Information Paper

AN OUTLINE ABOUT THE "MEDITERRANEAN FREE FLIGHT" PROGRAMME

Luigi Iodice, Giancarlo Ferrara, Teresa Di Lallo
Ente Nazionale di Assistenza al Volo
Ufficio Innovazione Tecnologica
Rome, ITALY
liodice.enav@interbusiness.it
gcferr@tin.it

1 ABSTRACT

In summer 1999, ENAV (the Italian Agency for Air Navigation Services) began the preparation of the "Mediterranean Free Flight" programme concerning flight operational trials on free routing and free flight in the Mediterranean area, starting from already mature or maturing CNS/ATM technology, and building the appropriate operational procedures for pilots and controllers.

Several European ATM Organisations, including AENA/Spain, DNA/France, EUROCONTROL, HCAA/Greece, LFV -SCAA/Sweden, MIA/Malta, NATS/U.K. are partners in the MFF programme that is led by ENAV.

The programme is aimed to address operational requirements to improve the capacity and the ATM system efficiency through the definition of free flight applications in the Mediterranean area, and to evaluate the operational impact of free flight in the future Air Traffic Management system. The goal is to define and validate the operational and technological framework, which leads to an effective implementation of new operational procedures rising from the newest ATM operational concepts and maintaining flight safety and increasing economic efficiency.

In order to achieve these overall objectives, a complete, technical and operational, evaluation of integration, interoperability and safe use of new CNS/ATM technologies and applications suitable for the future Mediterranean ATM scenario will be performed. It Appropriate new operational procedures for ATM staff and flight-crew will be investigated in free routing and free flight scenarios.

En-route airspace ranging from low to medium air traffic density is the ideal operational location for MFF flight trials. Real time simulation will be carried out and flight trials will be executed.

Further, technological, operational aspects, economic and safety issues related to free flight concept applications will be assessed and during the development of the programme, ranging over about five years, business and safety case analysis will be conducted.

The analysis of the data obtained during the simulations and airborne tests will provide indications to verify and validate:

- how to apply flexible airspace management;
- operational procedures for transferring separation responsibilities from ATC to pilots and vice versa;
- air safety implications;
- improvements in flight efficiency;
- HF issues and training for controllers and pilots in a free flight environment.

The results will be presented at international level together with possible guidelines and recommendations for the implementation of free flight in the Mediterranean area and in other areas with similar characteristics in order to address standardisation and for the further maturation of relevant CNS/ATM technologies and applications.

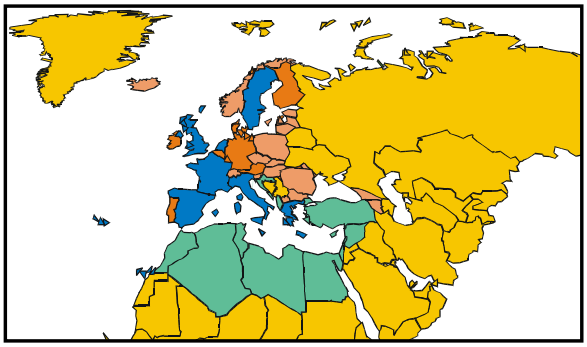
2 INTRODUCTION

The future ATM system will have to maintain or improve safety standards, increase system capacity and fully utilise capacity resources. The latter will include better accommodation of users requested flight trajectories, avionics capabilities and increased users involvement in decision making.

The geographic location of the Mediterranean Area between the European Core Area and the States of North Africa and the Near East is a critical factor

regarding future air navigation services provision in Mediterranean Coastal States. The Core Area already has a high-density of air traffic and the other areas have low/very low density and poor technological infrastructures.

Table 1 Mediterranean Area



However, this boundary situation along with Mediterranean peculiarity of low air traffic complexity scenario is an attractive motivation to initiate studies and validation trials concerning the latest CNS technologies and the most recent operational concepts identified in the Eurocontrol OCD and ECAC "ATM 2000+ Strategy" to accomplish EATMS.

The Mediterranean Free Flight programme will avoid duplications by using as input the available results of efforts from other European programmes/projects relevant for free flight operational concepts (e.g.: FREER, FARAWAY, NUP, etc.). MFF will also use the results of other relevant programmes/projects when they will be available (e.g. MAAFAS, etc).

Moreover, in the framework of the CARE programme (Co-operative Actions of R&D in Eurocontrol), ENAV has already started a co-operation with Eurocontrol to establish a sharing of efforts in the ASAS Action. While the Mediterranean Free Flight programme will be devoted to explore airborne separation assurance concepts and applications in En route airspace and in Low Density and Transition Area, the CARE ASAS Action would be devoted to Core Area and Terminal Area.

The eight member States of the Eurocontrol Agency affecting the Maastricht UAC have also launched a programme that is aimed to introduce free routing across their own airspace by 2003.

3 "MEDITERRANEAN FREE FLIGHT"

Specific simulations and/or demonstrations have already been conducted in Europe and in the United States to investigate the feasibility of free routing and free flight operations, however the Mediterranean Free Flight Programme comes from the lack of an integral investigation into the joint operations of CNS/ATM systems in Mediterranean airspace, both in a simulated environment and in an almost realistic one.

Mediterranean Free Flight is an operational programme mainly addressed to execute operational tests in Free Routing and Free Flight environments. Taking into account that some ATM R&D programmes connected to free routing and free flight are already completed, or under way, available results will be extensively used.

MFF leading objectives are:

- To provide technical and operational evaluation of integration, interoperability and safe use of mature CNS/ATM technologies and applications suitable for the future Mediterranean ATM scenario (e.g. enabling the introduction of free flight operations in Mediterranean area);
- To define and verify appropriate new operational procedures for ATM staff and flight-crew in free routing and free flight scenarios (e.g. the delegation of separation responsibility from ATC to aircraft and vice versa, through simulations and flight trials using a flexible, adaptable and scalable simulation environment integrated with specially equipped cockpit simulators and experimental aircraft);
- To take advantage of the inherent results to address standardisation and further maturation of relevant CNS/ATM technologies and applications both in ground systems and avionics;
- To define guidelines to implement free flight operations in suitable parts of the airspace.

The Mediterranean Free Flight programme will last about 5 years and is subdivided into two main phases.

Beginning with a survey of users' expectations and present air traffic constrains, the first phase is mainly addressed to define the reference ATM system architecture, the free routing and free flight scenario, the operational procedures, the avionics and the preliminary related safety issues also through an extensive use of both model based and real time simulations. The second phase is mainly addressed to test and verify the overall operational procedures, for both pilots and controllers, through an extensive flight trials programme; to perform a large scale validation programme and to develop a methodology for the Free Flight operations safety assessment. The gradually available Phase I results will steer the detailed definition of the Phase II activities.

3.1 Working Areas

The MFF contains seven main Working Areas:

✈ **MFF Operational requirements and procedures**

Free routing and free flight operational concepts, as defined in the Eurocontrol OCD (Operational Concept Document), will be studied in detail for those aspects that are typical to the Mediterranean Area. Operational requirements will be drawn up based on the new concepts of airspace regimes

(Managed AirSpace, Free Flight AirSpace, UnManaged AirSpace). The relevant CNS technologies that could enable free routing/flight operations will be defined taking into account the reference documentation available (e.g. Operational Concept Document by Eurocontrol, "RTCA Select Committee for implementation of free flight", etc,) and results presented and discussed at international level (e.g. Free Flight Phase One by the FAA, in the United States; FREER, CARE /ASAS and others by Eurocontrol, in Europe).

Flexibility of air space regime, co-operation in the decision-making process between airlines and ATM service providers, smooth transition from Free Flight Airspace (FFAS) to Managed Airspace (MAS) for aircraft to avoid unsustainable workload for ATC staff and to prevent unsafe operations, conditions for responsibility delegation, achievable separation minima in autonomous separation, resumption of separation responsibility by ATC, and so on, will be considered in order to set out proper operational procedures and phraseology for pilots and controllers.

Taking into account aspects regarding Air Space Management, CDM, ASAS, limited transfer of separation responsibility and HMI, the following procedures will be defined:

- Free Routing operational procedures (e.g. negotiation procedures between the ATM and the aircraft for the use of free routes, collaborative decision making applications, etc.);
- Free Flight operational procedures (e.g. delegation of responsibilities from controllers to pilots within the Free Flight AirSpace (FFAS) coming from Managed AirSpace (MAS) and vice versa, with special concern to the transition from Free Flight into Managed AirSpace, etc.).

✈ **Technological framework and Operational scenarios**

This stage is aimed to identify both CNS components and the most promising ATM applications and functions, that are adequate to introduce free routing and free flight in the Mediterranean airspace

For the assessment and identification of present technologies and operational applications that could be maintained in the FFAS, CNS technologies with their potential growth will be analysed. Particular care will be taken to the decommissioning forecast for some of the present technologies.

For the implementation of free flight operations in the Mediterranean area the following innovative CNS technologies and applications will be investigated:

- Satellite Navigation (GNSS-EGNOS).
- Air/Ground and Air/Air Data-Links: effective performance in the Mediterranean operational environment of VDL-2, VDL-4, Mode-S Extended Squitter DL and satellite DL.
- Automatic Dependent Surveillance: completion of ADS-B trials already in progress; utilisation of ADS-B in Air/Air surveillance (Airborne Separation Assurance System); effective performances of satellite data-link for ADS-A applications.
- Aeronautical Telecommunication Network: integration of ATSUs and various sub-networks in a unique communication infrastructure (ATN).
- Ground ATM applications and functions: Collaborative Decision-Making (CDM); Safety Nets (SNET); Medium Term Conflict Detection (MTCD); Trajectory Prediction (TP), etc.
- Air ATM applications and functions related to: Airborne Collision Avoidance System (ACAS); Cockpit Display of Traffic Information (CDTI); ASAS (Airborne Separation Assurance System).
- Functions for operational A/G communications via data-link: Controller Pilot Data Link Communications (CPDLC).

This work will support the definition of a set of feasible technological and operational scenarios.

The next step of activities will be the definition of architecture and specification of the ATM system to be deployed in the Mediterranean area. The ATM system specifications for the ATM Ground segment, the ATM Airborne segment and the Datalink communication segment will be defined. The system specifications will be particularly careful to satisfy the requirements of traffic management in transition areas between FFAS and MAS with reference to airspace boundaries and the possible modification of standard avionics by adding boxes instead of modifying the present boxes. Moreover, the Avionics system specifications should contain characteristics and performances for airborne self-separation management.

At this stage, the feasibility of technological and operational scenarios will be verified through ad-hoc model based simulations. Mathematical models will be expressly accomplished in order to perform the free routing and free flight operations. The modelling simulation will be developed based on the experience of other work already done by the MFF Partners.

This modelling simulation activity will continue in parallel with real-time simulation trials and flight trials in an iterative analysis of test results and refinement of MFF concepts and procedures.

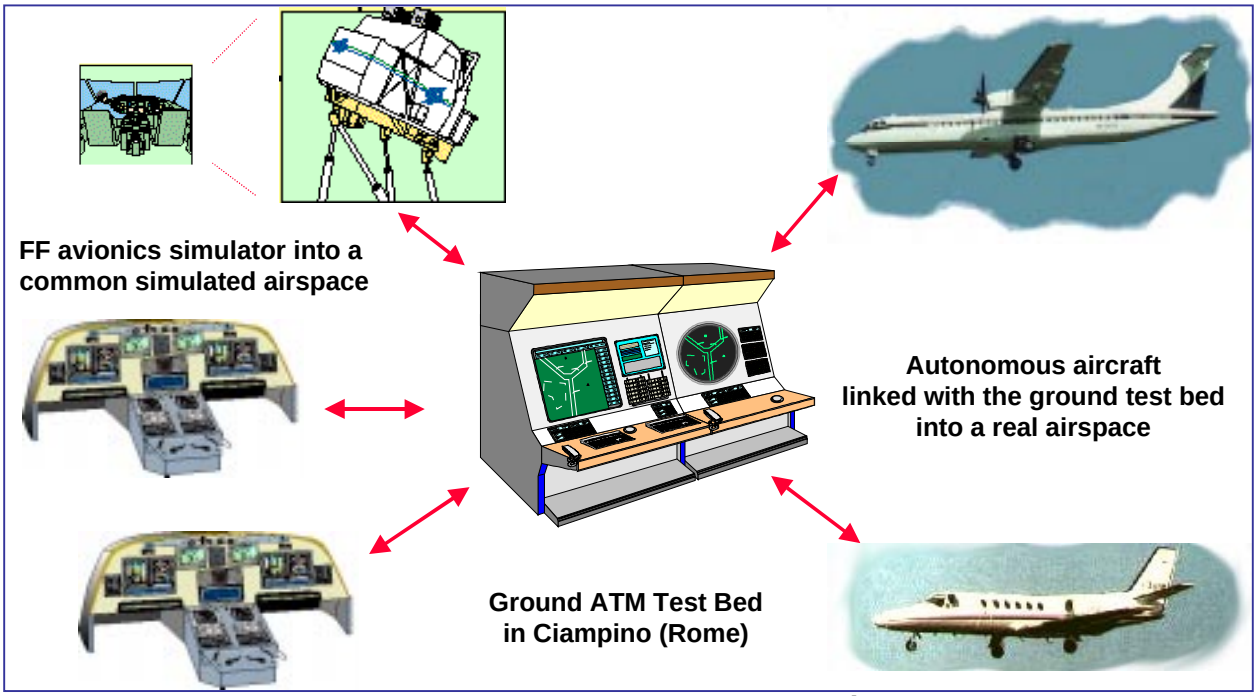
The achievable capacity increase rising from operational scenarios considered will also be investigated.

✈ Simulation Trials

An integrated simulation environment will be realised to address the full-scale simulation of Mediterranean Free Flight operational concepts. This experimental platform, called *Mediterranean Free Flight Simulator (MFF-S)*, will be able to test the MFF procedures/scenarios through the interaction among simulated ground and airborne systems, which will be operated by controllers and pilots.

MFF-S will be located in Roma ACC (Ciampino) and will include:

Table 2 MFF Test Bed Architecture



⇨ the *Ground ATM Test-Bed (GATM-TB)*: an experimental platform capable to test Free Routing and Free Flight operations for the ground segment; the GATM-TB includes an experimental simulation platform with both air traffic and environment generators to model the scenario behaviour, to configure start-up and to lead the simulation sessions. The GATM-TB will be designed to operate either in simulation mode or in "shadow mode" through appropriate integration with the operational data processing system. In this mode of operation, the GATM-TB will also be used in flight trials.

⇨ the *"Autonomous Aircraft" Cockpit Simulator (AA/C-S)*: a cockpit test platform for the airborne segment. The *AA/C-S* will simulate a realistic environment for aircrew (flight deck) and will be equipped with avionics capable of handling navigation, communications, ADS surveillance-data functions, ASAS/CDTI functions, piloting devices and whatever else will be identified for free flight operations. This platform will be used to shape "autonomous aircraft" functionality (i.e. mainly ASAS capabilities) and to test free flight conditions and operations. It will be exercised by commercial pilots in cooperation with airlines.

The extensive simulation trials programme will be conducted by using the GATM-TB connected to a few "Autonomous Aircraft" Simulators:

- the AA/C-S, located in ENAV MFF Simulation Centre,
- the Research Flight Simulator (RFS), located in Amsterdam,
- the TUB/ZFB A340, located in Berlin.

The real time simulations will allow:

- to test and to refine the free flight new operational procedures in a semi-realistic, repeatable and pre-operational conditions;
- to evaluate the adequacy and the efficiency of the capabilities provided by the new functions on board;
- to evaluate human factors issues and workload of both controllers and pilots;

- to test the adequacy of the contingency procedure during the simulation of degraded situations.
- to collect the essential data to address the MFF flight trials activities with aircraft, which will be fitted with specifically designed avionics.
- Multinational air traffic controllers and pilots will participate in simulation trials; they will familiarise with the new operational Free Flight concepts and will test Free Flight operational procedures and systems.

✈ **Flight Trials**

This is the most significant stage of the programme that will test and verify the most promising operational procedures/applications identified, for both pilots and controllers, supported by the identified technological solutions, in order to validate the simulation results.

The free routing and free flight operations, with special regard to the delegation of separation responsibility from ATC to aircraft and the related enabling technologies, will be tested in a pre-operational framework. The full scale MFF trials environment could be thought to be composed of two main segments, Air and Ground.

Depending on the type of flight trials session (specific experimental objective of each flight mission related to selected objectives), *the Mediterranean Free Flight Simulator* will be properly set up.

For the Air segment, a proper avionics configuration for "autonomous aircraft operations" will have to be designed, taking into account the simulation trials results and, if available, results from other relevant international projects. The avionics will need to have suitable functionality (e.g. ADS-B, TIS-B, ASAS capability, CDTI, Communication Management unit; Datalink for ATM Operational Communication; SATCOM facility etc.).

Experimental aircraft, i.e. *Autonomous Aircraft (AA/C)*, will be fitted with these avionics and other aircraft (e.g. Faraway/ADS MEDUP A/C, and/or other equipped airlines/military A/C that could be available) will be equipped at least with ADS-B/TIS-B functionality for passive interaction with both the previous ones and with the GATM-TB. Specific documentation will be prepared to obtain at least the necessary no hazard certification.

The flight trials will be arranged in steps:

- Step 1: A Citation A/C laboratory, already available, will be used, to test and tune some procedures, which will be identified and which will not need all the forecast airborne FF functionality later available.
- Step 2: One aircraft (ENAV's Experimental A/C) will be fully equipped for the "autonomous aircraft operations", the other air traffic, flying with FF roles, will be constituted by AA/C-Ss.
- Step 3: A more extensive series of trials: at least two AA/C fully equipped with the necessary avionics, together with some other aircraft, equipped with suitable avionics to allow at least passive interaction will be used. This test-bed solution arrangement could be useful to verify the capability of self-separation in a mixed environment with no fully free flight equipped A/C.
- Step 4: A stage to refine the results of the foregoing steps.

The information collected from the flight trials will be compared against the simulation trials data to refine ground ATM applications and functions, operational procedures and airspace organisation.

The situational awareness and performance of both controllers and pilots are critical points. A deep Human Factors analysis, during flight trials, will therefore be carried out.

✈ **Validation**

Improvements in safety, capacity, and efficiency are forces that are driving a transition from today's ATM system to a more flexible and economically beneficial future aviation system. The concept(s) of Free Flight is intended to provide increased flexibility and efficiency. To ensure that the desired efficiency improvements can be achieved, the relevant operational concept(s), requirements and procedures must be validated and the technologies that will be used must be accurately assessed against a pre-defined level of functionality, operability. Commercial benefits for the aviation community and industry have to be investigated and it must be ensured that the systems and procedures implemented are certifiable for the intended use.

In this framework, a system or a procedure is considered "valid" and "certifiable" if it provides an operational benefit and meets established users and service provider requirements related to safety, capacity, efficiency, economics, predictability, and flexibility. So, the term validation is considered as the evaluation of concepts, systems and procedures to determine their operational impact on users and service providers.

In MFF, validation will be intended as a continuous and ongoing process covering the entire programme from the concept(s) development, to the flight tests operations.

Standard validation methodologies used in various Institutions related to ATM as well as the results of projects in European and National R&D programs

currently in progress in this field will be taken into account.

The results of the validation process will be reviewed, during the programme, in co-ordination with the user community to determine if changes should be made to the proposed operational concept(s). If they need to be changed, the revised concept(s) would be re-inserted into the validation process.

Afterwards, the MFF programme concept(s) and system components being validated will be put through a verification process of their specific requirements.

During the system definition, the development and the integration activities, the equipment fitness-for-purpose will be demonstrated through validation and verification exercises as well as the procedures.

Finally, systems and procedures will be validated in the context of Simulation Trials and Flight trials.

In summary, the overall validation activities will:

- define criteria for the validation, at Mediterranean area level, of the Free Flight operations;
- determine if the Free Flight concept(s) is operationally feasible and certifiable;
- identify if the concept(s) needs to be modified based on simulation and data analysis;
- provide information for developing Free Flight operational procedures, automation, decision support systems, and training requirements with due consideration of human factors issues. This will ensure that the system will be human-centred and the human factors considerations will be taken into account for developing system requirements;
- provide a foundation for the development and/or modification of the MFF ATM architecture;
- provide information to support the Operational Benefits and the Safety Case development;
- ensure the appropriate simulation capabilities are available to meet the programme goals;
- demonstrate that MFF operational procedures are compliant with the defined requirements.

The MFF validation process will provide the opportunity to assess each relevant FF concept(s) and to determine its impact on operations. Further procedures validation will provide the opportunity to begin the development of the procedures necessary for the implementation of Free Flight concept(s).

✈ Operational Benefits and Safety Case

The operational benefits analysis, the definition of safety requirements and the safety case will be carried out, in order to support future decisions to implement free flight operations in the Mediterranean area.

The MFF foreseen operational benefits compared to the present operational service situation in Mediterranean area will be investigated. The comparison will take into account performance issues among currently used technologies and the new CNS/ATM key technologies for free flight.

Air safety implications will be analysed with the contribution of both controllers and pilots.

Safety studies will be initiated at same time as the MFF operational procedures definition so that safety risks will be identified and dealt with, while the opportunity for their mitigation in the concept(s) definition phase still exists.

The Safety Requirements will be refined by an iterative refinement process based on the experimental results.

The Safety Case will be an explicit study of safety related issues, the corresponding safety objectives, and associated safety risk assessment and risk management of the free flight operations.

This process will be based on an evolving Safety Case as set out below:

- Preliminary issue to set out the safety issues in relation to the initial stages of the operational procedures definition process covering concept(s) and/or feasibility studies. At this point, the safety-measured levels associated with various scenario options can be fully considered and weighted against other MFF/ATM system parameters.
- The intermediate issue is an expansion and refinement of the preliminary Safety Case and establishes the inherent Level of Safety of the MFF system as defined in the simulation trials but prior to flight trials.
- The final issue will take account of flight trials results and form the basis to support the exploitation of MFF results.

After the final Safety Case, any results will be examined against the MFF programme assumptions and objectives.

In other words, the safety case will be an evaluation process:

- the correctness and completeness of the MFF requirements specification in relation to the intended FF operations;
- the development of the MFF operational scenario taking into account the safety;

- the satisfaction of the prescribed Target Level of Safety (TLS) in the system definition, and;
- the adequate specification of equipment and procedures to ensure the required safety performance of the proposed concept(s) throughout its operations.

A specific methodology for the Free Flight operations safety assessment, based on the Safety Case, will be developed. It could be applicable on an international scale so as to promote global harmonisation and provide for a smooth transition from existing operations which have not, until now, had to deal with free flight.

✈ **End Results**

Following the performance of:

- the definition of MFF operational procedures,
- the flight trials analysis,
- the MFF Operational benefits and Safety Case,
- the validation activities results,

a final assessment of programme objectives will be carried out and a final report will be drawn up. The final report will include the description of the different programme phases and the results achieved. It will be presented at international level and might include guidelines and recommendations for the implementation of free flight in other areas with characteristics similar to the tested one.

3.2 Management structure

The Mediterranean Free Flight Programme management structure mainly consists of:

✈ MFF Programme Review Group (Co-ordination level). Partners and representatives from the relevant Organisations of stakeholders and any other technical, operational and scientific concerns, both national and international, associated with the programme (e.g. avionics manufacturers, ATM systems manufacturers, aircraft manufacturers.), etc., will be members of the MFF Review Group

✈ MFF Programme Management Board (Top Management level) with Representatives of each Organisation which is a Partner in MFF.

✈ MFF Project Team (Executive Technical level) with Representatives of each Organisation which is a partner in MFF.

✈ MFF Teams (Working level) with people of the Organisations, which have responsibility for the realisation of specific programme tasks.

4 CONCLUSIONS

Considering the previously stated Programme objectives, the expected positive spin-offs would be the following:

- To provide Europe with new more direct, flexible, non-congested routes towards African and Middle Eastern countries;
- To eliminate the bottlenecks in the air-routes with Europe, by adopting common operational procedures allowed by the CNS/ATM system;
- To improve flight economy through flight operations more linked with airline objectives;
- To support local economies by applying the results of the programme as useful guidance regarding the deployment of new ANS infrastructure/facilities, wherever beneficial or necessary.

The outlined programme will provide a valuable insight for the integration of future avionics capabilities within the ATM system as well as the design and integration of future ATM automation.

The results of studies and validation trials will be released to the international aviation community offering the opportunity to make use of them as appropriate.