# The Challenge of Security

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# Executive Summary



After the 11th September event, Security of Air Transport became a major concern for Society and ACARE has set up a Working Team to define R&TD addressing the security of the whole Air Transport activities, with "zero successful hijack" as a goal.

The scope is limited, in this first phase, to commercial fixed wings aircraft.

The Air Transport scenario used to guide the work is conform to the GoP Vision, completed by some assumption: development of freight transport which could be separated from passenger' transport, larger use of regional Airports, evolution of Air Traffic Management towards more autonomy delegated to Aircraft and towards 4 Dimensions trajectory control, using space based technologies.
The outlined scenario is in line with the ACARE report on the Challenge of more Efficient Air Transport.

The reflexion is based on a comprehensive view of the protection of the air Transport system, composed of the three elements: the Air Navigation infrastructure, the Airport and the Aircraft.

Air Navigation infrastructure security is based on: biometrics for detection of unauthorised person accessing to protected areas, assessing and protection against misuse of Air Navigation services.

Airport Security is based on biometrics to control passengers and personnel, information technologies to keep track of suspicious passengers while ensuring a minimum constrain for the usual users, new technologies for efficient detection of forbidden products in luggage and freight, methods and means to detect intrusion in wide area of Airport and prevent unauthorised take-off of aircraft.

Airborne Security is an ultimate mean for hijack dissuasion: automatic interdiction to flight into protected areas, automatic return of the hijacked aircraft to predetermined airfield.

The research recommendation are grouped into 3 contributors related to the three above components of the Air Transport System.

They are sustained by basic enabling technologies and Technology Integration Platforms (TIP), most of them are common with the Safety challenge.

Specific basic technologies to Security are related to biometrics, detection of dangerous products (weapons, explosive, biologics, chemical …), and secure communication.

It is a proposed Secured Airport technologies demonstrator as a specific TIP to the Security challenge, which will benefit also from some TIP proposed for the Safety challenge.

The future activities related to the Challenge of Security depend on decision of ACARE Members on future issues to be addressed for the second release of the SRA. Pending this decision, it is envisaged the following issues to be undertaken as next steps:

- Examination of potential Security issues specific to other aircraft than fixed wing commercial Aircraft;
- Research for practical metrics to measure the contribution of different research topics to the goals;
- Reflexion on potential additional contributors to the Security goal …

# Introduction

The attacks on the USA in September 2001 brought into sharp relief the exposed nature of the global air transport system. Aircraft were themselves used by terrorists as weapons for mass destruction and brought a new set of issues to attention.

In fact, if this new threat to society is not radically suppressed, in case of its occurrence, there will be a little choice than to sacrifice all the crew and passengers of the hijacked Aircraft to save thousands of lives on ground; this situation will lead to the citizen's rejection of air Transport and consequently to the bankruptcy of this industry.

Security is separated from safety issues. Firstly, safety concerns the safe operation of a planned and managed system whilst security defends that operation from the deliberate actions of the terrorist or criminal. Secondly, the priority to be given to security measures is essentially a political issue and political guidance and leadership will be needed to work out the measures needed. Meanwhile the aeronautics community is preparing the technologies and approaches that may be relevant and effective. The work does not take into account short term actions decided by authorities and currently implemented by airlines.

# Background

Until the 11th September event, hijacking of Aircraft was intended to satisfy specific request of its authors, taking as hostages the aircraft crew and passengers. In this case of attack, it is assumed that the hijackers will not deliberatly sacrify their own lives and the control actions were concentrated to safeguard the crew and passengers.

The 11th September event brought dramatic shifts in the dimensions of hijacking. The main stake is no longer the lives of people on board but the mass destruction of citizens on ground for political purposes. Furthermore, the hijackers are ready to undertake any action to satisfy their purpose, including the sacrifice of their lives.

The approach to Security of Air Transport will have to take into account these new facts.

## Air Transport scenario for the years 2020+

The Air Transport scenario adopted for the years 2020+, needed for the reflection on Security, is based on the following elements:

- In macroscopic terms, Air Transport growth will be conform to the GoP vision: triple traffic in Europe for the years 2020+, despite cyclical variations in annual growth. It is assumed that the 11th September event will not change the global trend;

- Aircraft fleet: freight transport will be significantly developed during the next 20 years; the world A/C fleet will be composed mainly by "today designed" aircraft, with a larger part of large A/C and a larger fleet for freight transportation; passenger and freight transports will be more separed to optimise their respective costs operations;

- The second decade might see more intensive use of automatic flight control and management for freight aircraft.

- Airport will remain the scarce resource. As it is likely that the construction of new airports or new runways will be limited due to environment concerns, regional airports will be more exploited to satisfy the demand;

- In terms of Air Traffic Management (ATM), the trends are towards Autonomous Aircraft for Free Routing with a prudent transfer of Aircraft separation task from ground to air;

- It is also predicted that Communication, Navigation and Surveillance (CNS) means will be more and more based on satellites (GPS, Galileo …).

The above assumptions are coherent with the outlined findings of the Challenge of more efficient air transport.

## Scope and methodology

In this first phase, this report focuses on the main sector of Commercial Air Transport based on fixed wing aircraft and does not take into account short term measures already decided by authorities and undertaken by airlines (doors …)..

The basic considerations for the work on the Security Challenge are:

- Necessity for a comprehensive view, not limited to the "model" of the 11th September event: hostile intentions take profit from any weakness in the defence system. The Working Team took into account the three components of the Air Transport system: the Aircraft, the Airports and the Air Navigation infrastructure.

- Successive barriers are necessary to ensure efficient protection: although it is necessary to have "zero access on board of unauthorised person or products" as a goal for ground security, as there are hundreds of Airports controlled by a great number of administrations around the world, in flight security is considered as the ultimate mean for hijack dissuasion.

- The threat considered in this reflexion covers the malevolent actions from inside the airports, the ATC centres or the aircraft, with the intent to use aircraft as a mean for mass destruction. The attack of aircraft and infrastructure of Air Transport from outside (missile, gun …), considered as more relevant to nations' Security and Defence domains, are outside the scope of this document focussed on R&TD matters.

- Although Safety and Security are different in their natures, one should consider how Security measures can contribute to Safety enhancement if economics aspects are to be considered

# Challenges and Goals

## Challenges

As **Figure 01** shows, three areas of security form the challenge arena:

– The security of the **Navigation and ATM infrastructure** is concerned with protecting the system from interference, including jamming, unauthorised communications, misuse of the ATM system and with providing secure means to maintain control of aircraft in transit.

– **Airport security** aims to establish a zero possibility for unauthorised access to or interference with aircraft or systems on the ground.

– **Airborne security** addresses the secure operation of the aircraft, unauthorised pilots, unplanned trajectories and the control of the aircraft to a safe landing.

## Goals

Corresponding to the scope outlined, the Goals are to establish zero hazards:

– from a failure of the Navigation and ATM system through hostile action,

– from an aircraft being hijacked on the ground, implying in particular zero access to aircraft of unauthorised person or product,

– from hostile action whilst in flight.

The general concept is a layered protection organisation, in which the Airborne Security to negate successful hijack action is the ultimate mean for protection.

The main research routes to reach the goals mentioned above are named Contributors. These Contributors are presented in **Figure 03** with milestones at 2008, 2015 and 2020, which are the dates where Research and Development should be achieved and actual implementation of proposed products / systems can begin, if the GoP vision for Air Transport in 2020 is to be realised. These milestones are referred to as short, mid and long term in the following text. The contributors are based on the methodology outlined in the section Background.

## Synthesis of contributors

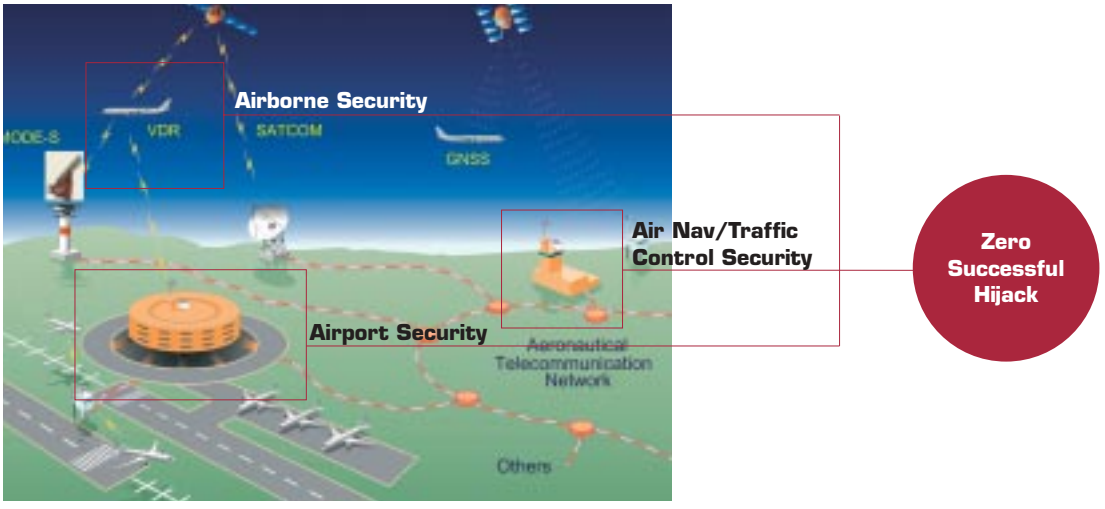



**Figure 01: The comprehensive approach to Security**

# Contributors

## Security of Navigation and ATM infrastructure

### Introduction

Prior to September 11th, no specific attention was given by Air Navigation Services to the potential use of an aircraft as a weapon. There is a need to reassess the existing systems and procedures in the light of such an event.

– More attention shall be given to a potential misuse of ATC facilities or navigational aids;

– The role of ATC in detecting and monitoring a hijack may become more critical;

– Further role of ATC such as taking partial control is even being envisaged by some experts.

There shall be no way to misuse either ATC facilities, or navigational aids, with the intend to trigger an aircraft collision with the ground or with any other aircraft.

In case of hijack of an aircraft, the first objective of ATC is to detect as soon as possible the event, and to transmit the information to the relevant authorities. Radio contact with the aircraft shall be maintained, if the pilot has the possibility to do so. It is essential that the aircraft continues to be tracked (by civil and/or military radar systems) even in the event it becomes non co-operative.

In a long term framework, under the assumption that very secure data-link is available, further role of Air Traffic Services may be studied.

### Solutions

SHORT TERM SOLUTIONS

*To Assess the potential of misuse of ATC facilities and navigation aids*

The potential of misuse of ATC facilities or navigation aids in order to trigger a collision should be assessed. The current systems and procedures were not designed to be robust in front of such an event.

In the framework of this study, special attention should be given to the possibility of radiating wrong navigation signals especially during the approach phase where auto-pilot coupling with ground aids or even GNSS is used, and where time to react is very short. Requirements to enhance monitoring of the navigation signals on the ground might be derived from such a study.

*To maintain radar contact*

Monitoring the track of a hijacked aircraft does not require any additional system if the SSR transponder is working. If the SSR transponder is intentionally shut down, monitoring the flight track might be impossible within en route ATC facilities, but will still possible in air defence control centres.

A study may determine in this case whether the existing co-ordination procedures between civil and military centres are sufficient, or if there would be some benefits in transmitting the relevant primary track to the civil facility.

In addition, there might be Safety benefits in transmitting this type of information in case of any transponder outage.

MID TERM SOLUTIONS

*To enhance the detection of hijacking*

Before September 11th, an immediate detection of a hijack was not considered as the highest priority. Assuming that the pilot has no means to inform ATC, detection may only be based on track deviation and/or lack of response to a routine radio communication message. Under this circumstance, automatic detection of track deviation could speed up the detection of hijacking.

In order to have a reasonable rate of false alarms of such a tool, important preliminary work is needed: One would have first to obtain that the intended flight track as computed by the aircraft is identical to the intended track as computed by the ground (which is often not the case due to non homogenous data-bases or computing algorithms).

Such studies may also benefit to Air Navigation Safety, since deviation from intended tracks, or non compliance to clearances may be the cause of ATC incidents, especially in crowded terminal airspace.

The implementation of such a tool is envisaged in the mid-term framework, as widespread use of data-link is required, in order to guaranty coherence of short term projected flight track between ground and aircraft.

LONG TERM SOLUTIONS

*To take partial control of the aircraft from the ground*

Even if in the long term it would be technically feasible to give piloting orders to the aircraft through datalink, it might be controversial to allow the ground to take full control of a hijacked aircraft. Study will be necessary to assess the acceptability of this procedure.

In the long term it seems possible to propose that the hijacked aircraft is put into a "protective" mode which performs the predicted flight track until full stop on the runway, or into another mode which prevents any possibility to the aircraft other then landing on an airfield.

It may be envisaged that the ground is in the decision loop for putting the aircraft in such a mode, but safety and security gains/drawbacks of such a process would have to be very closely studied.

# Airport Security

### Introduction

The Airport Security covers the protection of aircraft, passengers, population and strategic points against malevolent actions.
Unauthorised persons may try to take the control of an aircraft from the airport. Moreover, undesirable material could be carried in by passengers, crew members, airport personnel or unauthorised intruders. Undesirable material could also be introduced in the luggage or in the fret.

### Solutions

SHORT TERM SOLUTIONS

*Potential application of technologies from other domains to airport security.*

This solution focuses on research on existing technology from other fields (military, police, special forces, medicine, control process, anti-drug, money transfer, anti-gang…) that could be reoriented with little modification to be used in the airport security:

– to improve luggage and freight control
– to detect nuclear and biologic weapons
– to improve access control to airports areas for all personnel and passengers,
– to improve detection of access violation

Aircraft neutralisation on ground

This solution addresses research on technologies that will allow the prevention of unauthorised person to take control of an aircraft at parking, to access to the runway and to make take off impossible.
The research will be orientated both to non destructive and (partially) destructive means under the ground services (ATC, police…) control.
Several research directions will be investigated:

– to prevent unauthorised persons to steal an aircraft
– to prevent any aircraft taxiing or take off if not authorised by ATC
– to improve runway safety.

MID TERM SOLUTIONS

*Develop massive and fast identification means to support the passengers control*

The focus of this solution is on the development and experimentation of a complete system fed by intelligence and police data at local level.
This means to store undesirable persons data (and welcome persons) and identify them all along the pre-flight process from ticket reservation to shipping in order to:

– limit the "needle in a haystack" effect
– increase the difficulty for potentially dangerous persons to get aboard anonymously, while keeping a less constraining process for normal passengers.
– ease and speed up the normal passengers control, while keeping more resources available to control potentially dangerous persons.

The activity could benefit from the general studies conducted around massive data computing techniques and advanced database research.

LONG TERM SOLUTIONS

*Develop specific means for wide area access control*

This means to develop specific technology to detect any intrusion in a wide area (hundred of hectares) under all weather conditions while limiting false alarms for example due to animals or wind.
Multi-mode systems with common data processing will be necessary to obtain a sufficiently low false alarm rate.

Research will be focussed on various detectors, such as Lidar, millimetric radar, thermal camera and on data fusion and real time data processing.

*Develop new weapons detector means*

To develop existing and experiment new sensors technologies. Multi-sensor detection is a promising area, using several sensors and sophisticated software to improve the sensibility and reduce the false alarms rate:

– to detect explosives particles on human.
– to detect explosive or NBC materials in the fret.
– to detect small size weapons.
– to detect new materials.
– to improve real time performances.

The activity could benefit from sensors research conducted in nuclear industry and anti-drug domain, data fusion and pattern recognition research.

# Airborne Security

## Introduction

The 11 September 's events have initiated some rush programs to improve the protection of the cockpit (re-enforced and armored doors, cameras to monitor the cockpit entrance, modified transponders with secured access), but these initiatives will not be enough and new systems need to be implemented to reach the targeted objective.

As long as aircraft could be used in hijackings as a weapon threatening the lives of the passengers on-board but also as weapons of mass destruction, threatening lives and property on the ground as well as in the air, the air transport would be in jeopardy.

Making the assumption that it will not be possible to eliminate all the possibilities for terrorists to access aircraft and to guarantee that no weapon cannot be smuggled or hidden abroad, the objective of this contributor is to design and validate new systems and technologies which could be implemented on-board, to deter hijacking (deterrence for those who seek to carry out attacks) and to reduce or eliminate the consequences of a potential attack (counter measures against attackers).

## The Solutions

SHORT TERM SOLUTIONS

*Parametric study*

Implementation of new systems on board to enhance the security may require to review and to redefine the responsibility of the different actors.

For instance, the pilot, today, is considered as the only decision maker on board, in charge of the aircraft and of its passengers. In case of hijack, is it still possible for the pilot to keep this responsibility or is it necessary to transfer this responsibility to automatic systems or to the ground, in order to remove the potential psychological pressure generated by the hijackers?

Implementing new systems to enhance the security could also have an impact on safety. Which level of safety has to be met when the aircraft has to face hijacking? Which criteria have to be set up to select efficiently solutions enhancing the security?

All these questions have to be addressed and answered through a study gathering all the actors of the domain.

*Flight Trajectory protection*

It is proposed to design and experiment a system (extension of Terrain Awareness and Warning System) for preventing any suicidal maneuver by the crew, that would put the aircraft outside of its flight envelop or of any normal trajectory. The latter case may result in a CFIT (Controlled Flight into Terrain) or a crash into any populated area.

New generation aircraft are already equipped with Flight Control systems providing some automatic flight envelop protection. They are also equipped with an advisory system: TAWS (Terrain Awareness Warning System), providing advisory alarms to the crew in case of CFIT (Controlled Flight Into Terrain). It is proposed to enhance such systems to prevent terrorists to use aircrafts as weapons against ground populated area.

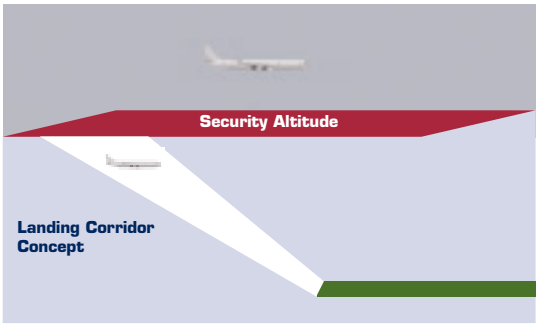



**Figure 02: Flight trajectory protection**

Using a database providing necessary data for all authorized runways, it is possible, for instance, to generate 3D corridors to these runways and algorithms allowing the aircraft to descend under a certain security level or altitude only if it is inside one of these approach corridors. As soon as a descending aircraft goes outside such envelop, the system will make the aircraft climbing back up to the secure altitude automatically. The principle is shown in **Figure 02**.

Such systems could also enhance the safety of the flight.

*Neutralization of aircraft cabin*

In case of critical situation, it could be necessary to disable or disorient potential hijacker in the cabin in order to neutralize their actions.

It is proposed to work on means to reach this objective, under the cockpit control.

Among other ideas, it is possible to foresee the use of products or anaesthetic gas which could be dispensed in cabin.

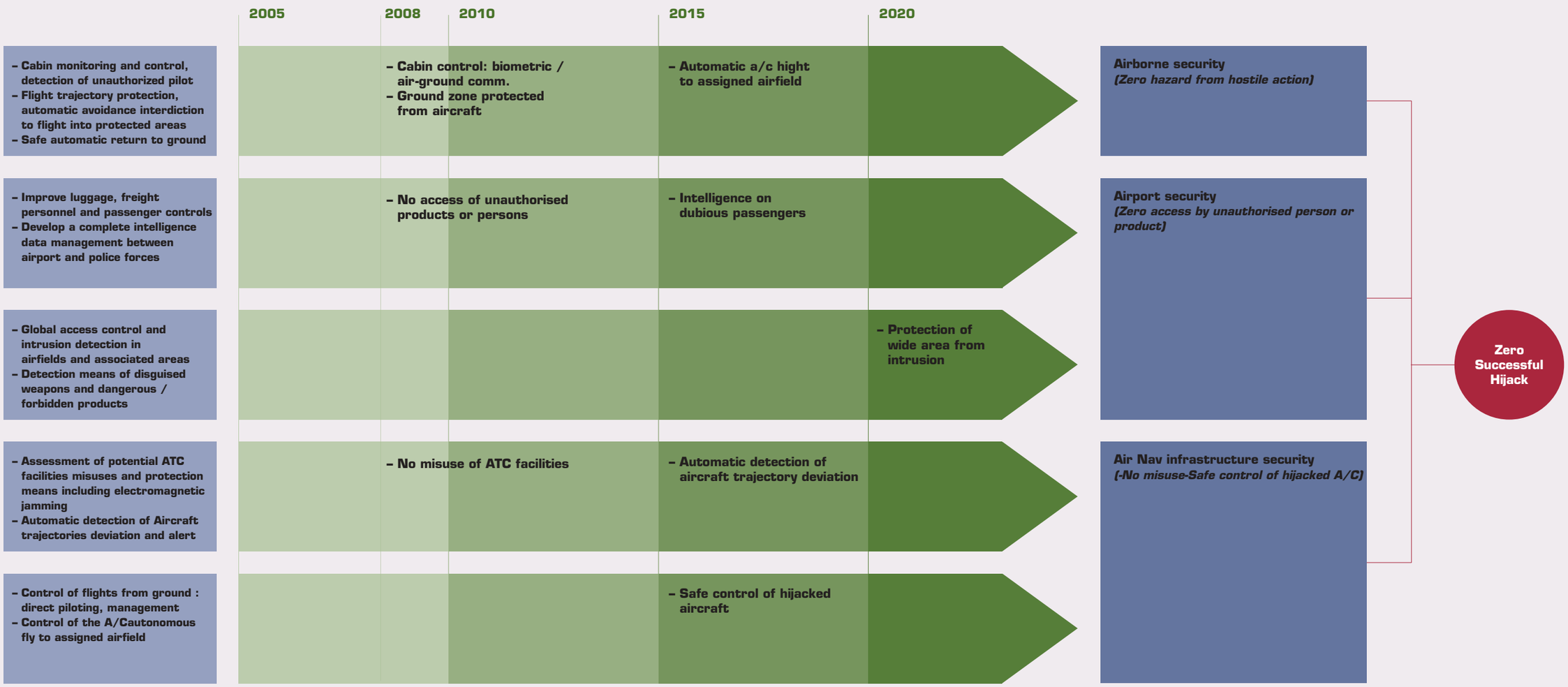
It is possible also to implement of a "turbulence" mode in the Flight Control system, generating shakes in cabin similar to these endured by passengers when the aircraft is flying in turbulent weather. Such a "turbulence" mode could be initiated by the crew, after normal procedure to inform the cabin that the flight is going to enter in turbulent weather.

MID TERM SOLUTIONS

*Safe automatic return to ground*

New generation aircraft are already equipped with systems allowing automatic navigation on a selected flight path (FMS) or automatic landing. It is possible to implement supplementary functions to control the hijacked aircraft. The system could select the nearest authorized airport and runway and automatically land the aircraft. This requires to define the flight path to follow, to inform the ATC about the new flight plan, dumping fuel if necessary, controlling automatically the extension of slats, flaps and landing gear as well as landing and stopping the aircraft on the runway.

Figure 3
Synthesis of Contributors for the Challenge of Security



# Activities for implementation of Contributors

## General presentation

The basic findings to reach the vision on Security are the Contributors; they are the backbone of propositions for R&TD planning.

Three activities are proposed for their implementation:

– Research topics related to Contributor's as described in chapter 3. They are, in general terms "system research" complemented by development of specific mock-ups, for test and validation, of small / medium sizes.

– This system research will have to be supported by basic research for enabling technologies progress. Basic technologies research are, in general terms, closer to fundamental research and might be applied to other domains than Aeronautics.

– Technology Integration Platforms (TIP), which are in general of large size and aimed to validate the concepts proposed in different Contributors. They might be ground validation benches or specific A/C equipped for flight validation and test in operational context.

The general presentation of activities for implementation of Contributors is summarised in **Figure 04**. The Solutions for Contributors are described in the previous chapter. The following paragraphs present the basic enabling technology needs and the Technology Integration Platforms.

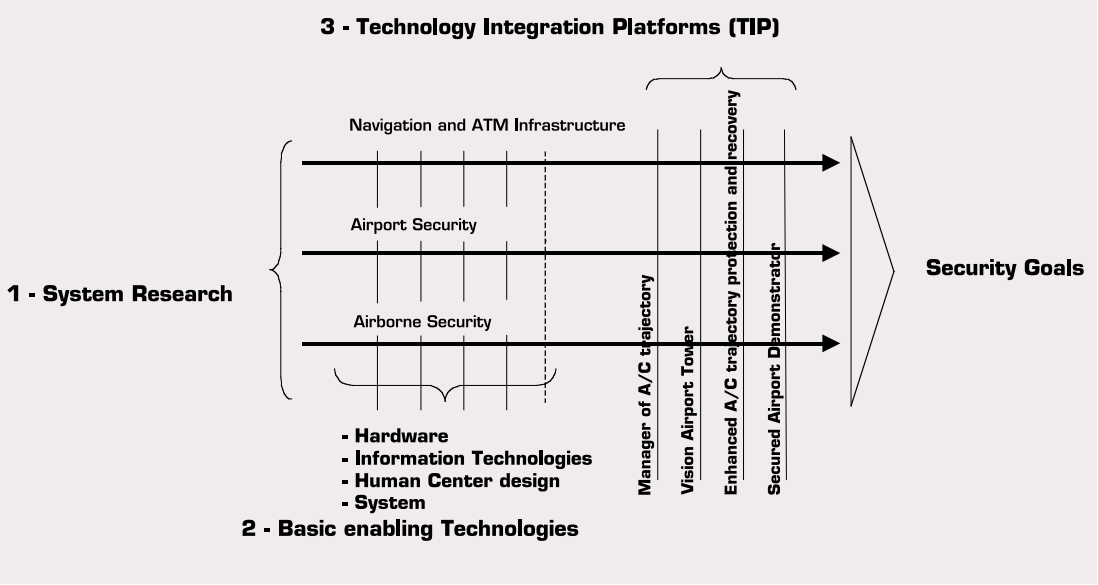



**Figure 04: The three Activities for the implementation of the Contributors**

## Basic enabling technologies

The basic enabling technologies which are specific to Security are presented in **bold** in **Figure 05**. The others items are common to Safety and Security. A more detailed description of the technology needs related to the different contributors is given in Annex 1.

**Hardware**

- Sensor (laser, light intensifier, radar infrared)
- Audio
- Radio Frequency
- Signal processing
- High bandwidth datalink
- **Real time detection of explosive/weapons/nbc products - Biometrics**

**Human Centered design**

- Human factors/behaviour/modelling

**Information Technologies**

- Data fusion
- Pattern recognition
- Terrain and obstacle database processing
- Satellite positioning
- Guidance system
  Visualisation including 3D
- **Encryption and secure communication**

**System**

- Prototyping tools
  Digital mock-up
- Simulation
- Integration
- System validation
- System of systems
- **Security and proof of Asynchronous software**

**Figure 05 : Basic technology needs for the Challenge of Security**

# Technology Integration Platforms (TIP)

Four TIPs are proposed. For economical reasons, the first three of them are common to the Challenge of Safety: this approach is confirmed by the technical analysis that has shown that the proposed TIP can be reasonably designed to validate technically several concepts.
The last one is specific to the Challenge of Security.

### Manager of Aircraft Trajectory - MAT -

This TIP will provide for a distributed management of aircraft trajectory, ensuring complementary and interoperability of the Airborne, Ground and Media segments. It encompasses the functions of preventing A/C from flying / taxiing conflicting trajectories, resolving residual conflicts and recovering from actual unresolved conflicts

Composed of interlinked Ground and Airborne segments, the system will provide dynamical re-allocation of responsibilities of crew and ATC on A/C separation in accordance with criteria for optimisation and the detection of abnormal trajectory of hijacked A/C.

### The Vision Airport Tower - VAT -

This TIP will be centered on the development of a comprehensive airport control tower display and communication system as a focal point for all relevant information. It will use all available and innovative technologies to enhance the access to information and the sharing of information among all persons involved in the ground movement at Airport

The objective is the enhancement of Airport operations capacity and safety as well as the detection of abnormal A/C ground movements due to hijackers.

### Enhanced Navigation, Guidance & Control System for A/C Trajectory Protection and Recovery - TPR-

This TIP will be used to validate the functions:

– monitoring A/C trajectory for non abnormal deviation,
– protecting A/C manoeuvring by enhanced flight envelop,
– recovering and return of the A/C to safe situation / trajectory,
– automatic control and safe navigation / landing of A/C at predetermined Airfield.

All these functionalities are designed to ensure the Safety / Security of A/C with regard to human errors or suicidal behaviour in case of terrorist attacks.

### Secured Airport Demonstrators -SAD -

The basic objective is to integrate new security devices on dedicated Airports for live demonstration of its efficiency. The security functions could cover: Airfield protection against intrusion, passenger / luggage and freight control, access control and airport security monitoring …

The objective is to validate the technologies in the real context of coordination / communication, organisation at airports.

# Conclusions and recommendations

The proposed R&TD intend to define equipment and systems that might be implemented in a certain time frame by concertation between the main stakeholders: ICAO, regulation bodies, ATM service providers, airport authorities, Industry, Airlines …

The complex issue of Security will need parametric studies involving all partners to define an outlined conclusion on trade-off between several factors: safety, security, economic constraints, human factors, … The issues that have to be addressed in the future would be, among others, guidelines for certification of Aircraft equipped with security devices, methods and tools for training of personnel for emergency situation as well as operational procedures (including legal framework) to be defined and implemented.

There will be many milestones in the roadmap towards the implementation of an efficient and economically viable Security system for Air Transport. This document presents, as the result of a cooperative work, a set of R&TD subjects to be carried out to define the feasibility of the proposed solutions, which are the basis for further investigations to progress along this roadmap.

Future work on the challenge of Security depends on the decision of ACARE on issues to be addressed for the second release of the SRA. Pending this decision, the following points could be taken as next steps:

– Extension of work to include other types of Aircraft (Commuter, business jet…) for identification of potential specific issues related to Security

– Research for practical metrics to measure the contribution of different solutions to the goals

– Viable Security solutions defined through economic assessment …

# Glossary

| | |
|---|---|
| ATC | Air Traffic Control |
| ATM | Air Traffic Management |
| CFIT | Controlled Flight Into Terrain |
| CNS | Communication, Navigation and Surveillance |
| GNSS | Global Navigation Satellite System |
| GoP | Group of Personalities |
| ICAO | International Civil Aviation Organisation |
| R&T | Research and Technology refers to developing new technologies – more specifically it covers basic research, concepts, technology development and technology integration & validation |
| SSR | Secondary Surveillance Radar |
| TAWS | Terrain Awareness Warning System |
| TIP | Technology Integration Platforms |

# Annex 1: Basic Technology needs

| Contributor | Hardware | IT Technologies | Human Centered | Systems |
|---|---|---|---|---|
| - Airport security | - Sensor (laser, light intensifier, radar, infrared)<br>- Signal processing<br>- Real time detection of explosive/ weapons/nbc products<br>- Biometrics | - Data fusion<br>- Pattern recognition<br>- Visualization | - Not applicable | - Prototyping tools<br>- Digital mock-up<br>- Simulation<br>- Integration<br>- System validation<br>- System of systems |
| - Airborne security | - Sensor (laser, light intensifier, radar, infrared)<br>- Audio<br>- High bandwith datalink<br>- Real time detection of explosive/weapons/ nbc products<br>- Biometrics | - Pattern recognition<br>- Terrain and obstacle Database Processing/ management<br>- Satellite positioning Guidance system<br>- Encryption and secured communication | - Human Factors/ behaviour/ modelling | - Simulation<br>- Integration<br>- System validation<br>- Security and proof of Asynchronous software |
| - Security of Air Navigation | - Audio<br>- Radio frequency<br>- Signal processing<br>- High bandwith datalink | - Pattern recognition<br>- Terrain and obstacle Database Processing/ management<br>- Satellite positioning Guidance system<br>- 3D Visualization<br>- Encryption and secured communication | - Human Factors/ behaviour/ modelling | - Simulation<br>- Integration<br>- System validation<br>- Security and proof of Asynchronous software |