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PUBLIC

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Validation of a European Gate to Gate Operational Concept for 2005-2010

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Executive Summary

The GATE TO GATE[1] (G2G) Programme is part of the Key Action "Sustainable Mobility and Intermodality" of the "Competitive and Sustainable Growth" programme of the EC, which contributes to the European Union transport policy.

The G2G Consortium covers eight states, all over Europe, and includes:

- Five ATS providers: AENA (SP), DFS (G), DSNA (F), ENAV (I), LFV (S),

- Six ATM systems, avionics or aircraft manufacturers: THALES ATM, SELEX, INDRA, THALES Avionics, BAE Systems, AIRBUS France,

- Four research centres or engineering companies: Deep Blue, NLR, ISDEFE and SICTA

- And EUROCONTROL.

The main objectives of the programme, each having associated deliverables, are:

- To define and describe a European gate-to-gate Integrated Operational Concept, the G2G IOC, consistent with other on-going Air European Programmes, and with stakeholders strategic plans, for progressive implementation, from 2010 onwards,

- To develop technical specifications focusing on the major improvements to be brought to the current ATM ground systems in support of the G2G IOC,

- To adapt existing ATM ground validation platforms, to make validation possible and to demonstrate the industrial capability to implement the required new functions,

- To get the operational concept evaluated and validated by operational organisations and staff.

The Programme aims at:

- Allowing a better understanding of links between proposed changes and resulting operational improvements,

- Preparing a wide dissemination of new technical means,

- Stimulating the introduction of new concepts beneficial to air transport, and

- Influencing future standards towards what ATM in Europe really needs.

To allow for participation of various European controllers on local platforms, and apply a realistic incremental strategy where parts of the concept are first validated before being 'put' together, the concept has been 'split' into three validation clusters:

1. Flow & Departure Management,

2. Tactical control en-route & Multi-Layer Planning,

3. Extended TMA Management.

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[1] GATE TO GATE (in upper cases, abbreviated into G2G) must be understood as the name of the programme while gate-to-gate is natural language.

Then the programme work plan is built in order to provide the best synergy over all steps of validation within each cluster, i.e. one WP per cluster, WP1/WP2/WP3 taking care of all definition and validation tasks, results being consolidated across these 3 WPs.

Finally, Work Package 4 is considering results from WP1, WP2, and WP3 to perform consolidated simulation exercises, using the programme reference platform in a more integrated –from concept point of view- perspective.

To ensure coherence and integrity among between Work-Packages, technical co-ordination activities are put in place, dealing with:

- Operational Concept

- Specifications (SSS System Segment Specification, SSDD System Segment Design and IRS Interface Requirements Specifications)

- Platform

- Validation

- Dissemination

Through an overall 4,5 years span, the main part of G2G programme has been devoted to validate the G2G IOC, representing 72% of programme effort (including platform and validation activities). The G2G IOC definition phase has represented 12% of effort. The rest of 14 % effort was dedicated to co-ordination activities (programme, WP and horizontal i.e. IOC, specifications, platforms, validation and dissemination) and 2% to dissemination activity.

In conclusion, during the Final Forum on October 2006, EC noted that though the complete validation of an integrated gate to gate operational concept had not been done,the concept discussions in G2G have helped to prepare the ground for, and will no doubt contribute to, the SESAR operational concept.

Likewise EUROCONTROL concluded that the G2G Concept is no single rigid and standardised ATC Operational solution, but one flexible Concept made of interoperable concept elements that are based on common principles and can be adapted to best fit multiple ATC environments.

As well individual conclusions have been presented by each ANSP.

The conclusions on validation results per cluster are the following (Extract from D0.4.4 [17]):

Concept up to 2012

- Airports and Flow

The airport related simulations were an early set of studies integrating several tools together. The emphasis was on operability and usability of a complex set of functions. The expected benefits were mainly in efficiency of airport operations. The Tactical Departure Management concept developed and built around the DMAN tool and efficient CDM has shown potential during validation to improve and smooth airport operations. The main conclusion is that the results were promising but that much more work is required to assess benefits and to establish network issues such as gate management impacts.

- En-Route

The en-route concepts of dynamic resectorisation and multi sector planning showed benefits in efficient use of airspace and operational staff which could translate into marginal gains in capacity.

Access to aircraft parameters via ADS-B was received positively by controllers

The datalink applications tended to either display a/c data on the controller HMI or were used to provide electronic assistance to existing control tasks (e.g. transfer frequency). There were no concepts tested that integrated the data available from a/c systems into ground systems. Thus the current open loop control system was not actively challenged.

The MTCD Problem Indicator was based on ground system trajectory prediction. This along with flight path conformance, is an area where the potential for using aircraft derived data within the trajectory monitoring and prediction functions could be beneficial. However, there was no opportunity to test these enhancements within GTG.

- TMA Arrivals

The WP3 work on an electronic environment and AMAN integration provided a similar level of capability to Rome and Paris. This was considered as an essential base from which further concepts, which make use of aircraft derived data to improve TMA performance, could be investigated.

Concept beyond 2012

- Automation

The Automation concept, investigated at DFS, could dramatically change the role of the controller by moving tasks to the ATC system. This concept is similar to recent studies in the US (comp. to Heinz Erzberger, "Transforming the NAS: The next generation Air Traffic Control System", ICAS 2004). Though there is a high degree of automation in ground systems the proposed concept does not require new aircraft capabilities. This makes a possible transition step relatively easy technically. The prototype developed in this project will be used further by DFS to continue this work. The theme is also in line with SESAR Deliverable D1 that states that "there is a need for a paradigm shift in the current concept of operations to break through the "capacity wall" … and "this shift will include an increased use of automation to do some tasks traditionally performed by humans".

- ASAS En-route

The indication from the participating controllers was that en-route ASAS procedures were difficult to implement.

It is necessary to conduct further studies to determine feasibility of the ASAS en-route procedures in the core en-route areas of Europe. The GTG evidence points towards ASAS Crossing and Passing as not being a feasible concept.

- ASAS TMA – Sequencing & Merging

ASAS in the TMA (sequencing and merging) was considered as feasible by the participating controllers. However flight deck issues and exception handling have not yet been addressed in detail.

For ASAS Sequencing & Merging no benefits to safety or capacity were observed.

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1. INTRODUCTION

1.1 Scope and Structure of the document

This document is the Final Report D0.5.2 related to the GATE TO GATE (G2G) programme.

It is supposed to provide a comprehensive and high-level operational understanding of the proposed ATM service derived from the G2G operational concept definition and the validation results.

The document is structured into the following sections:

Section 1: Introduction

This section introduces the scope and structure of the document, programme objectives and contains a description of the organization of the programme (Consortium, WBS, Effort) with contact details.

Section 2: ATM Service derived from the GATE TO GATE Operational Concept

This section provides a high-level overview of the proposed ATM service describing different aspects of Concept (G2G IOC, Cluster Concept, Key Concepts…) in the GATE TO GATE Programme.

Section 3: GATE TO GATE System Specifications and Architecture Activity

This section provides high-level overview of the different specifications activity and of the resulting deliverables (SSS, SSDD, IRS-APIs, High-Level System Architecture)

Section 4: GATE TO GATE Real Time Simulation Platforms

This section identifies the different ATM Real Time Simulation Platforms used by the G2G partners in their validation activities.

Section 5: GATE TO GATE Validation Results and Benefits

This section gives a synthetic view of the main results and benefits as outcome of the validation activity.

Section 6: Conclusions

This section identifies the main conclusions per cluster and those presented during the Final Forum.

Section 7: GATE TO GATE Partner plans with Results

This section details per key concept the development plan foreseen by each Partner.

 Section 8: GATE TO GATE Lessons Learnt and Recommendations

This section is giving an insight of the main G2G recommendations made by the consortium and provides also a feedback on working methods and processes of G2G consortium with the lessons learnt, good practices and recommendations.

Section 9: GATE TO GATE Public Documentation Baseline

This last section is referencing G2G public documentation baseline produced by the G2G consortium.

Appendix: Glossary

1.2 GATE TO GATE Programme Objectives

[Extract from DOW V3.5]

The final objective and justification of the G2G programme is an operational one: finding effective solutions to congestion, delay and safety problems experienced by air traffic in Europe, which are likely to increase dramatically to reach unacceptable levels in the next years.

The scientific and technological objectives are directly linked to this primary aim. They are:

- To define and describe an Operational Concept, taking TORCH as a basis to be refined and if necessary adjusted, consistent with other on-going European programmes, and correlated with the various Stakeholders Procedural and Technological Strategy plans.

- To develop technical specifications focusing on the major improvements to be brought to the current ATM ground Systems to be able to support this Concept (here, ATM ground Systems shall be understood as Gate to Gate ATM ground System).

- To adapt existing ATM ground validation platforms, with the primary aim to validate the operational concept proposed and to demonstrate the industrial capacity to implement the required new functions.

- To validate the operational concept, with the constraint to have the validation performed by organisations –ATS providers- and participants –controllers- actually concerned with the management and the operation of the ATM Systems.

Expected technical achievements relate to each of these objectives:

Operational concept
The expected output is the description of an operational concept implementable from 2010, consistent with EC and EUROCONTROL strategies, consistent with the procedures and technologies addressed in other European programmes, and likely to bring solutions to operational problems.

Technical Specifications
The output will be a set of functional, interface and performance requirements for ATM ground systems derived from the Concept definition.

Moreover, a generic design, based on the AVENUE one, will be produced in order to make clear the adaptation requirements of existing ATM validation platforms and also contribute, by associating main European manufacturers to this task, to future standardisation of products.

Platforms
The achievement will be ground ATM validation platforms implementing a part of the operational concept large enough to allow validation exercises to be performed successfully. The platforms will consist of ground ATM systems, with functional performances as defined in the technical specifications, connected to the simulation environment necessary to simulate the expected air traffic performances and the interactions with all stakeholders of future ATM (aircraft, airports, airlines operational centres…).

These platforms will make it possible to perform large and realistic real-time scenarios concerning the monitoring and control of air traffic applying those new conceptual improvements, ultimately from "an Airport Gate to an Airport Gate" for a flight.

Validation results
Conclusions on the operational concept and its likeliness to solve problems will be derived from results obtained by the programme, both by fast time simulation and from real-time validation exercises with operational staff (performed during the validation phase). The real-time exercises will be performed using the programme ATM ground platforms and therefore will concentrate on the flight phase from Gate to Gate.

All validation results will be analysed and made public.

1.3   GATE TO GATE Work Breakdown Structure WBS and Means

1.3.1 Work Breakdown Structure

The structure of the work breakdown of G2G was representative of the two dimensions of the programme. The first one being coherent with the "cutting" of the Concept into Clusters and the second one considering major tasks in the process of definition and validation of the Concept (i.e. Concept

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Elaboration, Specification, Development of validation platforms, Validation exercise and analysis, Dissemination).

The first dimension gaves its backbone to the structure of the work plan. There was one WP per cluster (WP1: *Flow and departure management*, WP2 *En-route and multi-layer planning* and WP3 *Extended TMA (liaison between En-route and TMA) and TMA management*). Particularly, each of these WPs will take the responsibility to perform the validation activities in relation with the relevant part of the Concept.

Another Work-package (WP4) carried out the validation activities considering the Concept in an integrated way.

Then, the second dimension structured each of WP1, WP2 and WP3 into three main tasks as referenced in first paragraph:

- Tasks WP1.1, WP2.1 and WP3.1 (Operational Concept Elaboration) defined (at detailed level) the operational concept, taking the work produced by TORCH as the basis, and ensuring consistency with other European programmes (AFAS, MA-AFAS, NUP, MFF) and participating European ATS providers strategies.

  The definition consisted of descriptions of the operational procedures and functional performances, but also of the expected performances behind the operational concept.

  These tasks were co-ordinated by WP0.1.

- Tasks WP1.3, WP2.3 and WP3.3 (Platform Preparation) prepared the ground ATM platforms that were used to perform the real-time validation exercises in each of these WP. These platforms integrated an ATM ground system, offering the level of functional performances and architecture as defined in WPx.2, together with the appropriate simulation environment necessary to simulate the other elements of the ATM environment (aircraft, airports, etc) in a realistic way.

  The preparation consisted of upgrading the platforms to the level required by the validation strategy. This upgrade was performed through adaptation of the existing or new software components that compose the platform with respect to technical specifications produced by WPx.2, and integration of these adapted components into the platform.

  The main reason to use several platforms was to allow local controllers to perform validation activities in their environment.

  Several "types" of platforms were used, i.e. platforms directly instantiated from the so-called referenced platform (managed by EUROCONTROL), platforms instantiated from the reference platform and modified locally to integrate some other components, other local platforms).

- Tasks WP1.4, WP2.4 and WP3.4 (Validation) carried out the different validation activities, using both fast time simulation and real-time simulation using the platforms provided by WPx.3.

  This included a description of the G2G 'Validation Strategy' (with production of scenarios) thus ensuring transparency of the Validation objectives and measures that were used in the simulation environment. These tasks organised the simulation exercises on the different sites, the collection and the analysis of results. It aimed to achieve such a high level of realism as is practicable within programme time and cost constraints. Where time or cost constraints were considered too restrictive this was reported.

WP4 had the major objective to perform some integrated validation of the overall concept. It primarily consolidated validation results achieved in WP's 1 to 3. WP4 therefore was organised into the same tasks (i.e. WP4.1, 4.2, 4.3, 4.4) as the other WP, to facilitate compliance with the main constraint which to ensure that "products" of WP1/2/3,x were developed from a G2G global perspective and then were applicable to WP4.

The platform to be used in WP4 was the AVENUE compliant ESCAPE ACE platform, which was mainly built from the ERIS EUROCONTROL Programme. This platform was named "reference platform" for the G2G programme, as it was used as the basis for several other local platforms in WP1, 2, and 3.

In addition to that backbone, the Work Package 0 (WP0: Programme Co-ordination and Management) was considered as the head of the structure. It provided all resources to ensure the administrative and financial management of the Programme (WP0.0), and all management tasks so that appropriate

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decisions were taken, whenever necessary, in a way consistent with the Programme objectives meanwhile reducing the risks.

Moreover the technical co-ordinators (W0.1 to 0.5) ensured that coherency and co-operation between WPs existed in the various technical domains (Concept, Specifications, Platform, Validation, Dissemination). They were particularly in charge to organise the work of the various WPs 1, 2, 3, and 4 so that consolidated G2G results (Concept definition, SSS, SSDD, IRS…) were produced.

In particular some tasks were directly managed through technical co-ordinators:

- Tasks WPx.2.1, WPx.2.2 and WPx.2.3 (System specifications, SSDD and IRS) described the generic system specifications (i.e. the system requirements) that an ATM validation platform should comply with, so that the operational concept described in WPx.1 can be implemented in a real time simulation platform and that this platform enabled the real time validation of those concepts. The description consisted of a System Segment Specification SSS document, a System Segment Design SSDD document and Interface Requirements Specifications IRS document. The IRS particularly continued the work on definition of APIs carried out during the AVENUE project: this work supported the standardisation of ATM validation activities in Europe for what concerned shared integration of software.

- Tasks WPx.5 (Dissemination) prepared the exploitation of the GATE TO GATE key results, especially concerning the validation results of the concept.

Therefore the overall work plan was the following:
- WP 0 Co-ordination
    o WP 0.0 Programme Co-ordination
    o WP 0.1 Operational Concept
    o WP0.2.1 SSS Co-ordination
    o WP0.2.2 SSDD Co-ordination
    o WP 0.2.3 IRS Co-ordination
    o WP 0.3 Platform Co-ordination
    o WP0.4 Validation Co-ordination
    o WP0.5 Dissemination Co-ordination
- WP x.2.1 SSS Contribution and Consolidation
- WP x.2.2 SSDD Contribution and Consolidation
- WP x.2.3 IRS Contribution and Consolidation
- WP x.5 Dissemination Contribution and Consolidation
- WP 1 to 3 for Clusters 1 to 3
    o WP x.1 Operational Concept
    o WP x.3 Platform
    o WP x.4 Validation
- WP4 Consolidated simulation
    o WP 4.1 Operational Concept
    o WP 4.3 Platform
    o WP 4.4 Validation

A summary of the high level structure of the programme is shown by Figure 1 on the next page:
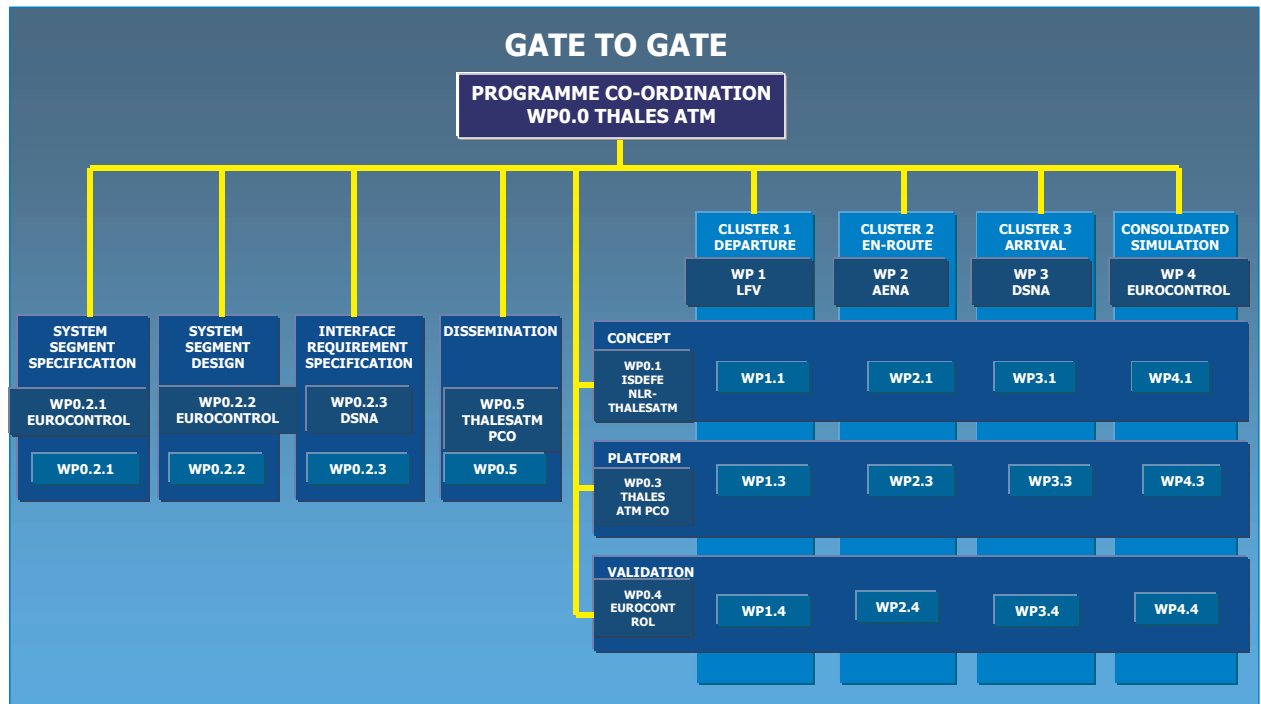
Figure 1 – GATE TO GATE Work Breakdown Structure

1.3.2 GATE TO GATE Consortium Composition and Contacts

The G2G consortium provided an optimum representation of European stakeholders:

- It provided representation of seven European states, i.e. United Kingdom, the Netherlands, Germany, Sweden, France, Italy and Spain (not including all other EUROCONTROL members, represented through EUROCONTROL).

- It provided a wide representation of the different kinds of stakeholders that have the most importance in the actual implementation of the concept. In addition to EUROCONTROL, it included ATS service providers (some also managing airports), all major European ground equipment manufacturers, avionics and aircraft manufacturers, and research centres. This wide composition should facilitate and accelerate the actual implementation of the operational concept and of its technical enablers.

- It was composed of:

PROGRAMME CO-ORDINATOR : THALES ATM (France)
PRINCIPAL CONTRACTORS :
AENA (Spain)
SELEX (Italy)
DFS (Germany)
DSNA (France)
ENAV (Italy)
EUROCONTROL (International)
Indra Sistemas (Spain)
ISDEFE (Spain)
LFV (Sweden)

ASSISTANT CONTRACTORS:

AIRBUS (France)
BAE Systems (UK)
Deep Blue (Italy)
NLR (Netherlands)
SICTA (Italy)
THALES Avionics (France)

The name and contact details of each G2G contractor are described hereafter:

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Figure 2 – Name and Contact Details

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1.3.3   Work Share per Partner, WP and Activity Domain

The total budget, as planned and actual, is the following with EC contribution:

Planned Budget (EURO)	Actual Budget (EURO)	EC Contribution (EURO)
29 998 150	36 372 342	14 980 094

Figure 3 – G2G Total budget

The explanation of difference between the planned and actual values of budget (without extra funding by EC) lies in :

- Extended contract period of 12 months
- Platform and validation activities were more effort consuming than foreseen, the Partners were willing and agreed this due to the good results of the project.

The work share per Partner is the following :
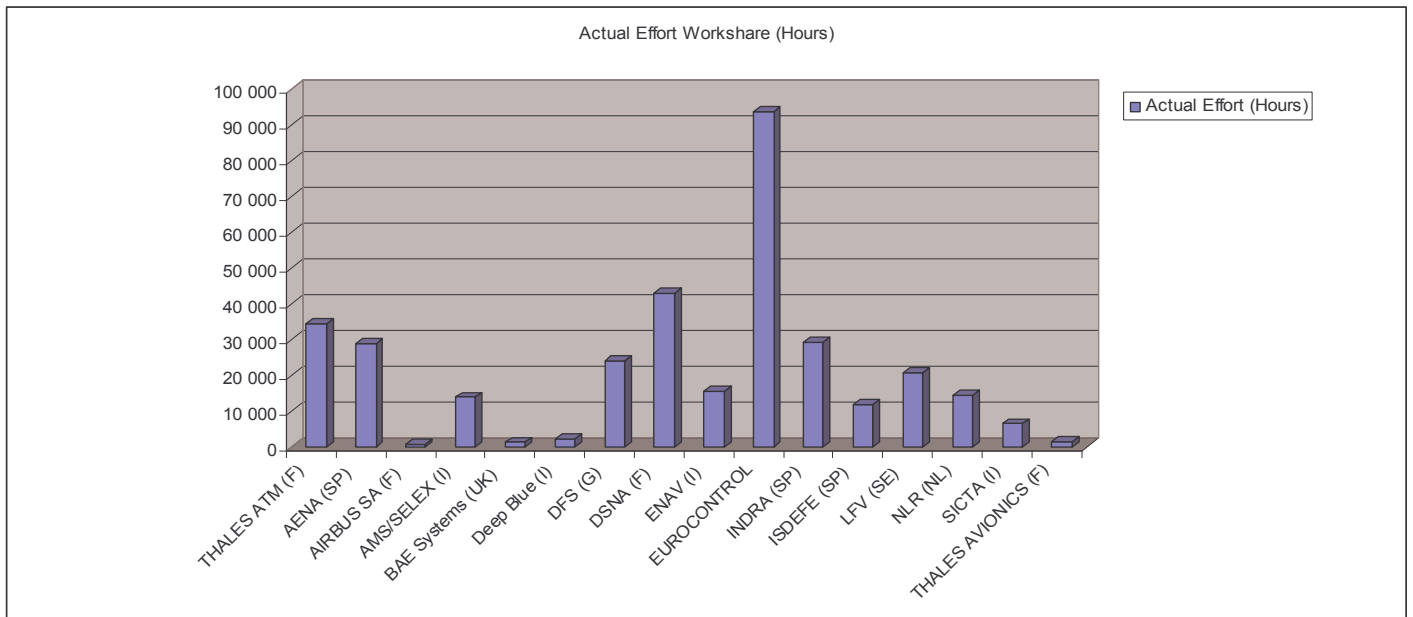
The effort per WP is the following:
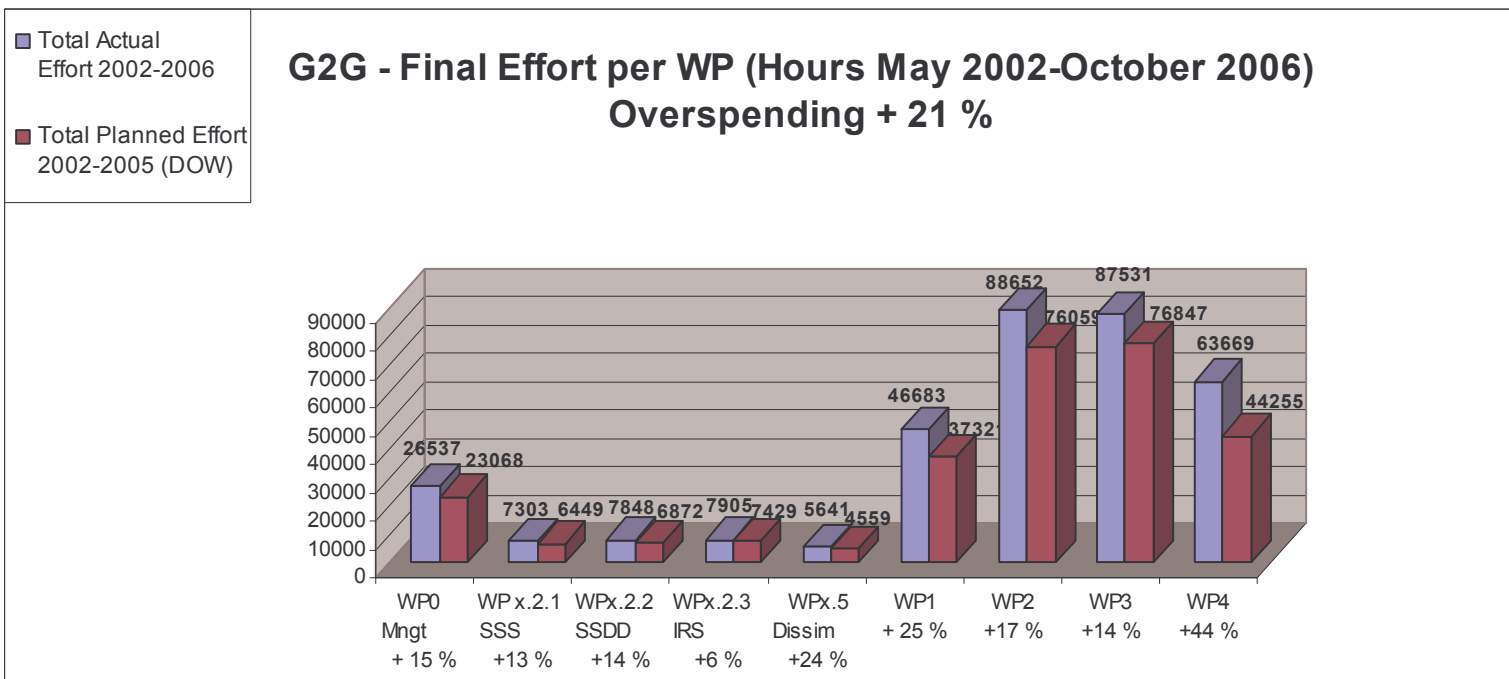
Figure 4 – G2G effort per WP

The effort percentages per activity domain are the following:
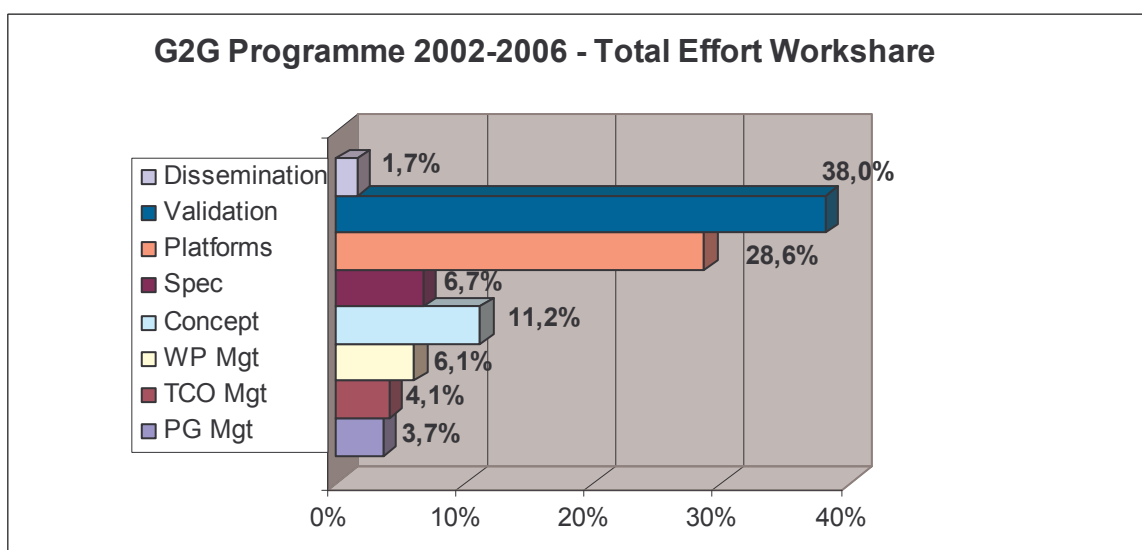
Figure 5 – G2G effort percentage per activity domain

2. ATM Service Derived from the GATE TO GATE Integrated Operational Concept

2.1 GATE TO GATE Integrated Operational Concept (G2G IOC) [1]

The G2G IOC was developed in 2003-2004 by the G2G partners to describe a candidate ATM Concept of Operation for implementation from 2010 onwards (being at an intermediate stage between current ATM operations and the EATMP OC).

The G2G IOC is consistent with EATMP OC but addresses a closer timeframe, particularly building on the work performed by earlier European R&D projects and assuming the possibility of a seamless and coherent evolution, in compliance with the ATM Strategy 2000+, towards the EATMP OC.

The ATM service derived from the G2G Integrated Operational Concept consists in:

- A traffic flow planning managed before and along all flight phases from departure gate to arrival gate,

- Based on 4D planning trajectory exchange between Stakeholders,

- Continuously optimized due to unexpected events, with more anticipation at all levels (airport, multi sector, E-TMA and TMA) and some delegation from controller to pilot,

- Provided by ANSPs to airlines from 2010 and giving benefits on punctuality and capacity, safety, economics, operability and environment.

The G2G IOC is providing detail on the following interrelationships between basic principles and benefits.

- It is based on **better collaboration** between ATM actors such as AOC, CFMU, ANSPs, Airport Operators and Aircraft; this is mainly implemented by **enhanced exchanges of accurate and reliable data** (e.g. the 4D Trajectories).

- This results in **enhanced situation awareness** especially on the ground and in the cockpit, and this increases firstly the safety and secondly the airport capacity (especially in low visibility conditions), and also, this allows **delegation of controller's tasks** (e.g. spacing and crossing) to the pilot.

- This also enables **more anticipation** with **optimised allocation of resources to traffic demand** and **continuous optimisation of planning** before and during the flight. And this improves the quality of prediction of **enhanced automated supporting tools** (i.e. AMAN, DMAN, MTCD, etc).

- And the result of this is an expected **decrease of the need for tactical controller's intervention** during the flight and thus a reduction of controller's workload per aircraft. Thus it is expected to achieve an increase of **capacity, safety and economics** (improving punctuality and optimised routing).

 (It shall be understood that G2G has mainly assumed an overall optimised ATM planning can be agreed by the ATM actors, but has not discussed the exact nature of this ATM planning, how this agreement is made and what target performance of the ATM System in terms of respect to this planning –e.g. it is particularly the C-ATM project that has developed further that last point-.

Anyhow, the elements looked at by G2G, in terms of increase predictability and support to the planning optimisation, are thought to be completely compatible when these points are refined).

Being not constrained by any descriptive standard, G2G Programme has thus chosen to structure the G2G IOC description according to some main features / elements (***Airspace Organisation &***

Management, Layered and Convergent Planning, Air-Ground Integration, Automation support, ASAS) giving a concrete vision which main improvement principles drives the G2G IOC development.

Each of these descriptive layers adds to the understanding of the Concept. The description does not pretend being exhaustive but focus and bring details on those main elements.

These elements are of different nature as it is recognised by G2G partners that there is no "perfect way" to describe an ATM Concept, but that it rather be a mixture of Conceptual Elements and of operational and technical Enablers.

2.2   GATE TO GATE Cluster Concept and Key Concepts

Not pretending at an exhaustive validation of the G2G IOC, but willing to a pragmatic approach and concrete validation results, the G2G partners have initially agreed on some main principles to structure validation activities. This approach was also influenced by the commitment to go on with the AVENUE specifications and development, and then to organise real-time simulations using AVENUE compliant platforms as main part of the validation process.

This approach can be summarised as:

- ANSP partners carry on validation activities, in their airspace and with their controllers, concerning some Concept elements, named as Key Concepts, of particular interest for them. These Key Concepts take into account one or several of the main features structuring the G2G IOC and are agreed by partners as solutions for potential operational improvements not limited to their G2G "local validation environment".

- These Key Concepts mainly concern elements in a specific ATM phase of flight (Departure, En-route, Arrival). This structures the G2G programme into three Concept / Validation Clusters (WP1, WP2 and WP3).

- EUROCONTROL is responsible for organising final programme simulations, integrating some of the most mature IOC solutions and demonstrating a coherent ATM operation in all phases of flights (WP4). Although not integrating every Key Concept, it shows evidence of the direction indicated by the G2G IOC. This represents a tangible operational and technical baseline, capable to evolve logically towards integration of other conceptual elements (see WP4 Operational Scenario D4.1 document [2]).

The overall view of G2G Clusters and Key Concepts are depicted in figure 7 here below:
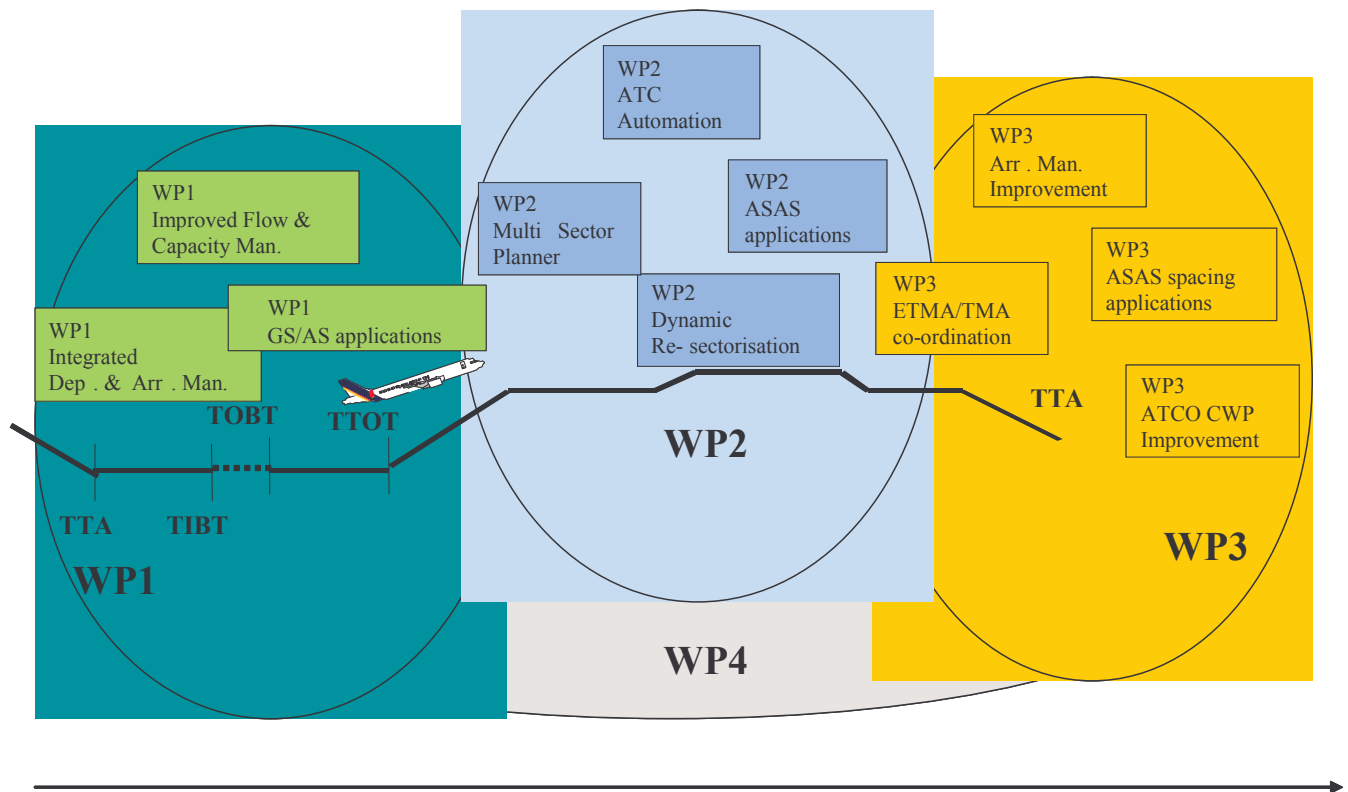
Timeline

Figure 6- Overall View of G2G Clusters and Key Concepts

Following this approach, in parallel to the development of the G2G IOC, the G2G partners have selected the so-called Key Concepts and then perform the more detailed description of the three Clusters Concept with Key Concepts, which are presented in the following sections.

2.2.1 Cluster 1: Flow and Departure Management

The detailed description of the cluster concept Cluster Concept CC1 and scenario is given in [3].

CC1- KC1: Ground and Airborne Surveillance Applications

This key concept addresses ADS-B and ASAS applications on ground and in the departure flight phase and aims at addressing safety aspects as well as ways to ensure smooth, continuous and expeditious operations on the ground, on the airport movement area, and in the air.

CC1- KC2: Integrated Departure and Arrival Management

Integrated Departure and Arrival Management, are addressing three essential aspects:

Tactical Departure Management, to address ground departure operations.

Departure and Arrival planning, to prepare Tactical Departure Management, and to address CDM aspects and to anticipate also shared use of the runway by departures and arrivals.

Integration of Departure and Arrival planning in order to deal with the problem how to come to an optimal planning of shared use of a runway, and how and when to be adaptive and flexible in the planning of the runway occupancy.

CC1- KC3: Improved Flow and Capacity Management

Improved Flow and Capacity Management will improve the regulation of traffic flows in the airspace and on the airports. Improved ATFCM aims at improving the regulation of traffic flows across sectors, while Refined Flow Management will have the objective to regulate arrival flows to congested destination airports.

The cluster 1 enabling technologies are the following:

Technology		GS/AS	Integrated Departure and Arrival Management	Improved Flow and Capacity
4D FMS	4D Flight Management System	X	X	
ADS-B	Automatic Dependent Surveillance-Broadcast	X		
AMAN	Arrival Manager		X	
ASAS Control Panel	Airborne Separation Assurance Control Panel	X		
A-SMGCS	Advanced- Surface Movement Guidance and Control System	X	X	
ASSAP	Airborne Surveillance and Separation Assurance Processing	X		
CDTI	Cockpit Display of Traffic Information	X		
CPDLC	Controller Pilot Data Link Communication	X		
CWP HMI	Control Working Position Human Machine Interface	X	X	
DMAN	Departure Manager		X	
E-TP	Enhanced-Trajectory Prediction		X	
FASA	Final Approach Spacing Assistance		X	
IFPS	Initial Flight Plan Processing			X
IRM	Integrated Runway Management		X	
PTC	Pre-flight Trajectory Co-ordination			X
RFM	Refined Flow Management			X
TACT	Tactical slot allocation system			X
TIS-B	Traffic Information Service – Broadcast	X		

Figure 7 - Cluster 1 enabling technologies

2.2.2 Cluster 2: En-Route and Multilayer Planning

The detailed description of the CC2 operational concept is given in [4] and operational scenarios in [5].

Cluster 2 considers three focal areas in the multi-layer planning plus the application of ASAS in a further integrated air-ground environment. Each of these areas will be addressed by one of the following Operational Concepts that operate at different look-ahead times.

CC2-KC1: Dynamic Re-sectorisation

Dynamic Re-sectorisation proposes a dynamic adaptation of sector boundaries to the changing traffic conditions, based on the continuous complexity and workload assessments that consider up-to-date data rather than historical demand.

An automatic support tool will assess the complexity of every sector and propose the best combination of sectors to avoid situations of low cost efficiency or low safety level.

CC2-KC2: Multi-Sector Planning

Multi-Sector Planning gathers a set of adjacent sectors under one single planning controller's responsibility. This will allow the planner to have an integrated picture of the traffic and will increase the planning horizon to anticipate the controller's responses to potential conflicts. Thus Multi-Sector planning can be seen as an extension of the current role of the planning controller.

CC2-KC3: ATC Automation

ATC Automation incorporates the planning controllers' intentions into the system that supports the planning process in order to stabilise the planning events and shifts the tasks performed by the planning controller to the automated system.

Rather than modelling the controller's behaviour, the automated concept approach consists of enabling the controller to reproduce and implement the system planning. The task of the controller is to check the system messages for correctness and to communicate these in a timely manner to the crew of the aircraft.

CC2-KC4: ASAS Applications

Taking into account the reference timeframe and the operational environment, three ASAS Applications have been considered. All of these fall within the two first categories of the Principles of Operation for ASAS (PO-ASAS – FAA/EUROCONTROL) as described in the following paragraphs.

- 'Enhanced Traffic Situational Awareness during flight operation' is included in the 'Airborne Traffic Situational Awareness Applications Category' and aims to enhance the flight crews' knowledge of the surrounding traffic and thus improve the flight crew's decision process for the safe and efficient management of the flight. No changes in separation tasks or responsibility are required for this application.

- 'Enhanced Sequencing and Merging' and 'Enhanced Crossing and Passing' are included in 'Airborne Spacing Applications Category' and require the flight crews to achieve and maintain a given spacing with a designated aircraft (limited in time, space and scope), as specified in a new ATC instruction. Although the flight crews are given new tasks, separation provision is still the controller's responsibility and applicable separation minima are unchanged.

Each concept described above is supported by additional ATC tools or technical enablers which are necessary in some cases as a precondition to apply these concepts:

- Medium Term Conflict Detection (MTCD) and Monitoring Aids (MONA) are introduced to improve the process of planning potential conflicts.

- SYSCO (System Supported Co-ordination) will support the (multi-Sector) Planner to carry out the main co-ordination tasks.

- Controller Pilot Data Link Communication (CPDLC) will allow for an increase in the air-ground integration to provide useful information with FMS trajectory and other Aircraft Derived Data (ADD) without using R/T that will be used for tactical and non-routine communications. In addition, due to the use of the data link (ACL and ACM), tasks may be redistributed between the executive controller and (multi-sector) planning controller thereby changing the current operational environment that will probably have some influence on the new concepts.

- ADS-B is introduced for tactical control in order to enhance surveillance and enable ASAS Applications. Extended surveillance information can be down linked by ADS-B. This is useful for predicting aircraft paths and to improve the ground data. Aircraft intention data and an integrated surveillance picture may be presented to the pilot to support a delegation of spacing tasks for certain manoeuvres, such as Sequencing and Merging or Crossing and Passing.

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- ATC Message Generator (AMG) is the main tool to support the ATC Automation Concept and will provide the controller with the main system planning instructions.

The detailed cluster 2 enabling technologies are the following:

Technology		DR	MSP	MTCD Support	Use of D/Link	AUTO	ASPA C&P/S&M
ADS-B	Automatic Dependent Surveillance-Broadcast						X
AMG	Advanced Message Generator					X	
APW	Area Proximity Warning					X	X
ASAS Control Panel	Airborne Separation Assistance Control Panel						X
ASSAP	Airborne Surveillance and Separation Assurance Processing						X
CDTI	Cockpit Display of Traffic Information					X	X
CPDLC (ACM/ACL)	Controller Pilot Data Link Communication	X	X	X	X	X	X
CWP HMI	Control Working Position Human Machine Interface	x	X	X	X	X	X
D/L FMS	Data link Flight Management System				X	X	X
ETLM	Enhanced Tactical Load Monitoring	X					
MONA	Monitoring Aids	X		X	X	X	X
MTCD	Medium Term Conflict Detection	X	X			X	
OLDI / SYSCO	On-Line Data Interchange		X		X	X	X
RCA	Remote Control Access						
STCA	Short Term Conflict Alert	X	X	X	X	X	X
TIS-B	Traffic Information Service - Broadcast						X
4D TP	Trajectory Prediction	X	X	X	X	X	X

Figure 8 - Cluster 2 enabling technologies

2.2.3 Cluster 3: E-TMA/TMA Management

The detailed description of the CC3 operational concept is given in [6] and operational scenarios in [7].

CC3-KC1: Arrival Management Improvement

Arrival Management Improvement is achieved by:

- Enhanced flight data processing,

- Enabling traffic balancing between sectors in an early stage of Arrival Management, and

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- Enhanced planning by adding new functionality.

CC3-KC2: ATCO CWP and Working methods Improvement

The ATCO CWP and working methods are improved by introduction of new working methods and assistance tools, by appropriate HMI and by access to additional information.

CC3-KC3: ASAS Applications

The basic ASAS application considered is the SPACING capability, which main objective is to provide a new tool for the controller to assist in maintaining separation. The new procedures introduced by the ASAS spacing application will be developed in such a way that this will take into account the interaction with the Arrival Manager in order to ensure the performance of an efficient sequencing process. Flight crews will perform these new ASAS tasks using new aircraft functions (e.g. Airborne surveillance, display of traffic information and ASAS guidance systems for pilots).

CC3-KC4: E-TMA/TMA Co-ordination

This concept investigates a solution to optimise the co-ordination and the transfer of aircraft between E-TMA positions (i.e. ACC arrival sectors) and TMA positions, in the perspective of alleviating the envisaged bottleneck that may occur at the E-TMA / TMA sector interface.

The detailed cluster 3 enabling technologies are the following:

Technology		Electronic Environment			ASAS S&M
		AMAN	CWP	E-TMA/TMA	
A-AMAN	Advanced - Arrival Manager	X			
ADS-B	Automatic Dependent Surveillance-Broadcast			X	
ASAS Control Panel	Airborne Separation Assistance Control Panel			X	
ASSAP	Airborne Surveillance and Separation Assurance Processing			X	
CWP HMI	Control Working Position Human Machine Interface	X	X	X	X
D/L	Data Link		X	X	X
E-TMA MTCD	Extended TMA Medium Term Conflict Detection	X	X	X	X
MONA	Monitoring Aids	X			X
OLDI	On-Line Data Interchange	X	X	X	X
	Stack Manager			X	X
TIS-B	Traffic Information Service - Broadcast			X	
TP	Trajectory Prediction	X		X	

Figure 9 - Cluster 3 enabling technologies

2.2.4 WP4: Integrated simulations

GTG WP4 is intended at the demonstration/validation of an operational baseline, integrating some of the GTG IOC Concept Solutions and encompassing different phases of flight: departure (partly); En Route; and arrival ATC (and corresponding to the GTG IOC *Medium-term centre planning*, *short-term planning* and *executive implementation* areas).

In effect, the selection of the different Concept Solutions part of WP4 Concept was principally made considering:

- The Concept Elements that were deemed mature to integrate together in order to permit a consistent demonstration / validation of an integrated solution;

- The technical capability of the real-time simulation platform used in WP4 (here, an existing constraint to the project / WP4 activity was to use a platform based on the AVENUE architecture. The platform used by WP4 was the ACE platform (AVENUE Compliant Escape)).

Apart from the benefits associated with each individual concept element (to be described in next section), the interest lies in evaluating whether their integration can be done in 'symbiosis' and what their overall benefits are for the ATM system.

Moreover, heterogeneous systems development and implementation is a major cost of ATM in Europe today. Thus the demonstration that one generic system can be adapted to provide successful operation in different airspaces / phases of flights is of prime interest to the ATM community.

As part of the GTG WP4 Operational Baseline, one shall differentiate between today's baseline functionality (mature enough to be considered standard in most ATC centres, and for that reason not of significant evaluation interest to GTG) and a more advanced one (future systems and functionality not consistently found in current ATC, of which are of interest to GTG).

The following table summarises where in terms of control phases advanced enabler functionality is available.

Enabler	Tower	DEP	En Route	ETMA	TMA	APP
TP – Maintaining accuracy		X	X	X	X	
CPDLC – ACM		out	in/out	in/out	in	
CPDLC – ACL		X	X	X	X	
ADAP – CAP		X	X	X	X	X
ADAP – PPD		X	X	X	X	X
ADAP ASAS Report			X	X	X	
AMAN – Landing lists	X	X		X	X	X
AMAN – IAF lists				X	X (SP)	
AMAN – Advice to IAF				X		
AMAN – Sequence manipulation				X (SP)	X (SP)	
AMAN – Runway slots (DEPs and others)	X	X		X (SP)	X (SP)	
ASAS – CDTI			X	X	X	X
ASAS – ASPA-S&M			X	X	X	X
MTCD – Conflict alerts			X			
MTCD – Management of conflicts			X			
MTCD – Transfer of conflicts			X			
MTCD – Categorisation of conflicts			X			
MTCD – Special Airspace Penetration			X			
MTCD – VERA			X			
MONA – Trajectory non-conformance		X	X	X	vertical	vertical
MONA – Trajectory reminders		X	X	X		
MONA – Activity prompts		X	X	X		
SYSCO – Flight plan consistency	X	X	X	X	X	X
SYSCO – Communications management	in/out	in/out	in/out	in/out	in/out	in/out
SYSCO – Co-ordination		out	in/out	in/out	in	

Figure 10 – WP4 enablers per control phases

Note: as part of the GTG Concept, a process is designed (potentially involving such enablers as PTC data link communication, DMAN and FLIPCY4D, and summarised as PTC process) to allow synchronisation between the air and ground trajectories before the departure. Although such process cannot be simulated in WP4 due to the lack of those enablers, the resulting conditions (i.e. consistency between air and ground trajectories at departure) are ones effectively applied in WP4 simulation, and therefore validation results will be relevant of such conditions.

3. GATE TO GATE System Specifications and Architecture Activity

The G2G consortium has decided to use different ATM real-time ground simulation platforms to perform the validation activity. Anyhow, it was decided to produce an unified specifications baseline (SSS, SSDD, IRS)[2] that:

- Could be used during the programme to discuss and agree on a platform functional content / evolution, at the overall programme level or between partners co-operating on upgrading a platform, whenever necessary,

- Could support the process of development / documentation of the AVENUE architecture[3] standard.

3.1 G2G SSS

The G2G SSS [8] is developed and presents <u>one</u> functional model representative of a generic G2G (ATM real-time simulation) validation platform / environment, encompassing all functions of the G2G programme actual validation platforms.

The functional model (see next figures) is composed of:

- The external entities, which are those functional elements not described in terms of requirements. These are the simulation environment elements (e.g. data preparation, airborne simulation) or other elements that are not in the scope of G2G Validation (e.g. Tower System is represented as an external element –although not the DMAN part which is in G2G validation scope-)

- The other functional elements whose description is developed in the rest of the SSS document in terms of functional requirements. This part of the functional model is aligned with the AVENUE logical architecture as designed in the G2G SSDD document.

 (System actors are also represented to provide understanding of their interactions with the different functional elements).

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[2] through committing to System Segment Specifications (SSS) / System Segment Design Document (SSDD) / Interface Requirement Specifications (IRS) (which is terminology for System specifications documents inherited from DOD2167), the point is not to force application of a common process of development / acceptance for all G2G project validation platforms adaptations. This is still responsibility of partner responsible for development to decide and apply its own "local" process, and then one between platform user and provider to agree on process of acceptance.

[3] The AVENUE architecture consists of functional, design, interfaces and software infrastructure specifications for ATM Real-Time Simulation platforms. This is to be considered as a meta-model allowing for different implementation choices, but yet facilitating the porting (exchange) of components onto (between) AVENUE compliant platform(s). Its development was initiated by the EC 4TH FP AVENUE programme and continued by the GATE TO GATE Programme

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Figure 11 – External entities of the G2G Functional Model
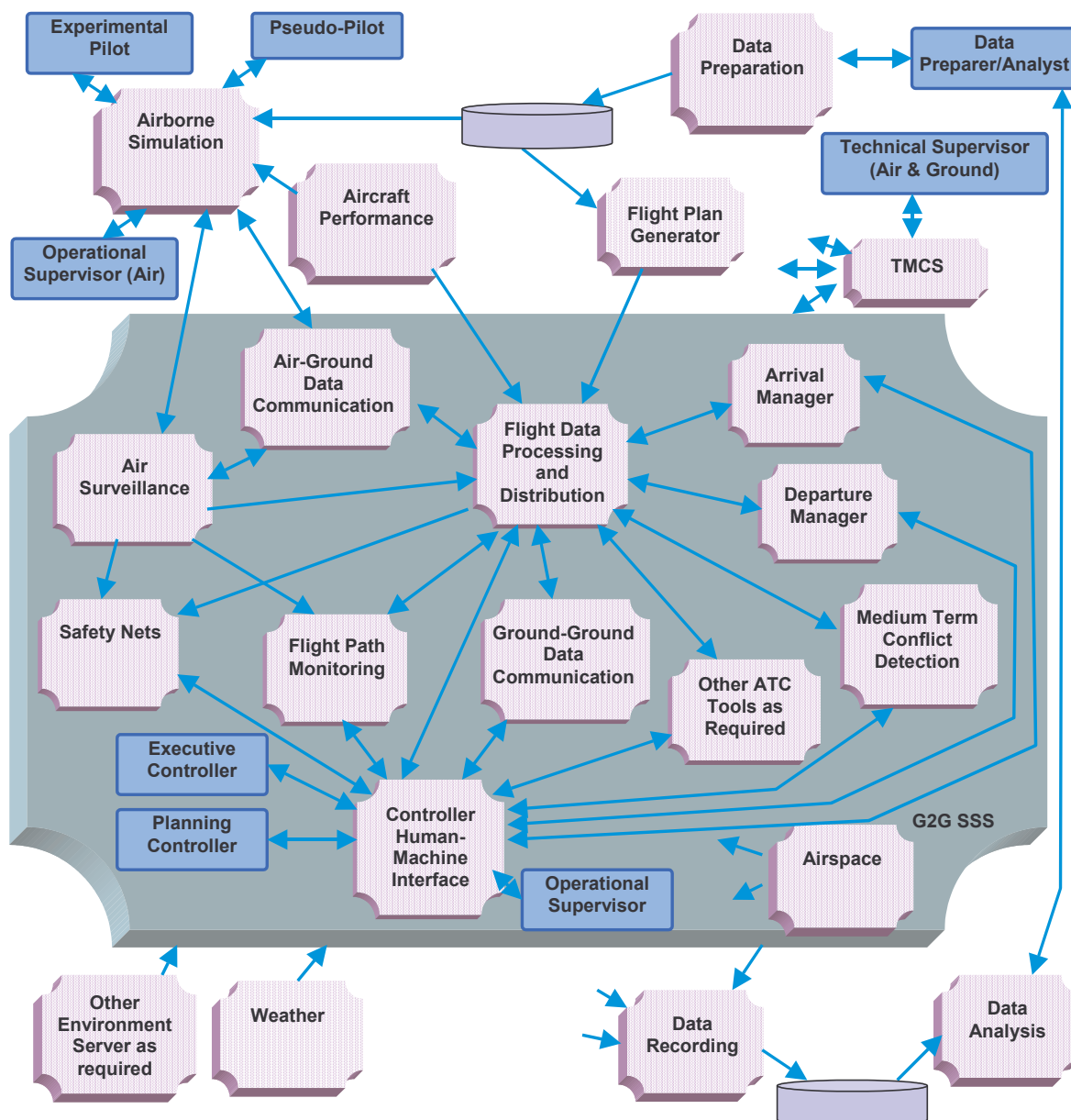
Figure 12 – G2G Functional Model

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This representation allows to provide a good overview of what a simulation platform environment is and how it is used, while also giving focus on the part that is subject to validation in G2G (ground ATM system elements).

As said before, the functional description part identifies functional requirements per functional element (in the "G2G SSS" group of previous picture). An attribute is appended to each requirement, denoting the platforms to which it is applicable.

There was consensus among the partners that it was not appropriate to use the SSS as contractual basis and as a reference for testing the correct functioning of the system..

Instead, it was deemed necessary to describe and let requirements at quite a generic level, so that it may apply to different platforms implementation, yet providing understanding of system impact of a concept solution. An annex provides the mapping of requirements to GTG key concepts and to the validation platforms.

As a conclusion:

- It allows understanding of ATM ground functions in G2G validation activities,

- It concentrates on controller tools and functions that directly support the operational concept,

- It can be re-used safely by other programme or entities as the contained information is reliable and of quality,

- It is coherent with G2G SSDD description.

3.2   G2G SSDD

The G2G SSDD deliverable is composed of 2 distinct documents:

1. The SSDD-LP (Logical Part) [9], providing a logical representation of the G2G architecture (concerning ATM real-time simulation platform), based upon the AVENUE architecture and extending it according to G2G SSS inputs

2. The SSDD-PP (Physical Part) [10], providing the description of an instance platform: the EUROCONTROL ACE simulation platform, used on 4 G2G simulation sites

This split allowed all SSDD partners to focus on contributions to the generic SSDD-LP part while EUROCONTROL concentrated its efforts in the production of the specific and platform-related SSDD-PP part.

Content of the SSDD-LP

The logical architecture developed in G2G has been based, as stipulated in the DOW, on the AVENUE logical architecture, with new extensions mainly in the areas of Automated Downlink of Aircraft Parameters, Operational Supervision and Arrival Management.

As in AVENUE, the G2G logical architecture was scoped to an En-route/TMA ATC system, not including the Tower related aspects (such as DMAN) or the aircraft (airborne applications). However, although both tower system and aircraft were considered as external entities, all links and interfaces with the En-route/TMA system were fully identified.

In addition to the description of all modules composing the G2G logical architecture, the SSDD-LP also provides:

- A definition of all interactions and data flows between logical modules

- A set of high-level logical use cases which aim at helping the understanding of inter-relationships between logical modules when they are collaborating to achieve an advanced functionality within the architecture

- A detailed description of the main high level data that are handled by the logical architecture

- A cross mapping of logical modules to the specification requirements, highlighting the alignment of SSDD-LP with the G2G SSS

With a full definition of the G2G logical architecture, the SSDD-LP provided a solid basis for developing the next level of design development: the IRS and SSDD-PP.

Content of the SSDD-PP

The SSDD-PP provides the description of the G2G physical reference platform, namely the EUROCONTROL ACE simulation platform composed of many sub-systems, the main ones being:

- The GROUND subsystem (mainly FDPS, RDPS, Conflict tools and CWP)

- The Multi Aircraft Simplified Simulator (MASS) to emulate air traffic

- The controller/pilot voice communication system (AUDIOLAN).

- The Integrated Preparation & Analysis System (IPAS) for preparation of traffic and configuration data and post-simulation analysis

The SSDD-PP did not cover all aspects of the ACE platform, not only to keep the document easy to exploit by G2G partners but also to avoid describing design aspects for parts of the platform which were irrelevant in the context of G2G (e.g. AUDIOLAN).

Consequently, the SSDD-PP had covered the complete GROUND system, including the aspects relating to the way the GROUND system communicates with all surrounding sub-systems. This scope had also the advantage of being aligned with the one of SSDD-LP.

In addition to the detailed description of all ACE physical components, the SSDD-PP also provides a model of execution which shows, via a set of use case realizations, the dynamic aspects of the platform.

3.3   G2G IRS

The IRS document [11] defines a new version of the interfaces of the AVENUE standard (AVENUE IRS). It is both a consolidation of the work initiated in the AVENUE project, and an enrichment of the interface definitions from an 'en-route' coverage to the terminal management area.

It provides interfaces description for AVENUE-compliant platforms incorporating evolutions needed for the G2G programme. This IRS complies with the AVENUE SSDD Logical Part developed during the G2G programme.

According to the AVENUE methodology, it is worth noting that:

- As the SSDD-LP, the IRS:

  o Focuses on the ground system, and does not define interfaces for the air system modules;

  o Defines interfaces of logical modules;

- The IRS aims to be independent of a particular kind of implementation. This is the reason why the APIs provides both events for asynchronous event-oriented implementations, and operations for synchronous oriented implementations;

- The IRS shall be seen as a catalogue of interfaces and associated data. An AVENUE compliant platform does not have to implement all the interfaces or to follow a physical decomposition aligned with the breakdown of the SSDD-LP logical modules. The physical components of such a platform will provide/use a subset of the operations defined in the IRS, and/or raise/consume a subset of the events defined in the IRS.

3.4   G2G High level System Architecture

3.4.1 Introduction

The purpose of this section is to provide a wider and most complete high-level view of the G2G logical system compared to the G2G System/Subsystem Design Document – Logical Part.

The G2G SSDD-LP, delivered in February 2005, is strictly scoped to the AVENUE architecture (as decided by the G2G SSDD team at the beginning of the design activity).

This AVENUE design however does not identify nor cover the full characteristics of the logical architecture from systems used in:

    - WP1 experiments (Departure & Flow),

    - WP2 experiments (En-route),

    - WP3 experiments (Extended-TMA and arrival management).

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As a consequence of this situation, the present chapter is an attempt to describe the most complete high-level logical system view, i.e. a generic synthesised view covering all functionality aspects of the set of RTS systems used within the G2G programme.

Objective

The objective and expected utility of this work is to support the dissemination of the G2G results:

- Providing at once an idea of the most complete scope of the G2G logical architecture as used in the G2G RTS experiments,

- To act as a complementary document to the G2G SSDD-LP document.

Proposed Methodology

The methodology proposed for conducting this work can be summarized as follows:

- Build upon the overall AVENUE logical model as defined in the G2G SSDD-LP, bringing it to a higher level of module decomposition.

- Extend this overall logical model in order to include all missing logical modules, identified from the various platform adaptation strategy documents.

3.4.2 Analysis

G2G SSDD view (AVENUE scope)
This paragraph identifies a list of logical modules, covered by the G2G SSDD-LP, that should be part of En-route and TMA system view:

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Logical module name	Logical module designation
Adap	Automated Downlink of Airborne Parameters
Agdc	Air-ground data communication
AirSurveillance	Air Surveillance
Aman	Arrival Manager
Corl	Track/Flight Correlation Management and Distribution
Cwp	Controller working positions
Environment	Environment
Fdpd	Flight Data Processing and Distribution
Fpg	Initial flight plan generator
Fpm	Flight path monitoring
Ggdc	Ground-ground data communication
Mtc	Medium term conflict
OpSup	Operational Supervision
Simulation	Tools for Simulation purpose
Simulation.Abs	AirBorne Simulator
Simulation.Pilot	Controller-pilot hybrid position
Snet	Safety net

Figure 13– G2G Logical Modules

The diagram below shows a diagram of the AVENUE modules as described in the G2G SSDD scope:
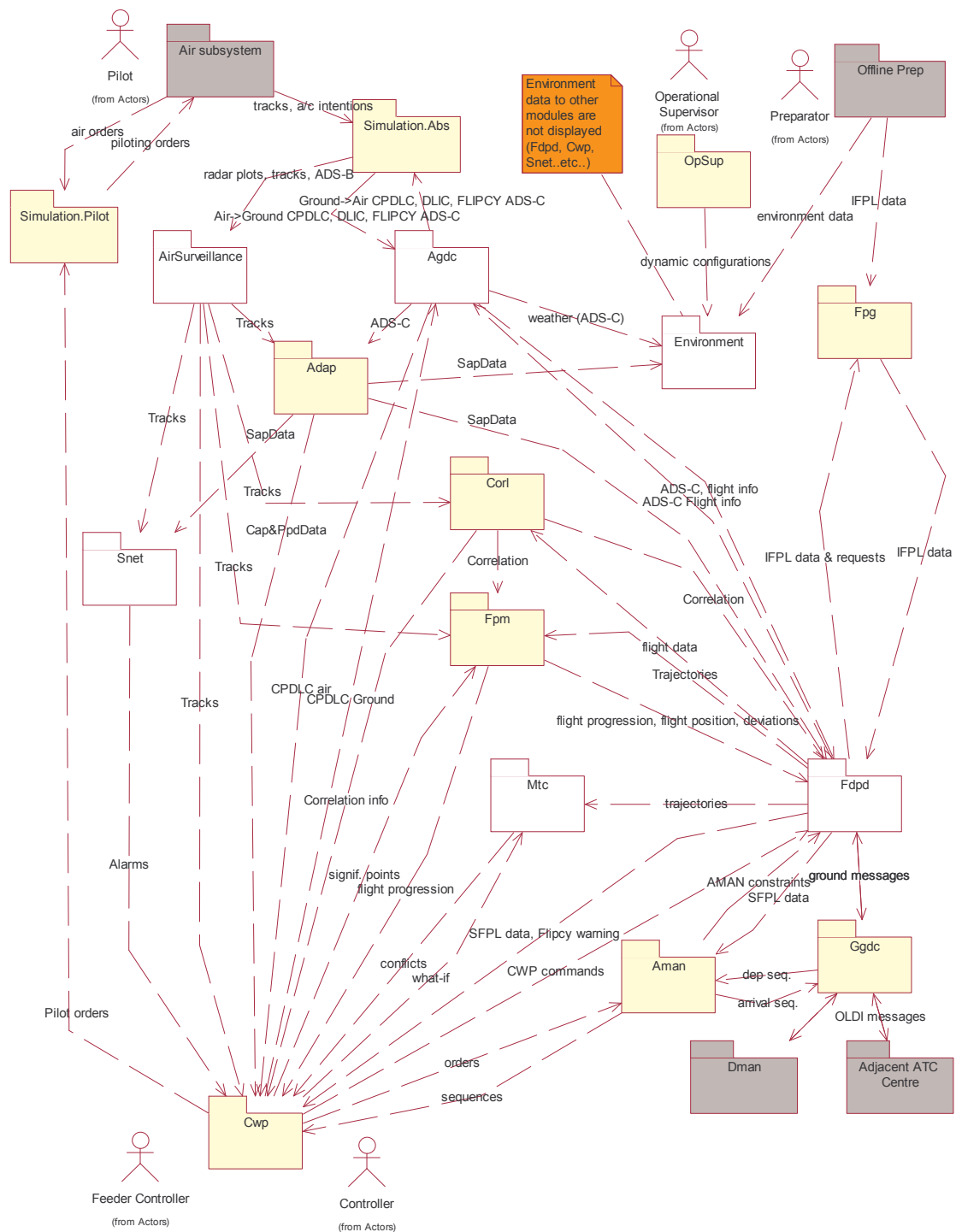
Figure 14 – G2G SSDD Scope with AVENUE Logical Modules

Note for the diagram: Avenue modules are displayed in yellow, super modules[4] are in white, External modules are in grey
Scope of WP1-2-3-4 vs. AVENUE

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[4] A supermodule is a collection of modules. Refer to G2G SSDD-LP for further details about supermodules.

Logical Modules	Cluster 1 LFV	Cluster 1 NLR	Cluster 2 AENA	Cluster 2 DFS	Cluster 3 DSNA	Cluster 3 ENAV	WP4 EEC
Adap	yes		yes (Cap)	yes	yes	No?	yes
Agdc	No	Yes (ptc, flipcy4D)	yes	yes	Yes (no dlic, adsc)	yes	yes
AirSurveillance	yes	Yes (no details)	yes	yes	Yes (no AdsB, Re)	yes	yes
Aman	no	yes	no	no	yes	yes	yes
Corl	yes	yes	yes	yes	no	yes	yes
Cwp	Yes	yes	yes	yes	Yes (including stack co-ordination)	yes	yes
Environment	Yes (no wea)	Yes (no wea)	yes	Yes (no details)	Yes (no acr, wea)	Yes (no wea)	Yes (no wea)
Fdpd	Yes (no Cdn, Ntf, Flipcy)	Yes (no details)	Yes (no Cdn, Ntf, Flipcy)	Yes (no details)	Yes (no Rte, Ssr)	Yes (no Cdn, Ntf, Flipcy)	Yes (no Cdn, Ntf, Flipcy)
Fpg	yes	yes	yes	Yes (for CFMU fpl link)	yes	yes	yes
Fpm	yes	yes	yes	Yes (mona included)	yes	yes	yes
Ggdc	yes		no	yes	no	no	no
Mtc	no	Yes (mtcd)	yes	Yes (mtcd)	no	no	yes
OpSup	yes		yes		yes	yes	yes
Simulation	no		yes	yes	Yes (no pilot)	yes	yes
Snet	no	Yes (stca)	Yes (no Msaw)	Yes (stca)	yes	Yes (no msaw)	Yes (no msaw)
Specific Mod							
Dman	yes	yes	no	no	no	no	no
Irm	yes	yes	no	no	no	no	no
Fasa	yes	yes	no	no	no	no	no
eTlm	no	no	yes	no	no	no	no
Cora	no	no	no	yes	no	no	no

Figure 15 — SCOPE OF G2G WP1-2-3-4 VS AVENUE

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Identification of modules not covered by AVENUE

Module acronym	Module label	Module description and links
Dman	Departure manager	Establishes and maintains the departure sequence Links: Irm, Cwp
Irm	Integrated Runway Management	Balances landings versus departures (providing rates for arrival and departures) on any single runway and allocates runway slots for both landing and departing aircraft Links: Aman, Dman
Fasa	Final Approach Spacing Assistance	Proposes correct spacing in-between aircraft on final approach in order to achieve safe and efficient mixed mode runway usage with both departing and landing traffic Links: Cwp
eTlm	Enhanced Traffic Load Monitoring	Predicts in real-time (on-line) the controllers workload in the near future time horizon. Links: Cwp
Cora	Conflict Resolution Advisory	Proposes conflict resolution advisories (produced using What-if Probing as a basis for combinatory generation of conflict solutions) Links: Mtcd, Fdpd.Sfp, Cwp

Figure 16 – Identification of G2G modules not covered by AVENUE

Consolidated G2G High-Level Logical System view

The following table lists all logical modules that are part of the high level logical system view (all G2G clusters considered):

Logical module name	Logical module designation
Adap	Automated Downlink of Airborne Parameters
Agdc	Air-ground data communication
AirSurveillance	Air Surveillance
Aman	Arrival Manager
Cora	Conflict Resolution Advisory

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Corl	Track/Flight Correlation Management and Distribution
Cwp	Controller working positions
Dman	Departure manager
Environment	Environment
eTlm	Enhanced Traffic Load Monitoring
Fasa	Final Approach Spacing Assistance
Fdpd	Flight Data Processing and Distribution
Fpg	Initial flight plan generator
Fpm	Flight path monitoring
Ggdc	Ground-ground data communication
Irm	Integrated Runway Management
Mtc	Medium term conflict
OpSup	Operational Supervision
Simulation	Tools for Simulation purpose
Simulation.Abs	AirBorne Simulator
Simulation.Pilot	Controller-pilot hybrid position
Snet	Safety net

Figure 17 – Consolidated List of G2G Logical Modules

Note: the new modules, as identified above, are highlighted in light blue.

The overall diagram for this G2G consolidated high-level logical system view is provided next page.

Notes for the diagram:
- Former Avenue modules are displayed in white
- New modules are displayed in blue
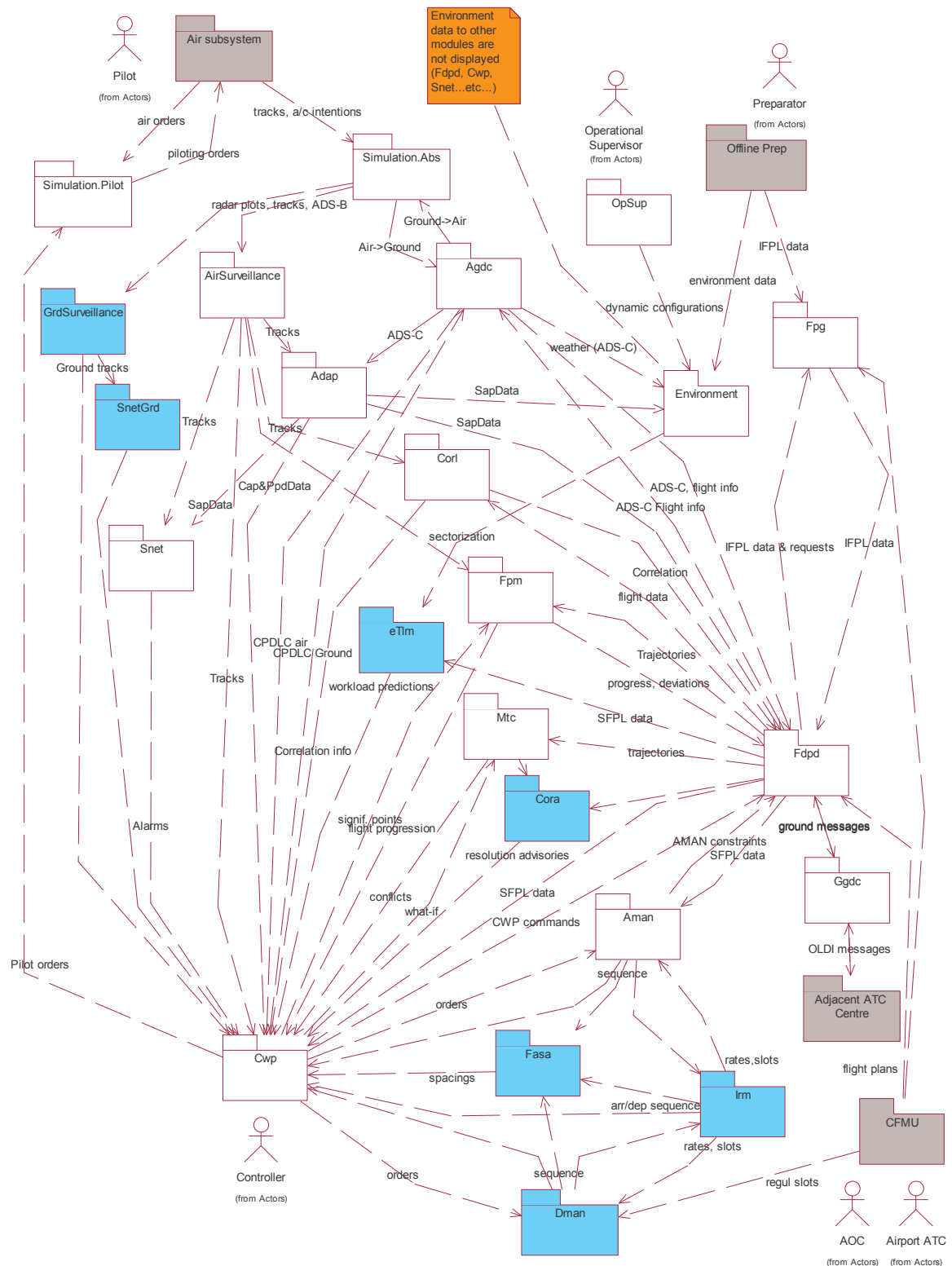- External modules are displayed in grey

Figure 18 — G2G consolidated high-level logical system

4. GATE TO GATE Real Time Simulation Platforms

The various platforms developed during the G2G programme are described hereafter:

Platform	WP	"AVENUE compliance"	Simulation Responsible	Simulation site	Integration Responsible	Co-operating partners (in component delivery / adaptation / integration)
i-acs + ACE (adapted) (+ NARSIM as traffic generator)	WP1	Yes (ACE)	LFV	Malmoe	LFV	LFV / EEC / NLR / THALES ATM
NARSIM + I-ACS	WP1	No	NLR	Amsterdam	NLR	NLR / LFV
ACE (adapted)	WP2	Yes	AENA	Sevilla	INDRA	AENA / EEC / INDRA
AFS	WP2	No	DFS	Frankfurt	DFS	
DAARWIN	WP3	Yes	DSNA	Athis Mons	DSNA	DSNA / THALES ATM
EAT (adapted)	WP3	No	ENAV	Roma	SICTA	ENAV / EEC / SICTA
ACE (adapted)	WP3	Yes	ENAV	Napoli	SICTA	ENAV / EEC / SELEX / SICTA
ACE	WP4	Yes	EEC	Brétigny	EEC	

Figure 19 – G2G RTS Platforms

All the G2G platforms were successfully delivered to ANSPs thanks to industry and EUROCONTROL support.

Although WP4 did not integrate all Key Concepts identified in WP1, WP2 and WP3, the final scope of WP4 activities represents an achievement never realised before in terms of integration and validation of various IOC Concept elements on the same platform.

Putting all these Operational Concept Enablers together in the way that was proposed in the G2G WP4 Simulation Concept was a first in Europe.

5. GATE TO GATE IOC Validation Results and Benefits

The results are presented according to phase of flight. The results for concepts with target implementation timeframe of 2012+ are given in a separate section at the end.

Note: This section is a synopsis of the information contained in the four G2G Simulation Report documents D1.4.4 [12], D2.4.4 [13], D3.4.4 [14] and D4.4.4 [15]. The detailed results, conclusions and recommendations emerging from the validation activities are captured in those documents.

Regarding to the G2G consolidated validation strategy and plan, it has been detailed in the D0.4.3 document [16].

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5.1 Flow and Departure Management *(extract from D1.4.4)* [12]

5.1.1 GS/AS Applications

GS/AS applications are aiming at improvements for ground surveillance (controllers) and airborne surveillance (crews). The ground part (ATC) was simulated and assessed in a limited way. The greater collaboration between controllers and pilots, especially on the manoeuvring area, that the enhanced situational awareness implies was studied and elaborated. The assumptions and workarounds for the cockpit, which were made and must be made for real-time simulation, were developed with close cooperation with airline pilots supporting the validation. Furthermore, almost all of the LFV pseudo-pilots hold valid pilot licence. Potential substantial workload reduction for the Ground Controllers could be seen, but procedures and concepts must be further developed before firm conclusions can be drawn.

Safety assessments of GS/AS applications runway incursion and routing functions were a main objective of the NUPII simulations, which used the same platform, operational environment and tools as GTG. Results can be found in NUPII RTS 4 documentation.

5.1.2 Integrated Planning of Arrivals and Departures

The concept of Integrated Planning of Arrivals and Departures was found to improve safety on the airport surface. There were fewer aircraft moving around the taxiway system (potential conflicts would be reduced) and workload saving led to a greater capacity to monitor traffic. The results give a positive indication but cannot be considered 'conclusive' due to the lack of exhaustive testing of specific 'risk bearing' scenarios.

Tactical Departure Management did not have an impact on taxiway flow, runway throughput or punctuality of aircraft departures during the simulation. However, the controller workload was lower due to the tool support. The Tactical DMAN did help improve the predictability of taxi out and gate availability times.

An issue not investigated was gate capacity. It was observed that DMAN delayed aircraft on stand in order to achieve reduced taxi queues. The impact on gate capacity of such a DMAN strategy needs further investigation.

Tactical Departure showed the ability to provide fuel savings through reduced aircraft taxi times and queuing, especially during peak traffic. In the Arlanda peak scenario nearly 5.5 tons per hour of fuel was saved assuming a queue reduction of ten to three aircraft on average. This was equivalent to 8 minutes less queuing for each individual aircraft The estimate in economic terms of fuel savings during an hour of peak traffic would be approx €3600. Carbon dioxide and noise emissions will also be reduced.

The results from the simulations showed a small improvement in spacing accuracy when using the FASA tool even though the FASA advisories that were supposed to help achieve this accuracy were not fully functioning in the simulation. WP1 concluded that this small benefit could be increased further when using a fully functioning and mature FASA tool.

The simulations also highlighted areas where predictability of arrival times and sequence could be improved through using **IRM** and **FASA**. The use of the IRM sequencing list gives a better picture of runway planning for an extended timeframe. The target time to threshold is known some way in advance and is more reliable this could become a major benefit to smoothing ATC and airport operations. In addition, the FASA tool requires adherence to standard arrival paths which also introduces greater predictability of actual track to threshold. By using similar arrival paths at all times the airlines will have a more predictable distance to touchdown on arrival to the TMA. The standard paths based on the PRNAV standardised approach paths flight patterns, also led to a more orderly presentation of traffic to the Final Approach controller. The result is a much smaller spread of flight path distribution within which noise can be contained. This reduces the areas affected by aircraft noise and the flight paths themselves can be designed to avoid areas where noise is an issue.

Some hazards were noted for the IRM and FASA applications. The FASA tool used did not have a conflict detection capability and therefore provided advisories that could place aircraft in unsafe situations. **FASA must therefore be further developed to detect potential losses of separation before calculating controller advisories**

The remaining hazards with the IRM and FASA applications were analysed in a specific safety study. It was concluded from this study that these hazards were caused by poor HMI design and issues concerned with tool maturity. It was agreed by all controllers that these hazards would be solved by improved HMI.

5.1.3 Improved Flow and Capacity Management

The Refined Flow Management (**RFM)** process was expected to show efficiency benefits in the arrival sequencing operation due to a reduction of arrival congestion and smoothing of the arrival flows when constraining certain flights at departure points. Results in the fast time simulation show a potential saving of 66 flight hours per day over all ECAC traffic for the reference case in 2004.

The two airports assessed (Arlanda and Fumicino) both indicated potential efficiency benefits by applying RFM for 2004 as well as for 2010 and no significant penalties due to departure constraints. Increased savings were identified for 2010, at least more than proportional to the increase of demand.

5.2   En-Route *(extract from D2.4.4 [13] and D4.4.4 [15])*

5.2.1 Data-link

All proposed CPDLC ATC instructions were used, and CPDLC usage was of 90% (compared to R/T) for Data-link equipped aircraft. The controllers perfectly understood when CPDLC instructions could be used; they could appreciate without any problem when a situation was non-time critical and allowed to issue a D/L instruction. No safety infringement was observed due to Data-link use.

One problem with Data-link experienced during the simulation was that controllers had some difficulty issuing Data-link combined instructions. This difficulty was mainly due to minor issues with the HMI (see Section 4.1.3) but meant that combined orders represented only 2% of CPDLC instructions, whereas they represented 5% of instructions given by R/T.

Moreover, the use of **Data-link** (CPDLC, ADAP and SYSCO) enabled controllers to operate in a dual-tactical role as opposed to the planning /multi-sector planning controller and executive controller partnership. Two controllers often shared the CPDLC communication tasks in that each controller focused on specific traffic flows, where and when possible.

Controllers agreed that the use of Data-link would fundamentally change their roles, responsibilities and working methods with the major changes coming from the introduction of task sharing, the reliance on the system for aircraft data and the possibilities offered by multiple instructions taking place at one time.

The passive CPDLC 'monitoring' did not affect controllers' situational awareness and provided two benefits in that they suffered less interruption while analysing or solving other problems, and could take more time to analyse the traffic situation and give an appropriate clearance following the 'assume'.

CPDLC instructions also provided many improvements on the safety side: R/T congestion, as it occurs today, will be less of a problem. CPDLC silent and electronic communication will reduce the nuisance "chatting" effect that occasionally takes place on the frequency. More importantly, it will help to reduce misunderstandings and ambiguity between controllers and pilots due to transmission quality, language proficiency and accent interpretation. In effect, there will be fewer occurrences of incorrect read back, cross-transmissions and less likelihood of requests to repeat instructions thereby, once again, saving valuable time.

The large R/T reduction provided by CPDLC instructions was translated into immediate gain in workload for the Executive Controller. The support of ADAP-CAP also provided gain in access time to important information and also contributed to R/T reduction and therefore to workload reduction for the Executive Controller.

The additional tactical or routine tasks delegated by the Executive Controller to the Planner Controller, on an ad-hoc basis or more systematically, were easily absorbed by the Planner Controller.

Two main issues were identified with the **Data-link** silent-transfer procedure and the potential increase in non-detection that 2-way communications has not been established between pilots and controllers. It is thought that with an integrated system it should happen even less than in current operations, but the monitoring functionality will need to be fully reviewed and evaluated in more detail before ICAO regulations could be modified in this regard. The second hazard was that an error in Mode C value might not be identified on a Data-link equipped aircraft on inter-centre silent handover because of the lack of a Mode C verification check.

A further hazard arises when some tasks are delegated from the Executive Controller and Planner Controller using Data-link. If there is a lack of co-ordination between controllers the possibility of issuing conflicting D/L clearances to a same aircraft may increase.

5.2.2 Medium Term Conflict Detection MTCD

Two types of **MTCD** usage were envisaged within G2G – Strategic and Tactical. MTCD was tuned to identify conflicts / risks from 20 minutes in advance to the predicted loss of separation, thus allowing a more strategic planning and hence supporting the *strategic* MTCD concept. In addition, a Problem Indicator (PI) symbol was highlighted as part of a track label when a loss of separation was predicted 5 minutes or less ahead. This can be considered more as a tactical alert to react upon, and hence supporting a *tactical* MTCD concept.

The concept of more strategic planning was more suited to larger sectors with reasonably stable traffic evolution and a less complex route network, than smaller sectors where airspace was more restricted and a higher proportion of conflicting aircraft were in climb or descent, making tactical resolution more appropriate.

The working methods tendency in smaller complex sectors towards dual tactical operations with high usage of CPDLC was contrary to the basic concept principles of strategic MTCD. The controllers in these sectors preferred to use the tactical option (Problem Indicators) available within the MTCD toolset (and it was also very appreciated in the larger sector). The appearance of PI was much appreciated in that they provided an early warning before the triggering of STCA. This "advanced STCA" indication provided controllers with an immediate situational awareness of a conflict

There was negative feedback received for the HMI of some MTCD tools, specifically with too many potential conflicts presented in some tools (and finally identified as 'clutter' information by ATCOs). As a result, too much controller time was spent looking at the tools rather than the radar screen. Controllers felt that configurable parameters for different sectors should be used depending on their traffic type, sector characteristics and intended usage (strategic or tactical) of the MTCD tools.

Controllers felt that the introduction of MTCD would not change the classic Planner Controller /Executive Controller roles, but that it may change the working methods. Then, the developed working methods tendency in some sectors towards dual tactical operations with high usage of CPDLC was contrary to the basic concept principles of strategic MTCD. (This reinforced the appreciation by the controllers in these sectors of the tactical option -Problem Indicators- available within the MTCD toolset).

In general, controllers felt that MTCD could increase their situational awareness. Controllers were less 'surprised' by incoming aircraft and missed fewer transfer/assume aircraft instructions. Similarly, another clear advantage was that MTCD made them aware of problems earlier, and provided them with more time to find a resolution. The majority of MTCD hazards identified were linked to reliability issues of the TP and MTCD information presented to controllers via the MTCD tools. Controllers also commented that an over-reliance on the MTCD tools could lead to traditional (radar) skills degradation. Controllers would need to retain traditional conflict detection skills to be able to detect when the tools were not correct and resolve the situations safely by themselves.

5.2.3 Multi Sector Planning MSP

The system functionality of automated co-ordination, together with the Multi Sector Planning working procedures enabled the successful introduction of the MSP concept to the simulation of Karlsruhe UAC.

When applying the MSP concept, it was observed that there was some decrease in flight efficiency to some aircraft. Controllers expressed an opinion that sometimes a less personal service could be provided to aircraft and many controllers did not rate their performance as one leading to an efficient traffic flow, this was not supported by the analysis – no difference in sector flight time detected.

A reduction of 50% of the verbal co-ordination was observed when using the functionality of automated co-ordination, together with the Multi Sector Planning. This reduction of task load was sufficient to support removing one planning controller from two sectors and adopting the role of MSP. The new MSP working procedures received mainly positive feedback from controllers for all simulated conditions at Karlsruhe UAC and Seville ACC.

With each MSP handling more flight entries per hour than a traditional planner controller, staff productivity increased. Between 5% and 15% of controller hours per day could be saved for the sectors studied in the real-time experiment when applying the MSP concept. These resources can also be used to open additional sectors, i.e. to indirectly increase the ACC capacity.

Controllers considered it necessary to clearly define the new responsibilities of executive and planning/multi-sector planning controllers, but they were reluctant about the idea of generalising the distribution of tasks in all

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sectors. They considered that different co-ordination agreements could be done in every sector/multi-sector area depending on the routes and structure of the airspace.

There was a decrease in situational awareness for the planning controller during high traffic situations. This could be improved by taking into account the structure of airspace to define appropriate Multi Sector Areas (MSA could be composed of small sectors with a main traffic over flight stream and with strong interrelation between them). There was a reduction of the common situational awareness (same view of situation held by planner and executive) in 2010-2012 environments. This was due mainly to the multi-sector planner not having the same situational awareness as today's planning controller This aspect may have been reinforced by the effect of moving simultaneously into an **electronic** (strip less) **environment**. Further experiments are needed on this issue of potential loss of common situational awareness.

5.2.4 Dynamic Re-sectorisation DyR

The controllers concluded that it would be acceptable to apply the **Dynamic Re-sectorisation** concept providing that it did not imply performing excessive sectorisation changes, and that it would be used carefully and only when the improvement to controller workload and conditions was evident.

The Enhanced Tactical Load Monitoring (eTLM) assesses the best sectorisation to apply using on-line fast-time simulations to calculate better workload distribution. Opening additional sectors or introducing new optimal sectorisations shows that a better balance of workload across all sectors in the ACC can be achieved improving efficiency of airspace utilisation. A potential capacity gain at ACC level can therefore be achieved. The eTLM tool was considered necessary in order to balance the workload among ATCO working positions. The refinement process from the first version of eTLM (which considered static curves of workload as a function of the number of incoming aircraft in the sector) to the second version (which uses on-line fast-time simulations to get more realistic workload distribution) was considered by the controllers to improve the usefulness of the tool.

DyR scenarios showed a better workload balance when simulating the 2010-forecast traffic (+25% of 2005). This improvement is maintained when increasing the traffic up to 40%, but from that point it appears difficult to show further efficiency gains from DyR. In some traffic situations improvements in efficiency were not as clear this was due to the fact that eTLM assesses the best sectorisation to apply based on a predefined set of possible combinations, and sometimes there are no combinations that avoid controllers' saturation. In order to guarantee that the workload between sectors is better balanced, a future increase in the number of the operative sectors and predefined sectorisations which eTLM can consider applying is necessary

Under all traffic conditions simulated by means of fast-time techniques, DyR scenarios showed a slight decrease of the total ACC controller workload, varying from 5% to 15% reduction.

Regarding situational awareness, a decrease was observed during the sector transitions. Mitigations could be:

- Reducing the number of 'traumatic' changes (changing sectorisation too often or creating new sector shapes);
- Increasing the number of training sessions for sectorisations which were typically used;

Integrating information at the ATCO working position related to the aircraft under his/her responsibility after the resectorisation.

5.3   TMA and Arrival Management *(extract from D3.4.4* [14] *and D4.4.4* [15]*)*

Two different environments were used to evaluate TMA early planning establishment and adherence, supported by an electronic environment, concept:

1. Paris TMA here the emphasis was on interactive HMI and supporting operating procedures in an environment where an AMAN has been in common usage for several years. The HMI features included a 'ball train' (an interactive, vertical display of the arrival sequence) and a 'stack manager' (an interactive, vertical view of the arrival stack),

2. Rome TMA here the emphasis was on the integration of an AMAN into the Rome environment in order to develop and procedures in relation to early planning establishment and adherence principle, that included use of some CPDLC messaging and DAPs.

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5.3.1 Paris TMA Environment

The advanced electronic environment saw several HMI features being tested and was considered by the E-TMA ATCOs to provide improvements through addition of some major functionalities (e.g. aircraft integration, electronic co-ordinations. Inputting clearances was found to be simple, fast and intuitive; and did not trigger excessive input errors, especially for the basic clearances. Aircraft assume and transfer functionalities were appreciated.

Some functionalities were missing or require optimisation in the advanced electronic environment i.e. the aircraft integration and the electronic co-ordination input and display require major improvements to be qualified as 'easy to use'. Special effort has to be put on the improvement of the mutual awareness for ATCOs working in the same position. The vertical view of the ball train was not so well accepted. Finally, the holding pattern management tool was used by half of the ATCOs and deemed as well integrated into the electronic environment.

ATCOS ask for a more advanced HMI for Data-Link ACL service with dialog windows enabling multiple clearances at TMA/E-TMA (e.g. clearing level and transferring to TMA).

As expected E-TMA ATCOs experience a slight increase in workload when the current AMAN HMI was replaced by the ball train due to the increased number and duration of telephone communications between E-TMA and TMA to counter some of the limitations of the ball train representation. This could be due to usability problems or lack of familiarity with the tool and airspace thus further experiments with a more extensive training would be necessary to definitely assess this.

The TMA ATCOs' workload is not impacted by the way traffic is handled and transferred by E-TMA ATCOs using the advanced electronic environment.

The AMAN combined with the use of the Sequence List in addition to TtL (time to loose) and TtG (time to gain) information supported improved E-TMA/TMA ATCOs situational awareness and the pre-sequencing and approaching process. Moreover this shared information strengthened the ATCO teamwork both between Executive and Planning ATCOs and between sectors.

The E-TMA ATCOs' opinion is that the advanced electronic environment does not allow anticipating and improving conflict detection compared to the paper strip environment. Moreover, results from Eye tracker data showed that in the advanced electronic environment, aircraft are individually monitored less on the radar display (longer period between two eye fixations on the same aircraft). However, no impact was noted on the number and gravity of infringements.

In the advanced electronic environment, the number of aircraft assumed in TMA, the number of aircraft landing on the main runway, the inter-arrival rate and the aircraft profile (flight time and fuel consumption) are similar to the paper strips environment. No impact on capacity.

5.3.2 Rome TMA Environment

Controllers in all sectors were able to apply proposed AMAN / planning related working methods. Virtually no delays were experienced at the Initial Approach Fixes with relatively few sequence changes recorded in the en-route and TMA sectors.

In the en-route sectors, it was felt that enlargement of the intervention area (the TMA or extensions into en-route airspace) would result in a greater ability to apply standard procedures, and hence provide a smoother operation. This was as realised in the simulation by extending the arrival management horizon and commencing sequencing planning earlier.

In the TMA, the integration of traffic for APP was then became an easier task due to the early actions of the en-route sectors.

Approach controllers, although not forced to execute the AMAN sequence, found their work eased by the action of the upstream sectors and most of the time realised the AMAN proposal.

Finally, controllers agreed that, with support from the AMAN tool, the earlier planning decisions meant that the final sequence was more easily realised with less co-ordination than would have been necessary without an AMAN system. It resulted in a balanced, smooth and more easily manageable sequence to the downstream TMA and APP sectors leading to less workload and risk in these areas, particularly in APP, where controllers had more time to focus on fine-tuning the integration and spacing of arrivals.

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There were also potential benefits on ground operations due to the reduction or avoidance of holding which supports reduced fuel costs. The improved predictability of estimated time of arrival facilitated better management of gaps in the arrivals to allow for departures.

On the aspect of data link communications CAP and (to a lesser extent) PPD were greatly used by controllers. This contributed to a reduction in routine R/T workload.

CAP was considered to be a more accurate alternative to radar derived ground speed information and provided increased situational awareness in that controllers could more easily verify when their tactical instructions (speed, heading and rate of descent) were being adhered to by aircrew.

CAP was appreciated equally in all type of sectors (En-route, TMA and APP), and "actual indicated airspeed" was considered a must in APP sectors, and when controllers had to adapt the speed of a trailing non-ASAS equipped aircraft in relation to a leader one.

Departure and En-route controllers used PPD PFL (Preferred flight level) information from departing aircraft to issue level clearances.

5.4 Concept Results (2012 and beyond) *(extract from D2.4.4 [13], D3.4.4 [14] and D4.4.4 [15])*

Certain concepts simulated and evaluated were considered as being more relevant to an implementation time frame beyond 2012. These were en-route Automation, en-route ASAS (S&M and C&P) and TMA ASAS spacing.

Because of the limited maturity of these concepts the results gathered relate mainly to concept applicability to future traffic demand and operational acceptability with a need to establish operational feasibility before addressing performance aspects such as capacity and efficiency.

5.4.1 Automation En-Route

The automation concept was at an early stage of the validation life cycle. Only iterative prototyping sessions with evolving system functionality and HMI development have been carried out in this project. The results indicated that this concept offered a high potential for reducing the controller workload and in getting a stable and predictable ATC system environment. Currently the largest error in trajectory prediction, the unknown controller intentions, to a great extent could be eliminated.

Regarding the operational procedures, the controllers agreed that the basic principles and procedures were usable. The procedures were quite easy to understand as well as rational and easy to learn and remember. More detailed procedures, especially for exceptions, have to be defined in depth in the future.

The HMI was also rated usable in general but showed some potential for future improvement. Certain HMI elements were too complex to handle and required too much time to understand. This was considered to be a disadvantage especially in high traffic situations.

The results for workload showed a positive tendency. Task load was successfully shifted from the controller to the system. On the other hand some concerns regarding the conflict solution strategies and the reliability of the automation tools remained. However, there was enough evidence to support the belief that further development of the automation prototype could offer effective workload savings.

The impact on efficiency regarding the automation concept could not be clearly derived from the prototyping simulations. The automated sectors could be manned by only one controller who, during the trials, could work the traffic according to the generated clearances. However, due to possible safety considerations no conclusions should be drawn from this.

5.4.2 ASAS En-Route

The ASAS Spacing applications "Enhanced Sequencing & Merging" and "Enhanced Crossing & Passing" were analysed by means of Fast-Time simulations in the German and the Spanish airspace respectively, in order to identify the applicability of these concepts to solve potential ATC Interventions, and to provide some inputs about the impact of typical controller tasks delegation on controller workload. ASAS Sequencing & Merging Applications were also assessed in real time simulations using Maastricht airspace in WP4.

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In the fast time simulations, two different sectors were examined for the applicability study of **ASAS Sequencing & Merging**:

- The highly loaded "Nord Radar 2" (NR2) - a sector of the flight information region Munich (EDMM) extending from Ground to FL315,

- "Nattenheim Low" (NTM Low) - a sector of the upper flight information region Karlsruhe (EDUU) extending from FL245 to FL295.

The main traffic flows within both sectors were analysed. The examination of a 2012 traffic sample within the NR2 showed that the Sequencing & Merging procedures were applicable and that sequencing was applicable more often than merging, but one has to take into account that 100% ASAS equipage aircraft was assumed. Taking into account a more realistic assumption of (e.g.) 30% equipage rate, the applicability seemed rather limited even in this very busy en-route sector.

The examination within NTM Low showed that in moderate to low traffic environment no applications of S&M procedures could be envisaged. This study suggests that no operational benefits because of the very limited applicability are expected.

The usability and acceptability of the ASAS Sequencing & Merging applications in the En-route environment was assessed in WP4 in a real time simulation.   The results confirm the findings of the FTS. The majority of controllers did not find the applications suitable to their environment and operation. Overall, controllers that used ASAS in RTS felt that it caused work for them and they could not envisage any benefits from using it in their En-route environment. Among the major issues raised were:

- ASAS as too time consuming – the need to use R/T, the number of procedural steps required, and the long phraseologies used,

- ASAS instructions penalise aircraft – the 'unfair' logic of making (e.g.) a 747 space behind a slower 737,

- Interfering Traffic – to benefit from the use of an ASAS instruction, the controller had to anticipate that no other traffic would impinge upon ASAS pair – a difficult task in complex sectors,

- Lack of Space required for long headings – some sectors are too small for Heading & Merge as aircraft can require a lot of space when on heading,

- Lack of Predictability – Controllers couldn't predict when the aircraft would finally merge to the same point/pass the target aircraft. Any uncertainty (especially in small airspace) is not acceptable to controllers.

There was also a very negative impact with regards to MTCD usage. The ASAS trajectories were unknown to both the system and the controllers and therefore could not be taken into account for the detection and calculation of potential risk and conflicts.

The controllers felt that for En-route operations, the drawbacks related to aircraft performance characteristics, R/T usage and trajectory prediction far outweighed any potential benefit that might be envisaged for sequencing and merging operations. They felt that ASAS usage would not help reduce workload and would not facilitate any capacity increase.

As to whether the roles and responsibilities were acceptable or not, controllers felt that lack of use and lack of suitability to the en-route environment meant they could not comment.

Controllers had strong negative opinions regarding any safety increases resulting from using ASAS. The lack of predictability of ASAS manoeuvres, especially the Heading then Merge Behind instruction, meant that controllers lost part of their picture of events and therefore felt the situation to be more uncertain and hence unsafe.   In addition, the ASAS algorithms only considered delivering spacing at the merge points and do not make any assurances about spacing before this point. Due to this it is possible that horizontal separation could be lost. Procedures were put in place to help avoid this type of scenario but controllers felt that the algorithm should ensure a spacing or minimum separation.

The ASAS Crossing & Passing Applications were analysed within the airspace of Barcelona ACC, which is characterized by having southwards and northwards traffic together with eastwards and westwards.   Therefore it was considered as an adequate area for this type of application in the Spanish airspace. Two sectors in Barcelona ACC were selected based on the characteristics of its traffic flow:

- LECBCE1 - a medium loaded and low problematic sector with mainly en-route traffic,

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- LECBCE2 - a high-level complexity sector, with most of the traffic in an evolution phase.

A 2010 traffic sample was selected and simulated in a future operational environment that included the foreseen advanced tools and services available beyond 2010-2012 (MTCD, CPDLC, TDM, and 100% ASAS equipage aircraft). In the crossing and passing manoeuvres, control tasks were redistributed and the controllers passed the vectors to the flight crew to be clear of the target aircraft, but they delegated the tasks of monitoring the spacing to the flight crew, instructing them to resume navigation once clear of the target aircraft.

The results showed that most of the ATC Interventions within sector LECBCE1 could be solved by means of C&P manoeuvres. The number of ATC Interventions was reduced because this is a medium loaded sector, but the typical en-route traffic allowed the utilization of this type of manoeuvres.

On the other hand, the applicability of C&P in the sector LECBCE2 was limited in spite of the high-level traffic complexity because this traffic is mainly in an evolution phase.

Executive Controller workload remained more or less constant in spite of C&P Resolution Manoeuvres within sectors where a medium/low number of conflicts could be solved. This is due to the fact that in the "Enhanced Crossing & Passing" Applications, the number of controller tasks is slightly reduced, but the complexity remains. The controller continues assuming the mental tasks of solving the conflict with the additional complication of defining if C&P could be used.

5.4.3 ASAS TMA sequencing

The approach to studying ASAS in Rome and Paris TMA's was different and does not allow for final conclusions at this stage. The real impact of using one or several merging points, depending on local TMA constraints, as well as benefits of early initiation of ASAS Links in the E-TMA is unknown at this stage. It is currently under further study by DSNA.

With regards to **AMAN/ASAS** integration, most controllers stated that the AMAN planning adherence principle facilitated the use of ASAS.

When initiating an **ASAS** link in en-route sectors, this was done mainly with conforming to the AMAN order proposed and there were then very few links which had to be broken in downstream sectors. This only occurred exceptionally and was easily performed.

In addition, upstream sectors activity, based upon planning adherence principle, organised a coherent and regulated delivery to TMA / Approach sectors, which aided application ASAS (sequencing and) merging techniques to integrate traffic in TMA / Approach. Indeed, controllers could easily used ASAS techniques to merge aircraft successive in the AMAN proposed sequence. In effect, very few AMAN sequence changes were required indicating that the controllers were mainly respecting the natural order proposed by the AMAN sequence.

In the Rome TMA simulations controllers agreed that building the AMAN sequence was somehow easier with ASAS as vectoring decisions in the form of merge behind instructions to achieve the required time spacing were delegated to aircrew (Note that ASAS time spacing was adapted to the specific runway spacing -120s for 6NM spacing on RWY 16R and 90s for 3NM spacing on RWY 16L).

With the 90s spacing delegation, spacing monitoring was sometimes assessed as an extra workload and the development of appropriate measures (human and system based) to support this activity was requested.

Comparison with sectors where ASAS was not in use showed that ASAS sequencing legs eased the application of ASAS S&M techniques.

Non-ASAS aircraft did not cause a particular problem in the sense they were managed as ASAS equipped aircraft but using classical vectoring techniques for merging. Here also, the AMAN sequence order was generally respected.

On a more cautious note, some controllers raised doubts with regards the effective use of ASAS in adverse weather conditions, and without AMAN support in smaller environments or those with many different aircraft types with wide ranging performances, and also in areas where strict airspace and environmental restrictions were in force.

On R/T communication a point for further investigation was while ASAS greatly reduced the need for tactical heading and speed R/T instructions (particularly in APP), these tasks were replaced by new R/T spacing instructions, which although considered to be less perceived workload, were more time consuming to perform than the replaced R/T tasks.

On data link messages CAP was appreciated equally in all sectors (En-route, TMA and APP), and "actual indicated airspeed" was considered a must in APP sectors when controllers had to adapt the speed of a trailing non-ASAS equipped aircraft in relation to a leader one.

Controllers were able to handle and land the targeted number of aircraft per runway with a very acceptable declared level of workload in all sectors. This is a positive result as the simulated level of traffic was quite demanding, but in line with anticipated traffic expectations.

The controllers felt that ASAS, coupled with AMAN, facilitated an optimised runway usage with more accurate and consistent delivery to the ILS. This was confirmed by analysis of the time spacing (at FAF for RWY 16L) between successive aircraft: in ASAS organisations, the distribution of the spacing was clearly centralised around 90s whereas in others it was much more dispersed between 60s and 160s.

Finally, if the integrated concept has demonstrated a potential for improved predictability and efficiency in a TMA environment, a "tailored-to-fit" re-think on airspace structure, sector manning configuration and inter-sector procedures will be required in order to ensure optimisation of potential benefits in that environment.

In general ASAS combined with AMAN provides ATCOs with a method of implementing the defined approach sequence, separating aircraft in time according to the landing rate.

The HMI visualisation proposed with ASAS links between aircraft enabled a quick and clear understanding of aircraft flows going towards the runways.

Stability of the sequence as prepared by the AMAN is a pre-requisite for a usable AMAN/ASAS system. This stability is a function of the environmental complexity (traffic surrounding the aircraft, difference of winds at different altitudes, etc.), influencing the continuity of the chains built earlier.

In all cases ASAS was found to be frequently used, even under complex and heavy traffic. ATCOs find the concept quite complex but succeeded in applying it which is encouraging.

In order to improve aircraft behaviors under ASAS spacing a crucial point is to address the application conditions and thus address the usability and usefulness of ASAS spacing.

6. CONCLUSIONS

This chapter aims at presenting the G2G programme conclusions from various viewpoints:
- G2G IOC validation results
- Overall results vs. Contract objectives
- Final Forum conclusions

6.1 Conclusions on G2G IOC validation results

(Extract from D0.4.4 [17])

This section draws conclusions to help identify strengths or weaknesses in the way the concepts have been evaluated during GTG. The objective is to identify possible actions to improve understanding about potential benefits and to identify any aspects that need to be targeted in future evluations.

Note - detailed conclusions on each concept element have been documented in the individual consolidated validation reports of D144, D244, D344 and D444.

While not all partners may be in complete agreement on every point, the following represents an integration of the individually drawn conclusions.

The validation results are split in two parts according to the maturity level:

- For concepts with target implementation timeframe up to 2012

- For concepts with target implementation timeframe beyond 2012: these were en-route Automation, en-route ASAS (S&M and C&P) and TMA ASAS spacing. Because of the limited maturity of these concepts the results gathered relate mainly to concept applicability to future traffic demand and operational acceptability with a need to establish operational feasibility before addressing performance aspects such as capacity and efficiency.

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6.1.1 Concept up to 2012

6.1.1.1   Airports and Flow

The airport related simulations were an early set of studies integrating several tools together. The emphasis was on operability and usability of a complex set of functions. The expected benefits were mainly in efficiency of airport operations. The Tactical Departure Management concept developed and built around the DMAN tool and efficient CDM has shown potential during validation to improve and smooth airport operations. The main conclusion is that the results were promising but that much more work is required to assess benefits and to establish network issues such as gate management impacts.

6.1.1.2   En-Route

The en-route concepts of dynamic resectorisation and multi sector planning showed benefits in efficient use of airspace and operational staff which could translate into marginal gains in capacity.

Access to aircraft parameters via ADS-B was received positively by controllers

The datalink applications tended to either display a/c data on the controller HMI or were used to provide electronic assistance to existing control tasks (e.g. transfer frequency). There were no concepts tested that integrated the data available from a/c systems into ground systems. Thus the current open loop control system was not actively challenged.

The MTCD Problem Indicator was based on ground system trajectory prediction. This along with flight path conformance, is an area where the potential for using aircraft derived data within the trajectory monitoring and prediction functions could be beneficial. However, there was no opportunity to test these enhancements within GTG.

6.1.1.3   TMA Arrivals

The WP3 work on an electronic environment and AMAN integration provided a similar level of capability to Rome and Paris. This was considered as an essential base from which further concepts, which make use of aircraft derived data to improve TMA performance, could be investigated.

6.1.2 Concept beyond 2012

6.1.2.1   Automation

The Automation concept, investigated at DFS, could dramatically change the role of the controller by moving tasks to the ATC system. This concept is similar to recent studies in the US (comp. to Heinz Erzberger, "Transforming the NAS: The next generation Air Traffic Control System", ICAS 2004). Though there is a high degree of automation in ground systems the proposed concept does not require new aircraft capabilities. This makes a possible transition step relatively easy technically. The prototype developed in this project will be used further by DFS to continue this work. The theme is also in line with SESAR Deliverable D1 that states that "there is a need for a paradigm shift in the current concept of operations to break through the "capacity wall" … and "this shift will include an increased use of automation to do some tasks traditionally performed by humans".

6.1.2.2   ASAS En-route

The indication from the participating controllers was that en-route ASAS procedures were difficult to implement.

It is necessary to conduct further studies to determine feasibility of the ASAS en-route procedures in the core en-route areas of Europe. The GTG evidence points towards ASAS Crossing and Passing as not being a feasible concept.

6.1.2.3   ASAS TMA – Sequencing & Merging

ASAS in the TMA (sequencing and merging) was considered as feasible by the participating controllers. However flight deck issues and exception handling have not yet been addressed in detail.

For ASAS Sequencing & Merging no benefits to safety or capacity were observed.

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Public

Date : 10th May 2007
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6.1.3 Performance

6.1.3.1   Safety

No concepts were tested in GTG that specifically targeted safety as a benefit.

6.1.3.2   Capacity

Several of the concepts tested showed some marginal gains in capacity, principally as a side effect of improving efficiency of airspace, traffic flow and/or staff management procedures. Nowhere was the potential for substantial gains in capacity from any single source directly investigated.

6.1.3.3   Efficiency

Most of the GTG concepts were targeted at improving efficiency in the management of airspace, staff, en-route flows, arrival streams and departure queues on the surface.

Most benefits documented are in efficiency

6.1.3.4   Environment

No concepts were specifically targeted at environmental improvements. Limited environmental impact analysis was performed. Some consideration was given to reduction of airport pollution through reduced taxi times.

6.1.4 General Validation Aspects

There is currently no clear, described and agreed process for the design and evaluation of ATM Systems or upgrades to ATM Systems. The process that was used within Gate to Gate was the then generally accepted approach but, with hindsight, this suffered from;

- a over-reliance on large real–time simulations (which are complicated to set-up and manage, impossible to control as experiments, and generally difficult to use to determine cause and effect),

- insufficient use of fast time simulation capabilities (the tendency was to use them to set up traffic samples and sectorisations for real-time simulations – there are many more capabilities to be exploited),

- insufficient use of prototyping - a key tool in exploring concepts and HMI at an early development stage

- insufficient use of network models to investigate e.g. impacts of AMAN/DMAN integration on gate management, effects of CFMU algorithm improvements on ECAC throughput, effects of capacity enhancements in one airspace on other ECAC airspace.

The potential future issue is that if R&D has no described process then, within SESAR, industrial processes that have been used to develop technology will be applied by default. Developing technical systems is not the same process as developing complex socio-technical systems.

An additional issue is the ability to have adequate access to controllers that have:

- sufficient time to support the project from the initial design;

- sufficient availability at critical moments;

- sufficient experience in the various ATM domains across ECAC airspace, and

- adequate skills in taking novel systems to their limits , as well as

- an open mind to see through 'teething' problems and view a potential end point, while

- allowing the system engineers the freedom to explore novel procedures without undue criticism.

A 'team' of such 'test controllers' would have helped.

6.2   Overall Results vs Contract Objectives

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This section presents the conclusions comparing the overall results versus the four G2G contract objectives (see below text *in italics*). The programme achievement towards these objectives is the following:

- *To define and describe an Operational Concept, taking TORCH as a basis to be refined and if necessary adjusted, consistent with other on-going European programmes, and correlated with the various Stakeholders Procedural and Technological Strategy plans:*

    ❑ The two first versions of the Integrated Operational Concept document were delivered and approved by EC. The last version of the G2G Integrated Operational Concept document D0.1.3 has taken into account change the validation results.

    ❑ Objective met but as intermediate step towards SESAR

- *To develop technical specifications focusing on the major improvements to be brought to the current ATM ground Systems to be able to support this Concept (here, ATM ground Systems shall be understood as Gate to Gate ATM ground System):*

    ❑ The G2G SSS, SSDD and IRS documents were delivered and accepted by EC.

    ❑ Objective met

- *To adapt existing ATM ground validation platforms, with the primary aim to validate the operational concept proposed and to demonstrate the industrial capacity to implement the required new functions:*

    ❑ The seven G2G platforms under the responsibility of ANSPs (LFV, NLR, DFS, AENA, DSNA and ENAV) and EEC) have been adapted successfully. Five platforms were compliant to ACE architecture.

    ❑ Objective met, platforms based on AVENUE compliancy

- *To validate the operational concept, with the constraint to have the validation performed by organisations – ATS providers- and participants –controllers- actually concerned with the management and the operation of the ATM Systems:*

    - This last programme objective constituted, during the last part of the project, the main task and priority for the consortium.

    ❑ All the Simulation Reports were delivered and accepted by EC.

    ❑ Concrete validation activity (27!) and results but …
    Objective partially met
        – Due to larger operational concept scope
        – Difficulty to integrate validation exercises
        – With insufficient quantitative measures
        – And to bring all the results together afterwards

6.3   Final Forum Conclusions

As culminating task of dissemination activity, the G2G Final Forum was organized in Paris on 18th and 19th October 2006. The objectives were four fold:

- To present the most significant validation results

- To explain the main conclusions

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- To make recommendations

- To pass on results and experiences

More than 20 speakers made presentations (see slides [18]).

About 70 persons attended the Final Dissemination Forum.

During the Final Forum the last session was dedicated to conclusions on G2G programme with various point of views delivered:

- Individual conclusions from ANSPs participating in G2G (AENA, DFS, DSNA, ENAV and LFV) and EUROCONTROL

- General conclusions (with respect to contract objectives)

- Final conclusions from EC perspective

These conclusions are detailed in the following sections 6.2.1 to 6.2.3.

Apart from the Final Forum, others main events or tasks were organized during G2G programme course as part of G2G dissemination activity, i.e.:

- G2G IOC Animation (see [19])

A G2G IOC animation was set up in order to present in an attractive way. It is composed of six operational scenarios: Refined Flow Management, Integrated Departure and Arrival, Dynamic Re-sectorisation, Multi Sector Planning, ASAS and E-TMA/TMA. It is based on flash development and includes a voice support.

- G2G Open Days and Newsletters (see [20])

Twelve Open Days were organized locally by ANSPs and EUROCONTROL in order to allow external participants to attend simulation exercises and to present first validation results. In support five Newsletters have been produced presenting a summary of these main operational results and forthcoming tasks. The list of G2G Open Days is the following:

- Langen DFS on 11th March 2004

- Malmö LFV on 16th February 2005

- Amsterdam NLR on 15th and 16th March 2005

- Seville AENA on 15th and 16th September 2005

- Athis-Mons DSNA 14th and 15th December 2005

- Langen DFS on 16th March 2006

- Rome ENAV on 27th and 28th February 2006

- Seville AENA on 6th and 7th April 2006

- Naples ENAV on 19th and 20th April 2006

- Stockhölm LFV on 1-2nd June 2006

- EEC Brétigny on February, March and April 2006 (Simulation)

- EEC Brétigny on 19-20th September 2006 (Results)

- G2G Final Brochure: during the Final Forum a G2G final brochure was handed out summarising all the main validation results (see [21]).

- Co-ordination with other projects and conferences or seminars participation

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The G2G dissemination activity consisted in co-ordination with other projects and participation to conferences or seminars. In addition the project has been presented at various smaller events too during its life time.

Main events were the following:

- ASAS-TN (2003, 2004): involvement in the consortium making available first orientations on ASAS P1 applications

- AFAS (January 2004): participation to the final user forum presenting the G2G operational concept

- NUP II (February 2004): presentation of the G2G operational concept, in particular ASAS P1 applications

- C-ATM[5] (15th December 2004): presentation of the G2G operational concept

- OPTIMAL[6]: preliminary discussion on common areas of interest and joint meeting OPTIMAL-G2G-CATM foreseen on 23rd June 05

- OATA: preliminary discussion on common areas of interest

- CAATS[7] workshops:

    - Budapest on 20th and 21st January 2005, to capitalise experience on validation, safety and human factors areas,

    - Lanzarote on 15-16th February 2006, best practices and methodology on validation, human factors and safety

- SWIM: participation in workshop Brussels on 27th and 28th April 2005

- FAA Conference in Baltimore on June 05: NLR presentation on Outbound Punctuality Sequencing by Collaborative Departure Planning

- FlySafe: exchange on G2G IOC

- ODT and EUROCONTROL related projects: G2G project presentation on 17th November 2005

- EC DG Research/TREN: Fifth Community Aeronautical Days, Vienna 19-21st June 06

    - G2G project presentation during ATM session Increasing Time Efficiency

    - Demonstration of G2G IOC animation at the exhibition

- SESAR co-ordination in the frame of G2G Final Dissemination Forum on October 2006

Moreover an EC Project Coordination Meeting was organised on 30th November 2004 involving various EC and EUROCONTROL projects (SEAP, EMMA, NUPII+, G2G, ASAS-TN2, C-ATM, OATA). The goal of the meeting was to launch a cooperative process between projects and to ensure that projects are aware of the need to take into account the proposed European ATM Master plan.

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[5] C-ATM (Phase 1): Co-operative ATM, provide a fully integrated and inter-operable air/ground environment encompassing Flow Management, Traffic Management and separation management. Assessment by live trials.
[6] OPTIMAL: Application of validation methodologies to assess a new approach and landing procedures and supporting ATC tools. Fast--time, real-time and flight trials will be performed.
[7] The CAATS project is sponsored by the European Commission's Directorate General for Transport and Energy (DG TREN), as part of the Sixth Framework Programme (6FP). The Commission has created CAATS as a tool to move towards a coordinated approach to Safety, Human Factors and Validation in ATM research in Europe and in particular within the 6 Framework Programme (FP6). Work on CAATS commenced the first of April of 2004. The objective is the coordination of processes and methodologies across European ATM projects in relation to Safety, Human Factors and Validation domains.

6.3.1 Individual conclusions from ANSPs and EUROCONTROL

AENA (see slides [18])

Presenter
José Miguel de Pablo
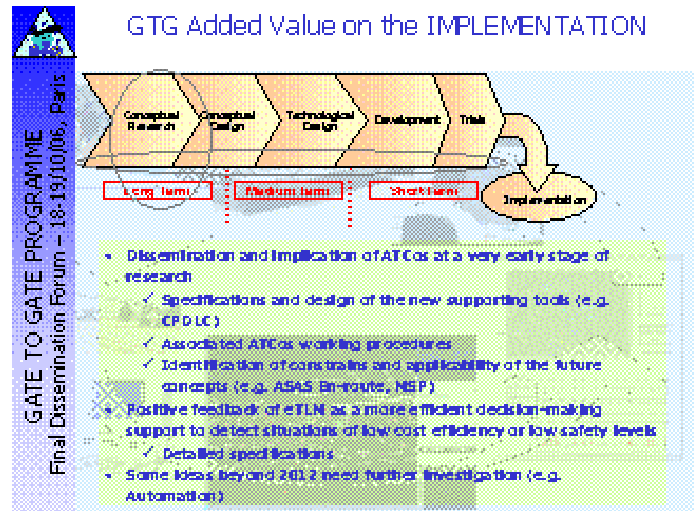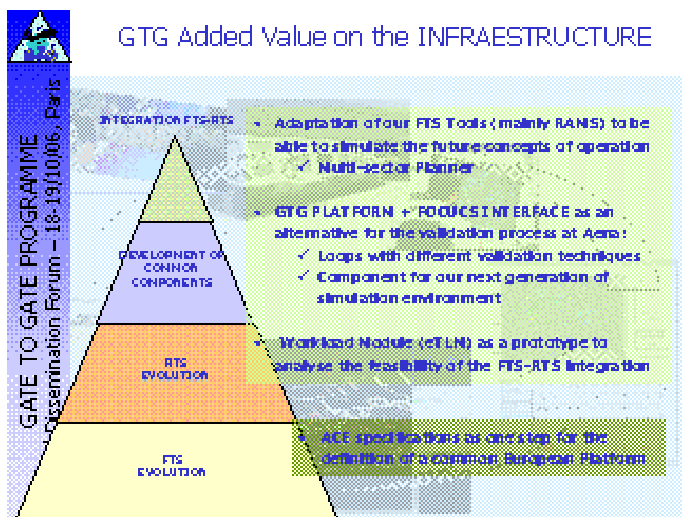*AENA, Head of Air Navigation System Development Division*
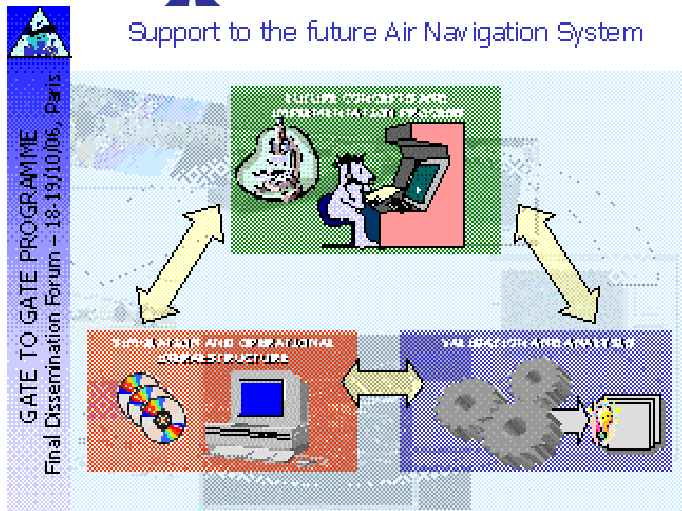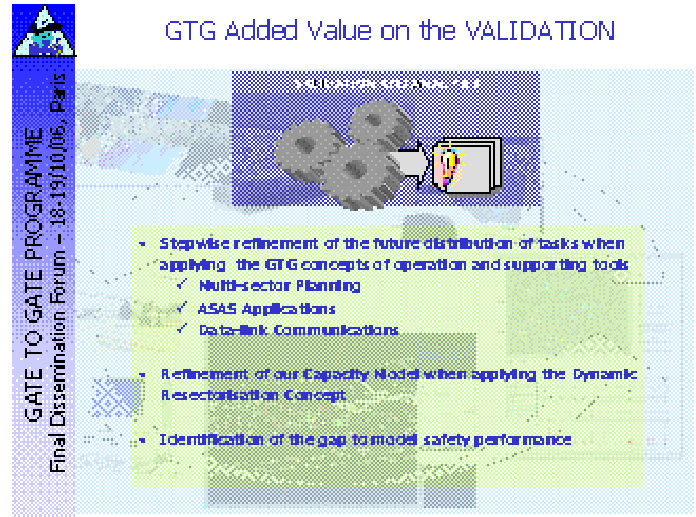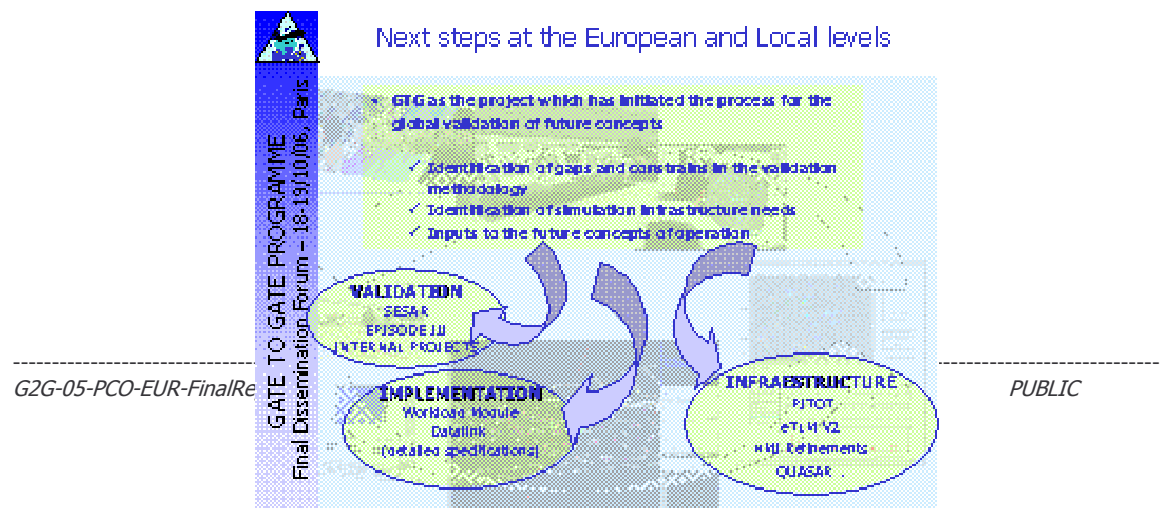
DFS (see slides [18])

Dr. Volker Heil
Head of R&D Unit

DFS Deutsche Flugsicherung

Conclusions automation

- Paradigm shift is possible
  - Tasks can be moved from the controller to the ATC system
  - Similar work is in US, e.g. Heinz Erzberger: "Transforming the NAS: The next generation Air Traffic Control System"
  - This concept addresses SESAR D1 demand "to match the strengths of the human operator with the power of automation"
  - Which paradigm is being shifted? Adaptive transition into a better future?

- Not on research agenda yet => advanced concepts need more emphasis
  - All technological enablers are already available
  - Standards (how to use a technical system) are needed
  - Basic research or just requirements definition needed?

- We are convinced that this approach is *one* possible answer to "break through the capacity wall" (SESAR!!)

DFS Deutsche Flugsicherung GmbH
19/10/2006, Dr. Volker Heil, R&D
- 3 -

Conclusions multi sector planning

- Stepwise validation approach defined in G2G

- Next generation of ATC systems (DFS: VAFORIT) enables operational implementation of Multi-Sector Planner
  - MSP allows efficient usage of new system functionalities
  - New working procedures/methods as validated in March 2004 in G2G show a lot of potential in terms of workload reduction (particularly for PC)
  - Airspace structure (DFS continuation with simulations in March 2006)

- Obvious benefits in terms of operational costs
- Indirect capacity effect: new sectors can be opened

- G2G project provided solid baseline for optimization of working methods and later adaptation of airspace structure with real time simulations

DFS Deutsche Flugsicherung GmbH
19/10/2006, Dr. Volker Heil, R&D
- 4 -

G2G experience of DFS

- Integrated concept of limited usefulness, only for the project, waste of resources
- Technical specifications triggered DFS work to provide AVENUE/ACE compliant interface to own real time simulator infrastructure
  - Important for future developments and validation work in the light of SESAR and iTEC
- ACE work partly successful
  - Platform could be used in Bretigny and other places, but caused 1 year project delay (project too long anyhow)
  - Transfer of components not successfully proven, e.g. each provider developed and used "own" AMAN, no components transfer took place from one ACE platform to another ACE platform
  - However architecture based on common middleware is basis for future operational developments
- (Local) Validation exercises very successful => happy ANSPs => happy DFS => Automation concept, MSP

DFS Deutsche Flugsicherung GmbH
19/10/2006, Dr. Volker Heil, R&D
- 7 -

Meeting G2G objectives

Objectives	Project view	DFS view
To define a European gate-to-gate operational concept Consistent with stakeholders strategic plans & for progressive implementation from 2010	Objective met	Objective partially met Limited use after G2G project Minor contribution to SESAR Definition Phase
To develop technical specifications focusing on the major improvements to be brought to the current ATM ground systems	Objective met	Objective met
To adapt existing ATM ground validation platforms, to make validation possible and coherent with the industrial strategy based on modularity, interoperability and usability	Objective met	Objective partially met Modularity and interoperability have not been demonstrated
To have the operational concept validated by operational organisations and staff (controllers and pilots)	Objective partially met Limited validation scope vs. concept Limited quantitative measures	Objective met Successful local validations Happy ANSPs

DFS Deutsche Flugsicherung GmbH
19/10/2006, Dr. Volker Heil, R&D
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DSNA (see slides [18])
Reza Djafarian, DSNA PCC representative
*on behalf of **Philippe Merlo**,*
Head of the Technical and Innovation Department (DTI)

A worthwhile experience for DSNA

- A good overview of many concepts for all phases of operations
- Fruitful discussions with many partners with various areas of expertise
  - Interoperability between concept elements
  - Maturity of concepts
- An incentive for more research;
  - DSNA investment in the program will exceed eligible budget by more than **40%**
  - Actual Ratio of EC contribution to DSNA investment less than 35%
- A green light for future industrial developments in ETMA/TMA
  - DSNA has launched ACROPOLE to define and deploy by 2012 the future tools in ETMA/TMA surrounding Paris Approach
    - Electronic environment (Paperless Controller Working Position)
    - Enhanced coordination tools
    - Vertical assistant displays
    - Promoting the use of touch input devices

GATE TO GATE PROGRAMME – Final Dissemination Forum – 18-19/10/06, Paris

2

Higher value for money in similar R&D programs are still possible by:

- Assigning objectives suited for the target stage of development in the ATM product life cycle.
- Improving task description and distribution before contract signature
  - Most management costs should occur during definition/negotiation phase
  - A Financial mechanism to support this phase would help
- adopting a balanced approach for EC sponsored research themes
  - Not too incremental:
    - to sufficiently address problems raised by users
    - to reduce national and European programs overlap
  - In investment intensive prospective projects:
    - Transition issues CAN NOT be overlooked
    - A smooth, safe and efficient path from existing to target systems MUST be found and evaluated

GATE TO GATE PROGRAMME – Final Dissemination Forum – 18-19/10/06, Paris

3

Higher value for money in similar R&D programs are still possible by:

- Allocating sufficient budget and time for concept element evaluations
  - Evaluation of global concepts should not reduce effort for in-depth studies of concept elements
  - Even familiar concept elements' evaluations require software developments
    - A classical conception/evaluation cycle lasts at least 3 years;
    - Shorter research periods constrain innovation.
- Maintaining local evaluations
  - The only driver of ANSP's decision to launch an industrial program.
    - Only local validation can check whether proposed solutions can be implemented
  - Local and generic evaluations are not incompatible
    - Generic evaluations offer guidelines for tools and procedures specification
- Improving flexibility for
  - EC to amend contracts according to its strategic agenda
  - Partners to :
    - propose amendments to programs they finance at 50%
    - Modify allocation of resources according to project needs during execution

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ENAV (see slides [18])
Luca Bellesia
ENAV CNS/ATM Experimental Centre
Strategy & International projects co-ordinator

ENAV SpA

ENAV Validation activities findings

AMAN

➤ Encouraging feedback on AMAN applicability in Rome ACC environment:
  ➤ Suitable for the operational scenario under evaluation;
  ➤ Useful in the real working environment.
  ➤ Necessity of implementing a Sequencing Manager in E-TMA.

➤ The validation activities have showed that:
  ➤ The defined AMAN tool and working methods allow a consistent and ordered management of the arriving traffic flows;
  ➤ Upstream sectors can easily pre-sequence the arriving traffic well in advance reducing delays and holding legs.

ASAS

➤ Based on the sequence provided by the AMAN, ASAS Spacing has proven to allow an easy and smooth sequencing of the inbound traffic, improving efficiency and punctuality.

G2G Final Dissemination Forum 18th-19th October 2006

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Exploitation/follow up of G2G results

Step 1 (timeframe 2007-2012)

➤ Based also on the G2G results, Ri.Se. phase 2 (Independent Parallel Approach in FCO) will be implemented by Spring 2007;

➤ Starting from G2G results and Ri.Se. phase 2 configuration, ENAV will design an Advanced-AMAN prototype and will validate the related working methods in a national project (starting by the end of 2007). The goal is to integrate A-AMAN in eATMs in 2012;

➤ Air/ground integration: building an ASAS enabling infrastructure. On going work is performed within the CASCADE Programme (Cristal Med) to continue with the implementation of ADS-B (Surveillance, operational acceptance 2008). ENAV supports a solution based on dual links (1090 ES and VDL4).

G2G Final Dissemination Forum 18th-19th October 2006

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Exploitation/follow up of G2G results

Step 2 (timeframe 2015+)

➤ Starting from step 1 achievements and based on SESAR reference/selected operational concepts, ENAV, within Episode 3 (2008-2009), will focus on ASAS Spacing application in E-TMA/TMA;

➤ Based on SESAR ATM Master Plan and Episode 3 results, ENAV will focus on the ASAS Spacing implementation by 2015 in the future e-ATMS/Coflight operational environment.

G2G Final Dissemination Forum 18th-19th October 2006

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Conclusions

➤ G2G project and validation provided fruitful results feeding operational concept and ATM development plans;

➤ ENAV is building on G2G findings to support the ENAV implementation strategy;

➤ ENAV expects SESAR to exploit G2G results, with particular attention to air/ground integration and ASAS.

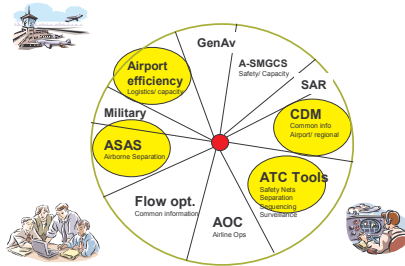*G2G Final Dissemination Forum 18th-19th October 2006*

6

LFV (see slides [18])
Manager ANS Development
Anne-Lovise Linge

LUFTFARTSVERKET

Vision

LFV is looking at a business case based on a mix of applications, airspace users, airports and ATC.

Single applications by a single technology is not financially motivated

GenAv
A-SMGCS
Safety/ Capacity
SAR
Airport efficiency
Logistics/ capacity
Military
CDM
Common info
Airport/ regional
ASAS
Airborne Separation
ATC Tools
Safety Nets
Separation
Sequencing
Surveillance
Flow opt.
Common information
AOC
Airline Ops

3   Air Navigation Services Department   LUFTFARTSVERKET

Integrated Arrival Departure

IRM – Integrated Runway Management
Multi runway – runway sequense – mixed mode

FASA ⇨ TMA2010+ cooperation Eurocontrol
IRM ⇨ ERAT, New cooperation opportunities – LVNL – NLR – NARSIM
⇨ SESAR/EPISODE3

(FASA – Final Approach Spacing Assistance)

ASD/DEV   2006-10-19   LUFTFARTSVERKET

Pre-Tactical Departure

DMAN
Close to implementation
⇨ Validation NUP2+

⇨ CDM Arlanda – Cooperation Eurocontrol
    - Arrival parameters
    - DMAN

⇨ SESAR/EPISODE3

ASD/DEV   2006-10-19   LUFTFARTSVERKET

Dynamic Sectorisation/Multi Sector Planner

To be integrated in existing E2K system
⇨ COOPANS

Thales – Sweden/Denmark/Ireland
⇨ SESAR/EPISODE3

⇨ En-route segments- DFS

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Arrival Management

⇨ CDM Arlanda – Cooperation Eurocontrol
  - Arrival Scheduler - CIES – Collaborative Information Exchange System
⇨ Green Flights – Trajectory downlink- predictability - SWIM/CDM
⇨ SESAR/EPISODE3/ co-operation
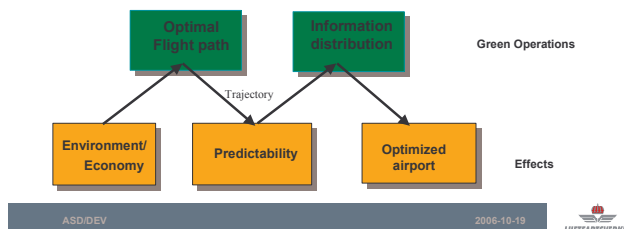
EUROCONTROL (see slides [18])
Pierre ANDRIBET
Core Business Manager, EUROCONTROL Experimental Centre

From G2G towards SESAR Concept Validation

G2G started to build the three fundamental pillars of a federated European Validation programme:

- An **integrated concept** (Overall / System view and « local » view)
- A robust and shared validation strategy based on an harmonised validation methodology (E–OCVM)
- A first step to build an **integrated validation infrastructure**

Integrated Concept

- All phases of flight covered,
- Overall / System view and « local » view analysed

- Over-ambitious project that had not the means to develop the future concept
- WP4 showed that the concept is not yet fully integrated and far from being completely mature

But it gave precious results that un-doubtfully will feed SESAR

Platforms and validation infrastructure

- An initial reference modular architecture defined and agreed by partners
- ACE platforms on different sites
  - Multiple instances with different industrial components / different providers
  - Different phases of flights
  - Interconnection with other platform
- G2G precursor to EVI (European Validation Infrastructure) initiative to support SESAR Concept Validation

Validation methodology: E-OCVM

- A structured and formal validation methodology refined and applied in G2G
- A standard, to be progressed, for all EC and EUROCONTROL concept validation activities
- E-OCVM will be used for SESAR concept validation and within Episode 3

Conclusions

6.3.2   General conclusions (with respect to Contract objectives)

The general conclusions with respect to G2G Contract objectives were presented by the PCO (see slides [18]).

6.3.3   Final conclusions from EC perspective

Morten Jensen
European Commission
Final G2G Forum

"Achieving the Single European Sky initiative requires an integrated (interoperable) European ATM system. This need was already obvious when the Commission launched the Single European Sky initiative in 2000 following the high-level group report.

At that time the European air transport system was suffering from significant delays and the ATM system would clearly be unable to cope with the expected future demand. A reduction in fragmentation and a new generation of the ATM system was needed –sooner rather than later - in order to meet the increased demand.

Whilst a lot of validation has been done, the validation of an integrated gate to gate operational concept had not been done and consequently the Commission saw the need to launch research in this area in 2001 in order to

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provide decision makers with the necessary input regarding capacity, efficiency and safety. The expectation was that this would entail a significant amount of simulations to provide this input.

The task consisted more precisely in the following activities:

- Development of a gate-to-gate operational concept for 2005-2010

- Continue the development of a European operational validation platform to support the integrated 'end to end' concept validation

- Validation of the operational concept through significant simulations

To achieve these objectives it implicitly meant that a critical mass of stakeholders would have to be brought together to agree on a possible future system and co-operate in its validation.

GATE TO GATE (G2G) was selected to undertake this research and the project was launched in 2002. It was the biggest and most ambitious ATM research project funded by the Directorate-General for Energy and Transport in the 5th Framework Programme.

In order to prepare for the future, G2G has proposed an integrated operational framework for implementation from 2010. Clearly integrating all phases of flight (departure, en-route and arrival) in a single operational concept is a highly ambitious, complex and risky exercise.

Since 2002 the G2G team worked to develop the integrated operational concept, defining the validation strategy and to develop the validation platforms. After this an extensive phase of validation with a total of 27 fast time and real time simulation experiments were carried out.

The attempt to bring together a significant number of stakeholders, who previously had worked in an isolated and segregated manner, was a major challenge and in a sense G2G has been a forerunner of even bigger projects, like SESAR.

The development of an integrated operational concept took more time than expected. In the meanwhile the concept has to a large extent been overtaken by other concepts and we now all expect that the SESAR programme will deliver the ultimate concept. But it is fair to say that the concept discussions in G2G have helped to prepare the ground for, and will no doubt contribute to, the SESAR operational concept.

During the project the ACE validation platform has been developed by EUROCONTROL and has been implemented by several of the project participants.

You can also say that the project has been successful in opening the minds of the stakeholders, fostering awareness of the need to reach an agreement on a European wide operational concept and taught the stakeholders to work together instead of working in isolation.

As mentioned, the project has carried out 27 simulations. The results have provided valuable input to decision makers regarding a number of concepts and enablers. This will help in the further development of these concepts and enablers and some service providers have already included a number of these in their current development plans. Some of them can be implemented in the shorter term whereas others can only be implemented in the longer term and can be of particular interest to SESAR.

I would therefore like to congratulate the G2G consortium with the work they have accomplished, which I am sure the ATM community will benefit from in the future and my acknowledgement of all the efforts that have been put into the work."

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Likewise EUROCONTROL concluded that the G2G Concept is no single rigid and standardised ATC Operational solution, but one flexible Concept made of interoperable concept elements that are based on common principles and can be adapted to best fit multiple ATC environments.

7.   GATE TO GATE PARTNER PLANS WITH RESULTS

Results Partner	Pre-Tactical Departure	Integrated Arrival Departure	Dynamic Re-sectorisation	Multi Sector Planner	Automation Concept	Arrival Manager	Electronic Environment and Co-ordination	Arrival & ASAS	SSS	SSDD-IRS
EUROCONTROL	Further work planned to done in the context of Episode 3 WP5	In general, these topics will be further investigated under the leadership of TMA2010+. Short term and direct follow up in the context of TMA2010+ in cooperation with LFV (Simulation in Spring 2007). Additional work anticipated in the context of G2G2 and then Episode3 WP5.	We expect to reuse the results and explore further in the context of Episode3 WP4 (in particular Cycle 2 in cooperation with MUAC). Findings are also being fed to ATC Domain Enroute activities	MSP: We expect to reuse the results and explore further in the context of Episode3 WP4 (in particular Cycle 2 in cooperation with MUAC). Findings are also being fed to ATC Domain Enroute activities. MTCD&CPDLC: We expect to reuse the results and explore further in the context of G2G2 and then Episode3 WP4 in coordination with FASTI (MTCD) and the ATC domain (CPDLC).		Enhanced Arrival Management/Electronic environment (earlier planning determination / enhanced planning adherence based on enhanced AMAN -better trajectory prediction-) : We expect to reuse the results and explore further in the context of G2G2 and then Episode3 WP5 in coordination with TMA2010+			G2G SSS was already used as a baseline for upgrading of to an ACE SSS	G2G SSDD-IRS is in use in EEC (as the physical model is the one of ACE System). ACE will be maintained and further developped. User group and cooparation agreements have been setup. We execpect it to become a key component of EVI (Eurocontrol Validation Infrastructure).
INDRA									Basis for standardisation and improvement of current products	Basis for standardisation and improvement of current products
ISDEFE	Basis for new research activities	Basis for new research activities	Basis for new research activities	Basis for new research activities	Basis for new research activities	Basis for new research activities	Basis for new research activities	Basis for new research activities	Basis for new research activities	Basis for new research activities
LFV	Will contribute to ongoing work for Arlanda in which airport CDM plays an important role	Worth continuing towards implementation	Will contribute to ongoing work to make en-route ACC operations more efficient	Contributes to ongoing work for possible implementation of this function for en-route ACC operations						
NLR	Applicable to ongoing RTD in optimisation of efficient use of capacity of the ATM system, based on 4D planning and CDM	To be used for preparation of mature prototypes, applicable for mixed-mode as well as segregated modes of operation, based on 4D planning and CDM	Might be applicable to ASM studies e.g. SESAR and Episode-3					Interesting starting point of more RTD investigations in benefits, sequencing stability and safety aspects	Standardisation to be taken into account as far as feasible and applicable	Standardisation to be taken into account as far as feasible and applicable
SELEX SI									basis for product development and enhancement	basis for product development and enhancement
SICTA	Basis for new studies/experiments	Basis for new studies/experiments	Basis for new studies/experiments	Basis for new studies/experiments	Basis for new studies/experiments	Basis for new studies/experiments	Basis for new studies/experiments	Basis for new studies/experiments	Basis for prototypes development/experiments	Basis for prototypes development/experiments
THALES ATM	DMAN integrated into our offers	Longer term	e-TLM to be further studied and refined to be integrated into our offers	MSP already operational	Longer term	Input to analyse whether the existing operational AMAN still needs improvements	SYSCO and vertical view implemented.Possibly further improvements in the future	Planned studies (at least Episode 3)	Input for product improvement	Input for product architecture improvement
THALES Avionics		Use of Aircraft 4D predictions and RTA function to refine the Integrated AMAN/DMAN should be experimented	Use of Aircraft 4D trajecotry to determine the ETA at each sector to be further experimented, as it will add robustness to the ground Trajectory Predictor		Further experiments ongoing on CPDLC (Episode III). Automation of digital clearances in the cockpit to be further evaluated				Automation of FASA in the FMS to be evaluated. ASAS S&M experiments to perform in next 10 years	

The following table presents the G2G partner interest to re-use results with further development plan.

Figure 20 – G2G partner interest to re-use results

8. GATE TO GATE LESSONS LEARNT AND RECOMMENDATIONS

This chapter gives an insight of the lessons learnt and main recommendations worked out by the G2G consortium during the programme course. It covers all the activity domains focussing as well on processes and content of results. More details on lessons learnt and recommendations are available in each separate Simulation Reports (see [12], [13], [14] and [15])..

INTEGRATED OPERATIONAL CONCEPT – G2G RECOMMENDATIONS

1. "Not re-invent the wheel" but use what is available, i.e. to take agreed external concepts and to reference to public and stored documents in the ATM R&D community (e.g. RFG)
2. To use recognized methodologies (e.g. OSED, modeling language)
3. Writing concept document make a well defined planning and stick to that planning avoiding negative impact on other activities such as validation
4. Small working groups recommended
5. To include Airlines in this "ANSP-like IOC" to ensure buy in

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SPECIFICATIONS – G2G RECOMMENDATIONS

1. Higher SSS level view more suitable (no "real" SSS)
2. To replace SSS by use case at system level
3. To re-use SSDD-IRS and maintain e.g. OATA

PLATFORMS – G2G RECOMMENDATIONS

1. Interoperability: to use operational platforms interconnected and to improve interoperability between platforms by fostering an open system architecture with connectivity between different environments (multi centre simulation experiments)
2. Have small, flexible prototyping platform
3. Best A single planning with properly plan platform usage during development and integration phases
4. To improve progress in ATM R&D by fostering open sources prototyping software (e.g. Linux)
5. To promote the use of one standardised platform (ACE)
6. ACE Simulation facility improvements (CWP, PWP, MONA, etc)

(See detail in D4.4.4 [17])

7. **Validation requirements on the ACE reference platform: Due to the long lead times from the description of functional and validation requirements of a concept to being able to utilise those capabilities requires a lifecycle of at least 3 years to feedback results to the concept development team, the contribution of platforms such as ACE to providing early evidence about the performance capabilities of ATM concepts needs to be better understood by programme negotiators.**

(See detail in D0.4.4 [17])

Validation – G2G Recommendations

1. <u>Safety</u>: **In order to ensure a balanced approach to developing ATM systems, safety and capacity should be considered together due to their dependencies.**

2. <u>Safety</u>: **It is now recognized that evaluating safety performance requires different simulation techniques than are in general use in ATM R&D at present.**

3. <u>Capacity</u>: **To make it possible, capacity modelling techniques need to be defined and agreed to cover the two following areas: i) Enable a quantification of the impacts of a change in operating procedures on local capacity, ii) Allow the capacity improvements on a local level to be extrapolated to other ECAC airspace and thus provide information that network models such as FAP (Future ATM Profile simulator) can use to establish network capacity gains.**

4. <u>Scope relevance and completeness of results</u>: **The issue of how to ensure relevance of results to ECAC performance needs should be addressed at the programme definition phase. This will require identification of bottlenecks to ECAC performance and causes of those bottlenecks**

5. <u>Scope relevance and completeness of results</u>: **The recommendation is that, for future programmes, the selection of concepts should take into account ECAC performance needs e.g. safety and capacity. It is essential that the appropriate ECAC level performance constraints (including causal aspects) are identified before validation commences.**

6. <u>Methodology</u>: **The validation strategy i.e. the selection of assessment tools, techniques and number of simulations, etc. should be done according to a validation methodology such as the E-OCVM.**

7. **Selection of concepts and simulations (number and type), target airspace or airports, should not be determined until ATM needs and validation objectives have been identified.**

8. <u>Methodology</u>: **The European Commission and EUROCONTROL should ensure that there is support available on explaining validation issues for programme negotiators when establishing new programmes.**

9. <u>Operational staff</u>: **An additional issue is the ability to have adequate access to controllers that have**
   - **Sufficient time to support the project from the initial design,**
   - **Sufficient availability at critical moments,**
   - **Sufficient experience in the various ATM domains across ECAC airspace, and**
   - **Adequate skills in taking novel systems to their limits, as well as**
   - **Being tasked to see beyond the 'teething' problems and view a potential end point, while**
   - **Allowing the system engineers the freedom to explore novel procedures without undue criticism.**

   A 'team' of such 'test controllers' would have helped.

(See detail in D0.4.4 [17])

10. <u>Strategy</u>: Clearly define the validation strategy and plan at the start of validation projects fixing realistic objectives

11. <u>Strategy</u>: To be honest when comparing in the beginning of the project about scope and results of validation activities (budget and time versus expected scope of activities and results)

12. <u>Methodology</u>: Stakeholder interaction should be improved from start (regular forums)

13. <u>Methodology</u>: Real GATE TO GATE validation to find the co-ordination problems

14. <u>Integrated Arrival-Departure Results</u>:
   - DMAN should be considered for implementation at major airports,
   - Flow management, more investigation is required in demand and capacity balancing
   - Refined Flow Management RFM, to look for institutional support
   - IRM / FASA, indications of the concept's feasibility are strong. Further development work should focus on HMI and algorithm

(See detail in D1.4.4 [12])

15. <u>En-route Results /Lessons learnt</u>:
   - The controller training should be increased in order to familiarise them with the working platform and the new concepts.
   - In order to reduce the influence of the new functionalities and HMI on the introduction of new concepts, an iterative adaptation of the platform HMI during the validation process would be necessary.
   - The measurement of capacity in future operational environments was stated as a difficult process. Several iterative steps and calibration processes were necessary to measure capacity by using fast-time simulation techniques.
   - Finally, it should be noted, that an extrapolation of the results obtained in the German and Spanish airspaces to other airspaces, is difficult. Actually the application of the new concepts depends heavily upon local characteristics, such as system capability, working methods and airspace structure. Therefore, in order to obtain definitive results, a more in-depth analysis should be performed taking into account the conclusions obtained in these simulations as a first step in the validation process.

(See detail in D2.4.4 [13])

16. <u>Extended-TMA/TMA Management Results - Advanced CWP</u>:
   - Satisfactory ATC Clearance ACL service usage requires a highly efficient implementation
   - To improve Planning and integration of flights
   - To consider vertical view as a potential enhancer of situation awareness (particularly in holding configuration)
   - Representation of information related to sequence and delays to be included as early as possible, even if less reliable when aircraft are far from IAF

17. <u>Extended-TMA/TMA Management Results – Electronic co-ordination</u>:
   - To perform co-ordinations for a group of aircraft

- ▪ **A better integration of the co-ordination functionalities in the Controller Working Position must be found.**

18. **Extended-TMA/TMA Management Results – ASAS:**
   - ▪ **ASAS must not be mandatory and applied when useful**
   - ▪ **ASAS requires well-defined procedures and suitable tools to work properly:**
      – Phraseology should be much more refined
      – Roles and working methods should be more clear and combined with supporting technologies (e.g. AMAN, CPDLC and ADAP)
      – ASPA S&M needs adequate recovery procedures in case of failure mode or particular situations (e.g. bad weather, emergencies)
      – Further studies on HMI design and development of supporting functions (assessment of delegation feasibility)

(See detail in D3.4.4 [14])

19. **ANSP recommendations on further work**

(See detail in D1.4.4 [12], D2.4.4 [13] and D3.4.4 [14])

20. **EEC further evaluation/validation works and EEC activity to follow-on G2G**

(See detail in D4.4.4 [15])

9.   G2G Public Documentation Baseline

The following table is referencing the public documentation baseline produced by the G2G programme. It is composed of a variety of type of documents i.e. deliverable, slide presentation, brochure, newsletter, animation, etc. All these documents are available on the G2G web site: www.g2g.isdefe.es.

Index	Title	Date	Author (s)
[1]	G2G D0.1.3 IOC (Final Description)	October 2006	THALES ATM NLR
[2]	G2G WP4 D4.1 Operational Concept Scenarios	January 2006	EUROCONTROL
[3]	G2G WP1 D1.1.2.1/D1.1.2.2 OCD and Operational Scenarios	January 2006	LFV NLR
[4]	G2G WP2 D2.1.2.1 Operational Concept	May 2006	AENA DFS
[5]	G2G WP2 D2.1.2.2 Operational Scenarios	January 2006	AENA DFS
[6]	G2G WP3 D3.1.2.1 Operational Concept	January 2006	DSNA ENAV
[7]	G2G WP3 D3.1.2.2 Operational Scenarios	May 2006	DSNA ENAV
[8]	G2G D0.2.1 SSS	December 2004	DSNA

Index	Title	Date	Author (s)
[9]	G2G D0.2.2 SSDD-Logical Part	January 2005	EUROCONTROL
[10]	G2G D0.2.2 SSDD-Physical Part	February 2005	EUROCONTROL
[11]	G2G D0.2.3 IRS	January 2005	DSNA
[12]	WP1 D1.4.4 Simulation Report	September 2006	LFV NLR
[13]	WP2 D2.4.4 Simulation Report	September 2006	AENA DFS
[14]	WP3 D3.4.4 Simulation Report	September 2006	DSNA ENAV
[15]	WP4 D4.4.4 Simulation Report	November 2006	EUROCONTROL
[16]	G2G D0.4.3 Consolidated Validation Strategy	June 2005	EUROCONTROL
[17]	G2G D0.4.4 Consolidated Validation Analysis	December 2006	EUROCONTROL
[18]	G2G Final Forum Slides	October 2006	G2G Consortium
[19]	G2G IOC Animation	December 2005	G2G Consortium
[20]	G2G Newsletters #1-5	March 05/July 2006	G2G Consortium
[21]	G2G Final Brochure	October 2006	G2G Consortium

Figure 21 – G2G Public Baseline Documentation

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APPENDIX I : Glossary

Acronym	Definition
4D	4-Dimensional
a/c	Aircraft
ACC	Area Control Centre
ACE	Avenue Compliant Escape
ACL	ATC Clearance and information
ACM	ATC Communications Management Service
ADD	Aircraft Derived Data
ADS-B	Automatic Dependent Surveillance – Broadcast
ADS-B-ACC	ATC surveillance for en-route airspace
ADS-B-ADD	Aircraft Derived Data for ground ATC tools
ADS-B-APT	Airport surface surveillance
ADS-B-TMA	ATC surveillance in Terminal areas
AFAS	Aircraft in the Future ATM System
AG or A/G	Air Ground
AMAN	Arrival MANager
A-AMAN	Advanced Arrival MANager
AMG	ATC Message Generator
ANSP	Air Navigation Service Provider
AO	Airline Operator
AOC	Airline Operation Centre
API	Application Programming Interface
APP	Approach Centre
AS	Airborne Surveillance
ASAS	Airborne Separation Assurance System
ASM	AirSpace Management
A-SMGCS	Advanced- Surface Movement Guidance and Control System
ASPA-C&P	Enhanced Crossing & Passing operations
ASPA-ITP	In-Trail Procedure in Oceanic Airspace
ASPA-S&M	Enhanced Sequencing & Merging Operations
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATFCM	Air Traffic Flow and Capacity Management
ATM	Air Traffic Management
ATN	Aeronautical Telecommunications Network

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Acronym	Definition
ATSA-AIRB	Enhanced Traffic Situational Awareness during flight operations
ATSA-S&A	Enhanced Visual Acquisition for See and Avoid
ATSA-SURF	Enhanced Traffic Situational Awareness on Airport Surface
ATSA-SVA	Enhanced Successive Visual Approaches
ATSAW	Airborne Traffic Situational Awareness (ASAS) applications
AVENUE	An ATM Validation Environment for Use towards EATMS
C&P	Crossing and Passing
CAP	Controller Access Parameters
CC	Cluster Concept
CDM	Collaborative Decision Making
CDTI	Cockpit Display of Traffic Information.
CFMU	Central Flow Management Unit.
CNS	Communications, Navigation and Surveillance
CORA	Conflict Resolution Assistant
CPDLC	Controller Pilot Data-Link Communications
CWP	Control Working Position
C-ATM	Co-operative Air Traffic Management
D/L	Data Link
DCL	Departure Clearance
DLIC	Data Link Initiation Capability
DMAN	Departure MANager
DOP	Daily Operational Plan
DOW	Description Of Work
DSC	Downstream Communications
DyR	Dynamic Re-sectorisation
EATMP	European Air Traffic Management Programme
EEC	EUROCONTROL Experimental Centre
EC	European Commission
eTLM	enhanced Traffic Load Monitor
E-OCVM	European Operational Concept Validation Methodology
E-TMA	Extended TMA
FASA	Final Approach Spacing Assistance tool
FDPS	Flight Data Processing System
FLIPCY 4D	Flight Plan Consistency Check 4D [AFAS]
FMS	Flight Management System
FP	Framework Programme
FTS	Fast Time Simulation

Acronym	Definition
FUA	Flexible Use of Airspace
GS	Ground Surveillance
GTG / G2G	GATE TO GATE
HMI	Human Machine Interface
IAF	Initial Approach Fix
ICAO	International Civil Aviation Organization
ILS	Instrument Landing system
IOC	Integrated Operational Concept
IRM	Integrated Runway Management
IRS	Interface Requirement Specification
KC	Key Concept
KCO	Key Concept of Operation
MA-AFAS	More Autonomous Aircraft in the Future ATM System
MFF	Mediterranean Free Flight
Mode C	Mode Contract
MONA	MONitoring Aids
MSA	Multi Sector Area
MSP	Multi-Sector Planning / Planner
MTCD	Medium Term Conflict Detection
N/A	Not Applicable
NUP	North European ADS-B Network Update Programme
OATA	Overall ATM/CNS Target Architecture
OC	Operational Concept
OCD	Operational Concept Document
OI	Operational Improvement
OLDI	On-Line Data Interchange
PCO	Programme Co-ordinator
PCPD	Planning Controller Potential Problem Display
PI	Problem Indicator
PPD	Pilot Preferences Downlink
PTC	Pre-flight Trajectory Co-ordination
R/T	Radio Telephony
RFM	Refined Flow Management
RTOA	Required Time Of Arrival
RTS	Real Time Simulation
S&M	Sequences and Merging
SAP	System Access Parameters

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Acronym	Definition
SESAR	Single European Sky ATM Research
SID	Standard Instrument Departure
SMGCS	Surface Ground Movement and Control System
SSDD	System Segment Design Document
SSS	System Segment Specification
STCA	Short Term Control Alert
SYSCO	System Supported Co-ordination
TEN	Trans European Network
TMA	Terminal Manoeuvring Area
TORCH	Technical, Economical and Operational Assessment of an ATM Concept Achievable for the year 2005
TP	Trajectory Predictor
TWR	Tower
UAC	Upper Area Control
WBS	Work Breakdown Structure
WP	Work Package

<<END OF DOCUMENT>>