IFATS

an Innovative Future Air Transport System concept

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Present studies concerning the future Air Transport System (ATS) generally propose generic operational concepts keeping an organisation with two groups of human beings, some airborne, the pilots, and others on the ground, the controllers, trying to manage this complicated system through voice or digital messages partially processed in real time by humans. In the meantime, the analysis of the causes of fatalities in the current ATS shows that, in many circumstances, human errors are dominant. As today's technical progress gives the impression that machine could overrun human decision in critical situations, an inevitable question arises: how far automation has to be integrated in the ATS to keep an acceptable level of safety? This question is difficult to answer without a clear view of what can be brought by automatisms. The methodology proposed by the IFATS project is to answer the question by studying an extreme solution, a revolutionary concept of ATS with the widest possible introduction of automation, both in the aircraft and in the ground control segment. Thus, the main goal of this project is to define a technically viable concept of a highly automated ATS where aircraft would be operating in automatic and autonomous modes, controlled and monitored by ground operators through a network-centric architecture. This approach is intended to find out an adequate level of automation for an acceptable future system and to identify the difficulties to overcome to build such an ATS, in both the technical and cultural aspects. The results expected from the project are a comprehensive view of what could be this extreme system solution and a clear understanding of its benefits and drawbacks. From this assessment, recommendations will be made for future research and development aiming at making possible an evolution of the present ATS towards a future acceptable one able to withstand safely the forecast traffic growth.

Acknowledgment

The IFATS project has been selected during the 1st call of the EUFP 6. It started in July 2004 for a 30 months duration. The overall ATS concept has been defined and several major workpackages will deliver their results during year 2006 (i.e. safety analysis, validation).

The IFATS consortium[3] has set up a users group formed of personalities coming for several organizations[4] involved in the Air Transport System. They are advising, together with the EU project officer in charge of IFATS, the consortium with essential comments and information.

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Introduction

A. General organisation of the current ATS

Presently, when joining two airports, aircraft can fly along any desired flight path within the coverage of ground navigation aids (VOR/DME) or within the limits of the capability of self-contained aids such as inertial navigation system and/or GPS. Nevertheless, as the traffic has to be managed by humans using radars or other localization means, there are still a limited number of waypoints and airways. Those waypoints are crossing points which may generate conflicts between aircraft when their trajectories converge on it at the same time and induce a risk of collision.

At the dawn of civil aviation, pilots resolved conflicts themselves because they always flew in good weather conditions (good visibility) with low speed aircraft in a low density traffic environment. On the other hand, modern jet aircraft do not enable pilots to resolve conflicts because of their high speed and their ability to fly with bad visibility.
Therefore, pilots must either have an onboard mean of getting an adequate situational awareness or be helped by an air traffic controller on the ground who has a global view of the current traffic distribution in the airspace and can give instructions to the pilots to maintain separation. As there are many aircraft simultaneously present in the sky, a single controller is not able to manage all of them. In France for example, airspace is partitioned into different sectors, each of them being assigned to a couple of controllers, these two controllers can control a maximum of 20 A/C in their "sector". Sectoring is currently done in an empirical way by some airspace experts who apply rules they have learned with experience. The sectoring modifications are usually due to traffic evolution over long periods of time and when a sector is regularly overloaded it has to be modified.

The structure of the current Air Traffic Management (ATM) system produces a structuration of the traffic based on the airways network, the sectorization and the traffic assignment (route-slot allocation). This structure of the traffic is much more capacitive than a free-flight system for which aircraft manage their trajectory themselves. Every year, the demand on traffic increases and generates congestion in the en-route sectors and in the terminal areas. In order to reduce such congestion, the airspace has been resectorised into smaller sectors for many years. The size of sectors has now reached a lower limit, being too small for further reduction and therefore such a process is no more valid and congestion in the actual sectors will grow up with the demand.
Consequently, this management of airspace structured to be handled by human beings, through voice messages, backed up by ground system such as STCA (Short Term Conflict Alert) or airborne system such as TCAS (Traffic Collision Avoidance System), may not be possible in the long term as air traffic is constantly increasing.

Considering the pilot role, flying precise trajectories (complying with Reduced Vertical Separation Minimum - RVSM- requirements and Required Navigation Performance– RNP), performing complicated approach and departure flight paths (to lower ground noise exposure and to take care of wake turbulence), landing and taking off in all weather conditions may become out of reach of even well trained and skilful human pilots.

In the meantime, the present and future development of reliable computers, powerful processing technologies and efficient data links gives the potential for a considerable evolution of automated safe air traffic control systems directly managing highly capable on-board flight management system (FMS) and auto-pilots. Moreover, the development of new techniques, like the Automatic Dependent Surveillance Broadcast system which enables aircraft to communicate to each other, offers a new way to safely manage the traffic and fly aircraft.

B. Automation level of the current ATS

1. Aircraft
On modern aircraft of the Airbus class, the initial take-off acceleration on the runway, the rotation and the initial climb (beginning 5 seconds after the undercarriage has left the ground) are not automated. All the following phases, up to the landing including braking, can be considered as automatic. During the “en route” phase of the flight, the transfer of some of the parameters of flight stored in the FMS is simply activated by the pilot. Nevertheless, some

actions are still not included in the flight management software, for example, spoiler extension and undercarriage lowering.
On the other hand, the movements on the ground (from the departure gate up to lining up on the runway and from the runway exit to the arrival gate) are not automated although the safety objectives require a drastic reduction of runway incursion and imply the centralized management of *all the vehicles* on airport platform. Several projects are considering A-SMGCS (Advanced – Surface Movements Guidance and Control Systems) which is an essential phase towards the situational awareness of both pilots and controllers but still with humans in the piloting and control loop [ref 1].

2. Air traffic management
The management of the air traffic is, currently, not automated, even partially [ref2]. Electronic helps exist, for example, safety nets which indicate the risks of conflicts between planes (separations lower than the standards) or aircraft spacing systems in the vicinity of the airport. It is the controller who makes the decisions. There are, however, automatic systems of information or alert announcing a risk, the gravity of which is estimated by the system (T-CAS or ACAS and GPWS). It can result an ambiguity which could drive to accidents: the system is human centered and consequently, our assumption is that the automatism may be able to find out a solution to a conflict far faster than a man…

Innovative Future ATS concept

A. Rationale

As a general context of the Air Transport System, several scenarios for the future possible evolutions of the ATS are considered in the ACARE SRA2 [ref 3]. Whatever will the reality be the requirements on safety are a challenge that automation could take up, as we will see later on.

Nowadays, on modern jet transport aircraft and thanks to the new technologies equipments, there is already a complete dissociation between the cockpit and the real world: there are little need for "air sense" and no need for visual navigation!
Is it worth having regrets for that? Indeed, a lot of airframes crashed because of human trusting their senses or illusions instead of having real situation awareness through aircraft sensors and instruments. Among these cases are too violent reactions made by pilots under stress without having made any proper analysis of the real situation, or having made an improper analysis due to an inappropriate training. Other typical cases are Controlled Flight Into Terrain (CFIT) in approach area due to a rather poor understanding of ground shapes and situation in space. This drove to the introduction of automatisms, quite robust to stress phenomena and not sensible to mirages, to secure the flights.

A few years ago, the introduction of an automated limitation of the load factor on the A 320 started a passionate debate among pilots willing to keep the choice of breaking the aircraft avoiding an obstacle or crash the plane on it. An exhaustive study made at that time showed that all recorded manoeuvres where load factor limits were exceeded were at least useless and even dangerous.
In order to solve the pilots' loss of traditional points of reference and face the rapid evolution of the aircraft system, lots of efforts have been made and lots of money spent to keep the "man in the loop". But one must not lose reality: automatisms have been designed to perform most of the functions needed to get a safe flight!
When the Enhanced Ground Proximity Warning System (EGPWS) generates, on the cockpit screen, shapes and colours supposed to represent a terrain which is not visible to a naked-eye, but understandable to a human having the faculty to interpret shapes, the automatism tries to explain to the pilot a reality that it fully perceives. It would be far easier in that case to leave the untalented but vigilant and disciplined autopilot deal with the problem and avoid a controlled flight into terrain than trying to explain the situation to the human pilot!
The TCAS is a second example: recent events (e.g. Zurich accident) show that, sometimes, pilot judgement may not be cleverer than that of the automatism…

Air transport, as all products, is subject to market conditions: it has to be continuously improved and adapted to the economical and cultural environments. And then, all errors, mistakes, unexpected behaviour must be patiently corrected without any hesitation and delay as soon they are identified.
It is always possible, and generally rather fast, to modify an automatism.
It is far more difficult, and always very slow, to act on human behaviour because of this complexity which makes its value.

When an accident, or an incident, is due to a breakdown, to a bad design, the equipment can be replaced by a new corrected version or a reinforcement of a structure can be done.
When it is due to the deficiency of an automatism facing an unexpected event, the software can be modified accordingly, for ever, for this particular event.
Both of these two measures can be done planet wide, to all concerned equipments or automatisms, at a pace corresponding to the seriousness of the encountered problem. In case of high risk, planes can even be grounded until an adequate solution is found.

But when it is the consequence of a human error due to inattention, indiscipline, tiredness, inadequate training, it is only through a long selection and training process in the frame of a close supervision that one can hope to improve the situation. Moreover, this process has to be culturally and socially accepted with the risk that the correction is not stable in time. Solutions often consist of setting new procedures to limit human deviation risks.
But an adverse aspect of the strict procedures setting appears, it stifles the main man quality: its initiative capability. If man slowly becomes a robot who has to copy the automatism behaviour, he does not offer any longer the expected reasoning dissimilarity.

Of course, experience feedback shows that automatisms may fail. Pilots have already detected automatism deficiencies when those equipments were still primitive and not correctly monitored. These occurrences are now infrequent as engineers make progress and experimentation process is enhanced. However, even man can fool about a parameter without noticing the resulting silly and dangerous situation represented by the current true value of this parameter!

An example of the comparison of automatism and human evolutions situation can be given with the landing operation. Despite many efforts, information improvements, better help given to crews, the manual landing, the kiss landing, stays high in the incident, even accident causes list. In the mean time, CATIII automatic landing, together with the automatic braking system, is now the best way to safely land an aircraft on an adequately equipped airport.

What could be the best solution, if any?
Finding out an answer to this question is the IFATS project objective.
Considering a completely new system, with the internationalisation of the control, using reliable communication and navigation systems, having human beings in ground stations where they can use best their reasoning capabilities in an adapted environment may not be so straying into fantasy…

Figure 1 : Illustration of the IFATS concept

B. IFATS approach description

A lot of studies and projects are currently already dealing with improving capacity, safety and security of the Air Transport System. But they are all considering that a pilot would remain on board the aircraft and a controller on the ground, both exchanging information by data links. One of the anticipated solutions to deal with the increasing traffic can be, as an example, the delegation of controller responsibility to the pilots to ensure that aircraft separation is maintained (ASAS concept).

The IFATS project considers an innovative future ATS (IFATS) beyond those mid term concepts.

Sharply speaking the basic hypothesis of IFATS is twofold:

- the ATM sector organisation is removed to satisfy the future demand of traffic,
- the human being is removed from the real time decision loop with the objective to increase the safety level in the air transport system: man is good at taking decisions with a limited number of parameters while most of the emergency cases in the ATS operations can only be understood through the processing and the interpretation of a large number of parameters.

Concerning the first of these two assumptions, the sector constraint is removed in IFATS by producing an organised transport system based on planned flight plans managed through a network centric architecture system. The IFATS ground segment of the overall system is in charge of that task and it is constantly linked to all aircraft in flight by secured data links.

Concerning the second issue, the potential structure of the investigated future air transport is widely based on an automation of the tasks of piloting aircraft and managing air traffic to a point where pilot and controller tasks would no longer be separated : they are performed together on the ground, with much less workload on ground personnel.

C. IFATS concept description

1. Flight plans generation

Let's imagine what could be the planning and the management of the air traffic in the IFATS environment.

The planning phase is initiated, during a given period of time and at a planetary scale. The airlines express their wills in terms of flights, i.e. destinations, number of flights, dates, schedules, etc… When all the demands have been received by a centralized Air Traffic Management international structure, a computation of these data gives an overall set of flight plans which leads to a fully conflict free traffic aiming at maximizing the satisfaction of airlines demands.
If this organisation is not accepted, other(s) scenario(s) are elaborated until a compromise is found.
At this level, the organisation may be compared to the current CFMU (Central Flow Management Unit) of Eurocontrol, the main difference is that we are talking about actual flight planning rather than flow regulation as today.
At the end of this phase, the planned air traffic is conflict free in the nominal case (considering, for example that all events are variable having a Gaussian probabilistic distribution and lying within two standard deviations). Consequently, the air traffic is organized well in advance, several months, for example, this is the "strategic" part of the ATM, it is called "strategic planning" in the IFATS concept.

2. Departure
As in today's airport, aircraft is connected to the passenger boarding bridge, being refuelled, and loaded with luggage and food (these actions do not require to be automated).
In the meantime, passengers are boarding.
Then, when the aircraft is ready, the cabin crew gives a "ready for departure" signal to the ATM as close in time as possible to the planned slot. If the flight slot is available and in coordination with all current departures, the aircraft is towed to the holding point by an automatic robot or taxies autonomously with electric engines fitted on its landing gears. Then, the engines are started when necessary during the taxiing phase. Finally, the aircraft lines up on the runway and takes off.
As all take offs are precisely sequenced according to the various sizes and weights of aircraft and as the local meteorological conditions are known, the take off sequence is optimised. Thus, the long waiting queues on the taxiways are suppressed.
In the overall sequence, if an aircraft is not ready to take its slot due to any problem (late passenger, luggage loss…), the slot is given to another ready aircraft. The crew of the aircraft or the airline staff asks for a new slot to the system with the new desired departure time.
The changes made to the initial strategic planning allow the definition of a new planning called the tactical planning. This planning will be adapted real time to the evolution of the situation as described hereafter.

3. En route and arrival phases
The concept that has been selected for managing the en route and arrival traffic is based on aircraft flying 4 D trajectories: the 3 dimensions of space and the time as a fourth one (3D+T concept).
Some definitions have to be given to understand clearly how the innovative future air transport system works:

- *Concept*: a generic idea of managing the aircraft trajectories (the word 'concept' is used in its common meaning);
- *Contract*: a mutual agreement between the aircraft and the ground (the word 'contract' is used in its common meaning);
- *Command:* the way the aircraft is managed to fly the contract.

A similar idea of 4D contract is proposed in some current projects like C-ATM [ref 4]
The guiding principle of the 3D+T concept is to know where the aircraft are to avoid a collision risk, i.e. there are two aircraft at the same place at the same time. This concept is also considered in other projects mentioning tubes in the airspace (a reserved conflict free area like in TALC concept - Tube Advanced Lane Control: [ref 5]).
The trajectories that have been generated at the strategic level are updated just before the flight with accurate weather knowledge. These 3D+T trajectories are "contracts" given to the aircraft.
These contracts are generated by the ground segment, according to the strategic planning, the aircraft capabilities, the airlines desires, the global traffic and the latest meteorological conditions and forecast. This is the tactical planning.
During the flight, the aircraft has to follow the "contract" given before the flight. So, it has to be at the right place, at the right time. Nevertheless, this contract is given with reasonable margins, allowing ground speed variations to follow the optimal Mach number or react to unforeseen events. In the facts, the position of the aircraft is not a point, but a volume in which the aircraft can "freely" fly. This volume is called the "freedom bubble" and is illustrated hereafter

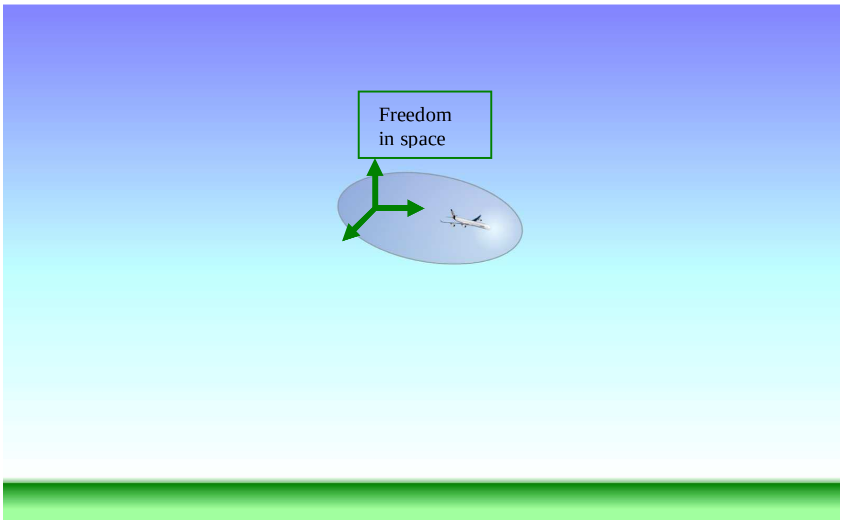

Figure 2: Freedom bubble

According to separation standards, the distance between the edges of two freedom bubbles is equal to a determined separation distance between aircraft.

Compared to the current separation standards set for manned aircraft in a manned control environment, these distances may be lowered in the IFATS time frame as current separations have been defined taking into account the latencies due to current air traffic control methods (voice messages exchanged between controller and pilots).

So, a second bubble is defined, it provides the separation between aircraft whatever is their position in their freedom bubble.

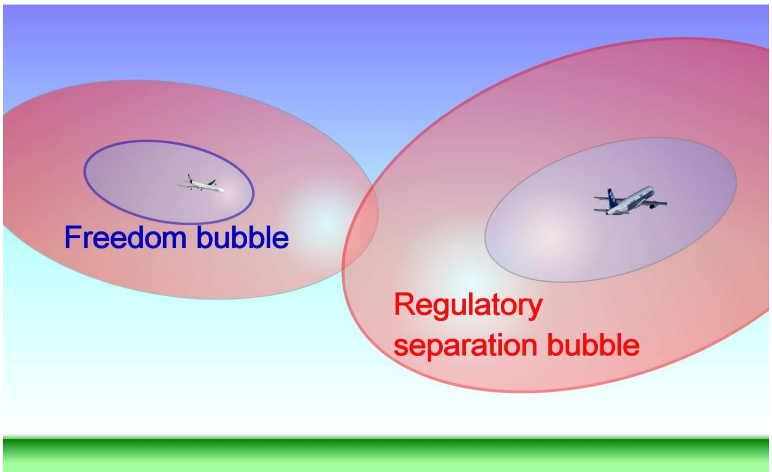

Figure 3 : Freedom and separation bubbles

In such a situation, conflict free flight is guaranteed as long as all aircraft remain within their respective bubbles, in other words as long as all aircraft are able to respect their 4D contracts.
Nevertheless, it may happen that an aircraft has to modify its ground speed or trajectory (due to a thunderstorm, or any event), so it will not be able to comply with the contract. When this situation can be foreseen several minutes in advance, the aircraft informs the ground segment about the situation and asks for a new contract. The ground segment then generates a new contract taking into account the overall traffic.

Several optimisation procedures can be considered at this stage. The new contracts can be calculated in order to optimize the overall traffic, this means that a lot of other contracts may have to be modified and real time constraints will be an issue, or the new contract is calculated in order to minimize the impact of the modification on other aircraft.
Moreover, two degrees of freedom can be considered to generate the new contract. Either it is possible to modify the speed of the aircraft or it is not possible to do so. In the second case, the second degree of freedom can be used, i.e.; the flight path that can be adapted to make possible the generation of a new set of conflict free contracts for the overall traffic. On figure 4, the flight path of one aircraft has been modified to avoid a crossing at the same position (X, Y, Z) and the same time (T3).

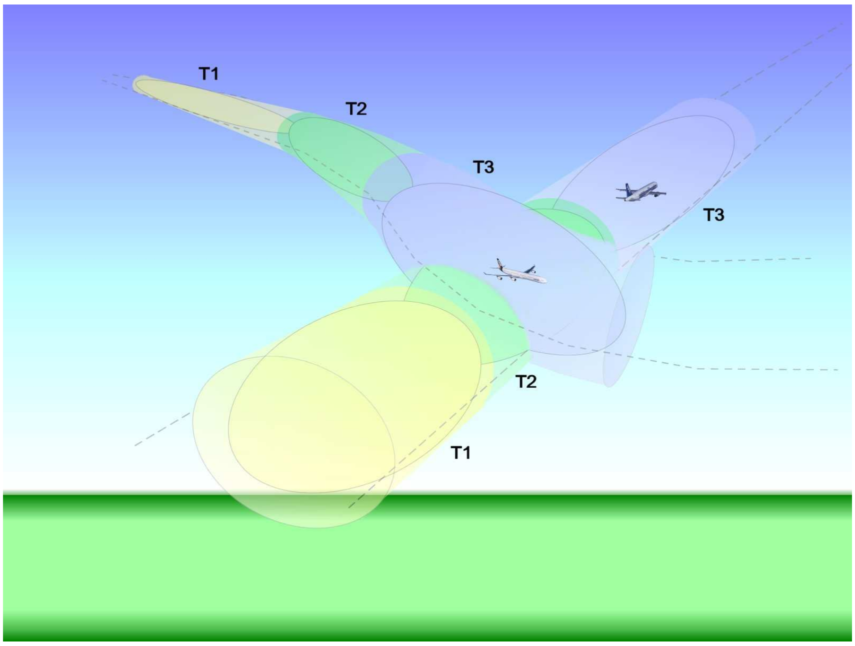

Figure 4 : Adaptation of flight path

4. Emergency management

In an emergency case, the procedure is different as there is no time for contracts negotiation with the ground segment. In that case, the aircraft in emergency uses its own information about the local traffic to generate a short term conflict free flight path compatible with its emergency situation and the local traffic.
Two types of situations can be considered here. Either there is a possibility to generate a conflict free flight path without any modification of the local traffic or the local traffic has to be modified to allow the aircraft in emergency to proceed as required by its failure status.
In the first case, the aircraft in emergency sends its new self defined contract to the ground and asks for a long term updated contract. In the second case, a local negotiation has to occur between neighbour aircraft to generate a number of short term 4D contracts. Then, these contracts are sent to the ground segment in order to get new long term 4D contracts.

D. General architecture of the Innovative Future Air Transport System

As defined previously, the system can only be practicable if the number of contracts negotiations is acceptable and if a single contract modification does not affect systematically the entire set of contracts, planet wide. Moreover, a direct dialogue between aircraft in the same airspace zone is necessary.

Addressing the issue of the number of contract negotiations leads to understand the reasons why such a negotiation is needed. The 4D contracts are defined by the ground segment taking into account at least the following information:

- AOC desires;
- Aircraft capabilities;
- Traffic forecast;
- Weather forecast;
- Wind field along the flight path.

The three first parameters are pretty well known, the last two may be more questionable if there is no possibility to update, somewhere in the system, a database having a real time meteorological information. Hence, as the 4D contracts calculation is based on those parameters, any significant difference between the weather forecast used to define a contract and the real weather [ref 6] encountered en route will drive to make difficult to respect the 4D contracts.

This is particularly true if the traffic is dense as, in this particular case, the freedom bubble size has to be reduced in order to accommodate all the traffic. When the traffic is low, the freedom bubble size can be increased making large unexpected variation of the groundspeed possible without any impact on the contract.

This has been a strong driver to the definition of the IFATS architecture: it has to be "network centric", i.e. using all elements of the system, whatever they are, air segment elements (aircraft) or ground segment elements (ATM stations, AOC,…), as "sensors" to get the best knowledge of the system state, including accurate meteorological situation. This architecture is shown on figure 5: all aircraft are sensors of the system; each of them is linked to the ground segment, either directly or via a satellite relay. Moreover, every single aircraft is communicating to neighbouring aircraft as shown for the yellow aircraft in contact with aircraft situated in the yellow area.

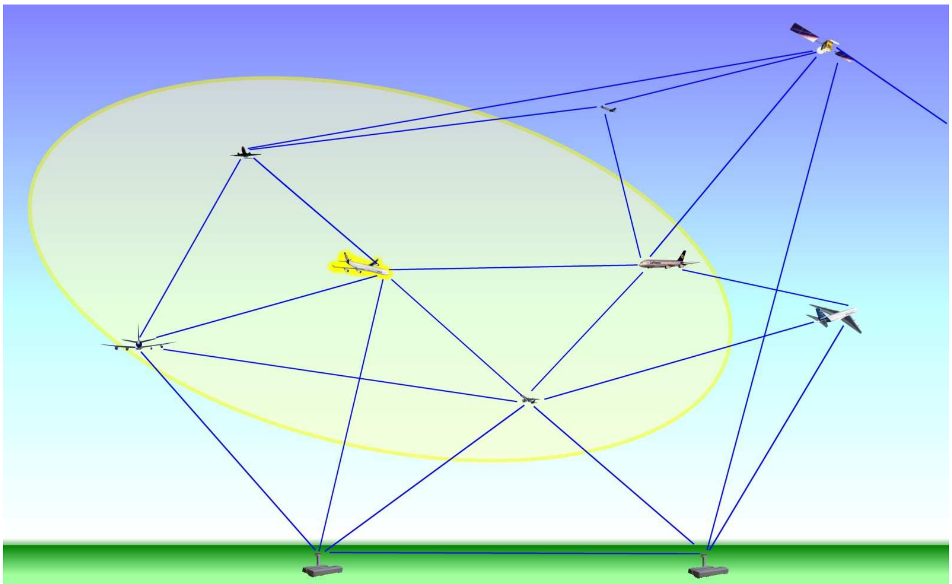

Figure 5 : Network centric architecture of the IFATS

Going back to the issue of contract negotiation, either the traffic is dense, i.e. the number of sensors is high, so the real knowledge of the wind field is great and the contracts can be very accurately defined enabling the possibility to have a low rate of contract negotiation, even with small size freedom bubbles; or the traffic is sparse, the wind field knowledge may be poor but the acceptable size of the freedom bubble will be high. In both cases, a low rate of contract negotiation can be anticipated. This has to be verified during the simulation phase of the project.

Addressing the issue of one single contract negotiation impact on other contracts is more difficult. It will obviously be a function of the density of the traffic and will depend on the optimisation that is required, overall optimisation of the traffic, or tentative to lower the impact of one single change to the other traffic, with a penalty to the aircraft requiring a change. This issue will be one of the outputs of the simulation phase of the IFATS project which is about to begin.

E. IFATS segments definition and attributes

1. Air segment

This is the IFATS aircraft. Input data for this fully automated air segment are the knowledge of its state given by onboard sensors, its long term intentions known through its flight plan, the local air situation perceived through co-operative messages from other air-segments as well as information from destination airport or "en-route" ground segment elements (flight plan updates, problems management…) or information of air traffic and environmental conditions in their neighbourhood.

Short to mid term tasks are performed by the onboard autonomous flight control system including the handling of emergency procedures to be applied in case of critical flight situations. Nevertheless, human being will stay in the loop and will be able to act from the ground to solve problems that cannot be solved by the onboard automatism.

The aircraft has to respect the 4D contract. When some difficulties are observed, two degrees of freedom can be used, either a variation in speed or a variation in trajectory, to comply with longer term 4D way points demand.

The aircraft failure management issue has to be considered in two different ways. Either the occurring problem is known, in this case, a palliative strategy has been implemented in the aircraft onboard systems, or the occurring problem is new.

In the first case, the aircraft automatically applies the pre-planned palliative strategy while, as this is already done currently, the airline maintenance team is made aware of the problem through messages sent by the aircraft to the ground. An interesting current situation is that modern aircraft can already send messages to the ground about the state of their systems without giving any information to the pilot if the problem is not considered relevant for the current flight (remote monitoring of the aircraft).

In the latter case, the occurrence of a new problem, the aircraft state is downloaded to a dedicated ground infrastructure, populated by specialists of the aircraft in trouble. These infrastructures are equipped with high capability computers and data bases: the specialists in charge of solving the problem in real time use these resources to find out the best strategy for the aircraft to recover from the trouble and then upload this strategy to the aircraft. Then the aircraft applies automatically the recovery strategy.

As a result of this organisation, two different kinds of ground segments are monitoring the flying aircraft:

- An airlines maintenance and fleet management ground segment;
- An aircraft manufacturer ground segment to deal with unexpected problems (typically at least one for each aircraft manufacturer).

A clear advantage can be foreseen from the network centric architecture of the system. All problematic situations descriptions are sent by the aircraft to its manufacturer, to a single point. So, the number of unexpected problems should decrease with time as experience feed back will be optimized thanks to this architecture.

2. Air Traffic Management and Control elements

The ATM strategic planning function performed by the ground segment concerns all aircraft which have to get flight plans in a co-ordinated manner. It represents the strategic level of the organisation of the overall traffic, world-wide.

It has to be widely geographically distributed and to be populated by "flight planners" replacing current non coordinated airlines planners and Air Navigation Services Providers (ANSPs).

When generating long term flight planning, airlines and ANSPs have to make coherent flight plans ensuring a general non-conflict situation at a continent level, considering a standard behaviour for all actors of the system with a level of accuracy which has to be estimated in the project.
Thanks to the overall automation of the system, all air traffic can be managed using an infinite number of routes generated as a function of meteorological conditions and other constraints, and which will be controlled, at the tactical level, by the co-ordinated ground segment elements.

The ATC function performed by the ground segment concerns all aircraft which have to be locally operated in a co-ordinated manner. It represents the tactical level of the organisation of the overall traffic, at a local level.
It has to be geographically distributed and to be populated by "aircraft operators" replacing current controllers and pilots. The geographical distribution can be compared to the present situation where successive hand overs are made from the departure ground airport control, tower control, en route-control sectors, etc. to the final destination ground airport control.
Aircraft taking off from an airport would be operated by a local ground segment. Then, en-route ground segments would successively hand-over the operation of the aircraft until its landing at its destination airport. As stated previously, the air traffic is managed using an infinite number of routes which have been generated at the strategic level and then controlled, at a tactical level by the co-ordinated ground segments. This latter control is made far easier thanks to the coordinated strategic flight planning.

In case of a ground to air data link failure between a specific aircraft and the ground segment, the aircraft can recover the situation using another aircraft as a relay via its air to air data link. When no contact can be established, aircraft will have to fly respecting their 3D+T contract up to the time when data link is recovered, in order to keep a conflict free situation.

F. Relationship between free flight and the IFATS concept

This section of the paper has been added to avoid any confusion between the IFATS concept and the free flight concept.
In simple words, IFATS concept is farther from free flight than the present ATS is, as shown hereafter.

The basic idea of Free Flight is to shift active control of aircraft to passive control with intervention of Air Traffic control in case of exceptions. Aircraft en route have no longer to use existing predefined airways, but are free to fly a preferred route. Conflicts, such as bad weather or loss of separation with other traffic along the preferred route have to be resolved by the flight crews, normally without any intervention from Air Traffic Controllers.

So, in the free flight concept, each aircraft flies a dynamic, user preferred flight path; making full use of on-board systems. Position and short-term intent information is provided to the air traffic service provider who performs separation monitoring and prediction functions.
User flexibility is the principle: users should have a choice of when, where, and how they manage their flight operations. For example, users should be able to pick departure and arrival times that suit their needs; similarly, users should be able to select the flight path that is most beneficial to them. Additionally, users should have the ability to manoeuvre their aircraft without ATC control when no ATM constraints or restrictions to flight are in effect.
Nevertheless, restricting the flexibility of the pilot will only be necessary when:

- potential manoeuvres may interfere with other aircraft operations ;
- traffic density at busy airports or in congested airspace precludes free flight operations;
- unauthorized entry of special use airspace is imminent or safety of flight restrictions is considered necessary by the air traffic controllers.

These latest restrictions make hard to believe that free flight is a long term solution for the future high density air transport system. As the popular quotation "**Your freedom ends where mine begins**" states, it appears to be very difficult to allow a total freedom to every air-space user.
The only possible way of doing this is to adopt a "first come, first served" principle in which flight plans would be successively given to users, the latest having the remaining possible flight paths which may be far from efficient. The resulting air transport system could not be optimised in order to deal with the growing traffic.

Another complicated point in the "free flight concept" is the handover from the controller to the pilot or from the pilot to the controller of the management of the situation. This can be done by voice or by data link. In both situations, misunderstanding and errors can occur and drive to dangerous situations.

IFATS concept puts the freedom benefit at the same level for every air space user. When a new one enters the game, freedom of others is restricted to take into account the desires of the new entrant.
As in the free flight concept, aircraft en route have no longer to use existing predefined airways. They are free to ask to the system a preferred route which will be allocated if there is a possibility to fly this route without compromising the flight path of other users. Under those circumstances, conflicts should not occur as all allocated routes are compatible (Vertical, horizontal and time separations). Moreover, the ground segment automatically monitors the overall traffic and alters some of the routes when and where necessary.
IFATS is a concept in which freedom is given for the preparatory phase of the flight, once the flight path is allocated, the flight becomes "fully constrained", and any alteration has to be "negotiated" with the ground segment.
Clearly, the continuous dynamic change of the overall situation in such a concept can not be handled in real time by humans. This is the reason why IFATS is based on a highly automated system in which all the segments can exchange information rapidly, efficiently and safely.

Conclusion

The IFATS project proposes to study a revolutionary concept for a future air transportation system by adding as much onboard automation and autonomy to the aircraft and to the ATM as necessary to fulfil the overall requirements of improved efficiency and safety of air transportation.

All the various air and ground components of the system communicate with one another through a network-centric architecture making all aircraft and ground stations as sensors of the overall system. Aircraft fly autonomously pre-programmed flight plans using sophisticated onboard computing and sensor systems while ground operators are responsible for the overall situation, whereabouts of aircraft and tracking of their intentions.
Functionalities of the system are flexibly distributed between the ground segment and the aircraft, relying on intensive data communication capabilities between aircraft, and between aircraft and the network of ground stations.

Current pilots and controllers tasks are deeply modified as the elements of the system communicate digitally: pilots can be removed from the cockpit and controllers work is transformed into system monitoring actions. Additional features are added like direct assistance from the aircraft manufacturer for in flight aircraft diagnosis and remote maintenance.

The anticipated outputs of the project are the identification of 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 and to analyse a procedure to migrate from the present situation to this future acceptable system taking into account the transition phase to be set up.

Reference

This paper has been written as a summary of the state of the IFATS project in October 2005. It is based on the documents that have been produced during the first year of the project; reference for the work is mentioned in those documents.
Information about the IFATS project consortium and current results are available on the project website.

www.ifats-project.org

Additional references
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