IFATS Report Summary

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Final Report Summary - IFATS (Innovative future air transport system)

The IFATS project studied a revolutionary concept for a future air transportation system (ATS) by adding as much onboard automation and autonomy to the aircraft as necessary to fulfill the overall requirements of improved efficiency and safety of air transportation. The two major characteristics have been:

- all the various air and ground components of the system communicate with one another through a network-centric architecture;
- aircraft fly autonomously pre-programmed flight plans using sophisticated onboard computing and sensor systems.

Ground operators are responsible for the overall situation, whereabouts of aircraft and tracking of their intentions.

The central goals of this project were:

- to define a technically viable concept of an air transportation system where aircraft would be operating with a high degree of automation providing autonomy controlled and monitored by ground operators through a network-centric architecture;
- to define autonomous operation procedures and optimise tasks sharing between the operators, the automated ground control system, the autonomous onboard computing systems and to identify any need for an onboard engineer;
- to determine the minimum requirements and functionalities of the onboard system, to ensure safe operation in the case of communication loss with the ground control system;
- to perform a safety analysis of the concept and to provide guidelines to certification issues;
- to identify the difficulties to overcome to build such an air transport system, in both the technical and cultural aspects;
- to find out an adequate level of automation for a future acceptable system;
- to analyse a procedure to migrate from the present situation to this future system.

Considering the IFATS methodology, which was to study a fully automated system in order to derive an acceptable future one, only the technical constraints have been considered. Indeed, cultural constraints (passengers to accept to fly a pilot-free aircraft) and social constraints (pilot and controller jobs not existing any more) bring to much show-stoppers for the IFATS methodology and have no real impact on the high level technical definition of such a system that has been pursued in the project.

The main technical constraints were:

- for the ground segment: to be able to automatically manage the traffic planning, taking into account the airlines wishes as well as the various uncertainties of the flights. The emergency situations have also to be managed, possibly with the man in the loop.
- for the air segment (the aircraft): to be able to fully automate the flight, i.e. the capability of the aircraft to manage all the flight phases and all the pre-planned emergency situations (see this notion later).
- at a more global level, the safety and security of the system has to be ensured whatever the situation could be. This is achieved through secured data links and adequate communication protocols.
Taking into account the identified main constraints, the functional analysis of the IFATS system has been performed. This analysis started by the definition of the function sharing between the air and ground segments.

To summarise, the ground segment is in charge of the system management that includes the four-dimensional (4D) contracts generation (strategic and tactical planning, on ground and airborne). The air segment is in charge of respecting the 4D contract given by the ground segment, of the trajectory monitoring and of new 4D contract requests (if needed). Other capabilities have also to be implemented on board, such as health monitoring functions, emergency situations management; update of the ATS database (especially for the current weather as any aircraft is a sensor of the system).

Based on the previous function sharing definition and on the observation of the current ATS functionalities, the IFATS concept has been defined. This definition started with the identification of the IFATS actors.

The specific IFATS actors were:
- the ‘air transport system management’ (ATSM) which is in charge of the management of the overall system, especially the 4D contracts management (computations for original flight planning and real-time update);
- the ground stations, which are the physical parts of the ground segment in charge of the air traffic monitoring function.

The IFATS concept was based on three ‘key notions’:

1. The 4D contracts: each aircraft is given a contract before its flight and it has the responsibility to respect it all along the flight. If it is not possible for any reason, it has to ask the ATSM for a new 4D contract or, at least, broadcast this information in the vicinity of its current flight zone; this will be detailed later in this report.
2. The 4D contracts are given to the aircraft with some margins (e.g. in order to be able to manage small differences between the predicted weather and the real one).
3. The 4D airspace: the four dimensions of the airspace are considered (x, y, z, t). Conflict-free flight paths are calculated taking into account these four degrees of freedom. The notions of waypoints, ATC sector and airways, which are essential to make a human air traffic control possible, can be abandoned.

The emergency / failure management was, of course, included in the IFATS concept definition. A comprehensive analysis of all the possible cases has been performed in the project. Generally speaking, if a failure for which a recovery strategy has been implemented occurs, this pre-planned recovery strategy is directly applied.

The IFATS concept and its expected capabilities depend on many factors; the weather forecast accuracy is a major one. To help analysing the sensitivity of the IFATS concept to this problem, a conceptual flight simulation has been developed, incorporating actual and predicted weather data and possible flight strategies.

This simulation goal was to set a rational basis for deciding on the IFATS concept implementation. The specific goals were:
- to assess the accuracy of weather forecast;
- to assess the expected flight path / time deviations from a pre-planned trajectory due to differences between the forecast and the actual weather;
- to analyse the effect of the ‘bubble’ size on the number of trajectory re-plans enroute;
- to estimate the effect of airspeed corrections on the above, by applying velocity control in order to decrease deviations in time / position.

The main objective of the simulation has been to obtain statistics of time differences between the pre-planned and the actual aircraft trajectories. To this end, different routes, departure times, and days of the year have been systematically analysed over a part of Europe. To reduce complexity, the flights were performed along the grid, at constant altitude and Mach, covering both north / south and east / west headings.
A quality of service (QoS) policy depending on the priority of the message to be transmitted has been developed. The services that could be needed for an IFATS aircraft are numerous, the most important ones are:

- 4D contract re-planning;
- weather transmission;
- immediate support request;
- maintenance purpose;
- communication with AOC.

Since bandwidth is scarce and will stay scarce in the future, the innovative proposed solution for the IFATS system was to share the bandwidth between different services and to set priorities between them. Obviously, when an IFATS aircraft needs a 4D contract update or an immediate support, the communication priority level must be high whereas weather transmission and maintenance support may have a lower one. In order to design the data link, the simulation tool enables to measure the required bandwidth and latency. The QoS concept, which is quite innovative in such a system, allows to share the bandwidth and to give access to the radio layer to the one that really needs it. Regarding security, each message is secured by a cyclic redundancy check (CRC) and an encryption key in order to avoid corruption of information and intrusion.

Since no pilot is present in an IFATS autonomous aircraft, its health monitoring should be based exclusively on purposely designed devices (hardware) and methodologies (software). Both solutions should contribute to the increase of the autonomous decision-making capabilities of the aircraft.

One should always expect that the introduction of extra autonomy in the pilot-less IFATS aircraft would lead to an even more complex system, which should be monitored even more accurately than by the past. Introducing even more sensors (hardware) for health monitoring purposes seems unavoidable. However, their number must be kept as low as possible, in order to maintain (if not improve) the failure probability rates, following the complexity increase due to the new sensors.

The approach considered in the IFATS project is faithful to the above mentioned principle. The health monitoring scheme of the IFATS aircraft has been designed to rely on available data from existing devices, which are processed via novel advanced algorithms and methodologies to deliver reliable health information about the monitored aircraft subsystems. Hence, the scheme may be used either as a stand-alone application or as a complementary device which cross-checks some existing health monitoring information, thus augmenting the analytical redundancy present onboard.

The IFATS concept is based on the fact that in all the airspace covered by the system, all IFATS aircraft are cooperative: they broadcast their position and speed via data-link. There are not any more conflicts as the ground segment generates conflict free contracts. The non-cooperative aircraft have to fly in specific areas, known by the system.

The new concept of IFATS dictates naturally new air and ground architectures (no pilot onboard, no ATC), innovative technologies (communication, sensors, computation, infrastructure etc.) and new concept of operation. These leads of course to new requirements in safety: more redundancies, higher reliabilities, lower probabilities for failures and finally, new airworthiness and operation rules adjusted to the new concept.

It is important to deal with the societal acceptability as early as possible: indeed, for such a project based on a disruptive approach, the risk of failure due to a rejection of the solution by the affected parties is high. Considering that IFATS - or future projects related to the development of enabling technologies - will propose the best technological answers, this is not yet enough to guarantee the acceptance of the solution by the affected parties.

The qualitative results that have been obtained are promising. With such a system, capacity, efficiency, safety and environmental friendliness are improved. Nevertheless, quantitative assessments need further in-depth investigation whereas the analysis of some issues, such as security, has to be detailed and extended.
At the end of the IFATS project, high level simulations prove that this extremely automated ATS where aircraft would be operating automatically, monitored by an automatic control supervised by ground operators, is a credible option. But further investigation is needed to identify what could be a transition phase between the current ATS and such a disruptive concept.

Related information

<table>
<thead>
<tr>
<th>Result In Brief</th>
<th>From auto-pilot to pilot-less flights</th>
</tr>
</thead>
<tbody>
<tr>
<td>Documents and Publications</td>
<td>Final Report - IFATS (Innovative future air transport system)</td>
</tr>
</tbody>
</table>

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