A FUTURE AIR TRAFFIC MANAGEMENT SCENARIO
A discussion Paper produced by GARTEUR Action Group FM AG03

March 1986

GARTEUR TP 024 prepared under the auspices of the Responsables for Flight Mechanics of the Group for Aeronautical Research and Technology in Europe.
# LIST OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>INTRODUCTION</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>ATM DEFINITION</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>ATM CHARACTERISTIC PARAMETERS</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>ATM OBJECTIVES</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>CHARACTERISTICS OF PRESENT DAY ATM</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>BROAD DIRECTION OF CHANGE</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>CONSTRAINTS AND CONDITIONS ON CHANGE</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>SOME SIGNIFICANT DEVELOPMENTS</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td>ELEMENTS OF A FUTURE SCENARIO</td>
<td>6</td>
</tr>
<tr>
<td>10</td>
<td>SUGGESTIONS FOR FURTHER STUDY</td>
<td>7</td>
</tr>
<tr>
<td>11</td>
<td>ORGANISATIONS ACTIVE IN THE DEVELOPING ATM SCENE</td>
<td>8</td>
</tr>
<tr>
<td>Annex 1</td>
<td>Membership of GARTEUR Action Group FM AG03</td>
<td>9</td>
</tr>
</tbody>
</table>
1 INTRODUCTION

This short discussion document has been produced by the members of GARTEUR Action Group FM AG03. The Group has members from NLR, DFVLR, RAE and RSRE; their task is to examine the necessary future integration of FMS and ATM systems. It was felt that a future ATM Scenario should be defined in order to provide a framework to help assess the benefits of the integration of Flight Management and Air Traffic Control Systems. This scenario was seen as an essential foundation to the work of the Action Group and the individual research programmes on data links, ATC systems and FMS being carried out in the national research establishments. It may contribute to useful discussion in the wider international debate taking place on future ATM systems.

2 ATM DEFINITION

Air Traffic Management is the term used to describe the total system, ground and air, needed to ensure the safe and efficient movement of aircraft, in all phases of operation. It covers airborne equipment (such as Flight Management Systems), the Air Traffic Control (ATC) systems, and in particular the procedures to integrate the two.

3 ATM CHARACTERISTIC PARAMETERS

An ATM scenario may be characterised by the following set of quantifiable parameters:

(i) Traffic load, and mix of aircraft types and avionic capabilities, as a function of time.

(ii) Airspace Architecture (including air routes and airports).


(iv) Information Services. (Current examples at ATIS, VOLMET, FIS etc.)

(v) Air Traffic Control Services.

(vi) Cooperation and Integration of Air and Ground Systems.

4 ATM OBJECTIVES

Air Traffic Management must aim to achieve:

(i) Maintenance or improvement of established safety levels.

(ii) Efficiency - important elements of which are:

   (a) Cost of implementation (both air and ground).
(b) Direct operating costs (including time and fuel cost).
(c) Capacity (airspace and runway).
But note that different operators and authorities would place different priorities on these aspects of efficiency.

(iii) Ability to meet individual user requirements.

These elements are inter-related and the relationships may well be very complex, but as an example, reduced direct operating costs could result from greater ability to achieve individually optimised flight profiles, achieved in turn through investment in greater capability (both in the air and on the ground).

5 CHARACTERISTICS OF PRESENT DAY ATM

Present day control of aircraft is not seen as being 'optimal' in the widest sense of efficiency. Without proper measures this lack of efficiency will increase in the future because of predicted growth in air traffic. In particular:

(i) The information flow within and between ATC organisations and the aircraft under their control is insufficient to support improvements.
(ii) ATC needs more sophisticated algorithms for prediction and optimisation.
(iii) Despite long term planning, ATC often relies on tactical intervention to resolve conflicts. Hence only limited accommodation of strategically optimised flight profiles is achieved.
(iv) The capability of airborne equipment in the fields of planning and optimisation has outstripped that of the ground system to support it. Operators are pressing to be able to more fully exploit such capabilities.
(v) Route structures are inflexible, based as they are on the location of navigation aids. Increasingly direct routings are allowed in quiet conditions.

6 BROAD DIRECTION OF CHANGE

(i) Improved handling and transfer of information between operators, aircraft and ATC centres.
(ii) Provision of facilities on the ground to assist in prediction, optimisation and monitoring, together with effective man-machine communication.
(iii) Resolution of conflicts more strategically, over longer time horizons.
(iv) Improved en-route capacity through exploitation of more accurate three-dimensional (3-D) navigation, and use of longitudinal (ie time) navigation and control to increase capacity of junctions and terminal areas.
(v) Improved accommodation of a flight's preferred profile in all phases of flight, based on company objectives.

7 CONSIDERATIONS AND CONDITIONS ON CHANGE

These guidelines for change should be observed:

(i) Must maintain safety at least equal to present levels.
(ii) Change must be evolutionary - ie take place in small, well defined steps, even into the distant future. In the early stages of change, this will imply compatibility with existing systems.
(iii) The system must be capable of working with a wide variation of traffic densities, aircraft types, avionic sophistication etc. There should be no discontinuous changes in procedures to cope with peak levels of demand.
(iv) The system must continue to operate following random disturbances, eg emergencies, errors in forecasting.
(v) Pilots and Air Traffic Controllers must be kept 'in the loop' to effectively manage and monitor the ATM process.
(vi) Penalties on specific aircraft types or operators should not be unreasonable.

8 SOME SIGNIFICANT DEVELOPMENTS

A number of new capabilities and systems are evolving, and will undoubtedly form components of ATM in the future. Examples include:

(i) Improved ATC algorithms to aid sequencing, conflict prediction and resolution.
(ii) FMS algorithms to provide multiple constraint four-dimensional (4-D) navigation, which are fuel and cost efficient.
(iii) Developments in man-machine communication, such as displays and novel interaction devices.
(iv) Improved communication/navigation/surveillance systems (eg mode S SSR, MLS).

(v) Developments in satellite technology, potentially providing universal communication/navigation capabilities.

9 ELEMENTS OF A FUTURE SCENARIO

(i) Improved navigation by suitably equipped aircraft, to increase capacity and availability of optimum flight levels.

(ii) Ground based, real time, database to provide short-term high accuracy forecasts of meteorological conditions (notably wind speed and direction, air temperature, icing index) in three dimensions, within the geographical areas of interest. Such a database would be updated by aircraft observations.

(iii) Earliest possible dialogue between aircraft and ATC to establish a flight's preferred four-dimensional profile, for forecast meteorological conditions etc. It is likely that such technology will be applied first to the approach task, then the departure problem and finally in the very long term, to achieve ramp to ramp clearance.

(iv) ATC performs 'collective optimisation' to resolve conflicts between individual preferred profiles. This would required information to be given to ATC on the cost sensitivities of an aircraft's profile. The rules for such 'collective optimisation' would require careful design.

(v) ATC clearances take the form of a rigorously defined four-dimensional tube in space. The dimensions of the tube must be established with respect to:

(a) Traffic density - in heavy traffic, more compact tubes would be required to eliminate conflicts. In lighter traffic larger tubes would give more freedom to cost-effectively absorb errors, eg in meteorological forecasts.

(b) The aircraft equipment fit - a poorly equipped aircraft would not have the capability to navigate within a narrow tube. This implies that poorly equipped aircraft limit system capacity-incentives should be built in to encourage upgrading of avionic equipment.

(vi) Well equipped aircraft would be capable of complying with the clearance unaided. Poorly equipped aircraft might require assistance, particularly in terminal areas where the constraints would be more stringent.
(vii) Communication between aircraft and ATC to update air/ground databases, alter optimisation objectives or revise ATC clearances. Three distinct levels of communication are apparent:

(a) Background level - automatic exchange of information between air and ground computers, without direct human intervention, eg meteorological data, aircraft data to aid ground tracking etc.

(b) Strategic level - human initiated exchange of relevant strategic information eg ATC planning, ATC strategic clearances.

(c) Tactical level - exchange of information requiring short term response, or where party channel is essential to enhance situation awareness of other aircraft, eg ATC tactical instructions.

Data link offers the most appropriate mechanism for background and strategic communication. For some time voice R/T would be likely to remain the primary channel for all tactical transactions, but later on it could not be excluded that data link would become the primary channel; voice R/T could also serve as a redundant back up for strategic data link exchanges.

10 SUGGESTIONS FOR FURTHER STUDY

(i) A collaborative demonstration of principle would required more specific description of a number of aspects of the scenario than has occurred so far. In particular:

(a) Broad description of FMS and ATC functions to participate in this scenario.

(b) Minimum set of parameters to describe aircraft's cost sensitivities for collective optimisation.

(c) 'Rules' for collective optimisation.

A major force towards change in the ATM system must be the end users, responding to demonstrable cost benefits. An important goal must therefore be the study of cost-benefit implications of the proposed methodology. Such analysis needs to be applied in the context of the total concept to produce meaningful results, although this should include cost sensitivities of more specific components, eg provision of improved meteorological forecasts. However, this is a complex issue, and is possibly outside the scope of this Group.
ORGANISATIONS ACTIVE IN THE DEVELOPING ATM SCENE

(i) ICAO
   - FANS Committee.
   - SICASP.

(ii) Eurocontrol
    - ATC Systems Concept Group.
      Data Link Working Group.
      Navigation and Separation Panel.

(iii) Euro CAE
     - MNPS Group.

(iv) ARINC
    - Developing future airborne system architectures.

(v) NASA/FAA
    - Working on a wide spectrum of air and ground capabilities
      eg National Airspace Plan, ATOPS program.

(vi) RTCA SC 155
     - Developing the future CNS.
Appendix

MEMBERSHIP OF GAREUR ACTION GROUP FM AG03

P. England (Chairman), RAE (Bedford) United Kingdom
P. Humphrey (invited member), RSRE United Kingdom
J. Thomas, DFVLR, Federal Republic of Germany
T. Hagenberg, NLR Netherlands
T. Dalm, NLR Netherlands
1. DRIC Reference (to be added by DRIC)  
RAE TM FS(B) 666

2. Originator's Reference

3. Agency Reference
N/A

4. Report Security Classification/Marking
UNCLASSIFIED

5. DRIC Code for Originator
7672000R

6. Originator (Corporate Author) Name and Location
Royal Aircraft Establishment, Bedford, Beds, UK

5a. Sponsoring Agency's Code
N/A

6a. Sponsoring Agency (Contract Authority) Name and Location
N/A

7. Title
Integration of flight management and air traffic management systems

7a. (For Translations) Title in Foreign Language

7b. (For Conference Papers) Title, Place and Date of Conference

8. Author 1. Surname, Initials

9a. Author 2

9b. Authors 3, 4 ....

10. Date
March 1987

Pages
27

11. Contract Number

12. Period

13. Project

14. Other Reference Nos.

15. Distribution statement
(a) Controlled by — Head, Flight Systems (Bedford)
(b) Special limitations (if any) —

If it is intended that a copy of this document shall be released overseas refer to RAE Leaflet No.3 to Supplement 6 of MOD Manual 4.

16. Descriptors (Keywords) (Descriptors marked * are selected from TEST)

Air traffic management. Flight management. Air traffic control.

17. Abstract
This Memorandum is the Interim Report of GARTEUR Action Group FM AG03. This group considers the Integration of Flight Management and Air Traffic Management systems. The Report introduces the Group's task, the relevant research programmes in NLR (Netherlands), DFVLR (West Germany) and RAE/RSRE (UK). It identifies the need for an ATM Scenario and the areas needing further research. The Report is concluded by a description of the proposed programme for the Group's second year's work. The ATM Scenario document provided earlier by the Group has been included as an Appendix for reference.