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iFly

Safety, Complexity and Responsibility based design and validation of highly automated Air Traffic Management

Specific Targeted Research Projects (STREP)

Thematic Priority 1.3.1.4.g Aeronautics and Space

iFly Deliverable D8.4
Non-Airborne Requirements in support of A^3 equipped aircraft

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Executive summary

Currently the aircraft are operating with the support from ground controllers who make decision and have control over the trajectories and incident management (conflicts resolutions, etc.) between aircraft. However, aircraft are becoming more autonomous due to improvements in sensors and onboard equipment in general, most especially in connection advances in trajectory management and the increase of self-managed flight operations.

The aim of the iFly project is to answer how the operation of an aircraft flying in a completely autonomous mode will operate, without the support of air traffic controllers during the en-route phase, using the aircraft onboard systems and taking into account that the aircrew take responsibility about the manoeuvres executed to avoid conflicts. This mode of operation is called the "Autonomous Aircraft Advanced"(A^3) because it develops a challenging concept of aircraft flying without the support of ground controller, given a prime role to aircrew with the support of the board equipments.

However for a full and safety operation in A^3, it is needed the support of some elements or non airborne systems. Without the help of these elements or systems the scenario in which aircraft fly with self separation capacity could not reach the safety levels desired in the operation. These elements could be used in the different phases of the flight in the future and could help significantly to solve potential conflicts to mid and long term

The autonomous concept is based in the capacity of aircraft to manage the current and future situation without the support of control ground based; the main source of information is provided by non airborne systems that will help to transmit information providing a clear picture to the actors involved.

The requirements, that are the objective of this document, are identified mainly in the following issues, identified in the technical annex:

- Communication requirements. Identification of the type of communications necessary to transmit information to Autonomous aircraft.
- Data accuracy, integrity and availability. This item identifies the requirements to ensure the robustness and reliability of transmitted data.
- Automated ground surveillance support requirements. Here are identified the requirements that could support the mid and long term operations due to in short term the conflict detection and resolution is done by airborne equipment.
- Network security. To ensure that the operation is secure, the communications network hast to transmit the information without permitting the intrusion of external elements that can degrade both safety and security levels
- Pre-flight requirements. The innovative A^3 operational concept implies that some current procedures will be modified and upgraded because it will possible to obtain a more reliable and accurate pre-flight information.
- Arrival and Departure Management requirements. The operation of aircraft flying in autonomous mode will be affected by existing constraints in the Self Separation Area (SSA). The transition form SSA to managed airspace has to consider the operational constraints. These requirements evaluate the operational scenario to facilitate the transition.

- Flow Management requirements. The role of Flow Management is upgraded based on the distributed air traffic flow management concept.

In summary this deliverable identifies those requirements that facilitate the flight in autonomous mode. The requirements will provide information to facilitate the operation, considering constraints such as restricted areas or weather conditions amongst others.

The following figure shows a general picture of this scenario and how non airborne systems will contribute to facilitate the operation.

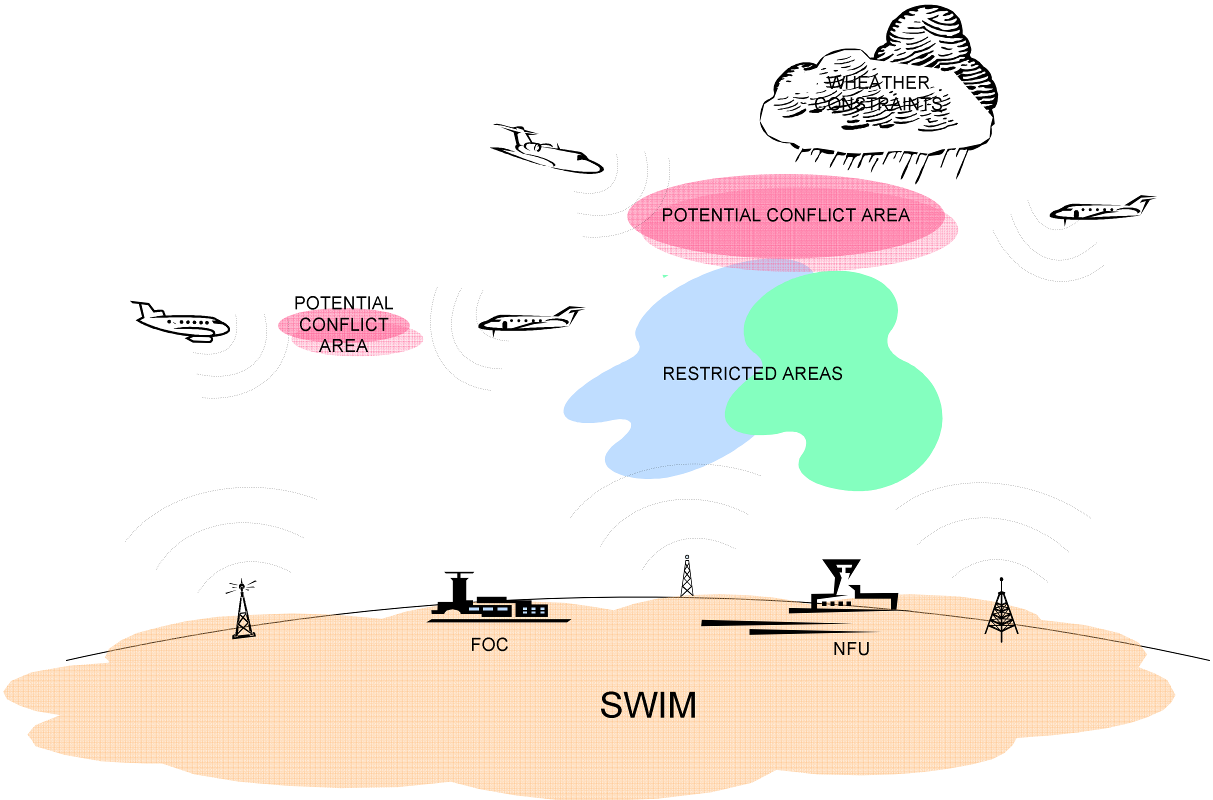

Figure 1 General Scenario

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1 Introduction

The A^3 ConOps developed in the Deliverable 1.3 describes how the full operative of the aircraft will be (focused on autonomous aircraft as defined in the A^3 ConOps), in the Self Separation Airspace. It also provides some procedures for the self separation operation and identifies the systems needed to enable the operation.

An important part of this operational concept is the identification of the enablers that will support the A^3 ConOps . Some of these enablers are ground based.

In the previous i-Fly Work Packages (especially D1.3. Autonomous Aircraft Advanced (A^3) ConOps) these systems were identified and an operative description of their functionalities was given.

The operation of the A^3 ConOps is based on the information provided by the onboard systems. However are aircraft are not working in an isolate mode as provide and receive information to/from other aircraft and ground based systems.Every aircraft will fly a Reference Business Trajectory (RBT). The Reference Business Trajectory (RBT), provides the trajectory that the airspace user agrees to fly and the service provider agrees to facilitate, maintaining separation from all other aircraft and other conflict elements, and adhering to Traffic Flow Management constraints (CTAs). This business trajectory will be updated with the support of the information provided by non airborne systems and the aircraft will broadcast their intent data based on the RBT information.

The full A^3 ConOps operation is strengthened with the support of the non-airborne systems, giving an added value to the whole A^3 ConOps scenario.

The ground system support to the A3 operation is focused on the following areas:

- Pre-flight and Flight Data. The whole information about the aircraft must be broadcasted, and used by the on board system to detect future conflicts, thus helping to optimise the business trajectories. This information will be transmitted using ground based systems.

- Ground Surveillance. The surveillance will be performed by the aircraft, but the ground systems will support them in the surveillance activities. These systems will help to confirm the information provided by the on-board systems.

- Robust and geographically – wide network. The information identified in the previous points can not be transmitted without the support of a network that gives timely information to the users.

- Information transmitted by Ground network will be trusted and reliable. It has to be clear that the information is degraded during the transmission by the network.

Aircraft flying in autonomous mode using non airborne systems is expected to provide its functionalities to improve the operability scenario.

1.1 Deliverable D8.4 Scope

WP8.4 produces a deliverable that collect Non-airborne Requirements which will be useful to support A^3 equipped aircrafts operation in the self separation airspace.

The deliverable produces a report from the non-airborne operations perspective. The objective is to identify and to define requirements of the systems that support the A^3 ConOps operation.

Non-airborne requirements cover systems and activities that are performed during en-route phase.

Following a bottom – up approach the next figure gives information of the steps covered.

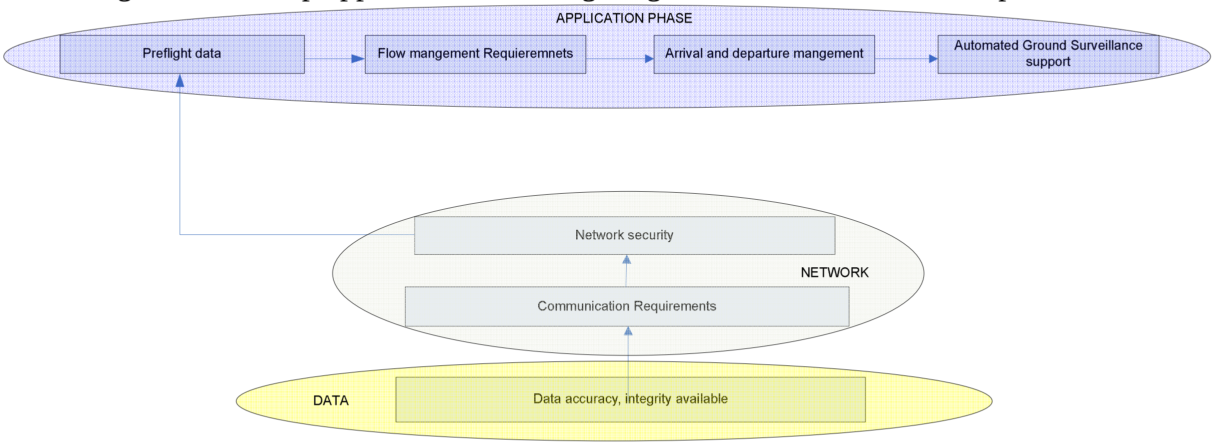

Figure 2 Methodology 8.4

1.2 Organisation of this report

Deliverable 8.4 report is organised in the following sections:

- Section 1– Introduction and scope:
  This section gives a description of the objectives of this Work package offering a high level description of the scope of the non airborne activities that support the A3 ConOps, Section 1.1-D8.4 scope. This section gives a description of the deliverable with a brief description of the methodology used to reach the objectives of this Work package.
- Section 2 Data. Identifies the Data requirements, which enable the iFly operation.
- Section 3 Communications. This section gives a description of the communication in the A^3 ConOps identifying the requirements needed.
- Section 4 Network security. In this section the requirements to guarantee a secure operation are provided.
- Section 5 Preflight requirements. To facilitate a safety flight the pilot will obtain the main information to facilitate an orderly flight. This information such as information of constraints and weather forecasts will be available through SWIM.
- Section 6 Flow management requirements. The Flow Manager in the A3 ConOps is responsible for performing the mid and short term the organization of all the flights, minimizing the delays in the route phase. and providing a structure to the airspace free of conflicts.

- Section 7. Arrival and departure Management. This section defines the requirements of arrival and departure management to be integrated in the collaboration decision making (CDM) process facilitating the operation of aircrafts flying in autonomous mode.
- Section 8 Automated ground surveillance support requirements. This section considers the information that can be processed by the ground surveillance systems and transmitted to the aircraft
- Section 9 concluding Remarks. This section will give the main conclusions in the activities done in the previous paragraphs

2 Data Requirements

The core of a safe and secure operation is the information transmitted through the communication network. The consequences of unreliable data are unsafe operations.

In general terms, data are used in whatever environment to deliver reliable information about the systems or pieces of equipment under control**.**

Data transmitted are:

- Aircraft Identification
- Current Position (coordinates, altitude and possibly velocity i.e. speed as a vector)
- Local meteorological information, (temperature, pressure, …)

It is recognised that the future of the communication in the ATM should follow an increase in the transmitted data while, at the same time, diminishing the workload of the air-crew and air traffic controllers involved in the process.

2.1 Data Communications in the A^3 ConOps

One of the main strengths of the A^3 ConOps is that it increases the autonomy of aircraft, delegating the separation responsibility to other aircraft, while trying not to increase the work load of the aircrew. However, to reach these objectives the development of an efficient data communication system is needed.

It is expected that the ground segment will hold a large traffic of general information about the situation of the air-space, constraints, restricted areas, weather conditions, etc.., and information about the aircrafts, RBT, updated RBT, aircraft situations or intent data.

The data must provide at least an unambiguous description of the information transmitted, (current position, weather conditions, etc…), must clearly identify the entity (aircraft, FOC, NFU, ANSP) to which the data are transmitted and the date and time by which the data are to be provided for AIP data and only the time in case of surveillance data, to be used in CD&R.

2.2 Data Requirements in A^3ConOps

Data will be transmitted through the communications network. To provide this service, general requirements about the technical data have to be defined.

2.2.1 General Requirements

1. REQ-DAT-GEN-1. The package data will be the unit to transmit the information.

2. REQ-DAT-GEN-2. The information must be transmitted without technical barriers, for an open system.

3. REQ-DAT-GEN-3. The information must be available for the all the actors involved in A^3 ConOps systems.

4. REQ-DAT-GEN-4. The information transmitted will provide with the information needed for safety A^3 ConOps flight.

2.2.2 Environment Requirement

The data must be adapted to a general environment and be easily understandable by all systems. The characteristics of those are:

1. REQ-DAT ENV-1. All surveyed data shall be referenced to WGS-84.

2. REQ-DAT ENV-2. A geoid model shall be used in order to express all vertical data (surveyed, calculated or derived) in relation to mean sea level via the Earth Gravitational Model 1996.

3. REQ-DAT ENV-3. Surveyed, calculated and derived data shall be maintained throughout the lifetime of each data item.

4. REQ-DAT ENV-4. Surveyed data categorised as critical or essential data shall be subject to a full initial survey, and thereafter shall be monitored for changes.

5. REQ-DAT ENV-5. The electronic survey data as reference point coordinates and raw data shall be captured and storage digitally:

6. REQ-DAT ENV-6. All survey data categorised as critical data shall be subject to sufficient additional measurement to identify survey errors not detectable by single measurement.

7. REQ-DAT ENV-7. Aeronautical information shall be validated and verified prior to its use in deriving or calculating.

2.2.3 Data Quality Requirements

Quality requirements for a data item within the scope of aeronautical data shall be established based on a safety assessment of the intended uses of the aforementioned item.

1. REQ-DAT-QUAL-1. - Where a data item has more than one intended use, only the most stringent data quality requirements, arising from the safety assessment, shall be applied to it.

2. REQ-DAT-QUAL-2. - Data quality requirements shall be defined to cover the following for each data item within the scope of aeronautical data and aeronautical information

   (a) The accuracy and resolution of the data item;
   (b) The integrity level of the data item;

(c) The ability to determine the origin of the data item;
(d) The level of assurance that data is made available to the next intended user prior to its effective start date.

3. REQ-DAT-QUAL-3. - All of the data items needed to support each application data set or a valid subset of the data set shall be defined.

3 Communication Requirements

Current air traffic management relays on the support from a communication network that can be used to provide with much needed information and services needed in the flight management.

Nowadays the activity in communications is done in the air – ground segment through voice communication channels between the aircrew and the controller. However, broadcast formats are being developed, which in turn may lead to new functionalities, unloading work load from the actors involved.

In the SSA, communications will be mainly based on data exchange and “data links”. The voice communications will be used as last resort to support the conflict avoidance manoeuvres.

3.1 Communications in the A3 operation

The A^3 ConOps concept relies on a high capacity COM infrastructure capable of transporting the high amount of data that needs to be exchanged between the different actors that provide information and use the different ATM services. The data link is considered as the main element to interchange information.

The following figure provides graphic information about the communications in the A3 environment. The communications in the A^3 ConOps will be based on the exchange of information between the different actors involved to facilitate the autonomous flight.

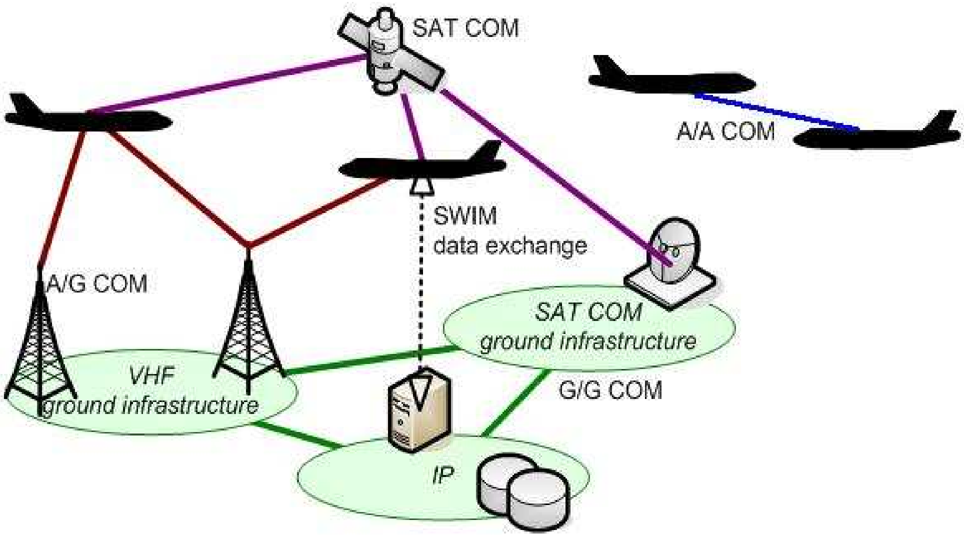

Figure 3 A^3 ConOps Communications

In this figure the elements in green shading are the on-ground ones considered in this document.

In the following paragraphs the communication requirements will be identified.

3.1.1 Type of Communications

Communication will mainly consist on data exchange, but voice transmission can also be employed. Data communications will be based on the exchange of information in the air – ground segment and between aircrafts (air - air).

In the first case the information can be broadcasted or transmitted point to point. The following table presents the main services provided by the communication considering its mode (broadcast or point to point) and its type. This table is focussed only on the air – ground segment, because the requirements for the air – air data exchange are out of the scope of this document.

DATA COMMUNICATION -Air / Ground Communication	
Broadcast	State and intent data
	Constraint areas / Areas to avoid
	Weather information
Point to point	State data (on request)
	Intent data (on request)

Table 1 Type of Communications

3.1.2 Air - Ground Communication

The air – ground communication will be held between the aircraft and the others actors that provide aeronautical information.

The communication types will be:

3.1.2.1 POINT TO POINT COMMUNICATIONS

These communications will be established between the aircraft and different aeronautical information services. In the case of point to point communication the information will be required by any of the actors, usually requested from ground.

Aircraft can demand information about position of other aircraft. This information can be:

- State Data. Individual aircraft can demand information to confirm the position of other aircraft. The information provided will consist on the position (latitude, longitude, flight level, time). This information will be updated with that provided by the different aircraft. These data must be updated with a period of less than 1 minute. this information will be saved and updated to be used by other actors. The aircraft will send state data to FOC.

- Intent Data. This information will update the data about the RBT of other aircraft. This information will be used to confirm and update the trajectories to identify possible conflicts. These data must be updated with a period of 5 minutes at least.

The communication will use ACARS protocol, which is currently working.

3.1.2.2 BROADCAST DATA

This way of communication will be used to transmit information needed by a lot of aircrafts. This information can be:

Constraint areas / areas to avoid.

These data will provide information of the structure of the operative airspace. This information will be used to improve the RBT of the aircraft.

- Areas to avoid: restricted areas. This information will be provided every time a new restriction in the airspace appears.
- Constraint Areas. These are the areas with restrictions identified,

The protocol used will also be ACARS.

The information provided will be about the location size of the area an duration of the restriction.

3.2 REQUIREMENTS

In the following paragraphs the requirements for the different type of communications are developed. The first division will be between data and voice communications. The type of data communication has been previously identified in the table above.

All the communication will have to meet the following requirements.

- REQ-COM-1. The systems on ground will be able to receive the information transmitted from the aircraft and send it to the end-users.

- REQ-COM-2. The communication systems must be able to assure that the ground based systems are connected and ready.

- REQ-COM-3. The communication network will be able to transmit all the information sent by the users of the system.

- REQ-COM-4. The ground based systems must be ready as long as needed by the operation in the airspace.

- REQ-COM-5. Communications must assure the level of safety needed in:
    - Data integrity
    - Robustness of the communication
    - Reliability of the information transmitted

- REQ-COM-6. The communication between the systems must be secure; the systems must be able to avoid any external attack.

- REQ-COM-7. Communications must be resilient to attacks on confidentiality, availability, integrity or non-repudiation.

- REQ-COM-8. The system must be resilient to delays or service interruption caused by network congestion or transmission errors on the physical layer.

- REQ-COM-9. Any type of aeronautical communication should have the property of being able to be transmitted. Voice, data (both open or encrypted), …

4 Network security

4.1 Introduction

Historically network security has been a complicated subject, only addressed by computer specialists; however as more and more people is becoming “wired” a more diverse group of users needs to understand the basics of network security. This is especially true in the context of i-Fly project as the introduction of the SWIM system in the A^3 ConOps incorporates an important network component to the concept, thus rendering the security of such a network a relevant issue.
Let us first define the concepts of network and security.

Network: A network is “any set of interlinking lines resembling a net” [1].

Security: A combination of measures and human and material resources intended to safeguard civil aviation against acts of unlawful interference[2].

Both definitions combined lead to a specific definition of network security (often recognised as information security) consisting on the provision of protection at the boundaries of an organisation by keeping out intruders, protecting data resources from attacks or simple mistakes by people within an organisation, by using data loss prevention techniques.

4.2 Communications Network within i-Fly

In the context of the i-Fly project, the organisation mentioned in the definition includes the actors participating in the A^3 ConOps operations:

- A^3 ConOps equipped aircraft with flight crews and their respective FOC
- ANSP (to coordinate departures and arrivals with FOC)
- Non-FOC airspace users
- SWIM
- Datalinks and their associated communication infrastructures such as VHF ground infrastructure, SATCOM ground infrastructure, SATCOM and ground network servers (Internet servers) [3].

Since the scope of the present document, D8.4, is limited to non-airborne equipment, the first bullet will not be considered completely, i.e. the A^3 ConOps equipped aircraft will not be addressed nor will the flight crews. However as FOC track the operation of their fleet through SWIM[4], which both are non-airborne actors, they will be considered within this document.

The next step needs to specify the non-airborne requirements for network security, in order to identify the type of information that will be exchanged through the network and the actors involved in such exchange.

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[1] The New Lexicon Webster’s Encyclopedic Dictionary of English Language. New York: Lexicon
[2] ICAO Annex 17. Security. Definitions. 7th Edition
[3] See figure 9.1 Overview of Communications data links considered in A^3 in i-Fly Deliverable 1.3 Autonomous Aircraft Advanced (A^3) ConOps v3.0, 29th January 2010
[4] i-Fly Deliverable 1.3 Autonomous Aircraft Advanced (A^3) ConOps v3.0, 29th January 2010

According to i-Fly Deliverable 1.3 Autonomous Aircraft Advanced (A^3) ConOps, the communications systems will be utilized for:

- Request for flight/trajectory changes
- Data exchange for distributed decision making
- Digital audio/video transmissions
- Shared data exchange with SWIM

In all cases information will be mainly exchanged between FOC and A^3 ConOps equipped aircraft through SWIM. As information will be available in SWIM, other actors such as ANSP, other A^3 ConOps equipped aircraft and their respective FOC may have, at some time, eventually access to the information to assess whether a long term conflict detection and resolution process needs to be started. The information sharing between FOC, ANSP and SWIM will be made through the ground network servers (e.g. based on Internet Protocols IPv6 or higher).

In certain cases, such as emergency situations, information from any ground based actor, such as FOC or ANSP, will be transmitted to aircraft through a voice channel that will make use of ground infrastructures as VHF or even SATCOM[5] and its associated SATCOM ground infrastructure.

4.3 Network Threats

Every type of information being exchanged in the A^3 ConOps is subject to a set of threats related to information protection[6] or misuse with the intention of commit an act of unlawful interference[7]. The most common and damaging threats are the following:

- Denial of Service (DoS): In this threat the attacker sends more requests to a host machine than it can handle. In the context of i-Fly, an example would be an attacker sending requests continuously to connect to SWIM until it is saturated (e.g. if SWIM would be capable to accept 20 requests per second, the attacker would send 50 per second). SWIM would not be capable to service all the attacker’s requests, much less any legitimate user.

- Unauthorized access: the goal of this threat is to access some resource that the host machine should not provide the attacker. This threat can be split into:

    - Executing Commands Illicitly: The attacker is able to execute commands on the host machine, either as a normal user or as administrator.
    - Destructive behaviour: the attacker can, through an authorised access, either modify (data idling) or destroy (data destruction) information.

[5] See figure 7.3 In-flight Traffic FOC Monitoring Scheme in A^3 in i-Fly Deliverable 1.3 Autonomous Aircraft Advanced (A^3) ConOps v3.0, 29th January 2010
[6] Introduction to Network Security. Matt Curtin. March 1997
[7] ATLANTIDA Security Risk Assessment v2.0. De la Fuente, S., Bueno, J. ATLANTIDA Project, May 2010.

In order to counteract these threats and make the i-Fly concept more secure, in i-Fly Deliverable 1.3 Autonomous Aircraft Advanced (A3) ConOps some high level requirements to network security were given. These requirements were:

- For every transmitted piece of information a different digital data encoding shall be used.
- Data encoding and transport issues cannot be delegated to ground. Communicating peers shall collaborate on it.
- When Commercial-Of-The-Self (COTS) products (like internet protocols) are used, communications shall be resilient to DoS and unauthorised access attacks.

4.4 Network Security Requirements

In addition to the above requirements, this section provides an overview of network security expected functionality, focusing on user-driven requirements.

The network security infrastructure requires a rich security framework permitting:

- Authentication – ability to verify the digital identity of the sender of communications such as a request to log in.

- Authorization – determines if a previously authenticated user is permitted to perform a given operation (e.g. access to data in the network, publish data in the network, invoke a service of the network).

- Confidentiality - protects messages or documents so that they cannot be made available to unauthorized parties.

- Data Integrity - provides protection against unauthorized alteration of messages during transit.

- Non-repudiation - ensures that a sender cannot deny a message already sent, and a receiver cannot deny a message already received. (Non-repudiation is especially important in monetary transactions and security auditing).

- Accountability - Provides secure logging and auditing. (Supports non-repudiation.).

- Resource Management – ability to monitor and manage communication resources (protocols, ports, IP addresses, etc.).

4.5 REQUIREMENTS

Given the nature of the i-Fly concept, and the wealth of data and the number of stakeholders, these requirements can be classified in the following areas:

- Users management
- Certificates and communication management
- Access right management
- Network governance and security monitoring

Moreover the requirements applicable to each area have been categorised as mandatory (for the sake of the network security the requirements need to be implemented) and desirable (the requirements are not really necessary to be implemented but they could be).

4.5.1 Users Management

- REQ-SEC-1. The network security service shall offer functionality for authentication, authorization, confidentiality, data integrity, non-repudiation, accountability and resource management.

- REQ-SEC-2. The network security service shall offer fine-grained access control mechanisms allowing user access to be defined at the data item and attribute level.

- REQ-SEC-3. The network security service shall offer a rich functionality for the definition of user (and associated attributes), and their classification into groups, roles, and organisations.

4.5.2 Certificates and Communication Management

- REQ-SEC-4. The network shall enforce separation of security domains.

- REQ-SEC-5. The network shall protect assets from denial of service.

- REQ-SEC-6. The network shall enforce secure import and export of authorized information into and out of its security domain.

4.5.3 Access Rights Management

- REQ-SEC-7. Access Control criteria may be based upon (a) assigned roles or (b) on some dynamic characteristic of the data being accessed – for example (i) geographical locations (ii) time (iii) value of a given attribute.

- REQ-SEC-8. The network shall offer guaranteed levels of data security, ensuring that commercially sensitive information, provided by competing businesses, remains segregated.

- REQ-SEC-9. The network shall grant access to all infrastructure services, services, data, dynamics (e.g. transactions, events, logs) in accordance with member identification and security service access privileges.

4.5.4 SWIM Governance and Security Monitoring

- REQ-SEC-10. The network shall uniquely identify and log all accesses to infrastructure services, services, data, and dynamics.

- REQ-SEC-11. The network governance shall establish, enforce and monitor network security policies.

- REQ-SEC-12. The network shall publish network service security policies for design-time implementation and run-time monitoring.

- REQ-SEC-13. The network shall formulate and issue run-time service security alerts.

5 Pre-flight requirements

The pilot-in-command has the final responsibility to make sure that flight preparation is complete and conforms to all requirements, and is required to certify flight preparation forms when satisfied that the aircraft is airworthy, and that other criteria are met in respect to instruments, maintenance, mass and load distribution (and the securing of the loads), and operating limitations of the aircraft.

Prior to any flight the pilot has to obtain all information to conduct a safe and orderly flight. Among these are necessary information regarding particularities concerning the airspace to be used and weather forecasts which shall be made available through SWIM. The information that the pilot has to obtain also includes up-to-date maps and an airport directory, which will help to prepare the flight in terms of flight duration estimation and thus the necessary fuel load according to the aircraft performances and the intended trajectory to be flown.

Prior to a flight the pilot in charge also has to read all the relevant NOTAM for the planned flight. NOTAM contain information e.g. about closure of runways, activation times of airspace restrictions and other. NOTAM are published by the responsible authority of each country in a special format and in English language. NOTAM shall be made available, by those authorities in electronic format, including up to date information and accessible via the SWIM network.

Pilots need also to know weather information related to the trajectory to be flown. The weather information is obtained from the responsible aeronautical meteorological service in each country. The activities of the aeronautical meteorological service are regulated in compliance with the provisions of the International Civil Aviation Organization (ICAO) and of the World Meteorological Organization (WMO). Responsible authorities shall introduce up-to-date meteorological information in the SWIM network to allow an efficient trajectory planning.

In addition, the Aeronautical Information Service (AIS) assists during pre-flight planning by checking and forwarding all pieces of information that may be necessary for a safe, orderly and expeditious conduct of flight.

5.1 Non-airborne requirements for Self-separating Airspace

In the context of the i-Fly project, A^3 ConOps equipped aircraft will most of the time conduct the flight in the SSA, although for take-off, landing and descent and approach phases in the Terminal Manoeuvring Area (TMA) A^3 ConOps equipped aircraft will share airspace with less advanced aircraft in an air traffic control environment (Managed Airspace). Thus, they need to comply different requirements, mainly those developed within SESAR or any further development to be made for those flight phases different to the A^3 concept[8].

Self separating airspace is all airspace where boundaries are defined in time and space by the dynamic allocation of managed (separator: ANSP) and unmanaged (separator: airspace user)

[8] An A^3 flight is defined as the flight between a departing TMA exit point, and an arriving TMA entry point, constrained by a Controlled Time of Arrival (CTA) at the arriving TMA entry point.

airspace. In this airspace autonomous A^3 ConOps equipped aircraft are responsible for separation and requires that all aircraft are visible to the separator. [9]

All aircraft operating or planned to operate in SSA share their flight data, including trajectories. The trajectories represent the business intentions of the airspace users. The business trajectories will be described as well as executed with the required precision to perform a safe flight.

Thus, in order to allow a conflict free trajectory and to enable trajectory replanning in case any conflict arises during the flight phase in the SSA, additional data that are not currently included in the flight plan are required. Changes to the flight planning system are required, for instance to incorporate information about the type of flight such as autonomous flight rules (AFR) or information about the advanced equipment of the A^3 ConOps equipped aircraft. Initial trajectories, and further changes, shall be made available in the SWIM network to allow Collaborative Decision Making (CDM) flow management process with Flight Operation centres (FOC).

With newer and advanced aircraft and systems, an aircraft's flight management system will be able to calculate the most advantageous trajectory for each flight and then down link these preferences to SWIM. Current systems are unable to make use of this information, and fleet equipage is not sufficient to deploy procedures to accommodate these advances. The term trajectory is utilised here to convey the idea that a flight planned route is richer in information that can be useful to every flight crew and FOC in planning separation. Information such as rates of climb and optimal power settings can be applied to aircraft performance models to more accurately predict an aircraft's time over any point en-route, necessary for planning tools and conflict detection and resolution (MTCD&R and LTCD&R) algorithms.

While the aircraft operator is today always aware of the manner in which he intended to operate his aircraft, in the future other aircraft operators will also be provided with more accurate estimates of future position or other aircraft allowing a most accurate planning of conflict free trajectories.

The evolve flight planning within the SSA airspace will:

- Provide specified information to every partner related to an intended flight or portions of a flight of an A^3 ConOps equipped aircraft;

- Provide reliable information leading to a more robust Operations Planning.

- Common flight data including the profile of the flight, accurate flight forecast data, meteorological data that conditions the flight profile and constraints will enable sharing to collaborate with the Airspace Users in optimising the conflict free trajectories;

- When any event is seen to require modification to the operations the effects of this change will be investigated collaboratively and automatically through algorithms, and solutions agreed;

[9] i-Fly Deliverable 1.3 Autonomous Aircraft Advanced (A^3) ConOps v3.0, 29th January 2010

- Ensure the consistency of the information used by different participants and provide the flexibility to be able to resolve identified problems efficiently and equitably.

In order to satisfy contiguous planning, collaborative decision-making and network management, more precise information about the flight, including trajectory data, needs to be shared between participants in flight operations within the SSA. Technical advances in networking and database servers are the essential enablers of the new flight data sharing environment within SWIM. The goal is that all partners will share trajectory information in real time to the extent required from the earliest trajectory development phase through operations and post-operation activities. Trajectory planning, collaborative decision making processes and tactical operations will always be based on the latest trajectory data. A trajectory integrating airspace constraints (adverse weather, restricted airspace areas) is elaborated and agreed for each flight, resulting in the trajectory that a user agrees to fly. This ensures that both the airborne systems and ground systems (e.g. surveillance systems) can build and maintain an identical view of the trajectory and its details using the shared information environment.

The trajectory management concept entails the systematic sharing of aircraft trajectories between various participants in the process to ensure that all partners have a common view of a flight and have access to the most up to date data available to perform their tasks. The A^3 concept therefore assumes the existence of a standardised trajectory sharing capability that is mediated by collaborative processes. The information to be shared will be more extensive than that which is carried in today’s flight plan messages, including both trajectory information and non-trajectory related information about the flight such as equipment, status, airframe identification, flight rules, etc. as required and appropriate.

The ability to generate trajectories in the SSA from flight plan data will be retained for those flights that are unable to comply with AFR in SSA requirements. For flights which will take place wholly or partly in the SSA, the traditional filing of flights plans is replaced by the action of sharing the information required about the flight, making it accessible for all concerned in accordance with predetermined rules.

5.2 REQUIREMENTS

The following is a list of the non-airborne pre-flight requirements.

- REQ-PFL-1. Aeronautical and flight information shall be made available by responsible authorities in the SWIM network.

- REQ-PFL-2. Up-to-date meteorological information shall be made available by responsible authorities in the SWIM network.

- REQ-PFL-3. A map and airport directory shall be made available by responsible authorities in the SWIM network.

- REQ-PFL-4. Provisions should be made to allow the inclusion of Autonomous Flight Rules (AFR) as a new type of flight in the pre-flight information provided by pilots to

ANSP. When an aircraft declares its type of flight as AFR, this information shall be made available in the SWIM network.

- REQ-PFL-5. Initial trajectories shall be made available by FOC in the SWIM network.

- REQ-PFL-6. Ground systems including SWIM should enable the reception and management of information required for planning and conflict detection and resolution tools such as rates of climb, optimal power settings, etc.

- REQ-PFL-7. There shall exist a standardised trajectory sharing capability that is mediated by a collaborative process, both for trajectories delivered before and during the flight takes place.

6 FLOW MANAGEMENT REQUIREMENTS

The Flow Manager is the entity responsible for performing the mid and short term the organization of all the flights within the airspace under its responsibility in order to achieve a safe and smooth air traffic flow, minimizing the delays in the route phase. Therefore its aim is to provide a structure to the airspace no conflict, for each flight the entire Shared Business Trajectory (SBT) is scheduled to be a traffic conflict-free, understanding that the SBT will be a deconflicted trajectory provided by the Flow Management for a given day.

6.1 FLOW MANAGEMENT IN A^3 ConOps

The A^3 ConOps only focuses on the en-route phase of flight; therefore the flow management requirements will be defined for the en-route phase.

The following paragraphs are devoted to the identification of the requirements for the air traffic flow management in the Self-Separation Airspace (SSA) for flights having reference business trajectories and ensuring their own separation from other aircraft and other conflict elements. The main source has been the deliverable D8.2, this document describing the activities of a distributed flow management in the A^3 ConOps airspace.

To define the requirements of Air Traffic Flow Management (ATFM) within self-separation airspace must be consider:

- The amount of aircraft flying in a certain airspace will depend of the actual restrictions (bad weather, constraints areas...).

- The self separation will be able to handle efficiently when the traffic density is below a certain limit.

- The trajectory information will be updated with the data information from the RBT.

- The airspace information will be based on the information provided in real time by aircrafts and airlines.

- The strategically no conflict routes will be used for the trajectory planning through flow restricted airspace aircraft operating in SSA use self-separation.

- The flights will be responsible themselves to handle specific weather conditions.

- The flow office will manage the RBT for re-route the trajectories around restricted areas.

6.1.1 Transition Operations

Transition operations involve the movement of aircraft from one airspace to another airspace. Two specific variants are discussed here.

- The transition from managed airspace to self-separation airspace.
- Vice versa the transition from self-separation airspace to managed airspace.

6.1.1.1 Transition from managed airspace to self-separation airspace

An aircraft exiting managed airspace into self-separation airspace will do the following actions at a specific Managed Airspace (MA) exit point.

The ANSP will be in the loop. The ANSP will be responsible of:

- The ANSP of the managed airspace will be responsible for both separation and flow management for the aircraft inside their MA.

- It is therefore that the ANSP will issue and update the exiting restrictions in order to maintain safe and efficient operations inside the managed airspace.

- The ANSP has to ensure that the business trajectory will be conflict free for a limited time when exiting managed airspace.

As the ANSP is not responsible for active separation control in self-separation airspace this means that the ANSP has to ensure the separation in another way.

Only the aircraft exiting from the managed airspace are allowed to enter the restricted airspace.

- Aircraft within self-separation airspace are not allowed to enter the restricted airspace or have to leave the restricted airspace as soon as it has become active.

6.1.1.2 Transition from self-separation airspace to managed airspace

An aircraft exiting self-separation airspace into managed airspace will do this at a specific MA entry point.

The ANSP will be responsible of the following actions.

- The ANSP of the managed airspace will be responsible for both separation and flow management for the aircraft inside their MA. Therefore the ANSP will issue and update the entry restrictions in order to maintain safe and efficient operations inside the managed airspace.

- The ANSP must always have the option to not allow traffic into the managed airspace at the last minute due to operational reasons. This means that the transition from self-separation airspace to managed airspace must allow for an a broad manoeuvre which can safely be executed. In other words, a strategically deconflicted broad route within the transition region back into the self-separation airspace is needed.

6.2 OPERATIONAL REQUIREMENTS

The strategic flow management process has a number of phases it goes through. It starts with pre-flight in the medium and short term. Once in flight the flow management process continues as the availability of airspace cells and trajectories change constantly over time. The main activities to perform in each phase are.

- In the medium term the shared business trajectories will be initially collected.
- In the short term the shared business trajectory will be updated to reflect new scheduling information and availability of weather forecast.

The ATFM in self-separation will provide information of how:

- To place constraints on the flight plans of aircraft to ensure that the medium and short term conflict resolution systems will not be faced with a situation that they cannot handle.
- To place constraints on traffic towards managed airspace entry points.
- To maximise overall performance of global operations in self-separation airspace.

The ATFM can not enforce any route compliance, but only the timing restrictions for a certain area or exit point.

The main function of ATFM will be:

REQ-FMA-1. To be aware of high complexity or high density areas in self-separation airspace.

REQ-FMA-2. To determine an applicable flow management restriction area for regulating high density areas.

REQ-FMA-3. To be able to limit traffic to the high complexity or high density area to acceptable levels by applying fair restriction rules.

REQ-FMA-4. To schedule traffic to the flow management restriction area in such a way that it complies with priority rules.

REQ-FMA-5. To identify the need for having strategic flow free of conflict in the flow management restriction area.

REQ-FMA-6. To identify the applicable no conflict routes through the flow management restriction area.

7 Arrival and Departure Management

The flight can be considered as an integrated operation consisting of different phases, such as "airport taxi, takeoff, flight, terminal area, en route, terminal area landing and airport taxi" there is a strong correlation and influence each phase.

Currently the arrival management and the departure management analyse the activities in the airport scenario improving the ground aircraft operations and the coordination between actors to provide services and efficiency to meet the objectives in declared the time.

In some airports, tools are in use to help this management, as the A-MAN and D-MAN. These tools can be integrated in the collaboration decision making (CDM) process.

In the following paragraphs the influence of this process in the A3 flight management is identified.

7.1 Arrival and Departure Management in the A^3 operations

One of the main challenges during the flight phase is gaining the ability to reach the objectives and perform an optimum trajectory, mainly when the aircraft is flying in airspace with restrictions. To identify the different areas of flight we define the following:

- Restricted Area. - This area is identified in the A^3 ConOps, corresponding to a forbid area of over flight. It is part of the SSA but can not be used in the usual operations.
- Constrained Area. - This area is fully operative but it has been need to implement flow time restrictions, due to an increase in the number of operations.

The airspace will be divided at least in three different type areas:

- The unmanaged airspace.
- High density areas – managed areas
- Self separating airspace (SSA).

The main pass points will be between the SSA and the managed areas. The pass from one area to other must be coordinated and synchronized with the different actors to avoid conflicts and potential delays in the RBTs of the aircrafts.

The optimum management of the ground operations will help the operations of the trajectories, optimizing the airspace availability. This management must differentiate the operations on arrival from the operations on departure. The following are the operation times in several phases of the on ground operation.

- For departure, the takeoff time is defined.
- For arrival, the operations of taxiways and the apron area are defined.

These operations will have a direct impact in the management of the RBT, mainly in the phases of arrival and departure of the controlled areas.

In the tactical phase the SBT of the aircraft is defined. This trajectory will have several defined times to pass by constraints points. Two characteristic points in the trajectory are those related to the entry to managed airspace. One of these entry points corresponds to the phase when the aircraft leaves the TMA and penetrates the SSA, and the other one to the phase when the aircraft goes into the managed airspace. Therefore is possible to define:

- Schedule Time of Arrival (STA). It is the time defined in the arrival phase, when the aircraft is starting the approach stage.
- Schedule Exit Time (SET): It is the time defined when the aircraft is in departure phase, leaving the MA and go in to the SSA.

The RTB identifies the pass time at the constraint point, but the target time is defined only when approaching the border with the managed airspace. There is a different target time for every constraint point. As can be seen, schedule and target times are not the same.

- Target Arrival Time (TAT). Defined for the entry point to the managed airspace.
- Target Exit Time (TET). Defined for the exit point from the managed airspace.

These times, defined in the RBT, will provide the A-MAN and D-MAN with tools that deserve to be considered for the trajectory management. The target is to give a pattern that helps in the management of trajectories near the constraints points in order to aid to the decision making, as for example with the priority issues. These data will be given by the FOC and NFU.

When the aircraft is in the execution phase, the objective is to pass by the constraint points in the time defined in the previous phases. In this phase the estimated time will be used. The objective is that the estimated time comes to agree with the target time defined for that point. Two different times are considered:

- Estimated Arrival Time (EAT) It is the time defined by the real and operative conditions of flight (delays…).
- Estimated Exit Time (EET). It is the time to leave the MA, considering the operative conditions of flight.

This information will be provided by the aircraft to the A-MAN and D-MAN, these tools defining the following processes (A-MAN and D-MAN) to reach the times defined.

The next figure is a graphic description of the process.

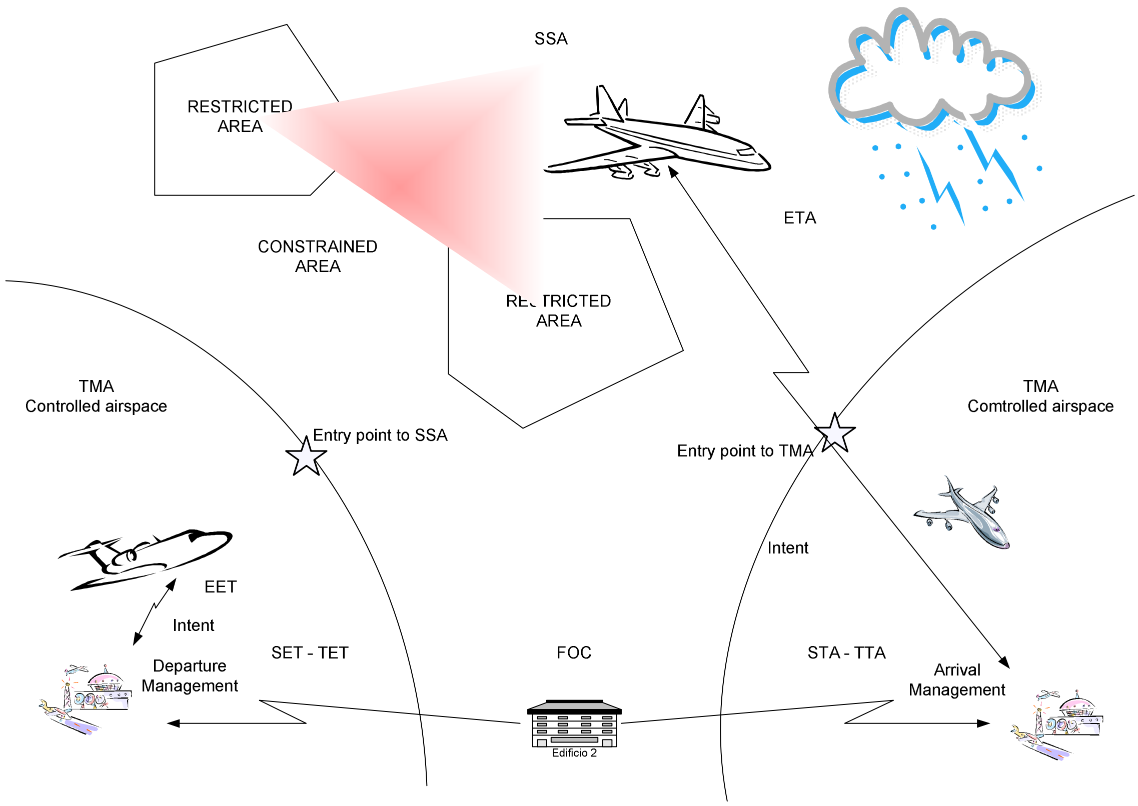

Figure 4 AMAN DMAN in iFly

7.2 REQUIREMENTS

The main requirements identified are:

REQ-MAN-1 When two aircraft have the same ETA, priorities will be applied to them at the entry points.

REQ-MAN-2 The estimated times will only be updated if there is a variation in the value.

REQ-MAN-3 In the initial state the estimated value must be equal to the target value.

REQ-MAN-4 The D-MAN and A.MAN will analyse the input times, giving the future CTA.

REQ-MAN-5 The definitive EAT must be agree with the CTA of the system.

REQ-MAN.6 The A-MAN will consider whether the capacity of the managed airspace is exceeded, before allowing more aircraft in the TMA.

REQ-MAN.7 The D-MAN will detect when the managed airspace is overload or saturated. In this case no new entry slots into the managed airspace will be given.

8 Automated ground surveillance support requirements

One of the tasks that controllers currently perform is that of “surveillance” of the airspace. To carry out this activity it is needed to use equipment and techniques that can provide information about the situation of the airspace.

Surveillance tries to go a step forward to foresee possible conflict situations, in which the controller gives orders to help to the aircraft involved.

The Automated Dependence Surveillance (ADS) tries to get direct information about the actors involved in the process. The information is provided by the aircraft flying in the airspace, thus obtaining it first hand from the different actors.

8.1 AUTOMATED GROUND SURVEILLANCE SUPPORT REQUIREMENTS IN IFLY

The iFly surveillance is based on a fully collaborative operation scenario.

Surveillance is based on the information provided by the actors involved in the flight process; aircraft provide their own information about other aircraft, weather conditions, etc. This information is processed by the ground surveillance systems and broadcasted to the aircraft or distributed on a case by case basis when requested.

The surveillance in the short term is performed by the aircraft’s on-board systems; these systems will identify and resolve the potential conflicts.

In the mid and long term, the on-board systems will resolve the potential conflicts supported by the information provided by on-board complex systems that will analyse.

To perform ground surveillance activity, ground systems shall be in the loop with the updated information of the airspace situation. Information will flow between the aircraft and ground systems and from these systems to the aircraft.

The transition area from SSA to controlled airspace is out of the scope of these requirements. Therefore the requirements will be only in the en-route phase.

In the following paragraphs the requirements for this ground equipment are defined.

8.1.1 Surveillance To Mid Term

The main process to detect and resolve conflicts in the mid-term will be based on the on-board equipment, the ground segment will be equipped with tools that will help the aircraft to resolve the potential conflicts.

Basically the information flows from the SWIM system to the traffic proximity detection and later to the aircraft.

This system will provide information about how the airspace in the mid term will be. This information will be transmitted to the aircraft, and the on-board systems will process the information to detect potential conflicts in the mid term.

The main source of information for the ground system will be based on the aircraft intent information transmitted from each aircraft and the updated reference business trajectory of the aircraft.

8.1.2 Surveillance To Long Term

The technical functionalities of these systems are similar to the system surveillance devices (mainly radar) for mid term.

The information flow has inputs from the FOC and NFU that will provide the RBT information from each aircraft and the results will be uploaded in SWIM for its transmission to the aircraft.

8.2 REQUIREMENTS SURVEILLANCE.

The ground systems requirements shall be based on the type of information provided to the on-board system and the reliability of this information.

REQ-SUR-1. The ground systems shall have the contractual RBT with the updated information provided by the aircraft.

REQ-SUR-2. The ground systems shall notify the aircraft of all the real traffic existing in MTAZ.

REQ-SUR-3. The ground systems shall be appropriately equipped to provide aircraft with reliable information about congested or complex areas.

REQ-SUR-4. The ground systems shall check the status of communications through the following messages:

- When the aircraft agrees with the current RBT, it shall send a “RBT conformance” message.
- If an aircraft detects a loss of conformance with its RBT, it will send an alert message and its status changes to “RBT non-conformance”.
- If an aircraft is not able to comply with its nominal RNP, it will send a “Nav systems deteriorated”.

REQ-SUR-5. Air data forecasts shall be broadcasted to all aircraft and uploaded to SWIM, so that every actor has access to them when needed.

REQ-SUR-6. The ANSP shall issue airspace restrictions in the form of areas to avoid and shall be uploaded to SWIM so that every actor has access to them when needed.

9 CONCLUDING REMARKS

This deliverable identifies the non-airborne requirements needed for aircrafts flying in autonomous mode.

The process used for the identification of these requirements is based on the analysis of information available in the iFly project and the knowledge of the operational scenario, with the performances expected in aircrafts flying in autonomous mode

To provide a reliable and truthful service facilitating the A3 operation is important to ensure the robustness of the information transmitted. These objectives have been defined to get operative requirements in the usual operation of aircrafts flying in autonomous mode.

Three layers of abstraction have been identified:

- Data Layer (DL) .This layer considers the raw data as source of information.
- Network Layer (NL). This layer considers requirements that facilitate a secure network operation, defining the segments used in the normal aircraft operation.
- Application Layer (AL). This layer identifies the requirements with a direct impact in the actors involved in the autonomous aircraft operation, aircrafts, pilots, FOCs, NFUs,

The main conclusions can be summarised in the following points.

In relation with the Data layer:

- Data have to be defined according to standards that facilitate the interoperability and the understanding between several systems participating in the A^3 operation.
- Quality of data transmission, has to ensure the safety levels required in the operation A^3 usual

About the Network layer

- Communications have be available for the actors involved in the A^3 operation.
- All elements that promote and support a safety and secure operation have to be put in place to avoid illegal acts of unlawful interference.
- Information has to be updated using the resources and elements available in SWIM.

Finally in the Application layer

- The main source of information is the RBT of the aircrafts flying in the Self Separation Airspace.
- The knowledge of the operational scenario is key to facilitate the correct operation of aircraft in autonomous mode. This knowledge only can be obtained through the data transmission. These data will facilitate the identification of problems and a normal aircraft operation

- The information provided by the RBT has to be clear, precise and reliable to avoid possible errors and misunderstandings between the actors involved in the operation.
- The information transmitted such as weather conditions, constraints, time of arrival, etc, has to be available to every aircraft flying in the self separation airspace to facilitate the safety of the operations.
- The Flow Management in the A3 ConOps has to provide information of the current situation of Airspace to support the definition and establishment of a deconflicted airspace.

I Appendix A: Acronyms List

Acronym	Definition
A^3	Autonomous Aircraft Advanced
ACARS	Aircraft Communication Addressing and Reporting System
ADS-B	Automatic Dependant Surveillance - Broadcast
ADS-C	Automatic Dependant Surveillance - Contract
AFR	Autonomous Flight Rules
AIS	Aeronautical Information Service
AL	Application Layer
AMAN	Arrival Manager
ANSP	Air Navigation Services Provider
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
CDM	Collaborative Decision Making
ConOps	Concept of Operations
COTS	Commercial Off-The-Shelf
CP	Conflict Prevention
CR	Conflict Resolution
CSZ	Comfort Separation Zone
CTA	Controlled Time of Arrival
DCB	Demand and Capacity Balancing
DL	Data Link
DST	Decision Support Tools
DL	Data Layer
EAT	Estimated Arrival Time
EET	Estimated Exit time
ECC	Error Correction Codes
EGPWS	Enhanced Ground Proximity Warning System
FFAS	Free Flight Airspace (outdated)
FMS	Flight Management System
FOC	Flight Operations Centre
GA	General Aviation
GNSS	Global Navigation Surveillance System
HF	Human Factors
HMI	Human Machine Interface
HS	Head of State
IAS	Indicated Airspeed
ICAO	International Civil Aircraft Association
LoC	Lines of Change
LTCD&R	Long Term CD&R
MA	Managed Airspace
MTAZ	Medium Term Awareness Zone
MTCD&R	Medium Term CD&R
NFU	Non-FOC Airspace User
NL	Network Layer

Acronym	Definition
RBT	Reference Business Trajectory
RNP	Required Navigation Performance
RTA	Required Time of Arrival
SSA	Self Separation Area
STA	Schedule Time of Arrival
SET	Schedule Exit Time
SBT	Shared Business Trajectory
SES	Single European Sky
SESAR	SES Advanced Research
SWIM	System Wide Information Management System
TAT	Target Arrival Time
TET	Target Exit Time
TMA	Terminal Manoeuvre Area
WP	Work Package

II Appendix B: Summary of Requirements

Req, Number	Requirement	Category
DATA REQUIREMENT		
REQ-DAT-GEN-1.	The package data will be the unit to transmit the information.	MANDATORY
REQ-DAT-GEN-2	The information must be transmitted without technical barriers, for an open system.	DESIRABLE
REQ-DAT-GEN-3.	The information must be available for all the actors involved in A^3 systems.	DESIRABLE
REQ-DAT-GEN-4.	The information transmitted will provide the information needed for safety A3 ConOps flight	MANDATORY
REQ-DAT ENV-1..	All surveyed data shall be referenced to WGS-84	MANDATORY
REQ-DAT ENV-2.	A geoid model shall be used in order to express all vertical data (surveyed, calculated or derived) in relation to mean sea level via the Earth Gravitational Model 1996.	MANDATORY
REQ-DAT ENV-3.	Surveyed, calculated and derived data shall be maintained throughout the lifetime of each data item.	MANDATORY
REQ-DAT ENV-4.	Surveyed data categorised as critical or essential data shall be subject to a full initial survey, and thereafter shall be monitored for changes	MANDATORY
REQ-DAT ENV-5.	The electronic survey data as reference point coordinates and raw data shall be captured and storage digitally:	MANDATORY
REQ-DAT ENV-6.	All survey data categorised as critical data shall be subject to sufficient additional measurement to identify survey errors not detectable by single measurement.	MANDATORY
REQ-DAT ENV-7.	Aeronautical information shall be validated and verified prior to use in deriving or calculating	MANDATORY
REQ-DAT-QUA-1.	Where a data item has more than one intended use, only the most stringent data quality requirements, arising from the safety assessment, shall be applied to it.	DESIRABLE
REQ-DAT-QUA-2.	Data quality requirements shall be defined to cover the following for each data item within the scope of aeronautical data and aeronautical information (a) The accuracy and resolution of the data item; (b) The integrity level of the data item; (c) The ability to determine the origin of the data item; The level of assurance that data is made available to the next intended user prior to its effective start date.	MANDATORY
REQ-DAT-QUA-3.	All of the data items needed to support each application data set and/or a valid subset of the data set shall be defined	DESIRABLE

COMMUNICATION REQUIREMENTS		
REQ-COM-1.	The systems on ground shall be able to receive the information transmitted from the aircraft and send it to the end-users.	MANDATORY
REQ-COM-2.	The communication systems must be able to assure that the ground based systems are connected and ready.	DESIRABLE
REQ-COM-3.	The communication network will be able to transmit all the information sent by the users of the system.	MANDATORY
REQ-COM-4.	The ground based systems must be ready as long as needed by the operation in the airspace.	DESIRABLE
REQ-COM-5.	Communications must assure the level of safety needed in: ▪ Data Integrity ▪ Robustness of the communication ▪ Reliability of the information transmitted	DESIRABLE
REQ-COM-6.	The communication between the systems must be secure; the systems must be able to avoid any external attack.	DESIRABLE
REQ-COM-7.	Communications must be resilient to attacks on confidentiality, availability, integrity or non-repudiation	DESIRABLE
REQ-COM-8.	The system must be resilient to delays or service interruption caused by network congestion or transmission errors on the physical layer.	DESIRABLE
REQ-COM-9,	Any type of aeronautical communication should have the property of being able to be transmitted. Voice, data (both open or encrypted), …	DESIRABLE
NETWORK SECURITY REQUIREMENTS		
REQ-SEC-1	The network security service shall offer functionality for authentication, authorization, confidentiality, data integrity, non-repudiation, accountability and resource management.	MANDATORY
REQ-SEC-2	The network security service shall offer fine-grained access control mechanisms allowing user access to be defined at the data item and attribute level.	MANDATORY
REQ-SEC-3	The network security service shall offer a rich functionality for the definition of user (and associated attributes), and their classification into groups, roles, and organisations.	MANDATORY
REQ-SEC-4	The network shall enforce separation of security domains	MANDATORY
REQ-SEC-5	The network shall protect assets from denial of service	MANDATORY
REQ-SEC-6	The network shall enforce secure import and export of authorized information into and out of its security domain	MANDATORY
REQ-SEC-7	Access Control criteria may be based upon (a) assigned roles or (b) on some dynamic characteristic of the data being accessed – for example (i) geographical locations (ii) time (iii) value of a given attribute.	MANDATORY/ DESIRABLE
REQ-SEC-8	The network shall offer guaranteed levels of data security, ensuring that commercially sensitive information, provided by competing businesses, remains segregated.	MANDATORY
REQ-SEC-9	The network shall grant access to all infrastructure services, services, data, dynamics (e.g. transactions, events, logs) in accordance with member identification and security service access privileges.	MANDATORY
REQ-SEC-10	The network shall uniquely identify and log all accesses to infrastructure services, services, data, and dynamics	MANDATORY/ DESIRABLE
REQ-SEC-11	The network governance shall establish, enforce and monitor network security policies	MANDATORY

REQ-SEC-12	The network shall publish network service security policies for design-time implementation and run-time monitoring.	MANDATORY
REQ-SEC-13	The network shall formulate and issue run-time service security alerts.	MANDATORY/ DESIRABLE
PRE-FLIGHT REQUIREMENTS		
REQ-PFL-1	Aeronautical and flight information shall be made available by responsible authorities in the SWIM network	MANDATORY
REQ-PFL-2	Up-to-date meteorological information shall be made available by responsible authorities in the SWIM network	MANDATORY
REQ-PFL-3	A map and airport directory shall be made available by responsible authorities in the SWIM network	MANDATORY
REQ-PFL-4	Provisions should be made to allow the inclusion of autonomous flight rules (AFR) as a new type of flight in the pre-flight information provided by pilots to ANSP. When an aircraft declares its type of flight as AFR, this information shall be made available in the SWIM network.	DESIRABLE
REQ-PFL-5	Initial trajectories shall be made available by FOC in the SWIM network.	MANDATORY
REQ-PFL-6	Ground systems including SWIM should enable the reception and management of information required for planning and conflict detection and resolution tools such as rates of climb, optimal power settings, etc.	DESIRABLE
REQ-PFL-7	There shall exist a standardised trajectory sharing capability that is mediated by a collaborative process, both for trajectories delivered before and during the flight takes place.	MANDATORY
FLOW MANAGEMENT REQUIREMENTS		
REQ-FMA-1.	To be aware of high complexity or high density areas in self-separation airspace.	DESIRABLE
REQ-FMA-2.	To determine an applicable flow management restriction area for regulating high density areas.	DESIRABLE
REQ-FMA-3.	To be able to limit traffic to the high complexity or high density area to acceptable levels by applying fair restriction rules.	DESIRABLE
REQ-FMA-4.	To schedule traffic to the flow management restriction area in such a way that it complies with priority rules.	DESIRABLE
REQ-FMA-5.	To identify the need for having strategic flow free of conflict in the flow management restriction area.	DESIRABLE
REQ-FMA-6.	To identify the applicable no conflict routes through the flow management restriction area..	DESIRABLE

AMAN DEMAN REQUIREMENTS		
REQ-MAN-1	When two aircraft have the same ETA, priorities will be applied to them at the entry points.	MANDATORY
REQ-MAN-2	The estimated times will only be updated if there is a variation in the value.	MANDATORY
REQ-MAN-3	In the initial state the estimated value must be equal to the target value.	DESIRABLE
REQ-MAN-4	The D-MAN and A.MAN will analyse the input times, giving the future CTA.	MANDATORY
REQ-MAN-5	The definitive EAT must be agree with the CTA of the system.	DESIRABLE
REQ-MAN.6	The A-MAN will consider whether the capacity of the managed airspace is exceeded, before allowing more aircraft in the TMA	MANDATORY
REQ-MAN.7	The D-MAN will detect when the managed airspace is overload or saturated. In this case no new entry slots into the managed airspace will be given.	MANDATORY
SURVEILLANCE REQUIREMENTS		
REQ-SUR-1	The ground systems shall have the contractual RBT with the updated information provided by the aircraft.	MANDATORY
REQ-SUR-2	The ground systems shall notify the aircrafts of all the real traffic existing in MTAZ	MANDATORY
REQ-SUR-3	The ground systems shall be appropriately equipped to provide aircraft with reliable information about congested or complex areas.	MANDATORY
REQ-SUR-4	The ground systems shall check the status of communications through the following messages: ▪ When the aircraft agrees with the current RBT, it shall send a “RBT conformance” message. ▪ If an aircraft detects a loss of conformance with its RBT, it will send an alert message and its status changes to “'RBT non-conformance”. ▪ if an aircraft is not able to comply with its nominal RNP, it will send a “Nav systems deteriorated”.	MANDATORY
REQ-SUR-5	Air data forecasts shall be broadcasted to all aircraft and uploaded to SWIM, so that every actor has access to them when needed.	MANDATORY
REQ-SUR-6	The ANSP shall issue airspace restrictions in the form of areas to avoid and shall be uploaded to SWIM so that every actor has access to them when needed.	MANDATORY

III Appendix C: List of References

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