational assessment studied the feasibility of selected ATM processes. The quantitative socio-economic benefit provided broad estimates. A general idea of the political viability of the operational concept was derived.

The complexity of the proposed new functions and the global effects and interactions made it difficult to assess the entire concept and to give precise figures for costs and benefits. No simulation environment that can reflect the entire European ATM system is currently available. Nevertheless it was possible to estimate the availability of necessary technical enablers in terms of time and money. New procedures and functions were simulated in specific environments, reflecting dedicated parts of the ECAC area (FIR, TMA, Airport). Forecast investment costs were added to these figures, indicating at least the order or range of necessary investments per stakeholder at the European level. Expected monetary and non-monetary benefits, resulting from implementation of the new proposed functions, were compared to these costs.

The principal conclusion reached from the assessment was that the introduction of TORCH will be useful and beneficial for European aviation. Since implementation is a very complex process, which requires the concerted action of all aviation stakeholders and all governments of ECAC States, there is no guarantee that all forecast benefits will be realised and that all costs will stay in the estimated range. Implementation of some functions or procedures may be delayed or prevented due to negative decisions of single stakeholders or states.

At the same time the continuous growth of air traffic in Europe dictates not to wait too long to reach full consensus in all matters of change. In some areas of ECAC, the demand is higher than the capacity. The delta between these two categories will extend every day. Therefore, TORCH suggests concentrating in a first step on implementation of new functions which are expected to be available in 2005. New functionalities (e.g. Departure Management) could similarly be implemented in a first step at major hub airports, then at medium-traffic airports and they could finally be integrated with Arrival Management Systems.

It is not very realistic to believe that all states and all stakeholders will choose identical solutions and implementation timeframes. Too different are objectives, political interests and economical power. Nevertheless it should be realised that there is a win-win situation for all stakeholders if the implementation of the new proposed functions approaches the expected benefits of this Operational Concept framework.

In conclusion, although the assessments of the TORCH Operational Concept only provided conclusions regarding parts of the concept, the results obtained indicate that early implementation of key features such as improved planning, information management and co-operative re-planning is feasible and would be beneficial to the overall European aviation community. This will be true even if not all States and stakeholders choose identical solutions and implementation timeframes, due to the differences in their objectives, political interests and economic power.

6.4. Recommendations for Future Actions

As stated above, the objectives of the TORCH project have, for the most part, been met during the course of the project. Nevertheless, some work remains to be done, primarily in the areas of concept development, validation and cost/benefit analysis. Future actions should therefore focus on the following areas:

- **Conceptual Development:** The concept of operations currently under discussion in Europe (e.g. Multi-Sector Planning, autonomous aircraft in future ATM) should be brought within the high-level operational concept with layered planning and re-planning/flight phases. In this complete ATM context, the missing low level functional descriptions should be provided. This has to be complemented with a selection process for the available options (e.g., Multi-Sector Planning could be implemented as complexity-based analysis, conflict-based analysis, flow-based analysis etc.). Furthermore, an outline architecture should be developed in order to derive implementation options. Of course, zones with different traffic densities and traffic complexity will need to be differentiated.

- **Validation Activities:** The main emphasis in the near future should be on validation activities rather than providing real-time platforms. The validation of an operational concept like TORCH requires a combined tool set with subsequent validation steps. The output data from one tool is used as input data for the next tool in a stage of dependent validation exercises. The format of the output of existing tools should be modified for this purpose. Certain functionalities may also need to be added in particular in the area of the proposed layered planning and re-planning (the core of the TORCH Operational Concept).

  In particular, a staged validation approach could embrace an ATFM model of TORCH which outputs an tailored DOP. This, together with additional flight plans and other non-planned events, would be used as input to a centre planning model, with attached new tool set like Traffic Load Analyser. The output of this tool would be input for Multi-Sector Planning, with associated tools like Medium Term Conflict Detection. Finally this is input to an real time simulator with tools like Conflict Resolution Advisory. Of course, the roles and tasks of the air traffic and flow controller have to be defined and described carefully because there will be significant differences from the current situation. Associated CDM applications (e.g. in the area of capacity / demand balancing) have to be defined and integrated.

- **Cost/Benefit Analysis:** In order to accelerate decision making for all stakeholders, a cost/benefit analysis (CBA) should be carried out. The CBA should be carried out in conjunction with the aforementioned conceptual development work and the validation activities because the assumptions of a CBA are highly critical and are often questioned. Moreover, the better and the more obvious the operational benefits are, the higher will be the cost benefit ratio. Also here different traffic zones and implementation strategies will need to be taken into account. A further differentiation as applied in TORCH (e.g., of stakeholders, traffic complexity etc.) should be pursued. If the outline of an architecture is already known, more precise figures could be provided by an CBA. The promising results of the Analytical Hierarchy Process (AHP) methodology could be an excellent starting point.

Appendix A. Stakeholders' Roles in the TORCH Concept.

Table of Contents

1. Introduction

The objective of this document is the description of the TORCH Operational Concept through the point of view of the main stakeholders involved. As a result of the WP6 Kick-Off Meeting three main areas have been selected to perform this type of description:

1. Layered Planning.
2. Re-Planning.
3. Real-time Operations (Flight Execution Phase).

These areas were used to present the TORCH Operational Concept in the TORCH User Forum held in Brussels on September 7th-8th 2000 as well as to perform the assessment phase in WP3,4 and 5 of the TORCH project [see D1.1].

2. Central Organisations & ATS Providers

2.1. Layered Planning

2.1.1. Central Organisations

More than a year before the Day of Operations a strategic frame has to be established by integrating the inputs from each stakeholder's individual strategic planning schedules (AO, APO, ATSP).

Three central data stores[1] are considered to be used in this process:

- An environment and forecast data store: Containing environmental data and weather and statistical forecast data.

- A central Demand/Capacity data store: containing individual demand and capacity data and consolidate Demand/Capacity data.

- A central DOP data store: Containing the evolving DOPs and the approved DOPs.

A central ECAC organisation will be in charge of maintaining these three data stores and they will be updated by the individual stakeholders during the Planning Process up to the development of the approved DOP.

The Airspace Management Cell will be in charge of developing a strategic Airspace Plan including the airspace structure and its predicted use. This data will be stored in the first of the three previous data stores. Along the optimisation process the Airspace Management Cell will optimise the airspace structure (fixed and conditional routes) and update the availability of SUAs and TSAs for the day of operations by the FUA collaborative process.

To provide more reliable traffic demand data, independent sources of data are integrated, such as travel booking organisations (GALILEO, AMADEUS, etc...), airline operators, national organisations and statistical forecasts.

During this period Airport slots are allocated, based on the airlines' scheduling, enabling airline operators to publish their Seasonal scheduling of operations (IATA Slot Co-ordination Conference) at least six months in advance to the day of operations.

The individual demand and capacity data is collected by the central D/C data store and, taking into account the environmental and weather forecast data, are consolidated using e.g. fast time simulations. If the simulation on the consolidated capacity and demand data shows that capacity and demand are not balanced, a conflict of interests resolution process is being carried out between the ATSP, APOs and the airspace users. This process will enable all stakeholders to plan their activities in advance for a time period in the future including the day of operations. For this CDM process rules are set to determine the access to airspace, routes and airports as well as capacity/demand prediction models.

Thus, the process consists of two steps: first step develops solutions for the capacity/demand imbalances and second step allocates demand/capacity resources and develops the plan. A central ECAC organisation[2] will host this demand/capacity balancing process, managing the search of shortfalls and strategies for solutions.

Within each loop of this planning process an evolved DOP has to be stored in the central DOP data store. At the end of the process, the day before the day of operations, the approved Daily Operational Plan (DOP) is distributed. It includes:

- The traffic demand, including flight plans with 3D flight profiles.

- The Capacity data (airspace and airports).

- The Airspace Plan, including fixed and conditional routes, as well as restricted areas.

Tailored versions of the approved DOP will be stored to the individual DOP of the stakeholders and to all regional DOP data stores[3].

All parties (including general aviation and military operators) are informed about the updated Daily Operational Plan in real-time and may take advantage of changing conditions in a continuous process.

---

[1] This is no architectural design issue. TORCH has used three central data stores for the business process modelling assessment of the planning phase.

[2] This organisation will contain the current CFMU functionality and could be the same that manages the three defined data stores. This political issue is outside the scope of the Project.

[3] The regional data stores could be four or five within the ECAC area, which could be managed and maintained by the national ATS Providers or by supra-national organisations.

2.1.2. ATS Providers

National Air Traffic Service Providers organisations will provide their individual plans of foreseen capacity for the day of operations to be stored into the central data store. They will provide the following data:

- Historical data and analysed air traffic statistics. Results from statistical data analysis.
- Long/medium term traffic forecasts trends in traffic demand growth.
- Constraints of ATM adjacent areas to their regional responsibility area: Acceptance rates, airspace constraints, expected airspace regime.
- ATS system capacity and options: sector and airspace capacity as result of e.g. fast time simulation and statistical data available from the ATM provider, Terminal Area ATM capacity, en-route ATM capacity, availability of ATM resources (ATM infrastructure, personnel).

These data will be stored, in addition to the data provided by other stakeholders, in the central D/C data store. Afterwards all data will be used by the demand/capacity balancing process. The ATS providers will participate on the conflict resolution process, which is to be carried out between them and the other stakeholders.

The involved ATS-agencies/units level ranges from individual planning carried at centre level, to an integrated planning carried at a multi-centre level for the Central Planning task, and from Multi-Centre to Centre Level for Local User Optimisation. After the re-planning process, the complete approved DOP will not be updated, only affected tailored DOPs will be updated.

2.1.3. Military Issues

2.1.3.1. Military ATM Provider

Segregated military ATM provider may be considered either as external ATM system with limited interfaces or as integral part of an TORCH Operational Concept. Depending on this decision the required co-ordination functions differ considerably. Although preference is given to the latter version, the Operational Concept has to cope with both versions. Anyway it is a political issue out of the present discussion.

Military ATC units will be treated as adjacent units if segregated from civil ATS. In this case it is necessary for the two systems to exchange information on planned flight trajectories and control intentions to maintain the efficiency and flexibility of the operational concept while retaining the target level of safety. It is anticipated that military air traffic will use ECAC ATM services which provide user preferred trajectories for priority flights, autonomous operations in FFAS and the allocation of segregated airspace, when required.

2.1.3.2. Military Agencies

According to OCD the introduction of the FUA concept is the first stage in a move to the optimisation and more flexible use of the ECAC region airspace resources. Planned extensions to the concept to include full ECAC-wide civil and military airspace co-ordination will pave the way to greater flexibility.

2.2. Re-Planning

The DOP is evolving until the day before the flight, when finally the DOP is approved. During the day of operations the plan can be re-planned and optimised until two hours before the flight. At this moment the flight plan (including flight 4D profiles) is approved and agreed by the ATFM and the AO. The data available on flights at that time are scheduled or planned times. Later changes to this period are managed by the ATS Centre Planner.

During the day of operations, each stakeholder, based on their tailored DOP will carry out the individual operations. All stakeholders permanently store their actual operational data to the affected regional operations data stores. The processes real time operational plan optimisation, en route planning and terminal area sequencing will use these data.

In case of unforeseen events (e.g. fast changing weather conditions or new flights not contained in the DOP) at the day of operations, a real-time re-planning is required. The stakeholder concerned to the event will have to rate the impact of the event to the running operations. The decision making between Central Re-planning and Local User Optimisation is related to the magnitude of the event and its consequences (local or non-local). A wide area event may trigger a DOP update; a local event may trigger a tailored DOP update or just a CDM action.

The tactical planning activities are developed during the time the flight is finally approved and the flights plans enter an ATS controller area, or the flight departs from an airport within the ATS controlled area,. During this phase some changes or events may occur, affecting the planned operations. From the ATS Providers point of view this phase, which includes functionalities such as En-route Planning or Terminal Area Sequencing, affects mainly local ATS Control Centres.

Regarding En-route Planning, En-route Metering functions are hosted and managed by the newly introduced “ATS centre planners”, and the Multi-Sector Planning will be performed by the Multi-sector Planner:

2.2.1. ATS Centre Planner

The ATS centre planner will:

Identify future traffic overload and congestion situations, with a time horizon of about 2 hours[4] through automated traffic analyser and workload predictor.

---

[4] The tactical planning phase starts 2 hours before the flight takes off. During this period of time the ATS Centre Planner deals with the local flow management function managing changes on the flight plan.

- Determine solutions varying from flow regulations, change routes, Terminal Area sequencing constraints, next unit/adjacent ATM sequencing constraints and change agreed airspace centre/sector acceptance rates etc...

- Negotiate solutions with planners affecting the situation through automatic negotiation tools and aeronautical network.

- Distribute changes to all affected stakeholders.

In order to analyse the planned (DOP) and actual air traffic situation and the availability of resources on centre and multi-centre level, En-Route Traffic Analyser and Traffic Load Analyser tools are used (with a prediction time horizon of at least 2 hours).

2.2.2. Multi-Sector Planner

The Multi-Sector Planner will:

- Detect conflicts within 20-30 minutes horizon through an MTCD.

- Find solutions to the conflicts detected with the assistance of a conflict resolution advisor.

- Decide on the solution to be taken and distribute it to the stakeholders.

- Deal with individual trajectory change request, assess and negotiate them with the AOC.

- In addition to the above task, the Multi-sector Planner could perform also tasks of planning controllers of individual sectors (avoiding inter-sector co-ordinations within the multi-sector area).

Multi-sector planning is a new function in ATC. Controllers will be able to plan traffic and solve potential conflicts by the use of MTCD. This permits the change from re-active to pro-active ATC.

The multi-sector planning concept implementation as described in section 2.3 will be essential for implementing new concepts of operations such as free routing.

2.3. Real-time Operations (Flight Execution Phase)

Specific ATC centres perform the following activities: collect surveillance data from different sources (PSR, SSR, GNSS, etc.), compile the surveillance picture for their area of responsibility (the set of these pictures for the whole ECAC provides a whole picture of the traffic in the ECAC airspace) and distribute the results (surveillance data, with correlated tracks) to ATS providers having requested it.

For the detection of future conflicts, the controller evaluates the position and current and future intentions of the aircraft to identify infringements of separation criteria between trajectories or between a trajectory and any defined airspace volume. Performance Management records separation infringements (number and quality) for later use.

[D3.4] Lists new ground and airborne tools introduced by TORCH (e.g. negotiation tools, ACAS, data-link, etc...) and summarises their influence on the technical and operational aspects within the TORCH context.

In the specific case of free-route airspace, the process is much the same, except that:

- Traffic is likely to be more complex, as free routing is normal in this airspace; traffic density is monitored to keep the situation under control.

- The controller is fully responsible for the aircraft.

- Specific equipment maybe onboard of aircraft flying in this airspace (e.g. ASAS).

3. Aircraft Operators

3.1. Layered Planning

The role of Aircraft Operators (AO) should move towards more involvement in the planning processes and in taking decisions together with ATS, airports and Central Flow Management e.g. regarding route negotiation and re-scheduling of flights. In case of constraints, the AO should be involved in decision taking because they are affected economically.

Flight Scheduling is concerned mostly with strategic events e.g. the aircraft/fleet purchasing planning, aircraft type allocation to route, seasonal flight scheduling. The result of these activities will be a published schedule covering a traffic season after co-ordination with airport and ATM authorities. The process begins 2 years in advance to the day of operations and will finish at the IATA Slot Co-ordination Conference. This plan will consider economic development forecast and the expected airport capacity for schedule planning.

Since the seasonal flight scheduling is published, AOs will start their individual planning process for the day of operations. Each AO will provide and update their planned demand data for the day of operations to the central D/C data store. They will provide the following information:

- Flight Plans (3D trajectories).
- AO individual preferences and options.
- The aircraft and flight-crew ability will also be included in their demand data.

By using the available Demand/Capacity information, AOs will adjust and optimise their individual planning, providing their new optimised planning data to the central data store. During this optimisation process AOs will be able to request for evaluation of FPL probing (What-If) to the central organisation in charge of demand/capacity planning. Airlines will have also the opportunity of performing their own simulations and FPL what-if probing.

In case of demand and capacity are not balanced, AOs will participate in the CDM process to find solutions for the predicted problems by adjusting their planned demand.

When the DOP is approved and distributed each AO will receive their own tailored DOP in order to carry out their individual operations. In case of a non-planned event concerned to an AO (e.g. an aircraft change due to technical problems) occurs, the AO will rate the impact of the event on the running operations (individual to the AO, regional or central), and depending on their magnitude an individual, regional or central re-planning process will be triggered. After re-planning the concerned DOP data store (individual, regional or central) will be updated.

If the AO plans an unscheduled flight during the day of operations, a request for re-planning of the DOP has to be made to the central flow planning (ATFM). By CDM procedures the central planning has to ensure co-ordination between Airports and ATFM slots before accepting the flight.

3.1.1. Military Aviation

To prevent problems related to the co-existence of civil and military flights, Military Agencies will:

- Exchange flight data with ATM for co-ordination of military and civil flights in appropriate airspace areas and to assure the integrity of national airspace (air defence task),
- exchange information on airspace usage (surveillance data, anticipated traffic, airspace constraints, route network, rules, regulations, procedures, etc...) to facilitate efficient use of airspace resources,
- provide Air Traffic Services to Operational Air Traffic (OAT).

This involves the exchange of planning and real time information concerning intended and current airspace usage, restrictions and forecast and real time data concerning individual flights.

3.1.1.1. Air Defence Operations

Provisions have to be foreseen in the Daily Operational Plan to accommodate operational air defence missions with appropriate priority as well as other state aircraft that require priority.

Air defence organisations are provided with that information on known air traffic necessary to perform their task.

3.1.1.2. Military Airspace User

Military aircraft need to be able to reserve airspace for training and exercise activities. This demand may be announced months in advance (large-scale exercises) or with relatively small pre-warning times. The Operational Plan Development integrates these requirements through established information links. It aims at reducing the effect of segregated airspace for other users to acceptable thresholds. Enhanced civil/military co-ordination, involving exchange of flight plan and airspace use information, enables military air traffic to take user preferred trajectories, thus improving flexibility and flight efficiency. The military airspace user makes available the reserved airspace for common use when not needed any more.

3.1.2. General Aviation

General Aviation (GA) is considered by the TORCH process under the same point of view as the other aircraft operators (AOs). The main difference between GA and airlines is that their demand is not usually planned as far in advance as the airline operations.

The Strategic Planning Phase for GA will remain basically as it is nowadays. Anyway GA will take advantage of the improvements developed by the TORCH Operational Concept. In this sense GA operators will collect suitable data to plan their flight (route and SUA dimensions and timings, capacity forecasts, airport arrival/departure slots, etc...) in an easier and quicker way.

The demand and capacity balancing process will take into account statistical forecast data about GA demand. As soon as general and business aviation operations are planned they are introduced in the system to update the DOP. GA flights may require special reservations of MAS to suit their particular requests (e.g. air shows). DOP, through CDM processes, will enable to react more quickly in the allocation of reservations of these MAS volumes.

Due to the fact that most of GA operations are not planned before the day of operations, they will have to be considered as non-planned events and will affect to the re-planning process. Anyway they take advantage of the enhanced planning environment described in the general description of the Strategic Planning Phase.

3.2. Re-Planning

During this tactical flow planning phase AOCs are aware of the traffic en-route and other useful information such as sector loads or dynamic capacity. AOCs have also to be informed about any disruption (strong lack of capacity) which may happen and may affect the planned flight. Along this phase the AOC can request changes on the flight plan using CDM procedures with the Local Flow Management. The AOC can request re-routing options, to get a user preferred route closer to their needs, or can ask for slot shifting, swapping, substitution or cancellation. The improvement to the current situation is that the information about real-time events -which may delay flights- is distributed in real time to enable the re-planning of affected flights.

The AOC has the opportunity to propose a new route to the Local Flow Management changing the previous one during this planning phase when more than two sectors are affected. The ATS Centre Planners assesses the traffic situation and approves or rejects the 4D-trajectory change requests (time is included).

CDM provides airline operators with the ability to negotiate their plans during the planning phase but also to exchange information using on-line communications including electronic conferencing means to handle critical developments in the airspace. Flight planning and flight plan preparation is generally supported by data processing systems (dispatch system) to improve operational flexibility and to reduce flight preparation costs.

3.2.1. Military Aviation

GAT flight planning is normally similar to that for civil operations, but flight plans may be submitted and have to be accommodated, at very short notice. Differences from the standard required airborne equipment fit is stated in the flight plan. Military aircraft not contained in the Strategic Plan have to be announced at least two hours before intended departure and will be included in DOP updates. Anyway some GAT and OAT missions could occur at short notice, thus flight planning turns into a real-time activity or with airborne equipment not compliant with civil requirements (special airspace allocation).

CDM processes take into account unforeseen events to improve the overall awareness. Military airspace users are informed about the updated DOP in real-time and take advantage of changing conditions in a continuous process.

3.2.2. General Aviation

The TORCH process treats general Aviation (GA) in the same way as the other aircraft operators. The main difference between GA and airlines is that their demand is not usually planned as far in advance as the airline operations. In this sense, all flights (e.g. business flights) not contained in the Strategic Plan have to be announced at least two hours before intended departure and will be included in DOP updates.

The availability of an updated DOP in real-time lets airspace users to inspect and analyse the current situation to assess the re-routing options and optimise the gate-to-gate flight trajectory. CDM processes are in charge of taking into account unforeseen events that may affect airspace users.

3.3. Real Time Operations (Flight Execution Phase)

Flight management on board is supported by FMS systems, which keep the aircraft in a 4-dimensional cell and provide high navigation accuracy in 3 dimensions, or advanced FMS systems providing navigation accuracy in 4 dimensions (lateral, longitudinal, vertical, and time). The systems are based on data link communication with ground systems for the exchange of data on e.g. meteorology, cleared flight path, requested (optimum) flight path (trajectory). A situation display (CDTI) will present a comprehensive and selected picture of other aircraft, their trajectory information, adverse weather situations and terrain features.

Throughout the flight, the FMS and the AOs databases are kept synchronised via data-link. The AOC monitors changes in weather, airspace and other CNS/ATM environment data and uses information-push to update the FMSs of affected flights. The AOC uses its real time data (flight operations by comparing planned track data with live position data, changes in weather and airspace and other CNS/ATM environment data) to optimise fleet operations and supply its aircraft with directives and environment data updates. In return, AOCs are notified of changing intentions that are proposed or decided by the flight crew.

3.3.1. ASAS applications

ASAS equipment onboard allows (although only a part of the fleet will have the necessary equipment) [See [D2.3 Annex A] and [D4.3] for ASAS applications]:

- Traffic situation awareness: pilot is provided with data on his environment (status, position, and when possible intentions of other traffic with respect to his own trajectory). This applies in the air, and also may apply on the ground (provided other aircraft and vehicles are equipped).

- Tactical co-operative applications help to manage the relative movement between two aircraft while they are in close proximity to each other. The pilot receives full responsibility delegation from the controller for the duration of the application with aircraft involved. The service has a clearly defined operational goal, with a begin and end operational event. Examples about these applications are Longitudinal station keeping (en-route and in TMA), and closely spaced parallel approaches (in TMA). [See ASAS applications and Longitudinal Station Keeping in [D4.3]].

Although presently and in the near future separation assurance will be a ground systems function, during the TORCH timeframe the responsibility for SA may be delegated to the aircrews of suitable equipped aircraft. The availability of this airborne function will highly depend on relevant technical enablers (CDTI and conflict resolution tools).

3.3.2. Safety Nets

This has to be supported by hazard assessment functions including further improvements on safety net functions (Short Term Conflict Detection, Area Proximity Warning, Minimum Safe Altitude Warning and Airborne Collision Avoidance) based on the integration of airborne and ground systems. Enhancements to the HMI will make these tools more usable by controllers and prevent false alerts.

3.3.3. Gate-to-Gate

Gate-to-Gate planning conducts those navigational, flight guidance and trajectory planning activities necessary for the successful conduct of the entire flight. The flight operations planning and the monitoring and control function of flight operations may be combined to form an airline operations cell (AOC) to provide consistent information management.

3.3.4. Free Routing

Regarding free-routing operations, they should be planned as soon as possible. Airlines may request preferred trajectories for their aircraft. But free routing may also be requested during the flight. In this case, the pilot may request changes in the trajectory in order to choose the best trajectory (outside the route networks). This request will initiate a trajectory negotiation process with the planning controller. In order to prevent overload of the executive controller, trajectory might be negotiated between pilot and planning controller. This negotiation has to be accurate. To improve trajectory negotiation, aircraft that want to use a preferred trajectory have to be equipped with FMS and data link. It is expected and assumed that, within the TORCH timeframe, only part of the fleet will be equipped.

3.3.5. Other Airspace Users

3.3.5.1. Military Aviation

Military flights operating as GAT will comply with the corresponding rules and procedures to the maximum extend possible. Aircraft operating as GAT on a regular basis will be equipped to the appropriate civil standard following appropriate procedures. Anyway some GAT and OAT missions will require special procedures to be developed in an ECAC-wide harmonised way. It should be noted that the ATS for OAT flights may be provided by military ATC, civil ATC or Air Defence.

Co-ordination with Military Operators, involving exchange of flight plan and airspace use information, will benefit to both Airspace Users and military air traffic enabling them to get user preferred trajectories, improving flexibility and flight efficiency.

3.3.5.2. General Aviation

Flights not equipped with data-link rely on voice R/T for the exchange of ATC instructions. For aircraft that can fly 3-D but cannot negotiate a 4-D trajectory, ATC using DMSwill provide departure trajectories that match the notified performance capability of the aircraft. In congested areas there will be the possibility of direct routing (subject to sector workload) and limited opportunities to perform real-time optimisation. In less busy airspace there will be more freedom to optimise the flight trajectory.

4. Airport Operators

4.1. Layered Planning

Today airport operations are not integrated adequately in the ATM process. Airport Strategic Planning starts years in advance. Resource planning should be performed in a collaborative decision making process involving all actors being part of the airport planning. Extra capacity may be made available by building alliances at neighbouring airports (airport cluster) to optimise their overall performance. Selecting airports for small aircraft or cargo operations to enable the dominating (hub) airport to cope mainly with wide body aircraft and high passenger's demand may do this. This sort of task splitting needs also to be integrated within an inter-modal planning that takes into account the roads and the public transport.

For the demand/capacity determination and planning airport operators will provide the necessary information to the central D/C data store. This information will contain the airport capacity, including operating hours, capacity values for different RWY/weather scenarios, acceptance rates, constraints and options. APOs will update this information if the situation changes before the day of operations.

Airport Operators, as the other stakeholder involved in the demand/capacity balancing process, will also participate in the CDM process to solve imbalances between capacity and demand. This process will enable Airport Operators to plan their activities in advance for a time period in the future including the day of operations, e.g. scarce resources like a runway system will be optimised.

In case of a non-planned event at the day of operations concerned to an Airport Operator (e.g. a runway closure caused by disabled aircraft on RWY), the APO will rate the impact of the event on the running operations (individual to the AO, regional or central), and depending on their magnitude central re-planning or local optimisation will be requested.

4.2. Re-Planning

Integration in a common modular planning system of arrival/departure managers (including sequencing and metering functionality) provides tactical arrival/departure planning for the next hour. It is updated continuously offering on-line aids to solve traffic flow problems in terminal areas. A human operator validates the proposed sequence. Arrivals, departures and ground movements are integrated to use optimal sequences: estimated times at various points including landing time, TMA entry/exit conditions, SID/STAR and runway allocated.

The airport operator monitors the progress of the DOP. It is kept informed through the central airport database (being updated by involved airport stakeholders). It is also responsible for monitoring other changes (e.g. weather) and communicating them as well as the resulting airport configuration to other stakeholders. Arrival and departure managers usually take data from other systems such as radar data processing, flight data processing and weather data processing.

CDM processes allow coherence between ATFM measures and airport capacity/resource planning during the tactical planning phase (introduction of stand manager, push-back vehicle manager and taxi planning manager). Today these processes are treated independently. In the same way a common situational awareness is provided to all stakeholders as well as common agreed algorithms for decision making processes (e.g. use of runway, order of departures). CDM processes also support the gate-to-gate strategy by data communication with en-route planning.

The Surface Management System is considered complementary to the arrival, departure and runway managers and the stand allocation service and the future evolution of this system will be its integration in a common planning system architecture to take advantage of collaborative planning methods in the whole terminal area.

4.3. Real Time Operations (Flight Execution Phase)

Data from information and management tools (especially aircraft movement data) already installed by various actors will be used as input data sources. Special data quality indicators will be given to identify the best information for getting optimum results.

Airport operations support, real time resource allocation and Surface Management function should be assisted by a Local Decision Support Tool (LDST) using commonly agreed algorithms, parameter and metrics. By this all actors will be given a common situational awareness representing the actual and planned overall situation at the airport. All actors will have access to this LDST and will be able to communicate proposals (what-if) and preferred solutions. All data will be transparent to the actors involved.

The LDST will give the actors a planning horizon of about 24 hours. Disruptions of service by emergencies (e.g. thunderstorms) could be more easily assessed and made visible to decision-makers. This refers also to short term contingency measures.

Solutions influencing the planned arrival times and arrival sequence should be co-ordinated with en-route planning to ensure an uninterrupted gate-to-gate planning process. In case surface management tools (A-SMGCS) will have no overall planning function, this can be done by the LDST as well. Surface Control Positions are in charge of monitoring, guiding and controlling aircraft on the airport.

In this sense a central airport database and an automated local decision-support tool manages the real-time resource allocation.

5. Regulators (CAAs, Military Organisations, Standard Regulators)

5.1. Layered Planning

ATM Regulator Organisations (or other authorised bodies as Standard Regulators, etc...) are provided with ATM data (statistical data, forecasts trends, current and forecast airspace utilisation, etc...) to support policy and regulation development. In this sense the performance feedback is used to identify deficiencies in Safety, Quality of Services and the effectiveness of the ATM system and consequently formulate strategic directions and policies, constraints, ATM infrastructure requirements and actions necessary to reach agreed targets for future operations.

Military operations are supported by efficient and effective civil/military co-ordination both at a procedural and system level. The rules applicable to this kind of operations are promulgated nationally although co-ordinated for harmonisation within ECAC between civil and military authorities.

5.2. Re-planning

Air defence organisations are provided with suitable information on known air traffic necessary to perform their tasks. Operational air defence missions are accommodated within DOP to respect their priority. No other organisations are expected to be affected by the tactical planning phase.

6. Weather Service Providers

6.1. Layered Planning

Meteorological data processing collects, collates, edits and provides a source for meteorological information for the entire area of interest, and ensures that meteorological information necessary for the safety, regularity or efficiency of air navigation is available in suitable form for:

- Flight operations including flight crews and services responsible to provide pre-flight meteorological information and in-flight information.
- The air traffic services units responsible for current ATM operations including flight information service.

It is provided meteorological information relevant for a defined area of interest and/or time window. Such an area of interest may be an airport, the area of responsibility of an ATM service provider, or the flight route/trajectory of an active or planned flight.

6.2. Re-Planning

Short term forecasts and current MET data are used for flight planning and during flight. These data will be selectively extracted from the relevant MET data bases (managed by appropriate weather service providers) using the flight plan data as a search criterion in order to present to the users only those data relevant for the planned flight. The user may also call down other MET data applying other user defined search criteria. The functionality required providing MET data to aircraft in flight may be implemented as part of the Flight Information Service (FIS) functionality. This component will receive current and validated MET data via data link (to a limited extent also via R/T) for the provision of individual and user specific MET information. It will relay to the MET Service meteorological data reported by aircraft in flight.

Weather agencies provide forecasts, extracts from the relevant MET databases data relevant for each flight, presents selected data to planning functions and provides access to MET data through other criteria when needed.

6.3. Real Time Operations (Flight Execution Phase)

Weather surveillance data, received directly from aircraft, will be routed to Weather Bureaux for the development of new forecasts / nowcasts. During the flight, MET relevant data are extracted from the databases and are presented to the controllers on screens. Transmission of weather information useful to each flight through data-link is part of the FIS. If needed the controller may provide weather information to the pilot via R/T.

Appendix B. Summary and Analysis of the Technical Assessment.

Table of Contents

Index of Tables

1. Introduction

This appendix:

- First briefly summarises WP3 objectives, method and results, concluding with what part of the TORCH operational concept could be considered technically feasible in 2005,

- then analyses results, focusing on 2005, and on uncertainties, decisions to be taken, and related risks in decision making (and possible solutions for mitigating these risks).

2. Summary of the Results of the Assessment of the Technical Feasibility of the Operational Concept

2.1. Objectives and Method

The assessment conducted in WP3 aimed at answering the following question:

"Will the ATM community be able to get technical products meeting the requirements of TORCH Operational Concept early enough and, if so, when?".

In this question, and in the following, "product" must be understood without any commercial connotation; that it can be used operationally is the only point of concern.

More precisely, the WP3 primary objective was to make clear whether, practically, the TORCH operational concept is technically feasible (in its time frame), i.e. **to make sure that all technical products required by the TORCH operational concept can be made available early enough to be put in operations before the end of the TORCH time frame (2005-2010).**

The second, related, objective was to try to determine how to proceed so that these technical products will actually be available early enough.

The method used for this assessment consisted of the four steps below:

- First brief assessments of critical enablers, to identify which ones are most fundamental, and most difficult to achieve.

- More detailed assessments of the ones identified at previous step, leading to schedules of the activities necessary before their operational use.

- Study of interoperability and interdependency issues.

- Possible transition steps.

The main aspects assessed in second step were:

- Critical TORCH requirements related to products to be assessed.

- How products that can be expected comply with TORCH requirements.

- Schedule of these products

Practically, for each item considered as both critical to the TORCH concept and difficult to achieve, the following points have been addressed:

- Maturity.
- Performance issues.
- Activities required to make it operational.
- Time required for each of these activities.
- Overall technical feasibility timeline.

Then, interdependency and interoperability issues have been addressed. When required, dates obtained from the previous step have been delayed to take these interdependency factors into account.

2.2. Summary of Conclusions of Individual Assessments

The following table summarises conclusions resulting from individual assessments.

In this table, grey boxes give an idea of the time necessary before the item can be used in operations.

<table>
<tr><th></th><th>2001</th><th>2002</th><th>2003</th><th>2004</th><th>2005</th><th>2006</th><th>2007</th><th>2008</th><th>2009</th><th>2010</th></tr>
<tr><td rowspan="5">Central organisations</td><td colspan="6">Demand prediction tool based on demand model</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="6">Capacity determination tool based on capacity model</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="4">ECAC-wide demand-capacity planning tool</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="9">Central DOP production tool</td><td></td></tr>
<tr><td colspan="9">Decision-support tool in case of an unexpected event with a wide effect</td><td></td></tr>
<tr><td rowspan="5">ATS provider</td><td colspan="4">Demand-capacity planning tools (for ATS providers)</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="4">Negotiation tool with adjacent agencies (for local demand-capacity planning by ATS providers)</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="9">Decision-support tool in case of an unexpected event with limited local effect</td><td></td></tr>
<tr><td colspan="5">Negotiation tool, with fast time simulation support, for negotiating with airlines, and with adjacent agencies</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="6">Ground "trajectory negotiation tool"</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="8">Airports</td><td colspan="4">Demand-capacity planning tools (for airports)</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="4">Negotiation tool with adjacent agencies (for local demand-capacity planning by airports</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Arrival manager</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">Departure manager</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="10">Various airport resources management tools (co-operative)</td></tr>
<tr><td colspan="3">Airport surveillance data fusion tools</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Airport conflict detection tool (runway incursion)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="6">Airport conflict detection tool (taxiway conflict detection)</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="5">Aircraft (equipage started)</td><td>VDL mode 2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="3">ATN router</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="3">ODIAC applications</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="7">ADS-B</td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Airborne A/G trajectory negotiation tool</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Table 2-1 Summary of Conclusions of Individual Assessments

2.3. Discussion of Interdependencies and Interoperability Issues

If a technical product is required by the TORCH operational concept, having it implemented is a necessary condition, but does not allow the actual implementation of the concept until it can actually be operated: if other products have to be adapted to communicate with it, they must be adapted first before making the new product operational; if some other functions are required, because they are used by the new product (pre-requisites), they have to be implemented first, too.

Major general interdependency issues are as follows:

- **The infrastructure required has to be ready before applications using it can be used**. This is especially important for communication infrastructures, as communication underlies much of the TORCH operational concept. This is true at all levels: local level, inside an organisation (e.g. in an ACC) or between organisations (e.g. in an airport, between tower ATC and airport authorities), up to the European level. Air/ground data communication is also a pre-requisite for some parts of the TORCH concept.

- **Common formats and protocols have to be defined before applications using them can run**. A typical example is the DOP. All applications using the DOP depend on its existence (and on the capability to produce an initial DOP).

- When a new tool has to communicate with another new tool, both tools have to be ready before they can be made operational. A typical example is the air/ground trajectory negotiation: both an airborne tool and a ground tool have to be operational to make the application work.

- Existing products have to be adapted to the presence of new ones whenever needed. These changes may sometimes involve a large work. For example, a surveillance data fusion system not dealing with ADS-B has to be adapted when ADS-B is made operational. This new source of surveillance data impacts on algorithms and on computer capacity.

2.4. Timeline

This timeline was expected to identify some transition steps toward the full TORCH Operational Concept.

However, as dates resulting from the assessment are not precise and certain, it would not make much sense to plan a very detailed timeline within TORCH time frame. It has therefore been decided to limit it to three steps (actually transition concepts), respectively about 2005, about 2007 and about 2010.

These transition concepts were defined according to what is expected to be technically feasible before each of these dates. This assumed that technical enablers which had been considered not schedule-critical in step 1 of the method are feasible before 2005. This also considered interdependencies (that may lead to further delay of some items).

Finally, the following table was obtained:

	Possible use for 2005	Possible use for 2007	Possible use for 2010
Central organisations	Co-ordination tool for airspace status management (for E1)	Demand prediction tool based on demand model	Central DOP production tool
	Fast-time simulation to ensure that the airspace plan is feasible (for E1)	Capacity determination tool based on capacity model	Decision-support tool in case of an unexpected event with a wide effect
		ECAC-wide demand-capacity planning tool	
		Fast time simulation tools (for E1; airspace plan development)	
ATS providers	En-route metering tools (for E5) (some exist in the USA)	Ground "trajectory negotiation tool"	Decision-support tool in case of an unexpected event with limited local effect
	Surveillance service system (for E7)	MTCD tool (using 4D FMS trajectories when available)(for E5)	Negotiation tool, with fast time simulation support, for negotiating with airlines, and with adjacent agencies
	Flight plan service system (for E7)	Conflict resolution advisor (for E5)	
	ATC automated system (for E7)	Airlines/MSP trajectory negotiation tool	
	Automated controller agenda (for E7)	Demand-capacity planning tools (for ATS providers)	
	STCA, APW, MSAW (for E8)	Negotiation tool with adjacent agencies (for local demand-capacity planning by ATS providers)	
Airports	Arrival & departure managers	Airport conflict detection tool (taxiway conflict detection)	Various airport resources management tools (co-operative)
	Airport surveillance data fusion tool	Demand-capacity planning tools (for airports)	
	Airport conflict detection tool (runway incursion)	Negotiation tool with adjacent agencies (for local demand-capacity planning by airports	
	Central airport database		
Airlines		Airlines/MSP trajectory negotiation tool	Decision-support tools (for taking advantage of the DOP flexibility)(for E4)
			Negotiation tool for changes in the DOP (for E4)
Aircraft	VDL mode 2	ADS-B	ASAS
	ATN router	Airborne A/G trajectory negotiation tool	CDTI
	ODIAC applications		
	ACAS		

Table 2-2 Technical Feasibility Times, by Transition Step, Taking Interdependencies Into Account

From this table, the following step for 2005 can be derived:

Operational concept technically feasible for 2005.

This step is much based on the current concept, with the following improvements:

- For ASM:
  - A better, and co-operative, airspace management.
- For ATC:
  - Introduction of en-route metering,
  - First data link applications,
  - and new tools for improving controller's capacity (including an automated agenda);
- At airports:
  - Arrival and departure managers.
  - A-SMGCS (including airport surveillance data fusion, and runway incursion detection).
  - A central airport database.

Later steps, for 2007 and 2010, would be:

Operational concept technically feasible for 2007.

- For ASM and ATFM:
  - Better demand prediction and capacity determination, and a better, and co-operative demand-capacity management.
- For ATC:
  - Better trajectory prediction through downlinking of 4D FMS trajectories (from equipped aircraft).
  - Adaptation of rules regarding control commands to facilitate the use of FMS.
  - Thanks to better trajectory prediction, introduction of MTCD and associated conflict resolution advisory.
  - Introduction of A/G trajectory negotiation.
  - Introduction of multi-sector planning.
- For airports:
  - Taxiway conflict detection.
- Surveillance:
  - ADS-B (for a better surveillance, and for preparing next step).

Operational concept technically feasible for 2010.

This final TORCH step involves several major changes:

- Introduction of DOP, and all co-operative processes related to DOP.
- Introduction of areas with delegation of separation assurance responsibility.
- For airports: better, co-operative, airport resources management.

3. Analysis of Wp3 Results, Focusing on 2005

3.1. Shortcomings and uncertainties

It may be considered that risks about the first (2005) step are only minor risks, as this is a short term time frame. It is true that much of this step is composed of items already operational at some places, or available as prototypes. Uncertainties for this first step are actually much lower than uncertainties for next steps, which are longer term.

Nonetheless, estimating schedules for future ATM technical development always is difficult, as past experience unfortunately shows (even when specifications for each item are available). Therefore, all times must be taken with much precaution.

But the main uncertainty factor related to the time of operational use of a technical enabler is the fact that the assessment has been done on a **technical feasibility** basis. As long as firm decisions on the operational concept, and decisions of launching associated technical activities are not taken, there cannot be any advance towards the operational use of new technical means.

3.2. Decisions to be Taken

All decisions to be taken to make the first step operational in 2005 have to be taken without delay.

Most of these decisions have to collective to be most efficient. However, if it happens that a quick collective decision proves to be impossible, who should take the decisions is mentioned between brackets (in italics). In some cases, several options have been mentioned, to ensure that the decision is taken somewhere.

Main required decisions are:

- Decision to quicken the implementation of the communication infrastructures required (both for ground-ground and air-ground communications); (ATS providers, airports, airlines, etc., each for their domain of responsibility);

- Decision to specify formats and protocols required for co-operation and not yet available; this includes improved co-operative airspace management, and en-route metering; several levels of functionality should be designed to make progressive implementation possible (if this is justified by the complexity level, and if possible); (EUROCONTROL);

- Decision to develop requirement specifications for required products, when not available; in the case of en-route metering, experience of other countries (such as USA) should be used as input; (EUROCONTROL; ATS providers, airports, airlines, etc., each for their domain of responsibility; manufacturers);

- If these protocols and specifications are available, or as soon as a draft becomes available, decision to develop an industrial product on this basis; this development should be the opportunity to detect possible problems, and to refine what has been adopted, before possibly generalising the protocol as a formal standard; (EUROCONTROL; ATS providers, airports, airlines, etc., each for their domain of responsibility; manufacturers);

- Decision to be taken by authorities concerned (airport authorities, etc.) to **use** the various parts of the concept, and to **schedule** this use. Other decisions are less difficult, as they derive from this schedule (e.g. order required products, organise personnel training, etc.). (ATS providers, airports, airlines, etc., each for their domain of responsibility);

3.3. Risks related to Decision Making and Mitigation

Main risks related to decision making are:

- That no decisions are taken, or that decisions are delayed again and again;

- That decisions taken in the different European states are not consistent, or even conflicting.

Decisions-makers are not sure that the proposed operational concept is the right one; they want to be re-assured about it before taking the decision. The problem is that, except for very simple issues, it is impossible to prove anything about a new concept. So, decision-makers often tend to delay decisions again and again.

A potential approach for solving this problem might be as follows:

- Decisions may be taken, even knowing that they may be bad decisions; of course, these decisions should follow validation activities, but anticipate the "proof" that the decision is good. This is the only way not to delay operations of what seems to be good contributors to a solution to traffic problems. Of course, if new studies show, after this decision, that adopting the concept would be a mistake, the ongoing work would have to be cancelled.

- The major problem with this approach is financial (investment lost if the decision is eventually cancelled, or if the solution proves to be inefficient). However, the stakes are so large that imagining new financial solutions should not be too difficult. For example, some form of insurance for the risk taken for development of tools required by co-operative concepts promoted at the European level, this insurance being possibly funded at the European level (other sources might be airlines? passenger taxes?).

The risk of conflicting decisions is less important: better conflicting decisions than no decisions at all or delayed decisions: harmonisation is a somewhat natural process, as solutions that prove good in some states generally tend to be adopted elsewhere.

Anyway, this risk can be mitigated through a mechanism as mentioned above (decisions without risks are favoured over risky decisions).

4. General Conclusions on Technical Feasibility

Most of the TORCH operational concept seems to be technically feasible within the TORCH time frame. However, this does not say anything about its practical achievability, which also requires acceptability by operational staff, acceptability by all organisations involved, including airlines, validation of its operational and economic viability, and not too much delay in decision making.

Some critical points are:

- For the schedules to be realistic, **definitive decisions to begin the development of technical products required have to be taken without delay**. As these decisions have to be taken by many stakeholders, and often have to be preceded by common decisions about co-operation, this is a difficult issue. If, decisions are not taken early enough, estimated dates have to be shifted accordingly.

- **It should not be considered that developing each product once is sufficient**: given the market reality, the same kind of products will probably be developed by several manufacturers, in most cases, or at least, some adaptations of a common product to each system would be required.

- **That a sufficient proportion of aircraft is equipped is sometimes a condition required for the concept to behave well** (e.g. the more aircraft equipped with 4D-FMS, the more acceptable MTCD tools are likely to be, thanks to more reliable future trajectories). This is also a difficult issue, given the number of different airlines, and especially small ones or airlines with old aircraft.

This leads to the following recommendations:

- **Stress should be put on prompt decisions to use new concepts, and decisions on the associated schedule for development of technical products required** (decisions by ATS providers, by airports, by airlines, etc.). Of course, some of these decisions may be changed if reality of life makes it necessary but, in practice, firm decisions are required to make evolutions in the ATM system possible. A mechanism promoting these decisions and making them less risky should be designed (e.g. some insurance scheme to protect against the risk that the promoted decision eventually proves to be a bad decision).
- Generally speaking, estimated schedules involve large risks. In some cases, risks may be reduced by organising necessary developments into several levels, that can be made operational one after another, thus making gradual implementation of the new function possible. This should be done whenever possible.

Appendix C. Summary and Analysis of the Operational Assessment.

Table of Contents

Index of Figures

1. Introduction

The purpose of this appendix is to give a comprehensive summary of the results of the Operational Assessment.

2. Scope of the Operational Assessment

The Operational assessment has been focused on:

- Innovative ideas and new or not yet implemented operational procedures,
- core area with main traffic and high delay situation,
- provision of selected example solutions for all flight phases, i.e. planning phase, arrival and departure phase including airport operations, TMA and en-route phase.

The operational assessment has provided values for delay, capacity, efficiency indicators and related metrics with respect to the selected scenarios. The scope of these scenarios usually is limited to a dedicated FIR or airport. An optimal situation would have been a simulation of all ECAC airspace and airports including Air Traffic Flow Management (ATFM) with respect to all stakeholders involved. Nevertheless, this kind of validation was not possible not only because of the existing tools limitations, but also due to difficulties for applying overall simulation results to specific areas.

The following assessments have been made (refer to Figure 2-1). The tools have been selected according to DEVAM proposed methodology.

1. A global improvement in planning phases (Daily Operational Plan) will be beneficial and applicable to entire ECAC airspace and will improve efficiency by maintaining as much flexibility as possible.

   Methodology and Tool: Business Process Modelling, BONAPART.

2. An urgent need to improve situation in Airports and TMA in high and medium density areas in order to decrease delays. Therefore better planning related tasks have been identified within TORCH as a possible solution together with an integrated arrival and departure management (as CDM implementation).

   Methodology and Tool: Business Process Simulation and Fast Time Simulation, BONAPART and SIMMOD.

3. The application of station keeping in TMAs gives the expectation of gains in efficiency and flexibility as complementary solution for improving TMA management in general.

   Methodology and Tool: Quality of Service (QoS) paper study.

4. Finally for tackling the lack of capacity and flexibility in the en-route phases, a set of solutions has been analysed. This includes en-route planning (by means of en-route metering and multisector planning) and more flexible use of airspace (by means of free routing and Flexible Use of Airspace FUA).
   Methodology and Tool: Fast Time Simulations, RAMS, PUMA, TAAM (FATIMA Package).

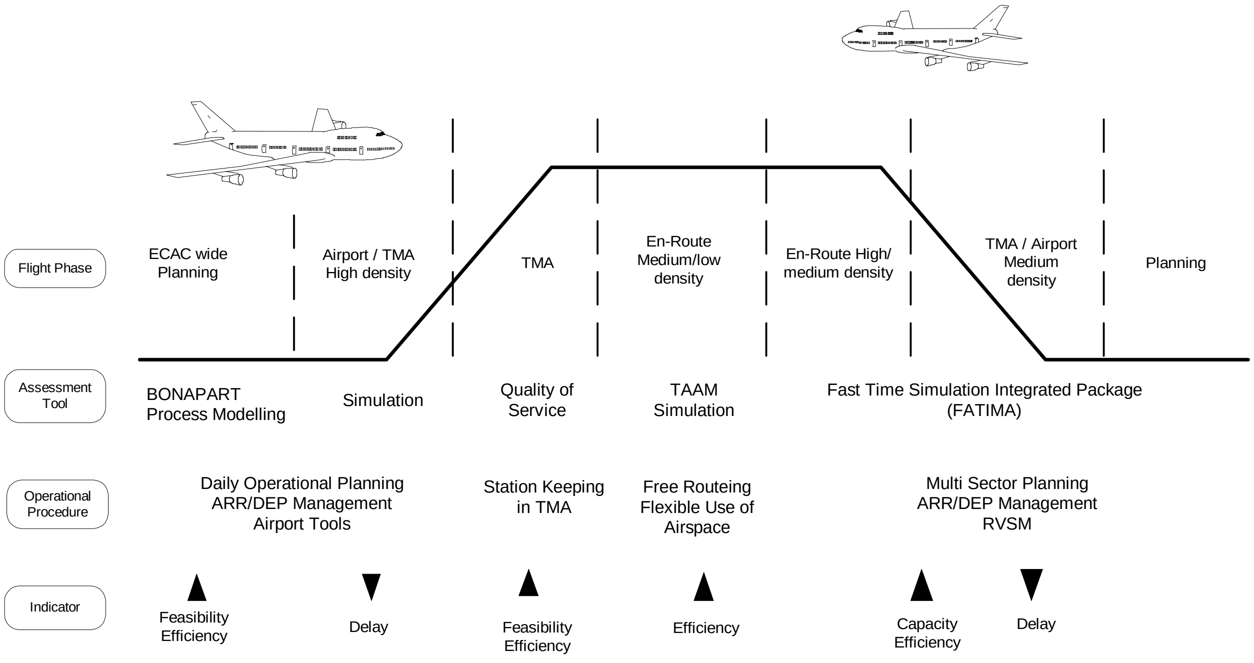

Figure 2-1 Scope of the assessment related to flight phases

3. Feasibility Analysis: Daily Operational Plan

The Daily Operational Plan (DOP) is a possible solution, as suggested by the EATMS OCD, to the structural problems affecting today ATFM. As pointed out by the EUROCONTROL Performance Review Commission (November 1999) the main structural problems that cause current ATFM delays can be resumed as:

- ATC capacity and demand imbalance.
- Airspace configuration ineffective.
- Forward looking planning insufficient.
- Staff-roistering for ATC sectors inappropriate.

Under this context the DOP is conceived as a further long term improvement in the planning process on ECAC level among all involved stakeholders. The DOP is intended to improve the process taking place from the strategic planning up to and including real time optimisation and is characterised as a look ahead planning function related to a specific Day of Operations.

3.1. Daily Operational Plan Objectives

The main objectives of this DOP are:

1. Enable layered planning process.
    - More accurate planning and balancing.
2. Early balance of demand and capacity:
    - Finishes 1 day prior operations and is updated during day of operations.
3. Better exploitation of available capacity.
4. Involvement of all Airspace users in DOP development.
    - Transparent decision making.
    - Synchronisation of data.

It is expected that all these mechanisms allow the implementation of the DOP principle to shift complexity into non-time-critical planning phases.

A model of all processes with interfaces and data flow was created in order to identify the functions, resources and data. It demonstrates the feasibility of the DOP development. The process Determine Demand and Capacity partly contains currently existing CFMU functionality. The scenario consists of two processes:

- Collect and prepare demand and capacity relevant information[1].
- Consolidate ATM system demand and capacity.

The system analyses the available capacity to define a series of configuration options for the allocation of resources in geographic, time, traffic mix and density terms. The anticipated capacity of the ATM system will be used as input for capacity management to meet demand. When comparing these processes with current CFMU functionality they extend this functionality e.g. by the enlarged planning horizon, more information and the evolving DOPs.

The process Develop and Implement Daily Operational Plan consists of six main processes:

- Simulate air traffic situation.
- Adjust capacity/ demand.
- Calculate Daily Operational Plan.
- Approve, tailor and distribute DOP.
- Replan central Daily Operational Plan at Ops Day.

The main differences to current practice include:

- Integration of stakeholders tools and processes (all stakeholders, e.g. airports),
- transparency of DOP development process by access rights for stakeholders,
- bottlenecks are early visible and can be worked on in a CDM process,
- more realistic trajectory calculation.

3.2. Availability of Required Input Data

The current status of the information flows required is gained from interviews and checked against the demand of information flow with respect to the model. This allows to determine whether it is feasible to facilitate and implement the information flows required by the DOP implementation.

Within the context of this study several interviews have been carried out in order to assess the feasibility of a DOP development process. The interview partners were chosen to cover the main stakeholders AO, APO and ATSP. In addition, weather forecast providers (WXFP) have been interviewed.

---

[1] Demand information comprises: Historical data and analysed air traffic statistics from different sources including airport and ATM provider statistics, results from statistical data analysis, long/medium term traffic forecast trends in traffic demand growth, special event data (international military training exercises or air shows, etc.) communicated by the responsible authorities (military or airports, flying clubs, etc.), adjacent airspace transfer rates/flights notifications from adjacent areas, general and business aviation demand, flight plans (3D trajectories).

Capacity information comprises: Airport capacity (Operating hours, capacity values for different RWY/weather scenarios, acceptance rates, constraints), ATSP capacity (Sector and airspace capacity as result of e.g. fast time simulation and statistical data available from ATM provider, Terminal Area ATM capacity, en-route ATM capacity, availability of ATM resources (ATM infrastructure, personnel), adjacent airspace/ATM capacity, (acceptance rates, airspace constraints, expected airspace regime).

The main focus was to investigate:

- (a) the availability and
- (b) the accuracy of the DOP relevant data.

The detailed results of the analysis of the process-specific information demand could be obtained from [43TL0103]. The interview results do not claim to cover the whole information flow needed in a DOP development. However, they provide a first assessment about the feasibility of a DOP development. A high amount of DOP relevant data are already available prior Ops Day.

3.3. Daily Operational Plan Conclusions

The DOP feasibility studies used both processes modelling and interviews, and both approaches indicate that an improvement in the process of planning ATM demand and capacity is possible. A DOP model has been successfully constructed using BONAPART Modelling tool. This model maps the interactions and information flows included in the mechanisms of the DOP. The model goes from an overview of the DOP processes and its development, passing by the study of the Central Operational Planning up to the Demand and Capacity Determination and the Development and implementation of the DOP.

The process model reveals required processes, interfaces and data needed for the DOP operation. The set of performed interviews with different stakeholders have confirmed the rationality of the model. Existing stakeholder tools and processes need to and can be integrated within the DOP[2]. For that integration it will be necessary to synchronise data as well as take into account planned upgrades of CFMU operations which are already underway.

From the interview process it has been concluded that there is not likely to be objections to a DOP concept; the required data will be available and should be provided as long as it is not passed to third parties. Much of the data relevant to the DOP is already available with sufficient accuracy, prior to the day of operation. Nevertheless it has to be noticed that weather influences may reduce the effectiveness of the DOP concept due to the level of unpredictability 1 day prior to operations.

The idea of combining Airport and Airspace capacity with Aircraft Operators (AO) demand, posed during the IATA SCC, possibly counters the opposition from AOs. Thus a proposal has been made to perform DOP fast time simulations after IATA SCC.

4. Airport and TMA Studies

The airport and TMA studies comprise the assessment of integrated arrival and departure management, new tools like wake vortex warning system and influence of better planning and co-ordination which could be achieved with tools like the Local Decision Support System.

4.1. Frankfurt Airport and TMA

This specific process model describes Frankfurt Airport with TMA and surrounding airspace sectors. The process simulation exercise consists of comparing the simulation scenarios “do nothing” and “TORCH-optimisation” to describe the optimisation potential in a quantitative way. Indicators and Metrics used are:

- *Waiting time*, which expresses resource unavailability by average values per aircraft and correlates with the published delay figures per aircraft, and

- *resource load*, which demonstrates the time-dependent occupancy of a resource during the day of operations.

The traffic input for the simulations on the ATM process model follows the STATFOR figures for the TORCH timeframe, that is Frankfurt traffic plus 25% for the year 2005. Especially new planning methods (DOP) and ATC procedures (TMA Sequencing) are expected to be used from 2005 onwards.

For the “do nothing” scenario of 2005 the objects of the ATM process model of Frankfurt Airport like processes, resources etc. and their parameters have not been changed compared with 1999. The input data for the simulation, however, have been increased by an “intelligent” algorithm, which inserts additional flights in possible time gaps and chooses a runway for the inserted flight depending on the flights ahead and behind.

The scenario of 2005 with TORCH functionality several process *parameters* have been changed in contrast to 1999 and the reference scenario:

- All airport and airborne operations and procedures in the scope of the ATM process model are well co-ordinated, because the DOP provides all stakeholders with more accurate data, which have been determined by overall CDM processes during the DOP development.

- New tools and algorithms used during Ops Day, e.g. High Approach Landing System, 4D-Planner, Wake Vortex Warning System, Local Decision Support System (LDSS) allow a lower minimum bound of separation of 2,5 NM instead of 3 NM.

The results of simulations show that the performance targets of considerably increasing the runway-throughput and decreasing total waiting time at the airport / in the air could be achieved by the a.m. optimisation. Exactly the same traffic input data as for the reference scenario have been

---

[2] For calculation of more realistic trajectories it is essential to get more precise data as used today within CFMU calculation as well as user preferred priority handling figures, e.g. hub and spoke constraints.

used, that means an increase of 25% compared with a day with average traffic in 1999.

1. Comparing the mean values for 1999, reference and TORCH scenario it is obvious that for both arrival and departure the increase of waiting time per A/C due to the much higher traffic in 2005 equals the decrease of waiting time by the TORCH optimisation in 2005. Therefore, it is indicated that the realisation of the TORCH concept could reduce the delay in 2005 to the level of 1999. Otherwise, there would be a delay per A/C about 15% higher for arrivals and 50% higher for departures than in 1999.
2. For arrival the composition of the total waiting time remains nearly the same from the 1999 scenario to the reference as well as to the TORCH scenario in 2005.
3. For departure, however, the delay increases extremely from 1999 to 2005 owing to the extended occupancy of the runway system. The reduction of waiting time from the reference to the TORCH scenario is mainly caused by the new tools and algorithms.

4.2. Madrid Airport and TMA

The study shows the operational gains provided by the implementation of the future concepts recommended by TORCH at Madrid Barajas airport. The proposed changes are the implementation of arrival management (scenario B1), and implementation of departure management plus integrated arrivals and departures management (scenario B2).

- Scenario B1 includes the implementation of arrival management in order to reduce arrival delays. This means the following changes:
    - Distribution of TMA-entry times, due to better en route planning, to show how arriving waiting time is affected.
    - Sequencing (optimal landing sequence) and metering (minimum spacing) between successive arrivals.

From the expected demand and entry times for arriving aircraft a optimal sequence is produced and the simulation shows:

- Increase in capacity and throughput at TMA and airport,
- decrease in delays and waiting times.

Testing several TMA entry times distributions should allow arriving aircraft to minimise waiting times.

Concerning the evolution of Arrivals Air Delay versus the Daily Operations a positive tendency in decrease of arrivals air delay could be observed as the traffic increases. For a traffic increase of about 400 operations per day a reduction in delay of about a half is experienced. The global delay for 1800 operations is reduced by 12% and for 1400 operations by 6%.

For runway 33R which operates close to saturation the positive effects are greater than for runway 33L in which the demand is not saturating the runway. Thus, the gain will be much more appreciable if the runway or the airport is close to saturation.

The optimisation due to better arrival management is positive. The two effects tested:

- Better distribution of TMA entry times due to better planning,
- optimal landing sequence and metering between successive arrivals,

produce an optimisation of the arrivals delay up to 15%.

- Scenario B2 includes the implementation of departure management plus integrated arrivals. In this case the changes aim at improving the use of taxiways and departure sequence and at reducing delays and ATC interventions. This means:
    - Better co-ordination of ATC, airport and airline operators. It will allow arrival and departure sequence optimisation by interchange AO schedule information, by knowing the state of airline ground operations (e.g. a 10 minutes advanced information of aircraft call for start-up would be of significant help).
    - Better co-ordination of ATC and apron control. It will reduce on-ground waiting times. Better co-ordination is expected to optimise use of taxiways (reduce delays and taxiway conflicts) and to optimise departure sequence.

The decrease of the Total Ground Delay versus the Daily Operations in Scenario B2 for two traffic samples of 1800 and 1400 operations/day has been studied. The gain decreases as the traffic increases, for a 1400 sample the ground delay reduction is about 7% and for a 1800 sample the gain is only about 5%. The mayor contribution to the Total Ground Delay comes from the departures (ground and queue), as it was also concluded for the Frankfurt assessment.

The maximum gain obtained in this exercise is about 10%.

5. Quality of Service Study: Station Keeping

5.1. Scope of the Study

An expected advantage of Station Keeping (SK) is to alleviate the controller’s workload since the task of maintaining and monitoring separations is distributed among pilots instead of being entirely in the hands of controllers. For the purpose of our study, we agreed on the following major characteristics:

1. Streams of aircraft engaged in “Station Keeping” follow equivalent 3D trajectories,

2. Aircraft within a “Station Keeping” stream must respect pre-defined in-trail separations,

3. Aircraft within a “Station Keeping” stream are delegated some tasks “normally” devolved to the ground.

The concept has been therefore addressed as a whole, i.e. including procedures, roles of pilots and controllers, and tools potentially available to pilots and controllers, taking into consideration the level of ATC equipment (e.g. AMAN) and airborne equipment (especially FMS) that can be reasonably achieved within the next five / ten years.

This paper addresses the applicability of SK in the context of high density TMA, and proposes a concept of operation aiming at improving the efficiency of guidance and control operations. The expected benefit is an increase of capacity through a better fluidity, predictability and regularity of traffic, and a better accuracy on arrival times. The concept may enable also a reduction of actual in-trail separations even though this aspect has not been considered as a major incentive.

However, it is not clear whether SK may not involve additional tasks (e.g. to prepare or negotiate SK procedures) which could reduce the gains of delegation. Furthermore, it is not yet proven that SK is acceptable to pilots as it involves apparently more workload for the aircrew, not to say more responsibilities.

In this study we tried to look for a better trade-off between:

- Individual flight management/constraints/optimisation (pilot’s concern),
- and overall flow management/constraints/optimisation (controller’s concern),

by proposing a concept of delegation in TMA which could:

- Alleviate controller’s task currently dedicated to adjusting and monitoring the speed of individual aircraft,
- whilst giving the pilot more autonomy in the management and optimisation of the descent profile within the constraints of TMA control.

The panel of avionics solutions considered here is shown in Figure 5-1:

- The pilot can either program the FMS or give orders to the FCU or adjust the aircraft configuration through the side stick.
- Priority is the following by decreasing order: Side stick, FCU, FMS.
  - ATC clearances are generally implemented through the FCU (e.g. speed, heading adjustments). This gives the pilot and controller orders a dynamic effect on the aircraft.
  - ATM requirements at Flight plan level are implemented through FMS programming.

The current mode of operation in TMA is FCU based. The use of FMS is worth considering to implement the proposed SK concept, because this mode would:

- Reduce the inter-dependency between aircraft in the same stream, thus giving each pilot the ability to execute his own optimised descent with respect to his own specific constraints or in busy complex TMA with various crossing in-bound out-bound routes optimise efficiency of a constrained arrival profile;
- Avoid flight stability degradations caused by sudden changes, thus giving pilots the ability to anticipate on manoeuvres;
- Enable to anticipate on aircraft inertia when changing the configuration (position, speed, heading..);
- Reduce real-time adjustments, thus alleviating pilot’s workload.

Using FMS depends on traffic complexity, stream stability and own aircraft capability. We have analysed the various avionics possibilities with these potential limitations in mind, i.e. using 4D FMS, 3D FMS and no FMS.

5.2. Summary of Station Keeping Findings

The principles that underpin this Station Keeping concept can be summarised as:

- Using time as the separation parameter between arriving aircraft, thereby avoiding the difficulties of maintaining a fixed distance between aircraft that are reducing velocity independently.
- Avoiding the use of ‘visual’ (CDTI based) spacing of aircraft using it instead as a monitor to ensure the respect of the smaller safety buffer, thereby avoiding an increase in the workload of pilots in an otherwise busy and time critical arrival phase.
- Using FMS capabilities to navigate the aircraft thus helping to ensure the most efficient use of resources (e.g. fuel, controller time) in a heavily constrained environment.
- Using arrival profiles that are always separated by more than the current minimum allowable until on final approach, thereby providing a ‘dampening’ effect when succeeding aircraft need to compensate for temporary reduction in spacing due to slightly different deceleration rates of different aircraft types ahead.

The concept has been elaborated taking account of the whole picture, i.e. applicable procedures, concerns of pilots and controllers, potentially available technical enablers including airborne based (e.g. FMS, ADS-B, CDTI) and ground based systems (e.g. AMAN).

The approach taken is innovative in the sense that both ground and airborne perspectives have been assembled in a common vision of the operational improvement. The stake was that both sides would be the winners of the game in the end. This approach should make it easier the capture of airborne requirements consistent with ground requirements, a point which is a major deadlock of current ATM R&D on air/ground data-link applications. In particular, the operational need has been expressed in such a way that it is possible e.g. to comprehend easily the type of information aircraft and ground systems need to exchange.

Various conceptual options have been investigated taking account of the unavoidable coexistence of different levels of airborne equipment. Models have been elaborated to test the feasibility in terms of safety protection and performance.

Those models will need to be dimensioned and exemplified in further studies.

The advantages and disadvantages of the selected SK Concept cannot be fully understood as a result of this analysis. There is a need to run some trials to investigate the impact at an operational level. In addition there is a need to extend the technological analysis to ensure availability of technologies to support the supply of data, operational procedures and safety requirements.

It is hoped that enough evidence has been provided to warrant further investigation of the described concept as well as to point out some of the aspects that need careful consideration in what is an extremely time and safety critical environment.

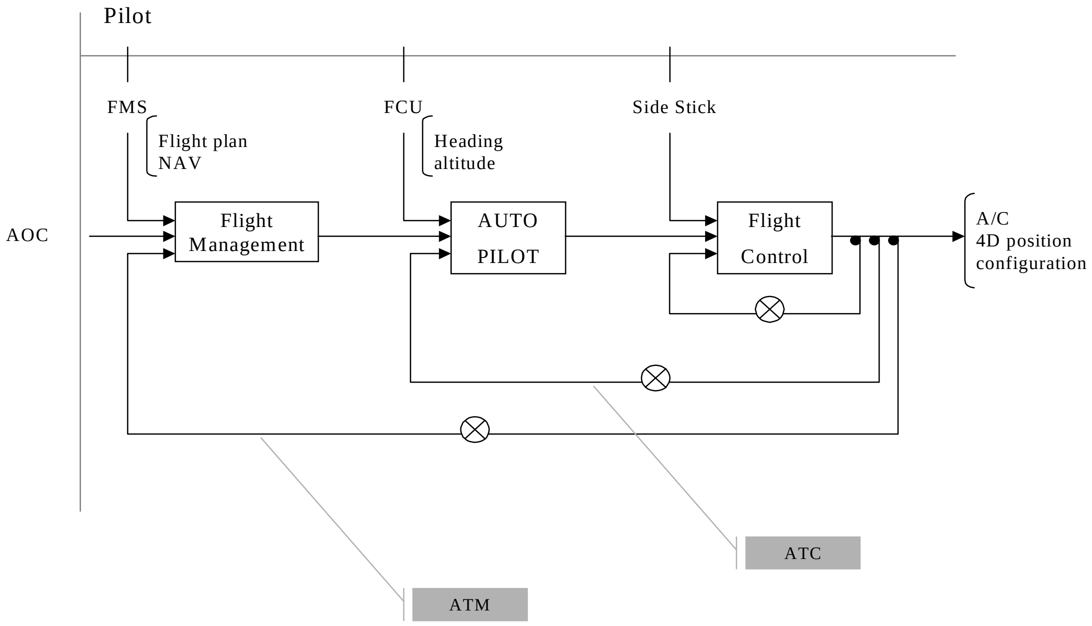

Figure 5-1 Control Loops in the aircraft

6. En-Route Studies

6.1. En-Route Metering Results

The aim of this study is to analyse the impact of the implementation of one of the principles behind En-route Planning in ATC, the En–route Metering function, specifically in airspace bottleneck displacements in time and location, by the use of Fast Time Simulation tools.

En-route metering is a function implemented through a possible "ATS centre planner" that:

1. Identifies future traffic overload and congestion situations, with a time horizon of at least 2 hours through automated traffic analyser.
2. Determines "optimum" solutions varying from change of acceptance rates, change of routes, etc...
3. Negotiates solutions with planers affecting the situation through automatic negotiations tools and distribute changes to the stakeholders

Supposing that these automated traffic analyser tools predict future traffic overload and congestion situations up to 2 hours in advance, the ATS centre planner should be able to determine the optimum solution with the assistance of the tools.

Modifications in traffic flows are proposed in order to avoid the appearance of the first bottleneck. These traffic flow modifications are proposed bearing in mind possible alternative routes for flights that flow through the overloaded sectors, supposing that these flights can be notified about the changes in their routes with sufficient time in advance.

As a result of these changes in traffic flows the traffic sample will be modified and bottlenecks displaced in time and location. Proceeding like this with the predicted bottlenecks appearing along the day it is possible to obtain a traffic sample with a minimum of overloaded sectors.

In the Fast Time Simulations of 12 Spanish sectors bottlenecks are progressively eliminated from one sector and switched in time. This exercise shows that it is possible within certain margins to eliminate bottlenecks if information is known with enough time in advance (around two hours) and when there are alternatives for re-direction of traffic.

Even if this functionality does not produce a direct increase in capacity, sectors overloads are removed, so that maximum flow has been effectively managed without stress in the system. If the function is implemented and there is confidence on the removal of the sector overloads, the declared capacity figure could be increased as effective real flow figures are recognised.

6.2. Multi Sector Planning Simulation Results

The Multi-Sector Planner (MSP) proposed in these simulations are based on conflict find and resolution at planner level, having a planning window extension up to 30, 40 minutes or up to 1 hour before the aircraft enters the area of responsibility. The MSP performs a conflict-based analysis of air traffic within his area of responsibility. Having accurate information about the expected 4D trajectories of the aircraft, future conflicts within the sectors analysed are identified. By means of an advanced MTCD a solution will be proposed by the MSP to avoid that future conflict.

The MSP is responsible for a set of adjacent sectors called Multi Sector Area (MSA). According to TOSCA study a MSP will normally operate in a MSA covering two or three sectors. As MSP can modify any flight trajectory in order to resolve a future conflict at any time the flight is passing through the MSA , the TC (Tactical Controller) and the PC (Panning Controller) of each sector in the MSA area will be aware that the MSP has issued a trajectory modification to a particular flight.

A stepped approach has been taken in order to study possible benefits.

1st step: Pre-assessment of tactical and planner controller workload when using advanced HMI.

This work has been considered fundamental in order to have a well defined, realistic and calibrated scenario for further advanced MSP functionalities and concept implementation.

Calculation has been done on how the controller workload (WL) is affected, (decreased), by the use of future systems having advance HMI ODIV IV type like and systems supporting this functionalities. The results of this first assessment are supported and are coherent with the results obtained by Aena and DFS through the SRATM project, in which a detailed evaluation of two candidate systems (VAFORIT and FOCUCS) were deeply analysed in real time and also through real and fast time simulation.

A significant workload reduction is achieved for both tactical and planner controller as a consequence of the new system functionalities. Workload improvement is around 30% for tactical controller and around 10% for planner controller. This improvement is translated in around 10-15% of gain in capacity depending on the sector.

2nd step: Assessment of a MSP working with the Tactical and Planner controller within his MSA.

In this assessment a MSP simulation for the sectors of a particular MSA (in this case with only three sectors) was carried out.

There is practically no significant improvement for the tactical controller by the fact of adding in the system the figure of a MSP that identifies and proposes solution for conflict in the planner layer. That is mainly because most of the conflicts detected and practically solved by such MSP would be anyway resolved by the planner controller in a normal situation, so no effect is really appreciable.

3rd and 4th step: Substitution of Planner controller functions by the MSP & Conflict Resolution Strategy with Data Link Communication.

The third step has been done to show the effect in tactical controller Workload (WL) due to data-link conflict resolution by the MSP. In this case TC only acknowledges and monitors the conflict resolution actions. Issues related with responsibility require nevertheless further considerations.

For analysing this possibility a new role sharing has to be put in place. Basically it is assumed that:

- The MSP will search, detect and propose solution for all conflicts that can be tackled at planning level, using MTCD.
- New co-ordination procedures between MSP and TC were considered. These should reproduce mainly the interactions between both due to conflict resolutions and due to individual flight plan management.
- Part of the tasks related to the flight plan management and electronic flight strips management, that previously was sector PC responsibility, was allocated to the TC, manly those related to monitor and organise flight strips of aircraft entering the sector and monitoring and management of flight strips while it is passing through the sector.

The main idea behind this assessment approach is to analyse whether the remaining task at the PC level produces a significant amount of WL.

The main results are:

- After the reallocation of tasks between the three main actors, the amount of WL that is still experienced by the PC is minimal. The PC WL is reduced by the conflict resolution capabilities of the MSP. In fact almost all conflicts in the planner layer are identified and resolved by the MSP. Thus, there is place for grouping PC positions and having a PC for a certain set of sectors (providing service to various TC) instead of having just one PC per each TC position.

- The performances of the TC are not too much affected by this redistribution of roles. And in all the cases when introducing the datalink capability for the MSP the situation is always improving. This grouping of PC positions will not have negative impact in the maximum WL performance of the TC.

Nevertheless even if there was a significant reduction in PC WL there is still a remaining part. Whether an MSP acting in a MSA with for example three sectors will be able to assume the Planning role completely depends on the amount and complexity of traffic. For analysing this in detail it is necessary to define and create a complete concept of operations, to define saturation thresholds and to perform a complete WL assessment.

Unfortunately, the level of operational procedures definition as well as tool performances, detection probabilities and performances of the MTCD are not yet defined. The level of uncertainty associated to the MSP is so high that it is not possible to quantify the MSP WL without further development of the functions and roles behind.

6.3. Free Routing Simulation Results

According to EATMS Operational Concept Document, various measures are already in hand to optimise the existing fixed routes structure in the ECAC region and to make greater use of RNAV capabilities. This feeds two options:

- The optimisation of traffic structuring in those areas where some route structures will still be needed to meet capacity targets;

- The use of free-routes and user-preferred trajectories, enabling flights to operate outside a pre-defined route structure.

Previous studies[3] demonstrated an increase of controller workload. In order to avoid redundancy with these studies, this assessment focuses on efficiency. The objective is to prove the benefits in terms of fuel consumption and flight time taking into account different factors such as sector density or crossed military areas.

Several requirements have been taken into account to choose the simulation area:

- presence of military areas
- sea entries
- large and not too complex area
- traffic density high enough.

Accordingly, the Brest FIR was chosen for the simulation implementation.

It is expected that within the TORCH timeframe only part of the aircraft fleet will be equipped with both FMS and air-ground data link facilities. If aircraft fly in dense traffic and request a direct route it will have to change its flight level in order to enable Free Routing. Taking into account these remarks flight time benefits for free routing are (refer to Figure 6-1):

- Aircraft that fly fixed route have no benefits.

- Results of aircraft which fly direct routes (Free Routing (FRG) class) show that there are real time benefits (between 3% and 3.5%). For FRG class, the percentage of aircraft equipment does not impact on this gain of time but this percentage of equipment impacts on time benefits realised by the whole fleet, as it could be guessed. The more aircraft apply free routing, the higher time benefits for the whole traffic.

- The percentage of aircraft performing Free Routing does not impact the gain in flight time. Furthermore, time benefits are much higher when aircraft do not change their flight level (~5% of time gains against ~2.5%). This can be explained by the fact that aircraft which change their flight level, also change the sector. These sector changes are not stereotyped and may create new separation problems.

Regarding fuel consumption:

- Aircraft that do not fly direct routes have no fuel benefits.

- Furthermore, aircraft that fly their own trajectories without changing their flight level save more fuel than those which change their flight level. The averages of fuel benefits are: 3.5% for aircraft without level changes and 2.5% for aircraft with level changes. When an aircraft modifies its flight level, it consumes more fuel, mainly when it climbs to reach its new FL.

- Aircraft that must go down under FL310 must climb to reach again this FL at the end of the direct route. This explains why the fuel gains are very low for this class though they fly a direct route. The other class of flights (those which does not change their flight level) present a significant gain in fuel consumption.

- Some of the aircraft that fly a direct route may consume more fuel than when they fly a fixed route. Results of scenario without flight level changes, very few aircraft have negative fuel benefits. Contrary, scenarios with flight level changes present around 23% of flights with negative fuel benefits. This is due to flight level changes and mainly to return to the original FL at the end of direct routing. Aircraft that have a positive benefit present around 8% of gain.

When looking to the possible benefits of the free routing according to sector density it is noted that:

- The benefit is assumed to decrease with increase of density. Values represent time benefits for aircraft that fly direct routes. For each aircraft, the average density of crossed sector has been computed. This diagram shows that the denser the traffic the smaller are the

---

[3] The effect of Direct Routing on ATC Capacity (study from DERA).

Free Route Airspace Project (FRAP).

Free Route Airspace Concept (FRAC).

time gains. So, free routing is recommended within sectors of low traffic density.

- As above, fuel benefits for aircraft that fly direct routes are linked to crossed sector density. These results go to the same direction of the previous results (time benefits) and confirm the fact that free routing should be recommended in sectors with low traffic density.

Aircraft that cross military areas have time benefits around 10% (all FRG aircraft considered). It is a high value and the benefit is not negligible. Flights that do not cross military areas have a lower time gain (around 2%). Flights that best benefit from crossing military areas are those with no FL changes.

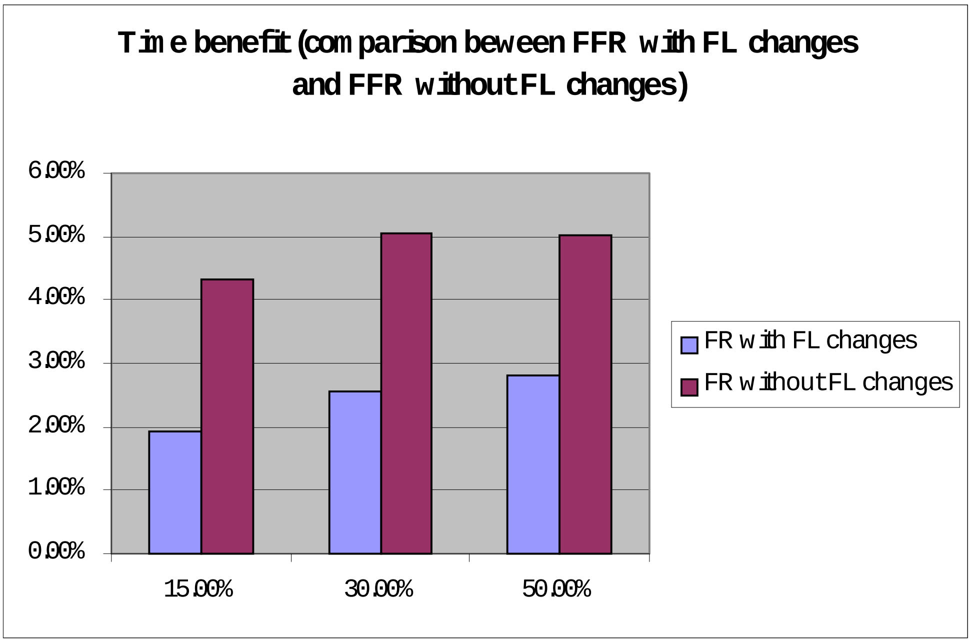

Figure 6-1 Comparison of time benefit according to FL changes

In general terms, time and fuel gains are clear. But gains are not very high and can be negative for some aircraft under certain conditions. Our conclusions are:

- Free routing should be applied within sectors with low traffic density, where benefits are higher.
- Free routing should not impose flight level changes to aircraft that want to fly a free route. When aircraft must change flight level, free routing benefits are not so important and may be negative for some aircraft, mainly in terms of fuel benefits.

  In order to apply free routing under the best conditions and to obtain the most benefits, aircraft that want to fly free routes should fly at a cruising altitude not much used by the other aircraft. This can be planned before departure. Then, they will cross sectors with low traffic density and do not change their flight level.
- Free routing combined with Flexible Use of Airspace (FUA) presents big benefits for aircraft that today go around military areas. Even if military areas will sometimes be closed, it would be very beneficial to open them to civil traffic, so that free routing is applied in optimum conditions.

This study focused on Brest region. The results of this study depend on the choice of this region. It would be very interesting to extrapolate results of this assessment to the ECAC region. The FIR was chosen according to its structure (not too complex, sea entries, presence of military areas, large area). For the ECAC region, conditions will be different and results can not reasonably be extrapolated. Several simulations, covering all the ECAC regions, should be conducted to know what the impact of free routing is.

7. Analysis of the Results and Conclusions

The operational assessment has gained first insights into the potential of the selected scenarios. They include new or innovative ideas (e.g. Daily Operational Plan or Layered Planning) and provide examples for all phases of flight (Airport, TMA and En-Route studies). A short analysis summarises the potential with respect to implementation from 2005 onwards.

7.1. Daily Operational Plan

In principle CFMU already develops an operational plan and simulates the anticipated air traffic situation. Nevertheless, there are several shortcomings[4] which question the effectiveness of the current practise [NOAA and CFMU visit]:

- At present no tools or models are available to support strategic ATFM.
- Unpredictable events may occur between slot allocation time and departure time without adequate reaction (co-ordination CFMU – ATCC/FMP – Aircraft Operator).
- Accuracy of data insufficient or even deliberately wrong (“cheating”).
- Declared sector capacity is average value but does not respect traffic complexity.

The feasibility study shows that a Daily Operational Plan can be developed by means of more accurate input data. The output data of existing planning and simulation tools e.g. of airlines should be integrated. An early balance of demand and capacity in a less time critical phase can be achieved by involving all stakeholders. Fast time simulations show potential bottlenecks several days before operation. Results should be made public in order to increase confidence in the balancing process.

The DOP is the first step in a layered planning and provides input data for the following activities on centre and sector level. It should not be seen as a rigid plan which will be put into operation. It is rather the base for re-planning base at this particular day of operation.

The qualitative analysis shows that there is a high potential in introducing the DOP concept. This feasibility study was not aiming to provide quantitative results which prove the advantages of a better planning and negotiation process in the strategic and pre-tactical phases. The main objective is to stimulate discussions and prepare further validation steps in order to utilise more efficiently already available resources and capacities.

7.2. Airport and TMA Studies

The airport and TMA simulations of Madrid Barajas (Fast Time Simulations) and Frankfurt (Process Simulations) have shown that the forecasted traffic of 2005 [STATFOR] can be accommodated. This could be achieved by means of better co-ordination through arrival and departure management by introducing new tools such as Local Decision Support System (enables information exchange, new CDM procedures and decision support) or Wake Vortex Warning System and High Approach Landing System (utilisation of minimum separation standards in all weather conditions).

The average capacity gain which could be achieved by the a.m. improvements is in the magnitude of 10% to 15%. This leads to the conclusion that further traffic increase until 2010 will cause further increase in delay if no other actions were taken. Examples for further improvements are the introduction of A-SMGCS or optimised TMA procedures. Otherwise, airports could become significant bottlenecks in the TORCH time frame.

The Quality of Service study about Station Keeping introduces the principle of using time as separation parameter, avoiding use of visual CDTI spacing of aircraft and using (3D/4D) FMS capabilities to navigate. Nevertheless, the advantages and disadvantages of the selected concept can not be fully understood as a result of this analysis and there is a need to run some trials to investigate the impact at an operational level. It is not fully clear how much Station Keeping will contribute to safety and capacity gains e.g. under bad weather conditions.

7.3. En-Rout e Studies

7.3.1. Re-Routing and Metering

For the simulation of en-route re-routing and metering functions tools like Traffic Analyser and Workload Predictor with a prediction horizon of about 2 hours have been assumed. They were used to identify overloaded sectors and to eliminate this overload by re-routing and metering of aircraft. The simulation shows that it is possible within certain margins to eliminate overloads when alternatives for re-direction of traffic are available. A better utilisation of the available capacity at centre and multi-centre level will minimise current central flow intervention.

7.3.2. Multi-Sector Planning

The Multi-Sector Planner (MSP) proposed in these simulations are based on conflict find and resolution at planner level, having a planning window up to 30, 40 or 60 minutes before the aircraft enters the area of responsibility. The reference case based on advanced HMI but still without MSP shows significant workload reduction for tactical and planner controller in the magnitude of 10% to 30%. Introducing several MSP strategies (additional MSP controller, data link for conflict resolution) no significant additional improvements or reduction in workload was obtained. Data Link slightly reduces workload. The level of uncertainty associated to the MSP simulations is so high that it is not possible to quantify the MSP workload without further detailed development of the functions and roles.

7.3.3. Free Routing

The Free Routing simulation focuses on efficiency. The objective is to prove the benefits in terms of fuel consumption and flight time taking into account different factors such as sector density or crossed military areas. In the simulation area FIR Brest flight time reduction was obtained in the magnitude of 3%, fuel benefits are in the range of 2.5% to 3.5%. The higher the sector density the lower the benefits are because of the increasing number of potential conflicts. Opening of military areas in this region leads to time benefits of about 10%. Therefore, free routing should only be applied in low density sectors, and flight level changes have to be avoided because these changes further reduce the rather small benefits in fuel and time. Most promising benefits could be obtained from opening military areas for civil traffic (applying Flexible Use of Airspace concept). The free routing area should comprise more than one single FIR in order to obtain more significant fuel and time benefits.

---

[4] Aside from the structural ATFM problems, refer to section C.3 and [EUROCONTROL PRC].

7.4. Conclusions

In general, the fast time simulation results concerning en-route phase show rather low potential in increasing capacity but some potential in making better use of existing capacity. Of course, these results should be validated by alternate scenarios and real time simulations. Possible reasons are the lack of maturity of the related concepts of operations (in case of multi sector planning or en-route metering), or in the scope of the simulation (in case of free routing).

Further emphasis should be put in advanced controller tools like MTCD or CORA and automation of tasks which alleviate the workload and could thus increase the controller capacity. Other important research areas which are not covered in these feasibility studies are e.g. the change of route network and sectorisation.

Benefits in capacity gain in 2005 to 2010 will not be achieved by implementation of a single tool or new procedure. The TORCH operational assessment results show that of the ideas tested short term benefits are more likely to be derived from improved planning. Improvements reviewed for the execution phases were dependent on the existence of new technologies and (automation & prediction) tools, which will not be so readily available in the short term.

Appendix D. Summary and Analysis of the Socio-Economical Assessment.

Table of Contents

Index of Figures

1. Introduction

Purpose of this paper is to provide an overview of the socio-economic assessment of the TORCH system, to highlight what are the problems associated with the estimation of the socio-economic impacts of a complex technological system like TORCH, and to suggest further steps that should be taken in the future in order to derive more accurate assessments for the new European ATM system.

An important step towards the development and implementation of an operational ATM concept for the year 2005 onwards for Europe is the assessment of the social and economic impacts that the system will have on all relevant stakeholders. Stated otherwise the viability of a new ATM system in Europe does not depend only on the technical feasibility of the proposed system concept but also on its economic feasibility and social acceptability. More specifically it is important for decision makers to know before the deployment of the system:

- If the proposed system is more or less cost-effective as compared to the existing base-line situation,
- how the different stakeholders are impacted by the introduction of the new system.

2. Scope of the Socio-Economic Assessment

The socio-economic analysis was achieved through the development of two forms of analysis i.e. cost-effectiveness analysis and social-impact analysis.

The Socio-economic impact assessment of the TORCH system possess certain characteristics that differentiate it from the classical impact assessment studies of new technological systems. The major features of the environment within which the new European ATM system will be evaluated can be summarised as follows:

1. The European ATM system is a rather complex technological system with numerous functionalities and strong interdependencies between its components.
2. The European ATM system covers an extensive geographical area with substantial social, technological and economic differences.
3. A new European ATM system like TORCH requires a quite long implementation time horizon.
4. The European ATM system involves a substantial number of stakeholders with different and sometimes conflicting objectives.
5. The impacts of the European ATM system relate to a multitude of performance objectives, i.e. cost, safety, controllers workload, level of service, delays, etc. which are difficult to be quantified in monetary terms.
6. While certain cost items of the TORCH system can be calculated with a fairly good accuracy, i.e. acquisition cost of the various system components, other categories of costs and benefits can be assessed only in a comparative sense, i.e. if there are superior or inferior to the existing baseline system.
7. The expected benefits from the introduction of TORCh was not feasible to be realised for the various scenaria using objectively estimated figures by simulation, which have focused on a dedicated FIR or airport instead of all ECAC airspace and airports.

Based on the factors listed above one can characterize the TORCH socio-economic and cost-effectiveness impact assessment as a problem with:

- High uncertainty in the estimation of the magnitude of the relevant impacts,
- high subjectivity in converting non-monetary to monetary impacts,
- high uncertainty in projecting the macroeconomic environment of the various countries impacted by the European ATM system for an extensive planning horizon, i.e. 2010-215.

The characteristics of the assessment of the TORCH system led to the conclusion that a traditional cost-benefit or cost-effectiveness assessment of the new European ATM system based on the monetary quantification of the system impacts was neither feasible nor reliable.

The feasibility of the precise estimation of the cost-effectiveness ratio of the TORCH system was hampered by the limited resources and time available for evaluation of a sufficient number of scenaria covering a wide spectrum of:

I. European air traffic demand forecasts,
II. European interest rates,
III. simulation of the TORCH system covering the European ATM space.

Even if the resources were available the expected reliability of the results, as compared to the required effort, would have been limited due to the high degree of uncertainty involved in all steps of the cost-effectiveness calculations.

The above findings led to the selection of an alternative methodology for assessing the socio-economic impacts and the cost-effectiveness of the TORCH system.

The proposed methodological approach is based on a qualitative assessment of the TORCH and the Baseline system. The proposed methodology combines quantitative measurements, where possible, with qualitative assessment based on expert judgement provided by a European panel of experts.

3. Methodology for Performing TORCH System Socio-Economic Analysis

The proposed methodology for assessing the overall TORCH system cost-effectiveness and social-impact analysis has the ability to:

- Consider the points of view of all stakeholders involved in and affected by the introduction of the new European ATM System.
- Consider all types of impacts including those that can not be expressed by hard quantitative figures.
- Allows for a sensitivity analysis of the results.
- Provides a relative assessment of the cost-effectiveness of the TORCH system over the existing Baseline system.

And it is based on the Analytical Hierarchy Process (AHP). Besides the AHP based overall cost-effectiveness assessment and social impact analysis of the system an attempt was made to estimate independently the expected costs of the system (with an order of magnitude precision) for all stakeholders, as well as the expected benefits of the system using a Delphi panel. The two parallel approaches, i.e. AHP cost-effectiveness and social-impact analysis, and the cost estimation coupled with the Delphi results, were used in order to check one against the other in terms of the validity of the results produced. Figure 3-1 presents an overall view of the methodology used to assess the cost-effectiveness of the TORCH system.

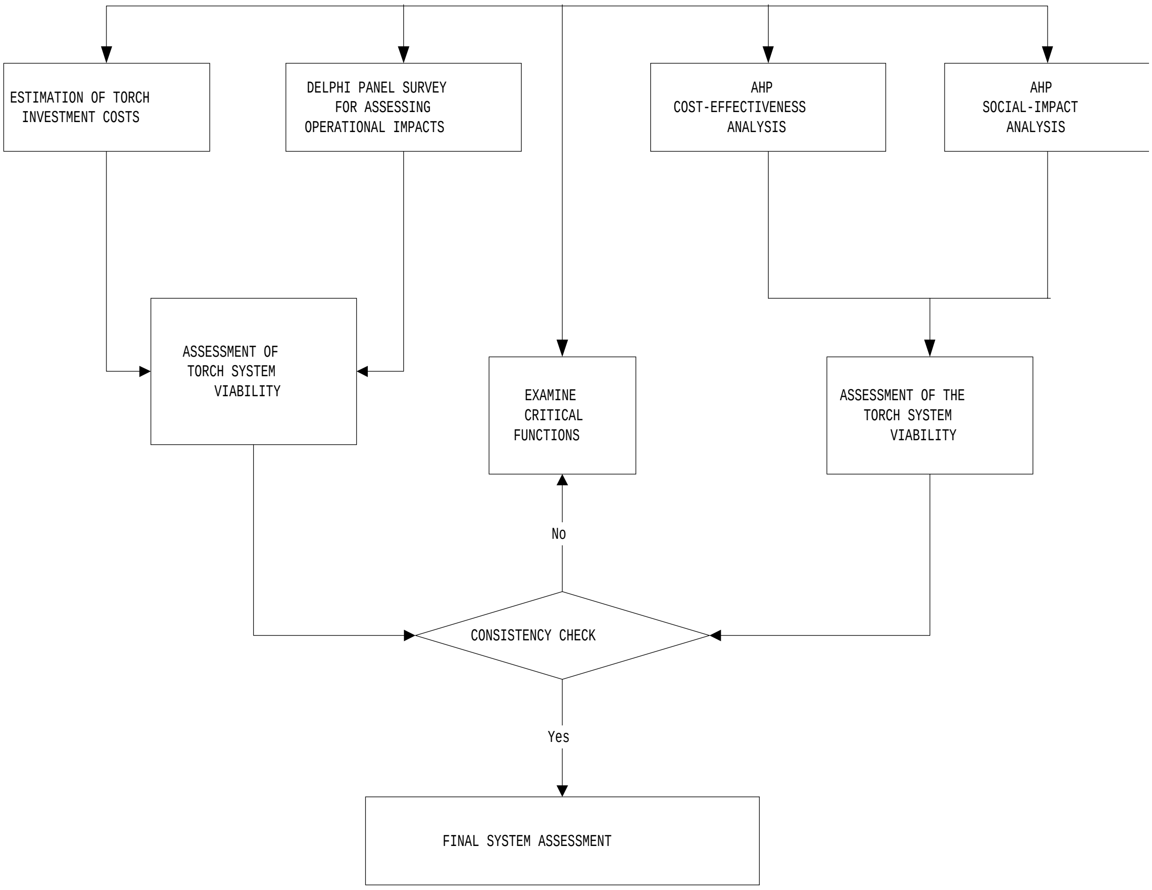

Figure 3-1 Methodological framework for the TORCH system Socio-economic Assessment

4. TORCH System Cost and Benefits

4.1. Costs Estimations

An essential issue regarding investment decisions for the new European ATM system relates to the magnitude of the investment and the allocation of cost among the various system stakeholders. The costs related to the investments required to implement the TORCH operational concept were calculated for the various stakeholders. Here, it should be stressed the fact that the estimated cost figures do not include costs or benefits related to the TORCH system operational impacts. The kind of costs address were those required to implement the operational concept, independently of the operational impact. This includes, for example, the cost of new tools, new personnel required, etc.. Furthermore, the calculated costs reflect a precision of an order of magnitude. Table 4-1 summarises the cost estimates for the implementation of the TORCH system for the time horizon 2005-2015 for all stakeholders.

Kind of stakeholder	One-shot costs (except airlines and airports)	Repetitive costs (MEURO)											Total
		Up to 2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
Airlines	(included in next columns)	2018	205	117	155	126	120	114	109	104	98	94	3260
ATS providers	577	80	229	229	275	275	459	459	459	459	459	459	4419
Central organisations	6	0	1	1	1	1	1	1	1	1	1	1	16
Airports	(included in next columns)	195	52	50	285	112	106	101	96	91	87	83	1258
TOTAL	583	2293	487	397	716	514	686	675	665	655	645	637	8953

Table 4-1 Summary of additional costs induced by TORCH (orders of magnitude)

As it can be seen in Table 4-1, the estimated cost for the implementation of the TORCH concept is in the order of magnitude of about 10 billion EURO. Looking at the allocation of costs among the major stakeholders, the highest share of cost (almost 50% of it) is allocated to the ATS providers. The second major cost bearer are the airlines, which account for almost 35% of the expected costs, while the remaining 15% of the cost is allocated primarily to the airports.

4.2. Benefits Estimations

As it is already been mentioned, operational benefits and costs were assessed through the Delphi panel survey. The Delphi Method has been applied in order to estimate the TORCH Operational Concept benefits, measuring subjectively the ATM system performance indicators identified. The study was focused on the following objectives: Safety, Capacity and Economy, measured through a set of indicators.

The panel of members was built covering the wide group of stakeholders in order to have valid results, who came from the CAVA and GAST members. A group of 23 experts answered the Delphi questionnaire from 19 different companies from six different European countries and belonging to six groups of stakeholder. The assessment of the potential benefits from the implementation of the TORCH system considered three alternative scenarios of traffic growth for the European ATM system. The expected benefits from the implementation of the TORCH system for the various categories of impacts can be summarised as follows:

- Safety.

  There is a general agreement that irrespectively of the expected level of traffic increase, the ATM safety level will be increased by controlling better the risk creation process related to the following: i) human error, ii) operational factors, iii) technical factors.

- Capacity.

  In contrast to safety, the expected capacity gains from the implementation of the TORCH system will be differentiated according to the forecasted traffic increase. As it was expected, the highest airport peak capacity gains (10-20%) are expected to be realised under the high traffic increase scenario, while the low traffic scenario is expected to yield improvements of at most 10%. Regarding the en-route sector capacity, the highest expected gains are between 10 and 20% and will be realised under the high traffic scenario. Here, it should be stressed that irrespectively of the traffic demand scenario, the TORCH system will decrease both the tactical controller and the planner controller workload.

- Delays.

  The expected decrease in delays due to the implementation of the TORCH concept is in the range of between 10% - 20% with the highest expected gains under the high traffic scenario. In terms of the block time benefits the TORCH system is expected to reduce them by at most 10%. Given the high cost of delays, recent estimates of delay costs for the European ATM system are about 596 MEURO. The expected reduction in delays represents a substantial measurable benefit (i.e. 60-120 MEURO savings per year), of the TORCH system.

- Fuel Consumption and Cost Savings.

  The expected savings in fuel consumption are estimated to be at most 10% with highest probability of affecting them under the low traffic increase scenario. Regarding cost savings it was found out that the overwhelming majority (100%) of the panel experts expect that the airline operators will have substantial cost savings, while strong majority of the experts (67%) believe that the ATM service providers will encounter also substantial cost savings from the implementation of the TORCH concept.

5. Cost-Effectiveness Analysis

The overall TORCH system cost-effectiveness was also assessed with the use of Analytical Hierarchy Process (AHP) technique [TORCH Deliverable D 5.2]. The objective of the cost-effectiveness assessment was to find out if the TORCH system will be more cost-effective in comparison to the existing base line system. The cost-effective assessment was carried out with the contribution of the European panel of experts that was convened in the TORCH User Forum, held in Brussels.

The application of the AHP for evaluating the performance of the cost-effectiveness assessment of the TORCH concept requires the hierarchical decomposition of the problem. For the problem under consideration the hierarchy consists of three levels: Goal, Criteria, and Indicators. For the calculation of the criteria and indicators priorities the judgements of experts on the importance of each element of the hierarchy (assessment criteria and indicators) compared each other with respect to each of the elements of the next higher hierarchical level were collected. The same steps with the appropriate changes i.e. identification of social-impacts measures and develop the corresponding AHP model, are also involved in the implementation of the social-impact analysis.

The performance metrics used for the overall cost-effectiveness and social-impact assessment of the TORCH system were compatible with those used in the Delphi panel survey in order to allow the comparison of the results derived by the two independent methods.

The AHP survey results provided useful information regarding not only the cost-effectiveness and social-impact assessment of the TORCH and Baseline system but also provided information regarding the relevant importance of the various metrics used in the assessment process. In addition the AHP analysis was able to identify the relevant preferences of the various stakeholders in terms of the assessment metrics and the sensitivity of the cost-effectiveness results in relation to the expressed preferences. The AHP results suggest that:

- The metric with the highest importance (65%) and impact on the selection of the new European ATM system was by far safety, irrespectively of the stakeholder group, while capacity and efficiency were ranked second and third with a relative importance of 20% and 15% respectively.

- The TORCH system is more preferable to the base-line system in terms of the overall cost-effectiveness, and derived benefits from the system implementation will exceed the costs required for the implementation of the TORCH system. These conclusions hold for the ungrouped data and for the majority of the various stake-holders involved in the cost-effectiveness assessment process. An important differentiation in the ranking of the two systems relates to the ATM organisations which believe that the benefits derived from the implementation of the TORCH system are not counterbalanced by the costs needed for the system implementation.

- The ranking of the TORCH system as more cost-effective than the baseline system is robust due to the finding relates to the insensitivity in terms of the relative importance of the assessment criteria

- The costs for implementing the TORCH system are considered to be substantial as compared to the costs needed for the continuation of the baseline system. Besides the tangible (directly measurable) economic benefits of the TORCH system there are also substantial intangible benefits derived from its implementation.

Regarding the social-impact assessment of the TORCH and baseline system it was found that the TORCH system outperforms the baseline system by a two to one margin. The superior performance of the TORCH system is confirmed by all participating groups. Again the ranking of the TORCH system is insensitive to the relative importance of the evaluation criteria.

The most important metric contributing to the social-impact ranking of the TORCH and Baseline systems is safety which accounts for almost 65 % followed by performance (14%), working conditions (11%) and environmental impacts (10%).

The superiority of the TORCH system in terms of its social-impacts is attributed to its better performance in terms of reducing delays and increasing safety and to a lesser extent to its impacts on environment and controllers working conditions.

5.1. Concluding Remarks

The analysis of the TORCH system inherent costs and operational benefits (through the Delphi panel survey) led to the following conclusions regarding the economic viability of the new European ATM system:

- Substantial investments are needed by all relevant stakeholders for the successful implementation of the TORCH system.

- The expected investments are likely to pay-off under the scenario of high traffic increase.

- The expected benefits will be allocated to all relevant stakeholders in close relationship to their investments.

- The expected benefits of the TORCH system will be derived from its positive impact on all performance metrics, i.e. safety, capacity, delays, cost-savings etc. This means that there are no trade-offs among the TORCH system performance metrics.

On the other hand, the AHP based overall cost-effectiveness and social impact assessments of the TORCH system versus the base-line system suggests that:

- The cost of investments in the new European ATM system will be substantial as compared to the continuation of the existing system.

- The tangible benefits (direct economic benefits) and the intangible social benefits that will be generated by the implementation of the TORCH system will exceed its investment cost.

- There is a wide agreement with regards to the benefits and costs that will result from the implementation of the TORCH system, as well as substantial consensus on the relative importance of the performance metrics involved in the assessment of the TORCH and the base-line systems.

- The evaluation results of both cost-effectiveness and social impact assessment are robust.

- The TORCH system will be beneficial in terms of all performance metrics with a pronounce lead of the safety improvement of the ATM system.

Finally, the comparison of the results of the two parallel approaches used to evaluate the socio-economic performance of the TORCH system are in complete agreement, and the two methods provide a confirmation on the expected social acceptance and cost-effectiveness viability of the TORCH system.

6. Recommendations

The results of the socio-economic assessment of the TORCH and base-line systems provide the ground for the following recommendations in terms of the TORCH system implementation:

- The TORCH system is more likely to be viable from a socio-economic point of view under a scenario of high traffic growth.

- All stakeholders have mutual benefits, i.e. a win-win situation. There are no trade-offs among the objectives and aspirations of the ATM system stakeholders. This makes possible the establishment of an effective stakeholder coalition for the achievement of the common goals.

- During the implementation process, priority should be given to those features of the TORCH system that have the highest bearing on the system safety.

- Considerable importance should be also allocated during system implementation on the TORCH system functionalities, contributing the most to the increase of the peak hour airport capacity and to features securing the minimization the deviation between scheduled and actual time of the aircraft.

- System implementation issues related to controller workload should be also taken into serious consideration, since they have a positive impact on both system acceptability and system safety.

7. Future Actions

Future actions regarding the evaluation of the TORCH system should be focussed on:

- Assessing the risk related to the TORCH investment due to factors stemming from the general macroeconomic environment and expected traffic growth.

- The more precise assessment of the costs involved in the development and operation of the TORCH concept. The estimation of these costs will become more precise and reliable after the final definition of the new European ATM system identified by TORCH.

- An effort to quantify some of the tangible parameters of the ATM system operation at a European wide level, i.e. delay costs, fuel cost of airlines, operating cost of airlines. This effort will necessitate the development/application of simulation tools.

An extensive dissemination of the TORCH project results to the relevant stakeholders and a subsequent survey of their preferences which will provide essential feedback for the refinement of the TORCH results.

Appendix E. Transition Guidelines.

Table of Contents

1. Introduction

The main purpose of this appendix is to describe the Operational Improvements of the TORCH Operational Concept proposed in three possible steps. First step will be year 2005, second step year 2007 and third step year 2010. The basis of this description will be the technical feasibility of the Operational Concept, presented in the D3.2 by a table including which technical products will be available in each of the steps dates. The target concept, and thus the last step, will be the Operational Concept presented in [61TI0102]. In each step, only new improvements will be addressed, including transition guidelines, from the point of view of changes in the philosophy of work, changes in procedures, changes in technologic products and changes in resources.

2. Layered Planning Phase

2.1. Step 1 (up to 2005)

This step is much based on the current CNS/ATM system operating in Europe, which is composed by a set of different national systems, interconnected only for some CNS functionalities [see D2.1], with the following operational improvements, apart from the improvements foreseen in the Convergence and Implementation Programme (CIP):

2.1.1. Central Organisations

- Improvement in Airspace Plan Development by the preparation of a flexible strategic airspace plan, that allows for changes in co-operation with airspace users. This requires:
  - Introduction of a central organisation (ASM Cell), which will prepare a central Airspace Plan, that involves the ECAC area.
  - Co-ordination with airspace users is made through written papers, discussions, etc.
- Improvements in Airspace Status Management by:
  - Periodically negotiated refinements of the airspace plan in order to define the route network: for airspace structure, access times and rules, ATM organisation required (sectors, staff,...).
  - Implementing a Co-ordination Tool for Airspace Status Management (e.g. a web site that ensure secure transitions). The tool will be used for the preparation of the refined airspace plan in co-ordination with airspace users.
  - The Introduction of Fast-Time Simulation tools (what-if functionality) to ensure that the Airspace Plan is feasible.
- Implementation of an environment and forecast data store: Containing environment data as well as weather and statistical forecast data.
- Introduction of the Aeronautical Telecommunication Network (ATN). This is required for the negotiation process and the distribution of information.

2.1.2. ATS Providers

The lack at this stage of the required technical means for the Strategic Planning phase will not enable ATS Providers to implement operational procedures related to the DOP implementation and optimisation before Year 2005. Some changes in the philosophy of work are required for this period, regarding the distribution of information (mainly capacity information) to the central European D/C database. As well as the identification of the privacy measures that will need to be enforced to ensure that the information is secure.

2.1.3. Airports

- Contribution to the demand/capacity determination and planning process by:
  - New airport Demand and Capacity determination tool to improve the airport strategic planning process: Airports Operators will determine expected long term demand and capacity under different conditions and scenarios, comparing long term airport demand and capacity under different scenarios. (Automated tool required).
  - Airport Operators will determine the need for new infrastructure to adapt capacity to expected demand (Long term resource planning).

2.1.4. Airspace Users

- Airspace Users will participate in the refinement of the Airspace Plan by the implementation of Fast-time simulation tools for negotiating the refinement of airspace plan (for airspace users).
- The role of airlines operators should move towards more involvement into the planning processes, by sharing their individual planning information, with the objective of taking decisions together with ATS, airports and Central Flow Management.

2.2. STEP 2 (From 2005 to 2007)

The main improvements expected for this period at the Strategic Planning Phase will be related to better demand prediction and capacity determination, and to better and co-operative demand/capacity planning management.

Changes in the philosophy of the planning process of each individual stakeholder are required to evolve from the current individual plannings that cause the current ATM capacity problems towards more collaborative planning based on the sharing of information. Stakeholders will have to distribute their planning information. Access to other stakeholders' planning information to perform their planning process will be allowed only when privacy and commercial interests are maintained.

2.2.1. Central Organisations

- Improvement of Airspace Plan development process. The plan should be flexible enough to allow for changes in airspace structure, classification and/or route structure according to the actual demand. To perform this process the ASM Cell will require a Fast-time simulation tool to prepare the airspace plan. The ASM cell will also require demand and capacity information from the demand prediction and capacity determination process, to carry out the simulations.

- Improvements in Demand/Capacity determination process:

    – A Central European organisation will be in charge of central capacity, and demand determination and balancing, leading the conflict of interest resolution process to be carried out between the involved stakeholders. The functionality of such organisation should also include the current central ATFM functionality (CFMU).

    – Implementation of a central Demand/Capacity data store, containing individual demand and capacity data as well as consolidated demand/capacity data. The data store will be maintained and updated by the mentioned central organisation.

    – Permanent Demand prediction at all time horizons –from years in advance to real-time operations-, based on the data provided from multiple sources and processed through a demand prediction model and on the prediction of impact on each area. This function is supported by the implementation of a required demand prediction tool based on demand model.

    – Permanent Capacity determination at all time horizons by area, based on data from many sources (Airports, ATS providers, ...), processed through a Capacity Model. This process will be performed by a capacity determination tool based on the capacity model.

    – Use of the Aeronautical Telecommunication Network to distribute the capacity and demand information.

- Improvement of the central demand-capacity planning process. This process will consist of the central identification of capacity shortfalls, and of the development of ECAC-wide capacity management solutions geared towards providing the optimal economic benefits. This process will be supported by and ECAC-wide demand-capacity planning tool. The process contains currently existing CFMU functionality

2.2.2. ATS Providers

- Contribution to the capacity determination process. ATS Providers will provide their day of operations individual capacity plans to be stored into the central D/C data store. This capacity information includes the TMA, sector and airspace capacity as well as the results from their individual analysis. The implementation of a tool for the provision of capacity information is required for this process.

- Contribution to the Local demand/capacity planning process. National ATS Providers will lead the local demand-capacity planning process. This process will consists of the permanent local identification of capacity shortfalls and development of proposals that take into account the conclusions provided by the central demand and capacity planning process. This process will be supported by a central demand and capacity planning tool adapted for TMA and en-route sectors.

2.2.3. Airports

- Contribution to the capacity determination process. Airport Operators will provide the necessary information to the central D/C data store. This information will contain the airport capacity, including operating hours, capacity values for different RWY/weather scenarios, acceptance rates, constraints and options. This information will be updated in case the situation changes before the day of operations. The implementation of a tool for the provision of capacity information is required for this process.

- Contribution to the local demand-capacity planning process. Airport Operators will identify capacity shortfalls and possible solutions (short-term resource planning), in collaboration with airlines, central organisations (ATFM), ATS providers, aircraft handling agents, etc.

2.2.4. Airspace Users

- Airlines operators will perform flight scheduling, taking into account strategic events, such as aircraft/fleet purchases, aircraft type route allocation and seasonal flight scheduling. The result of these activities will be a published schedule that covers a traffic season after co-ordinated with both airport and ATM authorities. This plan will consider economic development forecast and the expected airport capacity for schedule planning.

- After the seasonal flight scheduling is published, airlines will perform their individual planning for the day of operations. Airline Operators will contribute to the demand prediction by providing their planned demand data to the central D/C data store (Flight Plans, individual preferences and aircraft and crew availability). A tool for the provision of the demand information is required.

- Participation of Aircraft Operators in the Demand/Capacity planning process. AOs will have access to the D/C data store, where solutions to the capacity shortfalls (identified during the demand/capacity planning process) are included. Being aware of this information Airlines will be able to take new decisions and re-plan their activities.

- Other airspace users, such us Military operators and general aviation, will also contribute to the demand prediction process by providing their planned demand information as soon as it is available. They will also have access to the data store taking advantage to plan their activities.

- Military Operators will also provide the required information for the Airspace plan development, informing about Military Areas which may be opened to commercial traffic at some times

2.3. STEP 3 (From 2007 to 2010)

Along this period several major changes will be made. The main changes will be the implementation of the DOP development process and the introduction of airspace areas with partial delegation of separation assurance responsibility (e.g. free-route airspace).

2.3.1. Central Organisations

- Introduction of areas with partial delegation of separation assurance to aircraft. The Airspace Plan will be able to define areas with partial delegation of separation assurance to aircraft (within the Managed Airspace), such as Free-route airspace or reserved areas for Longitudinal Station Keeping (en-route and TMA). It is required and expected that in this timeframe there will be a significant number of ASAS equipped aircraft.

- Introduction of CDM into Demand/capacity Planning process. The demand/capacity planning process will be improved by the introduction of "conflict of interest" resolution processes carried out between the ATS Providers, Airports operators and airspace users. CDM rules will be set to determine the rules for access to airspace, routes and airports. This process will enable all stakeholders to plan their activities in a more effective way for a time period that includes the day of operations. All stakeholders will have to be integrated negotiation tools.

- Introduction of the Daily Operational Plan (DOP) development process. This process is carried out after the negotiation and the demand and capacity balancing the process. The DOP development will include the following improvements:
  - Implementation of a central DOP production tool. This is required for this process and should be hosted by a European central organisation (such as the CFMU) which will also maintain and update the central DOP data store.
  - The DOP will evolve together with the updated stakeholders' plans. The plans should be included in the evolving DOP until the day before the day of operations. At this date the DOP will be approved and distributed in tailored versions to the involved stakeholders (Airspace users, airports, ATS providers, ...).
  - Introduction of a Central DOP re-planning process. During the day of operations, planning inaccuracies and unforeseen events will require real time re-planning by the involved stakeholders. Central re-planning will be triggered by wide area events (that have a wide effect), which require DOP updates. This process will require the implementation of a central DOP production tool functioning in an "update" mode.

2.3.2. ATS Providers

- Contribution to the CDM process during the demand/capacity planning. ATS Providers will participate in the negotiation process, to be carried out with the other stakeholders, to optimise the DOP. ATS Providers will use a negotiation tool, with "what-if" functionality, provided by fast time simulation, for negotiating with airlines, and with adjacent agencies.

- Local DOP re-planning and optimisation process will be led locally by the national ATS providers. During the day of operations, planning inaccuracies and unexpected events will require real time re-planning. Local re-planning will be triggered in case of unexpected events with limited local effect (en-route or TMA). This process will require the assistance of a decision-support tool. After the re-planning process, only the affected tailored DOPs will be updated.

2.3.3. Airports

- Contribution to the CDM demand/capacity planning process. Airport operators will participate in the negotiation process, to be carried out, with airlines and with adjacent agencies or airports, to solve the imbalances between capacity and demand and thus, optimise the DOP.

2.3.4. Airspace Users

- Contribution to the CDM demand/capacity planning process. AOs will participate in the negotiation process, with other stakeholders, to find solutions for the predicted capacity/demand imbalances by adjusting their planned demand. A negotiation tool for changes in the DOP is required for this process.

- During the DOP optimisation process, AOs will be able to request "FPL probing" –to investigate the effects of their proposed changes- to the central organisation in charge of demand/capacity planning. Airlines will also have the opportunity of performing their own simulations and "FPL probing". This will allow airspace users to predict potential bottlenecks and decide whether to change their planning or not, taking advantage of the flexibility of the DOP to choose the best solution for their future flights.

- Central re-planning and local optimisation. Planning inaccuracies and unexpected events raised during the day of operations will require real time re-planning. Aircraft Operators will be notified of changes in their tailored DOPs by ATS Providers or the Central organisation, depending on the effect of the event (local or wide respectively).

3. Re-Planning Phase

3.1. Step 1 (up to 2005)

Main improvements expected for this period at the Tactical Planning Phase will be mainly related to the introduction of a new position, the “ATS Centre Planner”. At this stage, only the first steps for implementation of the Tactical Planning Phase will be taken. Further enhancement will be introduced during next steps. That new concept is to optimise traffic flows for groups of centres. Some required infrastructure for the new functionalities will be implemented at European level and for all stakeholders such as the Aeronautical Telecommunication Network, regarding air/ground and ground/ground information management and distribution.

Additionally, a local flow planning element will be introduced, terminal area sequencing, integrating AMAN and DMAN. The integration with the ground movement management tool will starts at this stage.

3.1.1. Central Organisations

Regarding the tactical planning phase, no operational improvements are expected during this period for Central Organisation, apart from the Central DOP re-planning process dealt with in the strategic phase (see point Step 3 of the Strategic Planning Phase).

3.1.2. ATS Providers

- Introduction of *ATS Centre Planner position.* ATS providers will introduce a new role (at Centre or multi-centre level) that analyses the agreed DOP and current air traffic and resources. This new position will include the current FMP and it will be limited to the identification of traffic overloads, congestion situations and airspace acceptance rates, without negotiation capabilities with aircraft. En-route metering tool (traffic analyser) will became operational (some existing in the USA).

- Controllers will take advantage of a better sequencing with the use of information coming from integration of arrival and departure managers and surface management tools at airports.

3.1.3. Airports

- Introduction of *arrival & departure managers* working on an integrated way in TMA / APP. In order to obtain the optimal flow of traffic, arrival, departure and surface movement tools will be integrated. Arrival and departures sequences will be managed and optimise taking all constraint into account, including ground constraints (depending of the level of integration). HMI developments will be necessary to integrate information into the control positions, but not additional staff is foreseen. Improvement in surface management tools (surveillance data fusion or conflict detection) will help to enhance data used by arrival and departure management tools.

- The ATN infrastructure will enable to integrate data-link functionality (e.g. pre-departure clearances and ATIS messages) in order to increase the information useful for controller.

- Creation of a *Central airport database.* Information stored will be widely accessible to all stakeholders. The ATN is required as communication infrastructure.

3.1.4. Airspace Users

At this level of implementation, the airspace user will not need to introduce any improvement on board. However, it will be possible to have the necessary infrastructure to begin datalink applications:

- VDL mode 2.
- ATN routers.

3.2. STEP 2 (From 2005 to 2007)

The main improvements expected for this period at the Tactical Planning Phase will be mainly related to the introduction of the Multi Sector Planner. Changes in the philosophy of the planning controller role will occur with the introduction of MSP because he/she would perform some planner controller’s tasks[1]. Co-ordination between controllers (ATS Centre Planner, MSP, planning controller and tactical controller) will be a key issue to take into account in order to achieve an efficient operation of the control tasks.

3.2.1. Central Organisations

No central organisations’ operational improvements, related to the Tactical Planning Phase are expected for this period of time.

3.2.2. ATS Providers

- Introduction of *MSP*. This actor relates to operations at the ATS centre level where there is more than one control sector involved considering current traffic and also traffic from adjoining centres (time horizon up to

---

[1] Functions and roles assigned to the MSP in the operational assessment did not provide significant improvements. Those need to be developed and detailed deeper. Therefore, it is open the possibility with further development of such role that MSP replaces planning controller position, but here it is stated in addition to current sector planner.

30 minutes). He/she will balance the traffic load between sectors and manage the sequencing of arriving. At this strategic level, he/she will be the main link between ground and air as for trajectory negotiation issues. Some tools will support this role:

- A/G data link services will enable to improve the 4D-trajectory prediction with downlinked airborne data
- Trajectory negotiation tool for 4D trajectory negotiation with airlines and aircraft. Although principally considering aircraft with 4D trajectory prediction and guidance capability, the MSP must also cater for less well-equipped aircraft, requiring shorter time horizon and more tactical control strategy.
- MTCD tool taking advantage of the use of 4D FMS trajectories from equipped aircraft (the more equipped aircraft, the more efficient MTCD tool).
- Conflict resolution advisor (CORA), which will help to the MSP to take decisions in order to solve future conflicts.

3.2.3. Airports

There is no operational improvement foreseen at Strategic Planning Level at airports for this period.

3.2.4. Airspace Users

Main changes introduced from the user point of view for this period will be both downlink 4 FMS trajectories and the introduction of A/G trajectory negotiation capability. User will be able to change 4D approach profiles due to operational preferences or priority changes among arriving company flights.

- Introduction of 4D trajectory negotiation between ATS providers and airlines. AOCs will be involved in the trajectory negotiation at Strategic Planning Phase. They will introduce their preference in the CDM process when MSP establishes flow regulations and asks for changes and negotiates the aircraft trajectories. Additionally, negotiation with en-route metering will be also possible when necessary. This task will be assigned to dedicated airline staff.
- Aircraft will have the possibility to negotiate trajectories with ATS providers, taking into account the airlines preferences due to the shared information means, thanks to the availability of an *A/G trajectory negotiation tool* on board (see datalink capabilities in the flight execution section).

3.3. STEP 3 (From 2007 to 2010)

Along this period full integration of airport resources management tools will be made. The introduction of more accurate 4D flight profiles and areas of partial delegation of separation assurance will enable station keeping operations (see flight execution).

3.3.1. Central Organisations

No central organisations' operational improvements, related to the Tactical Planning Phase are expected for this period of time.

3.3.2. ATS Providers

Full implementation of ATS centre planner with the use of a *negotiation tool*, with fast time simulation capabilities, for negotiating with airlines, and with adjacent agencies. Once flow regulations and entry/exit conditions are established as needed, this position will be able to inform and negotiate those conditions with aircraft affected.

3.3.3. Airports

Main improvement is the integration of resource management tools at the airport (e.g. meteorological conditions, runway status, wake turbulence effects, noise-sensitive areas, stands manager, pushback vehicle manager or taxi planning manager) with the arrival and departure managers, which will entail more information taken into account and more accurate to manage 4D approach trajectories.

3.3.4. Airspace Users

Airlines and aircraft will increase negotiation with ATC of clearances for 4D flight profiles due to more accurate 4D constraints. No other operational improvements are envisaged for this period.

4. Real Time Operations Phase (Flight Execution)

4.1. Step 1 (Up to 2005)

During this first period of time, the main operational improvements will strongly depend on the new required systems to be implemented in both ground (ATC centres and AOCs) and on-board, and on the infrastructure required. The main improvements will be the introduction of first data link applications (non-time critical ODIAC applications), and new tools for improving controller's capacity. The main key issue will be the percentage of fleet equipped with the required systems.

4.1.1. Central Organisations

Regarding the flight execution phase no operational improvements are expected during this period. Therefore, some required infrastructure for the new functionalities will be implemented at European level such as the Aeronautical Telecommunication Network, to be used, in this case, for the sharing and distribution of surveillance and flight plan information.

4.1.2. *ATS Providers*

Some improvements are expected on the *Ground-based Separation Assurance, monitoring and control:*

- Improvement in surveillance functionality. Each ATC centre will collect surveillance information from several sources (PSR, SSR, etc.), compile the surveillance picture for their area of responsibility (not including airports) and distribute the results (surveillance data, with correlated tracks) to ATS providers having requested it. This function will be supported by the implementation of a surveillance data fusion system, at the level of control centres.
- Introduction of a flight plan service centre, collecting and making available up-to-date information about flight plans, including information from downlinked FMS trajectories.
- The executive controller performs the same kind of work as today, but using data link for routine instructions. Except for emergencies, instructions always have to be usable by FMS (No instruction such as 'heading x')
- Controllers are assisted by an automated agenda for planning and organise their work, at the optimum way
- Introduction of the RVSM in the entire European airspace.

Some improvements on *Hazard Assessment* functionality are expected. The safety net will be widely implemented along the entire European airspace:

- Implementation of the ground-based Short Term Conflict Alert (STCA) tool along all the ECAC area.
- Implementation of the Area Proximity Warning (APW) tool along all the ECAC area.
- Implementation of the Minimum Safe Altitude Warning (MSAW) tool along all the ECAC area.
- Integration of airborne and ground systems.

4.1.3. *Airports*

- Implementation of the Central Airport database to manage the real-time resource allocation.
- Improvements in Airport *Operational Plan Monitoring.* The airport operator monitors the airport situation, having the ability of reading and writing the central airport database.
- Introduction of some *Surface Movement Management* functionalities:
    - Surveillance information will be obtained from the fusion of data from various sensors (e.g. SMR).
    - Conflict detection on airport with the help of a conflict detection tool for the Runway.

4.1.4. *Airspace Users*

- The implementation of Data Link Communication means on board (VDL mode 2 and ATN router) in order to implement ODIAC applications, which will:
    - Help the executive controller to perform the separation assurance and monitoring functions.
    - Enable the AOC monitor the progress of its flights and detect real-time events –which may delay flights-, having the opportunity of re-planning the affected flights.
- Improvement on *Hazard Assessment* functionality by the implementation of the improved ACAS systems (ACAS II and III) on board. The improvement of the safety net functions is based on the integration of airborne and ground systems.

4.2. Step 2 (From 2005 to 2007)

The main improvements expected for this period will be the implementations of ADS-B and the A/G trajectory negotiation, in which Airlines and ATC centres will participate.

4.2.1. *Central Organisations*

No central organisations' operational improvements, related to the flight execution are expected for this period of time.

4.2.2. *ATS Providers*

The main expected operational improvement is the enhancement of the surveillance system by the introduction of ADS-B and integration of this system to the surveillance data fusion system.

4.2.3. *Airports*

The main expected improvement for this period is the introduction of conflict detection on airport runway area, with the help of a conflict detection tool.

4.2.4. *Airspace Users*

- Contribution of airlines to the trajectory negotiation. The availability of an Airline/MSP trajectory negotiation tool will enable airlines to negotiate trajectory changes.
- The implementation of ADS-B in aircraft will improve the ground-based surveillance function.

4.3. Step 3 (From 2007 to 2010)

Main operational improvement of this period is the introduction of areas with partial delegation of separation assurance to the aircrews of suitable equipped aircraft, and the introduction of free-route operations, due to the implementation of ASAS and CDTI.

4.3.1. Central Organisations

No central organisations' operational improvements, related to the flight execution are expected for this period of time.

4.3.2. ATS Providers

The main operational improvement related to ATS providers is the introduction of free-route airspace. In this case the controller is fully responsible for the aircraft. Free-routing operations will be supported by specific on-board equipment of aircraft flying in this airspace (e.g. ASAS).

4.3.3. Airports

Improvement on airport resource management, in which managed resources are used in relation to operating flights. Implementation in airports of various resources management tools (co-operative), such as stand manager, pushback vehicle manager, taxi planning manager, collaborating with arrival and departure managers.

4.3.4. Airspace Users

The main operational improvements are supported by the implementation of new equipment on-board, such as the ADS-B, ASAS, CDTI and conflict resolution tools:

- Improvement of air-crew traffic situation awareness: Pilot is provided with data on his environment (status, position, and when possible intentions of other traffic with respect to his own trajectory).

- Introduction of ASAS applications such as Longitudinal Station Keeping (en-route and in TMA), and closely spaced parallel approaches (in TMA). In these cases aircraft will manage their relative movement with the other aircraft. The pilot receives full responsibility delegation from the controller for the duration of the application of aircraft involved.

- Introduction of free-routing operations. Although airlines may request should plan free-routing operations, during the flight; the pilot may request changes in the trajectory in order to choose the most convenient trajectory from the airline point of view.