Project no. TREN/07/FP6AE/S07.71574/037180 IFLY

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 D2.3
Identification of human factors for improvement of the A^3 ConOps

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Due date of deliverable: 22 December 2008
Actual submission date: 22 December 2008

University of Tartu

Version: 1.4

Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)		
Dissemination Level		
PU	Public	✓
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

DOCUMENT CONTROL SHEET

Title of document:	Identification of human factors issues for improvement of the A^3 ConOps
Authors of document:	Claudia Keinrath, John Wise, Amel Sedaoui, Aavo Luuk
Deliverable number:	*D2.3*
Project acronym:	*IFly*
Project title:	*Safety, Complexity and Responsibility based design and validation of highly automated Air Traffic Management*
Project no.:	*TREN/07/FP6AE/S07.71574/037180 IFLY*
Instrument:	*Specific Targeted Research Projects (STREP)*
Thematic Priority:	*1.3.1.4.g Aeronautics and Space*

DOCUMENT CHANGE LOG

Version #	Issue Date	Sections affected	Relevant information
Draft	25 Sept 2008	All	
0.1	09 Oct 2008	All	
0.2	12 Nov 2008	All	
0.3	01 Dec 2008	All	
0.4	16 Dec 2008	All	
1.0	22 Dec 2008	1, 4, 5, 6, 9	
1.1	29 Jan 2009	All	
1.2	12 Feb 2009	All	
1.3	17 April 2009	All	
1.4	11 June 2009	1.3, 2.1, 2.7.3, 2.7.4, 2.8.3.2, 2.9	

		Organisation	Signature/Date
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External reviewers			

Executive Summary

Background: The iFly project (iFly 2006) is planned to develop a highly autonomous ATM design for en-route traffic, which takes advantage of automated aircraft operation capabilities and which is aimed to manage a three to six times increase in current en-route traffic levels providing simultaneously improved safety levels.

The present document is the third deliverable of Work Package 2 of iFLY project. The report presents the critical review of the Autonomous Aircraft Advanced (A^3) ConOps, developed in the D1.3, version 2.6_fb_mk_fb_pc, dated 17/04/2009 (iFly 2009) of the Work Package 1.

The aim of the present deliverable is to identify human factor issues in the D1.3 developed high level A^3 ConOps description. These issues may either trigger further elaboration and refinement of the A^3 ConOps description, and/or may influence the vision how A^3 equipped aircraft fit best within the SESAR concept development.

The present deliverable D2.3 performs a critical analysis of the A^3 ConOps design that has been documented in D1.3, taking into account the advanced future ATM development programs SESAR (SESAR 2007) and NextGen (Joint Planning and Development Office 2007) and other ongoing ATM research projects. In addition, information from iFly WP7 Pre-Brainstorm meeting and Brainstorm meeting (see iFly 2008c, iFly 2008d) about hazards related to autonomous flying have been used. The report evaluates the A^3 ConOps proposed in D1.3, from human factors perspective, mainly through analyzing airborne situation awareness (SA) issues. It also emphasizes the need for clearer distinction of A^3 airborne and ground based functionalities of self separation-based flying.

Results of the deliverable: Main findings resulting from the critical review of D1.3 are related to:

- Ground support issues
- SWIM-related issues
- Minimal operational requirements
- Transition issues
- Human/ automation relationships issues
- HMI and communication issues
- FOC/flight crew relations issues

Interactions with other iFly deliverables: The key deliverable for the present deliverable is D1.3 (iFly 2009), prepared by WP1. In preparing of the present deliverable also previously released deliverables from WP1 D1.1 (iFly 2008a) and D1.2 (iFly 2008b) and from WP2 D2.1 (iFly 2007b) and D2.2 (iFly 2007c) have been used. The results of the present deliverable will be used by iFly Work Packages for refining the A^3 concept from human factors and airborne responsibility point of view.

The present deliverable D2.3 provides the input for those Work Packages which will either focus on developing technologies whose requirements arise from the ConOps (WP3.2, WP4.2 and WP5.3), or will perform risk/safety assessments of the ConOps under WP7.1 (see iFly 2007a), or refine the A^3 ConOps (WP8.1). The present deliverable will serve as the basis for WP2 final deliverable D2.4, which main objective is to suggest potential improvements of the A^3 ConOps for the issues identified within the current D2.3 report, and which should be picked up during the refinement of the A^3 ConOps within WP8.

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Section 1 - Introduction and Background

1.1 Objectives of iFly project

Air transport throughout the world, and particularly in Europe, is characterised by major capacity, efficiency and environmental challenges. With continued growth in air traffic a three to six times increase is predicted for 2020. These challenges must be addressed if we are to improve the performance of the Air Traffic Management (ATM) system.

The iFly project definition was begun as a response to the European Commission (EC) 6^{th} Framework Programme call for Innovative ATM Research in the area of "Aeronautics and Space" (iFly 2006). The program is expected to develop novel concepts and technologies with a fresh perspective into a new air traffic management paradigm for all types of aircraft in support of a more efficient air transport system. It is aimed at supporting the integration of collaborative decision-making in a co-operative air and ground based ATM end to end concept, validating a complete ATM and airport environment, while taking into account the challenging objectives of SESAR.

iFly will develop a highly autonomous and distributed ATM design for en-route traffic, which takes advantage of aircraft self separation capabilities and which is intended to manage a three to six times increase in current en-route traffic levels. Analysis of safety, complexity and pilot/ controller responsibilities, as well as subsequent assessment of ground and airborne system requirements will deliver a coherent set of operational procedures and algorithms, thus demonstrating how the results of the project may be exploited.

The aim of the iFly project is to develop advanced operational concepts of airborne self separation. Initially the A^3 concept develops an approach fully based on airborne responsibility. According to this concept, all autonomous aircraft flying in Self Separating Airspace (SSA) are capable of providing self separation without the ATM support from the ground. As the result of the second design cycle, the refined concept will take into account the limitations in assigning more responsibility to airborne side, revealed on the previous design cycle and will elaborate the vision how A^3–equipped aircraft fit best within the SESAR thinking regarding future ATM.

1.2 iFly Work Package 2 (WP2)

Changes in the air traffic management system irrevocably cause changes in the role of the human involved in that system as a result of technological & systemic changes. When the system becomes more and more automated, a shift in tasks and responsibilities of the human controlling the system becomes possible. In the iFly concept the human operator (the cockpit crew) is responsible for the actions and tasks of self separation he/she performs during enroute phase of flight. This responsibility will become a core issue in aerospace operations, if decisions and actions of self separation will be carried out without being required to request permission from another actor (ATCo).

Important in this, is that many functions in autonomous aircraft operations will be supported by automation on the flight deck and there should be a balance of responsibility between automation and human made decisions. As long as the human remains responsible for the resulting actions of the human-machine system, he/she also needs to be able to control the system. When the system is fully automated and the human is out of the loop, it is not possible to hold him/her responsible for the resulting outcomes. On the other hand, human-centered automation of (parts of) a system can also support the human to maintain control over the situation, especially in complex systems like an aircraft.

Therefore, human responsibility is a key factor in determining where, how, and to what extent an iFly like system can be automated. Traditionally in air traffic management environment this responsibility has been spread across the airborne and ground side of the system. Current developments in ATM show a shift towards a more decentralised system, with increasing tasks and likely more responsibilities for the airborne side, i.e. the cockpit crew. This side forms the starting point for the current project, therefore the question that arises is: "What responsibilities should be assigned to the airborne side of the system assuming a new task distribution implied by autonomous ATM?" Work package 2 considers these issues in more detail.

Work package 2 is divided into two parts: 1.) "airborne responsibilities" and 2.) "bottlenecks and potential solutions", both of them consisting of two sets of tasks.

Part 1: Airborne responsibilities

WP2.1 Identify current and new responsibilities of cockpit crew during en-route phase of flight.

WP2.2 Analyse Situation Awareness, Information, Communication and other cockpit crew tasks.

Part 2: Bottlenecks and potential solutions

WP2.3 To identify bottlenecks in responsibility issues.

WP2.4 To develop potential human factors improvements for A^3 ConOps.

Tasks of WP2.1 have been addressed in deliverable D2.1 (iFly 2007b) and tasks of WP2.2 in D2.2 (iFly 2007c).

As a result of the D2.1 new and changing pilot tasks and responsibilities were identified. These pilot tasks served as an input for detailed analysis of situation awareness issues in the cockpit and pilot tasks related to them in the D2.2. The results of D2.2 have been used in the present deliverable for critical analysis of the A^3 ConOps specified in D1.3, mainly from the angle of providing and maintaining situation awareness of the cockpit crew.

The aim of the current deliverable D2.3 is to address the WP2.3 issues. As the initial options for allocating responsibility to the cockpit crew have been identified in WP1.1 (iFly 2008a) and WP1.3 (iFly 2009), WP2.3 will be searching for inconsistencies in these options and will question them, to prepare the second design cycle for improvement of the A^3 concept. This is in contrast with the common way, in which first a concept is fully developed regarding the technical systems, and after this, responsibilities are assigned to the applicable actors.

As explained, the present deliverable D2.3 is based on critical analysis of the ideas expressed in the iFly WP1 deliverable D1.3 "Autonomous Aircraft Advanced (A^3) ConOps" (version 2.6_fb_mk_fb_pc, dated 17/04/2009), using additional information from iFly WP7 Brainstorm meeting (see iFly 2008c; iFly 2008d) about hazards related to self separated flying.

WP2.4 tasks "To develop potential human factors improvements for A^3 ConOps" will be addressed in D2.4 as follows:

After WP2.3 has identified human factors responsibility bottlenecks where additional ground support is required (in the tasks and functions, where it is impossible to allocate all responsibility to the airborne side of the system), the goal of WP2.4 is to develop potential mitigating human factors related measures of these bottlenecks for the A^3 ConOps. These potential mitigating human factors measures are taken into account for the refinement of A^3 within WP8.1 (see iFly 2006, p 45).

1.3 Objective of the report

The objective of the present document is to find the critical issues in the current status of Autonomous Aircraft Advanced (A^3) ConOps as proposed in D1.3, which need further elaboration for improving the viability and safety aspects of the A^3 ConOps.

Description of human factors and airborne responsibility bottlenecks found in the iFly A^3 ConOps is based on the critical review of iFly WP1 deliverable D1.3 version 2.6_fb_mk_fb_pc, dated 17/04/2009.

The deliverable evaluates the A^3 ConOps, proposed in D1.3, from human factors perspective, mainly through analyzing human factor issues.

1.4 Document Layout

The present D2.3 document is organized around the structure of the D1.3, because it seems the best possible way to give the reader the comprehensible view of the critical human factor and responsibility issues raised in relation to A^3 ConOps topics. This aim is further followed by using the indication of D1.3 sections and subsections numeration in the titles of review sections and subsections of the present deliverable. Further on, important paragraphs to review were copied from D1.3 and included into the present document, accompanied with comments from human factors (HF) and responsibility point of view. For their better exposing the original D1.3 paragraphs copied are highlighted in gray and printed in italics, while comments to them are written by using normal font.

Accordingly the structure of the document starts with *Executive summary* and is composed of two chapters and Appendixes.

Section 1 – Introduction and Background starts with the Objectives of the iFly project, brief description of the aims and the content of Work Package 2 (WP2), the Objectives of the D2.3 and the layout used in the D2.3 document.

Section 2 – Critical review of the deliverable D1.3 includes nine sections:

Section 2.1 – HF issues raised to Section *2 "Background – Air Traffic demands"*
Section 2.2 – HF issues raised to Section 3 *"Airspace"*
Section 2.3 – HF issues raised to Section 4 *"Assumptions"*
Section 2.4 – HF issues raised to Section 5 *"A^3 Enablers"*
Section 2.5 – HF issues raised to Section 6 *"Basic flight description"*

Section 2.6 – HF issues raised to Section 7 *“Pre-flight Strategic Flow Management”*
Section 2.7 – HF issues raised to Section 8 *“Autonomous Flight Operations”*
Section 2.8 – HF issues raised to Section 9 *“A^3 Systems”*
Section 2.9 – Concluding remarks

Appendix includes three parts:
Appendix 1 – HF issues raised to Section 10 *“Operational Scenarios”*
Appendix 2 – Acronyms
Appendix 3 - References

Before starting the reading of the main text of the present deliverable the reader is additionally reminded about the fact that the present deliverable reviews the D1.3 version 2.6_fb_mk_fb_pc, dated 17/04/2009, the latest version available during the D2.3 present version preparation process.

Section 2 - Critical review of the deliverable D1.3

2.1 HF issues raised to Section 2 "Background – Air Traffic demands"

2.1.1 HF issues raised to Subsection 2.2 "Future ATM System"

> *…, A^3 en-route operations are based on the assumption that flight crews are the sole separator from traffic and all other hazards given the appropriate infrastructure, equipment and training. (cf. pages 20-21)*

HF Issues (Nr. 1):
The situation will be new for those future generations of ATM personnel and cockpit crews who will have to implement airborne self separation. These major changes will affect not simply the ATM environment, but a lot of organizations and e.g. the performance of humans behind those organizations (flightcrews, ATCOs, FOCs) as well as the level of automation (onboard systems and infrastructures on ground) within these organizations to enable the achievement of self separated flying.

Under these new situations there will be novel uncertainty, ambiguity and unpredictability relative to the stable and familiar environment. These novel (from the human participant point of view) aspects of the envisioned change and new environment may temporarily cause the need for organizational and personal adaptation, which may result in higher stress levels and inadequate division of attentional resources of human participants both in the air and on the ground. The resulting lack of, diminished or displaced situation awareness may raise the potential of human optimal performance to deviate from what the system designers had aimed for.

2.2 HF issues raised to Section 3 "Airspace"

2.2.1 HF issues raised to Subsection 3.1 "Airspace Definition"

- *Self Separating Airspace (SSA): all airspace whose boundaries are defined in time and space by the dynamic allocation of Managed and Unmanaged airspace. (cf. page 23)*

HF Issues (Nr. 2):
The dynamic allocation of airspace boundaries may currently become the cause of uncertainty, which should be minimized for human participants in the system. However, in this future highly automated, datalinked context, where traffic is much more predictable and visible, it **may** also facilitate to keep the pilot in the loop, keep him/her vigilant and active.

At the same time a higher workload of the flight crew can be predicted on some occasions. Let us take for example a military area which is not active when the SBT becomes an RBT. During the flight this military area becomes active by short notice (a very rare event, but potentially conceivable). The crew would have to re-plan the route and update the RBT. And negotiations with the FOC might be necessary too. The knowledge about such rare events might keep the aircrew more vigilant, but the procedure initiated by such an event might lead to higher workload of the crew and all other parties which might be involved.

2.2.2 HF issues raised to Subsection 3.3 "Airspace Boundaries"

- *SSA is delimited, together with MA and UA, by dynamic allocation, in a service-oriented approach: the ANSPs will issue through SWIM the allocation of airspace, as part of the Collaborative Decision Making (CDM) flow management process with Flight Operations Centres (FOCs). (cf. page 25)*

HF Issues (Nr.3):
Dynamic allocation of airspace boundaries may bring in too much uncertainty for the flight crews, if this information happens not to be easily available (see comments above).

To overcome the lack of predictability in dynamic and complex systems, there is a need for adequate strategies: either trying to survive by doing simple actions (which is not possible in iFly, regarding the level of complexity introduced in it) or by planning one's reactions and being ready for contingencies. In planning it is assumed that the joint cognitive system is able to make predictions and mainly to adapt to the posed demands. The level of complexity introduced by iFly (e. g., conflict detection and resolution, traffic constraints) should be reduced whenever possible to keep the resources for handling other complex situations aside from dynamic boundaries.

The uncertainty linked to non-fixed SSA boundaries is somehow in contradiction with the current safety philosophy in dynamic environments based on planning of actions in order to manage all the possible contingencies.

Possible, but not easy solution of the dynamic boundary problem is: Changes in boundaries cannot take place until the information has been appropriately distributed and responded to.

2.3 HF issues raised to Section 4 “Assumptions”

- *All aircraft are equipped and certified for self separation; this may include data link capability, Human Machine Interface requirements and support automation. (cf. page 26)*

HF Issues (Nr. 4):
The above mentioned statement implies that there will be uncertainties regarding the equipment and requirements which will be needed to operate in the Self Separating Airspace (SSA). There is the possibility that some users will operate with a full suite of the very best avionics and others might want to operate by using the minimal equipment. What they will choose will depend on the performance level they want to reach. The performance level is defined by the level of traffic density/complexity in which an aircraft still can safely operate. The performance levels might be different according to the area, e.g. there will be a difference between oceanic areas and parts of Europe.

What is sure is that *“iFly aims at managing a three up to six times increase in current en-route traffic levels”.* In a first step iFly has to determine specific levels of safety and performance in order to build hypothesis regarding the minimum equipment needed. These hypothesis need to be validated in order to see if the level of equipment meets the safety and performance requirements. If the envisioned equipment doesn’t meet the requirements, equipment has to be redesigned.

Due to the stage of the project, the question of the minimum equipment requirements has not been answered yet. This document is based on the assumption that all aircraft operating in the SSA are equipped with the minimum equipment needed to operate safely on highest performance level.

- *Within A^3 ConOps it is assumed that intent information will be available. The airborne system is designed to ensure self separation even without this data; however, in this case, the maximal attainable ATM performance will be different. (cf. page 26)*

HF Issues (Nr. 5):
It seems essential that having intent information available will make both automated and human prognosis less uncertain. In highly uncertain situations the demands for SA are higher and more costly than in less uncertain situations. Also the potential need for larger (both in time and space) manoeuvres will stem from higher uncertainty and/or ambiguity of the data.

SSA is such a highly dynamic, complex and not completely predictable environment, that the crew needs to plan its actions in order to be ready to respond to contingencies. The absence of ‘intent information’ means less predictability of the traffic, and thus less strategic preparation based on an adequate SA; i.e. crew will not have the ‘big picture’. Surviving by simply reacting is not possible in such a dynamic and complex environment. The crew needs to observe, interprete, evaluate and plan before acting (with reference to the basic cognitive functions). The crew needs to think ahead in time and to anticipate; the absence of intent information is thus a *conditio sine qua non* to operate in SSA.

> • *SSA may be monitored by ground/external surveillance systems, but no ATC separation services will be provided to the aircraft while inside it. (cf. page 27)*

HF Issues (Nr. 6):
In further developments of the airborne self separation ConOps both the ground support and ATC issues have to be developed together, as by the time of A^3 implementation the concept of ATM/ATC may be substantially different from today's views and the airborne self separation demands onto ground support through SWIM can be further developed compared to the present A^3 ConOps stage.

> • *Operations in Unmanaged Airspace (UA) or transitions from/to UA will not be considered in this ConOps.(cf. page 27)*

HF Issues (Nr. 7):
As depicted in the ConOps there is also a possibility to enter the SSA via the unmanaged airspace. Let us assume that a general aviation aircraft departed from its home airport with the intention to complete the flight within unmanaged airspace due to visual meteorological conditions. Suddenly the weather condition changes, the flight cannot be completed within the unmanaged airspace – transition to SSA would be necessary.

Such a flight might not have submitted an RBT, is not under the control of ATCos and might be equipped with the minimum technology necessary to operate in the unmanaged airspace. Such a transition might be very critical. Who would take the responsibility that this flight is conflict free when entering the SSA? Must the pilot of such a flight first contact ATCos from the nearest managed airspace and describe his/her situation? Who is clearing this aircraft for a short usage of the SSA due to a weather related "emergency"?

The probability that such an intruder aircraft gets into conflict with an A^3 aircraft near a TMA is relatively high, and due to the fact that this is a very critical airspace (lot of transitions from one to another airspace and the change in responsibilities), such a confrontation might be even more critical, in terms of actions related to conflict resolution short before entering the TMA. CD and CR algorithms must assure that such big differences in capability characteristics are taken into account.

An additional complication of the situation just described may be introduced by the dynamic change of SSA boundaries. Will the pilot of the aircraft described above get the necessary information of already being within the changed boundaries of SSA? If SSA can dynamically change, then by definition even those aircraft not flying in SSA will need to be informed in some way.

The above described scenario might not be an issue, but in the development of ConOps the transitions from unmanaged airspace to SSA should be considered.

2.4 HF issues raised to Section 5 "A^3 Enablers"

- *All A^3 airborne systems are designed as on board decision support tool, i.e., tools that aid flight crew in the decision making process, (e.g., conflict detection and resolution, strategic trajectory management) and thus will contribute to the safe and efficient operation of the aircraft. These tools will monitor the environment, alert the crew of possible conflicts and provide resolutions when necessary. (cf. page 28)*

HF Issues (Nr. 8):
The level of support offered by the tools available in a given cockpit will probably be different. Although difficult to achieve at the present stage of development of A^3 ConOps, the attempt to define the minimal operational requirements (and to describe the concept with concrete typical scenarios) would be helpful.

It seems that A^3 ConOps already attempt to allocate some functions to automation, supposing that it will replace the human for some 'demanding' situations instead of being supportive to them. The alternative proposed in the iFly D2.2 was to think of the airborne system as a joint (man-machine) cognitive system and to define what functions need to be accomplished, how it can be achieved and then identify the right level of automation needed (Hollnagel, 1999). This would avoid the classical situation of loss of control and SA due to human substition by machine.

- *Advanced airborne automation is foreseen to improve Situational Awareness (SA) and aid in the decision process. These applications will include new weather data fusion applications, warning functions and guidance algorithms. (cf. page 28)*

HF Issues (Nr. 9):
Although difficult to achieve at the present stage of the self separation ConOps, the attempt to define the minimal operational requirements would be helpful.

Automation must be implemented in a very smart way to improve Situation Awareness since both the level of automation and the kind of automation are crucial for the SA and safety. Therefore, implementing more automation does not mean that it assists to gain an appropriate level of SA. Determination of the appropriate level of automation also requires consideration of environmental conditions.

Additionally, in further developments of A^3 ConOps the term "Situational Awareness", used in D1.3, should be replaced by "Situation Awareness".

- *The new functions foreseen in the A^3 ConOps will require an appropiately designed Human Machine Interface to obtain the required level of Situational Awareness (SA) and to aid in the decision making process. (cf. page 28)*

HF Issues (Nr. 10):
The important task related to the development of such new HMI's will be to figure out which information shall be provided to the crew at which time and according to which situation and in a second step the question of how to display the information has to be answered.

See also previous comments 8 and 9.

- *New procedures and flight rules will be required to operate under the A^3 ConOps, these include the rules for autonomous operation. (cf. page 29)*

HF Issues (Nr. 11):
The development of procedures and flight rules will be critical to safety. Hence, all enabling parts must be known to the designers. E.g., present iFly doesn't consider transition phases. But these phases are of major importance for an efficient A^3 concept. So the definition of entry and exit points – which is missing in the actual A^3 ConOps – is critical concerning the development of rules and procedures.

- *The A^3 ConOps foresees the use of a future Flight Management System that is integrated with the Decision Support Tools (DST) for autonomous operations. (cf. page 29)*

HF Issues (Nr. 12):
Authors of the ConOps might want to consider if the FMS itself or the information available trough the FMS will be integrated in DST for autonomous operations. Although difficult to achieve at the present stage of the self separation ConOps, this paragraph also shows the need for the definition of the minimal operational requirements for self separated flight.

Automation must be implemented in a very smart way to improve Situation Awareness since both the level of automation and the kind of automation are crucial for the SA and safety. Therefore, implementing more automation does not mean that it assists to gain an appropriate level of SA. Determination of the appropriate level of automation also requires consideration of environmental conditions.

Especially modifications within the FMS functionality are very critical to safety. The aircrew must be aware of which information is taken under consideration in which situation, at which time point – to make sure that they are at every time able to fly the airplane manually in case of a system failure.

2.5 HF issues raised to Section 6 "Basic flight description"

> *4. Upon arriving at the TMA (~100-200NM before Metering Fix) the aircraft will lock into the ground Arrival Manager (AMAN) system, which will:*
> *a. Sequence all arriving aircraft.*
> *b. Issue a CTA with a fixed required time for TMA entry.*
> *In addition:*
> *c. The onboard system will increase the 'priority' level and broadcast this to other aircraft, so that it has priority over other, non-TMA appproaching aircraft (departures, en-route aircraft).*
> *d. The responsibility for separation with other aircraft remains with the flight crew, but the design of TMA entry points (both in space and time) should in principle allow the aircraft to ensure separation from other traffic while being able to conform to its CTA.*
> *e. The aircraft may also be given a Traffic To Follow (TTF) and Spacing Interval (SI) to enable airborne spacing. (cf. pages 30-31)*

HF Issues (Nr. 13):
This is the issue of ground support, to be elaborated in further developments of ConOps.

Nevertheless, in the Concept of Operations the design of the entry/ exit points is not discussed. These points and their definition is very critical, especially if one considers an emergency. It might be difficult to develop transition rules without knowing anything about the definition of entry/ exit points. This is a topic which is very critical to safety.

> *5. The aircraft reaches the arriving TMA in compliance with its CTA at a predefined TMA entrance point, and conforms to the Air Traffic Management requirements inside the arriving TMA. When entering the TMA the aircraft will cease to perform self separation and will again be controlled by ATC. (cf. page 31)*

HF Issues (Nr. 14):
Post flight concerns

One main issue will be the reporting culture which will be different and maybe even more difficult. When is a report necessary? Will we fall back to a "blame culture" to kick some competitors out in order to gain more advantages? A single complaint may not be strong enough, but when a company suspects consistently aggressive behaviour from a competitor, statistics will do. This implies all datalink data would need to be stored for years in a central database. It does not really need to use an aircraft-individual (onboard) data storing system. It might be useful for example to store information like: Delay of accepting or declining new CTAs.

Or will more violations be the order of the day? What will be the consequences for violations? This might be a very critical topic in an A^3 environment. To overcome this problem it might be important to install e.g., an incident/ accident reporting box, comparable to a black box, where all relevant flight data and other information will be stored.

2.6 HF issues raised to Section 7 "Pre-flight Strategic Flow Management"

- *The aim of the Pre-flight Strategic Flow Management is to provide a structure to the airspace, which is strategically de-conflicted. This means that for each flight the entire Shared Business Trajectory (SBT) is scheduled to be 'a priori' traffic conflict-free, and also free of areas (in space and time) where the air traffic complexity or congestion reach unacceptable levels for the normal course of the operations. (cf. page 32)*

HF Issues (Nr. 15):
Already today, a large number of parameters must be analyzed in order to ensure a safe flight. An individual flight route must be calculated and optimized for each flight by using updated daily data concerning air traffic, airspace, airports and weather information as well as performance data of the aircraft. Different wind forces and flight levels for example have a major impact on fuel consumption and flight duration, and overflight fees vary depending on the overflown terrain. Today, the freedom to calculated optimal flight routes taking all the important parameters into account is restricted by the given route structure. Usually, the calculation of a flight plan is completed within two to four hours prior to departure.

In an iFly environment the main responsibility during this phase will lie within the Flight Operations Centers (FOC), Non-FOC Airspace Users (NFU) and/or Air Navigation Service Providers (ANSPs). All actors will express their preferences for a given flight route by issuing a Shared Business Trajectory (SBT) request to the Air Traffic Authorities which will be negotiated during the Collaborative Decision making (CDM). Additional data, beside the one stated above, regarding other flights and their, probably already requested routes, must be integrated into the calculation process. Getting the right information at the right time from the appropriate channel will require some time and will be an organizational challenge. A retrofit of the existing systems will be a prerequisite.

"First come first serve" strategy in filing a Shared Business Trajectory (SBT) may be the order of the day. The later an airline will get into this process the more difficult it might be to find a optimal route. This might probably call for a strategy of filing a flight plan very early, with the result that the SBTs might be not up to date at the time of departure, when the SBT becomes the RBT, which in turn might lead to recalculations and short-term changes after departure.

What would happen if an aircraft would miss the allocated slot? Would the crew have to submit a new SBT – because if the crew would just change the departure time, the original SBT would probably cause many conflicts – when departing at a later time? How long would it take the crew to file a new SBT? How do missed slots in general affect the whole system in an iFly scenario? Is this an additional issue to be analyzed?

FOCs are responsible for the safe planning and conducting of their own 'airlines' flights, with the goal of providing operational benefits to the airline. This responsibility also includes the fuel calculation for each flight. Today there is a tendency to take just the minimum necessary amount of fuel (considering regulations) on board to save money, which is possible due to the fact that flights are pretty predictable due to predefined route structures and the experience, FOCs' have gained over the years. With the introduction of the new ATM system, routes are no more that predictable, thus fuel calculation is getting more difficult. Among the reasons for this might be manoeuvres arising due to conflicts, restricted areas, weather, and the attempts to gain advantages from wind conditions. All these effects influence the fuel consumption in a negative or positive way and make predictions more difficult.

Another topic which might be worth to adress here is that today different countries have different overflight fees. The proposed ATM system gives the advantage of defining self-knitted flight routes, and therewith the possibility to avoid over flying such outpriced areas. The transportation of special freight might be easier and probably cheaper because this can be taken into account when defining the flight route. So pre-flight actors might want to beacon their routes close to the boarder of expensive or delicate areas, if it has sense in meeting their overall goals. During the planning the actors have to be aware, that conflicts might force the affected aircrew to avoid hazards spaciously which in turn might force the aircrew to over fly delicate, expensive or dangerous areas. These are aspects which have to be considered during the planning phase and might extend or complicate the process. As stated at the beginning of this paragraph, different overflight fees is a topic of todays ATM and it is absolutely conceivable, that under Single European Sky regulations the concern about different overflight fees may change or even cease.

It should be noted that in the USA and probably in the EU as well – there is currently a large amount of gaming in the ATM system by the various airline FOCs. They are very close to the chest about what they are going to do and certainly what they tell the ATC people. There are many organisational and operational change scenarios possible, including the role of nations and ANSPs.

Collaborative decision making was foreseen as the ideal way of interaction between system actors, involved in the future definition of the SSA, based on the established SBTs. The ATCos role will certainly evolve under this new concept. Up to now, the ConOps assume that no ATCo interference is needed. But, if we consider that ATCos nowadays collect all flight plans, established on the basis of approved and published routes, supervise their safe execution by keeping the flying aircraft separated. Under A^3 ConOps, this role will shift from coordination between FOC's onto the ground (pre-flight) collaboration as FOC's will negociate SBT. In fact, ATCos will have the role of the 'facilitators' to enable negotiations, based on a common situation awareness and problem comprehension.

2.6.1 HF issues raised to Subsection 7.1 "Flight Operations Centres"

2.6.1.2 HF issues raised to Subsection 7.1.2 *"In-flight Traffic Monitoring by FOC"*

HF Issues **(Nr. 16)**:
This will become a more important task for the FOCs. Strategic changes might be elaborated on ground and decisions might be just sent to the aircrew for confirmation. The FOC might need more and accurate information regarding several topics; e.g. weather, position of own aircraft in relation to competitors, etc.

- *A voice channel will be maintained for emergency purposes. (cf. page 35)*

HF Issues **(Nr. 17)**:
Will there be a voice channel to communicate with the FOC also under normal conditions? This is not stated in the ConOps. This is an important point, but could also

be mentioned under “Communications”. We need to define what the flight crew will need to know to be able to monitor their place and safety in the system.

RT will become a non-routine skill, with all the retention and training issues that come with that. On top of that: even today, English proficiency and intelligibility is an issue, but if the RT is only used for a few safety critical and emergency situations, proficiency may be even lower. The recent proficiency regulation for ATCos should not be removed (despite less RT usage).

In the case of an emergency iFly proposes to have a voice communication channel. It is not clear if all aircraft operating in the SSA will have to monitor this frequency or if this frequency will be accessible just for involved and neighbouring aircraft. In the first case many aircraft will be bothered with emergency situations they are not involved in. And in the latter case some aircraft involved might be excluded because of a failure in calculating ‘who needs to receive this information – who not’. Radio communication procedures shall be adjusted and renewed according to SSA users needs in case of emergencies as well as for normal operations.

2.6.2 HF issues raised to Subsection 7.2 ”Non-FOC Airspace Users”

HF Issues (Nr. 18):
NFUs will be integrated into the ATM organization by ANSPs due to the fact that they might lack the infrastructure that airlines possess to participate in the high-level CDM process. NFUs will be treated in this process as ‘second class’ actors or in contrast, priority class (government, military). To gain all the benefits from the new system NFUs might start to think about paying FOC services, depending of course on the cost benefit analysis. In the USA already today many corporate operations contract with an independent operations service to save the costs of a stand their own FOC.

This investment of course must lead to measurable profit, especially for small airlines. In turn they might think of equipping their aircraft with the minimum required equipment, to save some money in the retrofit process or they might consider not to participate in the new ATM system at all. If they decide not to invest in FOC services, the responsibility for pre-flight activities will lie on the aircrew. This might increase their pre-flight workload and demands for organizational competences. In case they pay for FOC services, it might be difficult for the FOC to accommodate different company philosophies and needs.

2.6.3 HF issues raised to Subsection 7.3 ”ATM Ground Support”

- *While ATC is not a controlling entity in the A^3 ConOps, other ground-based actors are required for SFM and flight support. This maintains the notion that this ConOps is ATM ground supported, however, without the presence of ATC. (cf. page 35)*

HF Issues (Nr. 19):
As the concept of ATM/ATC 2025+ may be qualitatively different from its present understandings, it is necessary to handle ATM ground support and ATC in further ConOps developments together.

- *The role of ATM Ground Support in the A^3 ConOps concerns:*

> ○ *Pre-flight Strategic Flow Management*
> ○ *Transition Operations from MA to SSA and vice versa*
> ○ *The support services that are defined in the A^3 ConOps for the aircraft to achieve an adequate situational awareness. (cf. page 36)*

HF Issues (Nr. 20):
It seems necessary to differentiate between those functions of ground support provided through SWIM and the others provided directly to the airborne system. It would be something like an attempt to differentiate between the strategic (memorized) and tactical (real-time) information. It has to be analyzed, where the things like weather and weather based changes fit in this paradigm.

> - *A major role will be provided by SWIM, which will serve as the primary source of information for flight optimization and long term area avoidance. (cf. page 36)*

HF Issues (Nr. 21):
The ground support functions of SWIM should be specified in further developments of ConOps from pilot's perspective. Scenario based design will facilitate this development.

> - *ATM ground support tools that feed SWIM will provide aircraft information for traffic relevant to the own ship but which resides outside the aircraft detectable range (cf. page 36)*

HF Issues (Nr. 22):
How is SWIM-generated information provided to the aircrew or even FOCs?
It has to be investigated if the source of the data, e.g. SWIM, or air-air data must be depicted to the pilot or not. The accuracy of the data might change due to their source, which is very important for critical decisions.

> - *SWIM will also play a major role during Non-normal and Emergency operations. (cf. page 36)*

HF Issues (Nr. 23):
It seems, at least partly, contradicting to the previous statement about SWIM. In Non-normal and Emergency operations the value of real-time information in the vicinity raises more quickly than the value of distant and long-term information. Demands to SWIM information need to be specified for normal, non-normal and emergency situations.

2.6.3.1 HF issues raised to Subsection 7.3.1 *"ANSPs at Terminal Airspace Area"*

> - *It is recognized that it is not possible to coordinate the overall SBT configuration when regarding departures from/arrivals at TMAs without the participation of the Air Navigation Services Provider that manages the TMA. (cf. page 36)*

HF Issues (Nr. 24):
There are some responsibility issues coming up again, to be developed as a part of ground support in further versions of ConOps.

- *ANSPs at TMAs will be considered as the Air Traffic Authority when there is need for arbitration regarding conflicting SBT proposals. (cf. page 36)*

HF Issues (Nr. 25):
Here it is understood that if conflicting SBT are proposed and SWIM and FOCs cannot successfully negotiate, the ATCo will have the authority to make a choice that resolves the conflict. This would make sense and should be done before the SBTs are official.

2.6.3.2 HF issues raised to Subsection 7.3.3 *"Support Services"*

HF Issues (Nr. 26):
SWIM and non-SWIM support services from the ground need to be specified. Which information will be provided by which support service? How are the support services connected? How is the flow of information organized? Which information processing is visible to the end-user (aircrew) and which is not?

SWIM is a key element in A^3 ConOps because it provides (as stated in the A^3 assumptions) the necessary information to support the adequate situation awareness of the crew, which is needed for handling the new responsibilities. Are the actual specifications defined for SWIM (as part of SESAR) sufficient to respond to iFly information needs?

2.7 HF issues raised to Section 8 "Autonomous Flight Operations"

> ○ *A Minimum Equipment List (MEL) for autonomous operations can aid the determination of the appropriate flight condition. It lists the instruments and equipment that may be inoperative without jeopardizing the safety or capabilities of the aircraft. It is developed for a specific aircraft and type of operation and is approved by the appropriate authority (the FAA for civil registered aircraft in the United States, EASA for civil registered aircraft in Europe, etc). It also includes procedures for flight crews to follow when securing or deactivating inoperative instruments or equipment.*
> *(cf. page 37)*

HF Issues (Nr. 27):
What is needed and missing in the A^3 ConOps, is a list of minimum requirements which enables an aircrew/ aircraft to operate in a SSA – not a MEL. E.g., is a CDTI a minimum requirement? Is a graphical display of the situation a necessity? Or would it be enough to provide the crew with a list of aircraft involved in a conflict?
Such information is missing and will definitely not be provided by the FAA or EASA.

2.7.1 HF issues raised to Subsection 8.1 "Flight crew roles, tasks and responsibilities"

> - *The flight crew will have new Decision Support Tools which will help reduce mental workload. Traffic & navigation-related information will be displayed through a Human-Machine Interface (HMI) that allows for quick and easy decision making, and easy manoeuvre implementation. The design of the Decision Support Tools will give each crewmember usable, flexible and informative means for supporting SA and aid in their specific decision making task. (cf. page 38)*

HF Issues (Nr. 28):
There is a lot of automation forseen in the proposed ATM system which is meant to 'assist' the crew in their new task. One challenge posed by automation is to keep the human in the loop, which does not mean that humans should merely react on suggestions of the automated system, but be able to make a careful decision based on well-understood information. One important issue in introducing automation is to find the right level of information that has to be provided in order to enable the aircrew to follow the underlying processes, understand the 'problem' and accept proposed solutions or find alternative solutions if appropriate. It should be added, that the level of automation may need to vary as a function of environment and crew workload.

The choice made in the current ConOps was to allocate part of the functions, necessary to assure self separation, to automation, considering this *'substitution'* (of human) more efficient because humans can not handle the needed amount of information to guarantee the adequate situation awareness for conflict detection. This kind of function allocation will not mean actually an increase in SA (as stated in ConOps) as crew may not get the understanding of the environment while being exposed to the computed "big picture". Nowadays, ATCos are well aware of both the big picture and threats, and crews trust ATCos' instructions for that.

Automation must be supportive, not burdening. There is already a lot of automation on board and manual operation takes a backseat, aircrews are bred to press buttons and fully rely on the systems. This might be a safety issue to be developed further in ConOps, especially for the situations, if the system fails.

Based on the complexity of the proposed system and the consequent wealth of different information and graduations of information depending also on the urgency of information or reliability of data used within the decision support tools, it will be very difficult to provide the crew with the right information at the right time to enable them to draw the right conclusions and make the right decisions. Even if it would be technically feasible to reliably exchange data between the crews (and SWIM) and a conflict probability indication as well as a possible solution, certain HF issues arise: appropriate HMI will be very important to assure easy human processing of relevant information as well as procedures to clarify which crew are supposed to do what: Will the system suggest both crews to adjust or only one? Is it the crew that first proposes an alternative that will be served first by SWIM? The inter-team relations (the crews + SWIM) should be carefully designed.

2.7.2 HF issues raised to Subsection 8.4 *"Autonomous Flight Rules"*

- *Autonomous aircraft (Aircraft that operate in SSA and that perform self separation) have to abide to the following rules:*
  - *Autonomous aircraft are responsible for maintaining separation with all other aircraft.*
  - *Autonomous aircraft are required to maintain separation from designated areas and no-fly zones.*
  - *Autonomous aircraft are required to adhere to flow management constraints. Renegotiation will have to take place if these constraints can not be met.*
  - *Lower priority autonomous aircraft involved in a medium term Intent based conflict ruled by priority are required to manoeuvre to solve it sufficiently in advance, so that the conflict does not continue until the conflict resolution becomes a short term cooperative conflict.*
  - *Autonomous aircraft shall not manoeuvre in a way that creates a short term (3 to 5 minutes) cooperative conflict.*
  - *The trajectory of autonomous aircraft shall at no time place the aircraft in a 2 minutes state vector conflict (blunder protection).*
  - *Autonomous aircraft shall not enter Managed Airspace without the approval of the controlling entity of that airspace. (cf. page 41)*

HF Issues (Nr. 29):
The rules should be formulated as simple and intuitive to follow.

Regarding bullet 3: How will the renegotiation process look like? Who is going to be involved? Who is going to be affected? Which information is needed to successfully renegotiate?

2.7.3 HF issues raised to Subsection 8.6 *"Conflict detection and resolution"*

2.7.3.1 HF issues raised to Subsection 8.6.1 "Long Term Area Conflict Detection (LTACD)"

- *The Long Term Area Conflict Detection functionality will apply to the LTAZ and detect any conflicts with "areas to avoid". The crew will be informed of these conflicts so that appropriate action can be taken. (cf. page 46)*

HF Issues (Nr. 30):
It is not yet clearly specified, where the ground support ends and airborne LTACD starts. It should be specified via which channel, which interface the crew will be informed.

2.7.3.2 HF issues raised to Subsection 8.6.2 "Medium Term Conflict Detection and Resolution (MTCD&R)"

- *The Medium Term Conflict Detection and Resolution module takes into account own trajectory intent information and that of surrounding traffic, up to 15 – 20 minutes (up to the time that it is possible to obtain reliable information) and area information.*
  - *Traffic Conflict Resolution uses priority rules to determine which aircraft has the right of way and which aircraft has to manoeuvre.*
  - *The aircraft which has to manoeuvre is required to do so, as stated in the AFR Rules, so that the conflict resolution is not delayed up until the point the conflict has to be resolved by both aircraft.*
  - *Resolutions will be displayed in the form of a modified route which can be implemented automatically or manually through the Flight Management System.*
  - *The flight crew should be able to consider the appropriate conflict resolution manoeuvre, evaluate several options, and execute any given manoeuvre, with the only constraints being:*
    - *The manoeuvre has to solve all conflicts.*
    - *The manoeuvre shall not create new conflicts and be conflict free up to a TBD time (e.g., 10 min) beyond the medium term look ahead time.*
  - *Medium term CR will, under normal circumstances represent the most cost-effective traffic separation assurance option, since comparatively small changes in the trajectory will be sufficient to ensure aircraft separation. (cf. page 47)*

HF Issues (Nr. 31):
"*… all conflicts*" may be too broad definition. "*The manoeuvre shall not create new conflicts and be conflict free up to a TBD time beyond the medium term look ahead time"* – How fast is SWIM expected to be in responding, when traffic is dense and the destination airport is fully loaded?

MTCD&R seems as the optimal CD&R module and optimal timeframe; most of CD&R events have to take place by using this module and in this timeframe according to the present A^3 ConOps, but it may happen, that the available prognosis in this module and in this timeframe is not accurate enough to make final CR decisions. It may happen that only the probable cases of future conflict resolution needs can be forecasted by this module, because the execution of specific conflict resolution cases on the basis of imprecise information available at that module in this timeframe may ask for too extensive manoeuvres (both in time and space). Such manoeuvres may be too time and fuel consuming to execute. Maybe, the CR decision can only be preliminarily prepared on the basis of information obtained from this CD&R module and the final CR decisions have to be made by using the Short Term CD&R information instead.

The crew might additionaly want to know about the accuracy of the used data which lead to an alert in order to choose the optimal resolution for the conflict.

2.7.3.3 HF issues raised to Subsection 8.6.3 ”Short Term Conflict Detection and Resolution (STCD&R)”

- *The Short Term Conflict Detection and Resolution module considers the best traffic information available up to the 3 to 5 minutes range, as well as area information. The traffic information may include the first level of intent (i.e, turn point or level-off altitude within 3 to 5 minutes). It is assumed that under normal operations the ownship aircraft will always be able to consider at least its own first level of intent.*
    - *Target State information, which is providing information on the horizontal and vertical targets (heading, speed and altitude) for the active flight segment, can be used as first level of intent.*
    - *The traffic state vector extrapolation is considered to be representative up to 5 minutes ahead.*
    - *Short Term CR will enable a quick execution of the conflict resolution; this will involve:*
        - *Fast automated assessment and calculations*
        - *Presentation of simple manoeuvre options to the flight crew*
        - *Primary focus will be on CR execution instead of trajectory management (cf. page 48-49)*

HF Issues (Nr. 32):
Concerns expressed above about MTCD&R module may shift the actual conflict resolution need to STCD&R module and timeframe. This means that MTCD&R module and timeframe will be useful only for obtaining necessary levels of SA to prepare the CR manoeuvres to be executed later on by STCD&R module in short term timeframe. This will cause the crew to cumulate their peak responsibility decisions and actions of self separation into short time period prior to predicted conflict. From human factors point of view the comfortable medium term period of CR will be replaced by time pressured short term CR period. As a consequence the CR situation may reobtain high stress generating features for pilots. Measures in the MTCD&R algorithm should be taken to avoid this situation to happen.

But we speak here still about some minutes. The issue is more related to the time a proposed CR manoeuvre is valid and how much time the aircrew will get to make up their decision. Because if the proposed solutions would change with respect to the remaining time to loss of separation (TCAS alert) this would be very irritating and confusing because they would have to start their decision making process over and over again. Or it would lead to the effect that the crew would just take the first solution without thinking about it (waiting and thinking would just be time consuming and frustrating).

The availability of ASAS has twofold impact to the crew behaviour both today and in the future. From positive side it will certainly lower the potential stress of crew members, who know that they are backed up by another safety shield, but from negative side it may cause the dangerous attitude of overconfidence in the system performance and the lack of readiness to act if the crew action is inescapable.

2.7.4 HF issues raised to Subsection 8.8 ”Priority rules”

- *In case of identical priority levels, an arbitrary procedure (based in the aircraft call signs for example) will be used to ensure that priority is always unambiguous. (cf. page 51)*

HF Issues (Nr. 33):
The class of the aircraft and the purpose of its use may need to be taken into account. It may be worth of considering to give the FOC-based aircraft priority over non-FOC aircraft among normal aircraft in the table 8.7.3.

2.7.4.1 HF issues raised to Subsection 8.8.1 *”CTA requirements considerations”*

- *As aircraft get closer to the TMA arriving point (Metering Fix), the Arrival Manager (AMAN) will/can issue an updated CTA with a reduced window size. As a result the onboard priority level will increase accordingly. In other words, when aircraft get a tighter constraint they also have a higher priority. The priority level is no indication of position in the arrival sequence but is only used for Medium Term conflict resolution. (cf. page 51)*

HF Issues (Nr. 34):
It is unclear, how the priority level of other aircraft in the vicinity will be detected in relation to the own aircraft. If the priority will be determined automatically from SWIM-derived data, then due to different time lags in contacting SWIM by different aircraft the priority information may quickly become outdated and even conflicting.

It would have to be SWIM. As priority will be set dynamically for both aircraft, it is SWIM that should issue at a particular moment the decision which aircraft has to take action and then stick to that decision (even when priority might change afterwards). Pilots should not became tactical in the sense that just waiting with a decision would result in a situation that they no longer have to take action because they now have a higher priority so that the other crew will have to take over (that would be re-entering the chicken race). At what point will SWIM issue the decision which crew has to adjust?

2.7.4.2 HF issues raised to Subsection 8.8.2 *”Manoeuvrability considerations”*

- *The aircraft manoeuvrability classification, concerning:*
  - *Speed envelope*
  - *Turning radius*
  - *Climb rate*

will be considered in the priority level determination (cf. page 51)

HF Issues (Nr. 35):

It seems, that the normal aircraft with higher manoeuvrability characteristics could always get the lower priority levels and should have to manoeuvre more than the others (perhaps airliners). The priority rules should not be ambiguous in this aspect.

There may also be issues other than the aerodynamic ones listed. For example, the health of a patient in a medivac aircraft may dictate much milder maneuvers than what the aircraft is physically capable of performing.

2.7.4.3 HF issues raised to Subsection 8.8.3 "Mission statement categories for priority determination"

- *The aircraft mission will be reflected in its priority level. The following table summarizes some of the categories considered for priority determination:* *(cf. page 51)*

HF Issues (Nr. 36):
There may also be issues other than the aerodynamic ones listed. For example, the health of a patient in a medivac aircraft may dictate much milder maneuvers than what the aircraft is physically capable of performing.

2.7.5 HF issues raised to Subsection 8.9 "Transition Operations"

- *The A^3 ConOps does not consider transition operations in/out SSA, however a few outlines are given in order to provide a more complete vision of this Operational Concept.*
- *ANSPs managing TMAs are responsible for separation and flow management for aircraft inside their MA. The following relationship exists between the part of the aircraft's trajectories that takes place in SSA and the transition to MA:*
  - *ANSP will issue arriving and exiting CTA restrictions in order to maintain safe and efficient operations inside the TMAs.*
  - *When required by circumstances, ANSPs will broadcast new CTAs for aircraft entering or exiting TMAs.*
- *Aircraft will leave the departure TMA in a position, time and course specified by their 4D take off and departure trajectory contract. The ANSP will have to ensure that the active RBT will be conflict free for a TBD timeframe (e.g. 10 min) when leaving the TMA.*
- *The aircraft will have to meet the arriving TMA CTA under the following conditions:*
  - *The aircraft has to be conflict free when entering TMA airspace.*
  - *The aircraft speed and course will conform to a 4D trajectory contract into TMA.*
  - *The aircraft needs to be able to anticipate any failure to meet the CTA requirement and inform the ANSP in advance, so that the CTA and entry requirements can be adjusted accordingly.*
- *CTAs will be produced by CDM (Collaborative Decision Making) between the Pre-Flight actors and ANSPs. The resulting exit/entry TMA organization (at the SFM level) should ensure, in principle:*
  - *Conflict-free normal operations (i.e. if aircraft do comply with CTAs, they will be conflict-free in the immediate vicinity of the High Density – TMA boundary).*
  - *The achievement of a safe, orderly and expeditious flow of traffic.*

> - *The goal is to avoid generation, at a managing level, of any ‘a priori’ conflicts.*
>
> - *Controlled times of Arrival are* ***not*** *exact times for arrival. Rather, they represent a time window whose margins are refined in the course of the flight:*
>   - *Initially, the ANSP gives the aircraft a CDM-originated CTA, along with a time window, representing the original estimation for that particular aircraft arrival.*
>   - *As the flight progresses, the time window is reduced, reflecting the aircraft actual manoeuvres; this process takes place without the need of a RBT modification (for example: an aircraft has had to solve several conflicts and thus its CTA-compliance is displaced towards a later time, but it is still inside the original CTA interval; a new and reduced interval is defined in order to allow the aircraft to still comply to CTA).*
>   - *At the final stages of the aircraft’s en-route phase of flight, a ‘CTA lock-down’ is issued in the form of a fixed CTA, along with an appropriate priority level increase for that aircraft; at this point the time for the aircraft arrival is fixed. (cf. page 52-53)*
> - *The ANSP may issue spacing instructions (TTF and SI) to equipped aircraft in order to enable them to transition from a 4D operation to a Merging and Spacing (MS) operation. Aircraft that are actively spacing outside the TMA are still required to remain separated from all other aircraft. However, spacing aircraft will have priority over normal non-spacing or non CTA constrained aircraft. (cf. page 52-53)*

HF Issues (Nr. 37):

The time short before entering the arrival TMA will be a critical phase regarding safety and responsibility issues, for the aircrew as well as for the ATCos. ATCos will have to monitor the inbound traffic in SSA to ensure a optimal handling of the traffic when inside the TMA. The aircrew might follow some instructions of the ATCo, e.g. pilots might be asked to perform merging or in-trail spacing before they are entering the TMA, while remaining responsible for self separation and therewith ensuring safety.

The Airborne – Airborne datalinks for Sequencing and Merging could be included in the active trajectories, making the aircraft to adjust to the flow automatically. ATCo would only have to monitor that the flow is as planned. The same would be the case if Sequencing and Merging would take place within the TMA. Under normal conditions, the ATCo workload will be low here.

Compared to arrival times, the arrival points or entry points to TMA may not be clearly defined. Those entry points might even change due to conflicts short before entering the TMA. This circumstance might again lead to a high level of workload on the ATCo side even in normal conditions. In this case the main bottleneck of today’s ATM system would still sustain: the limited capacity of the ATCo in terms of workload.

We might consider a possible solution by assigning all the aircraft in some zone abound the SSA with slightly different altitudes – e.g. within X miles of the SSA aircraft entering or departing would enter on even thousand and those just passing by would use odd thousands.

2.7.6 HF issues raised to Subsection 8.10 ”Military operations”

> - *The A^3 ConOps is primarily aimed at the operation of civil transport aircraft.*

However, aircraft performing military or national tasks can be accomodated in this concept.

- *All military aircraft (fighters, transport, UAVs, etc) have to be properly equipped, capable of self separation and follow AFR rules to be able to enter and operate in SSA, just like all other aircraft.*
- *While it is outside the scope of this ConOps to assess all possible military operations, two cases are considered, in order to show the potential flexibility of the A^3 ConOps:*
  - *The interception of a civil aircraft by an air defence fighter.*
  - *the operations of a head-of-state aircraft. (cf. page 53)*

HF Issues (Nr. 38):
It seems necessary to define all the possible legal military operations that can take place in the SSA of military conflict-free state (including military training and “war games”).

2.7.6.1 HF issues raised to Subsection 8.10.1 *”Intercept missions”*

- *The mission requirements of air defense fighter aircraft in an interception mission may be opposite from the main basic assumptions presented in this ConOps: while the goal for autonomous aircraft is to maintain separation, intercept missions require that fighter aircraft get close enough to the target aircraft without being detected.*
- *In order to avoid detection by the target, the intercepting aircraft may:*
  - *deactivate the Air-Air DL, while retaining ‘IN’ (receiving) functions operative, allowing it to achieve traffic SA through Air-Air DL and SWIM;*
  - *indicate to SWIM that own position updates will not be made available to other SWIM users.*
- *Due to the fact that intercepting aircraft cannot be detected by other aircraft, interceptors will have the sole resposibility to maintain separation with all other aircraft. (cf. page 54)*

HF Issues (Nr. 39):
Perhaps the intercept mission should be in parallel considered both as a military operation and also as a special case of non-normal operations in SSA.

A distinction should be made between a hostile enemy aircraft entering the airspace and an airliner that has lost transponder or is being hijacked. For the hostile act, the actions will be appropriate, but not for the airliner being intercepted. Either pilots or bandits in an airline aircraft should know that the intercepting aircraft are coming.

2.7.6.2 HF issues raised to Subsection 8.10.2 *"Head-of-state aircraft operations"*

- *Head-of-State (HS) aircraft will require that other airspace users maintain a larger than normal separation distance. Furthermore, there may also be a requirement that other aircraft should be unaware of the presence of such a valued aircraft.*
- *HS aircraft may opt to use a common / generic call sign which will make the aircraft indistinguishable from other traffic aircraft.*
- *HS aircraft may also be using a higher separation class and/or priority value, which will force other aircraft to maintain a larger separation distance and require them to move first in case of conflict. (cf. page 54)*

HF Issues (Nr. 40):
As in the case of intercept mission the head of state aircraft operations may need parallel consideration both as a military operation and also as a special case of non-normal operations in SSA.

2.7.7 HF issues raised to Subsection 8.11 "Non-normal and Emergency Operations"

2.7.7.1 HF issues raised to Subsection 8.11.1 *"General considerations"*

- *The terms 'Non-normal operations' and 'Emergency Operations' in the A^3 ConOps refer to:*
  - ***Non-normal operations:** those operations that require a modification of normal operations, as they have been defined in the A^3 ConOps, but where the aircraft can still meet the required safety levels under the general assumptions made.*
  - ***Emergency operations:** operations where safety levels for the aircraft cannot be maintained under the general assumptions made in the A^3 ConOps.*
- *In general, the following considerations apply for Non-normal and Emergency operations:*
  - ***Concerning overall self separation capabilities:** Aircraft that are aware of the fact that they are no longer capable to self-separate will be required to enter Managed Airspace as soon as they are able. Other aircraft will have to perform all separation requirements regarding that particular aircraft when it still is inside SSA. Non-normal aircraft may be required to transmit their operational performance level, which is an indication of their self separating capabilities.See table in section 9.2.4.*
  - ***Concerning medium term conflict management:** When an aircraft is in a non-normal or emergency situation the crew or automation will update the condition level of the aircraft. The condition in which the aircraft operates will affect the priority level that will be broadcasted. Aircraft in a non-normal or emergency situation will broadcast a higher priority level.*
  - *Concerning short term conflict management:cooperative resolution manoeuvres in State Based CR will ensure that the conflict will be resolved even if the participating Non-normal aircraft is unable to*

manoeuvre.

- ○ ***Concerning surveillance capabilities**: Loss of Air-Air DL will have to be indicated to the SWIM network by any means possible. Ground applications will continue to track the aircraft through position reports and/or radar returns. Other aircraft will continue to receive surveillance updates for this aircraft through SWIM network as long as the aircraft is in SSA.*
- *When an aircraft trajectory information is not available through any of the normal means, SWIM might provide dynamic RAA around a non-self separating aircraft. Affected traffic will avoid that RAA as an area conflict.*
  - ○ ***Concerning Navigation Performances**:any aircraft that is not able to conform to its broadcasted intent, will have to indicate this to the SWIM network. The procedure may require the aircraft to broadcast a different SM class in order to maintain the safety level of the operations.*
    (cf. page 55-56)

HF Issues (Nr. 41):

Remark: "Concerning overall self separation capabilities: Aircraft that are aware …" – The term "*aircraft*" is not appropriate here!

In case the conflict detection and/or conflict resolution tool might fail, the aircrew might be able to solve such a situation because they still have an overall picture of the situation, depicted on a traffic display. But if one considers a total breakdown of traffic information on the part of the onboard tools or on the part of data transmission, it would be impossible for the crew to operate in the SSA anymore. In such a case several aircraft operating in the SSA would have to leave the SSA.

In case the ATCos are envisaged to serve as a fallback option in such emergency situations, ATCos would have to monitor the traffic in SSA all the time; otherwise they would be not prepared, not to mention the workload which would rest on their shoulders. Responsibility issues would arise when they are asked to propose a solution for a given problem.

The fallback may also be in an automated system. In SESAR the full fallback to ATCo is not considered as an option. Perhaps for the en route phase, it may still be an option (requiring considerable standby workforce and training though).

Another issue might raise due to the fact that iFly aims to restrict voice communication to emergency situations only. This might lead to a feeling of isolation in future cockpits and might also foster a more competitive behaviour which might again lead to the "playing chicken" behaviour during the resolution phase of a conflict. FOC center might become ATCos in terms of "whom to call when something goes wrong".

Assuming that one aircraft has an emergency to the extent that the aircrew is not able to assure self separation, it will be an extreme situation to handle for this aircrew, but the main responsibility and pressure lies on the shoulders of the aircrews operating in the vicinity. They will be responsible to separate themselves from the emergency aircraft. The level of workload and stress level could increase to an unacceptable limit if there are no clear procedures available for these situations.

2.7.7.2 HF issues raised to Subsection 8.11.2 *"Non-normal Operations"*

- *With regard to non-normal operations, it is expected that there are one or several aspects of the A^3 ConOps ATM system that require the involvement* *of an ANSP.*

- *The degradation in the specified levels of performance for non-normal operations, will require modifications of the operational procedures to maintain the required safety levels under the A^3 ConOps.*
- *Non-normal ATM performances can be classified as a reduction in:*
  - *Navigation performances*
  - *Communications/Surveillance performances*
  - *Trajectory and conflict management performances (cf. page 56)*

HF Issues (Nr. 42):
The ground support aspects of non-normal operations need further development in the ConOps. The content and the procedures of ground support have to be elaborated by possible classes of non-normal operations.

2.7.7.2.1 HF issues raised to Subsection 8.11.2.1 "Navigation performances"

- *Required Navigation Performance Capability (RNPC) is defined as a parameter describing lateral deviations from assigned or selected track as well as along track position fixing accuracy on the basis of an appropriate containment level. RNP types specify the minimum navigation performance accuracy required in an airspace.*
- *If an aircraft is not able to conform to its broadcasted trajectory (a certain RNP being considered), it will broadcast its 'non-conformance' status – when there is a non-conformance with the RBT – and/or a message of 'Aircraft Navigation Equipment Status - diminished', along with the reduced RNP type, as stated in the Information Flows table of section 9.2.4.*
- *The Separation Minima class regarding the non-conforming aircraft may have to be adjusted to reflect diminished navigation performance. The SM class of the aircraft will be broadcasted and made available to the SWIM network. The flight crew of other aircraft will be able to distinguish the different SM class, but otherwise will proceed as normal. (cf. page 56-57)*

HF Issues (Nr. 43):
Same as previous (Nr. 42). The ground support aspects of non-normal operations need further development in the ConOps. The content and the procedures of ground support have to be elaborated by possible classes of non-normal operations.

2.7.7.2.2 HF issues raised to Subsection 8.11.2.2 "Communication/Surveillance performances"

- ***A Communication/Surveillance performance drop may impact either:***
  - *An aircraft's ability to determine its position and trajectory (Surveillance).*
  - *An aircraft's ability to communicate its position and trajectory (Communication).*
- ***Surveillance:** if an aircraft is not able to accurately determine its position and trajectory, then this information will have to be made available to all surrounding traffic. SWIM may continue to provide position updates for this non-normal aircraft correlating available data with other secondary surveillance means (e.g. primary radar). The non-normal aircraft may still be able to provide reduced self separation capabilities. As with the case of reduced navigation performance, the non-normal aircraft SM class may have to be increased to reflect the reduced positioning accuracy.*
- ***Communications:***

- ○ *Loss of Air-Air DL communications will be compensated by SWIM. However, the SWIM update rate and accuracy might reduce ASAS performances. The non-normal aircraft will communicate its operational performance level and its SM will be reclassified to reflect the situation.*
- ○ *Loss of SWIM communication will merely cause a reduction in ASAS efficiency and trajectory management capability, but will not result in greatly diminished ASAS performance. Aircraft's SM may not have to be reclassified.*
- ○ *Simultaneous Air-Air DL and SWIM loss will effectively make the avionics of that aircraft 'blind', and therefore incapable of self separating. The aircraft is required to reach MA as soon as able, and use all means available to communicate its position to other aircraft. The tasks of maintaining separation from that aircraft will fall upon nearby aircraft's flight crews. (cf. page 57)*

HF Issues (Nr. 44):
Same as previous (Nr. 42, Nr. 43). The ground support aspects of non-normal operations need further development in the ConOps. The content and the procedures of ground support have to be elaborated by possible classes of non-normal operations.

2.7.7.2.3 HF issues raised to Subsection 8.11.2.3 "Trajectory and conflict management performances"

- *If an aircraft has only a partial loss of its CD&R performances, and it is still capable of performing self separation, given that the situation:*
  - ○ *Does not require too much effort from the flight crew, and*
  - ○ *Does not represent problems that are too complex for a reduced capabilities on-board system, the aircraft will continue to operate under the appropriate priority levels and SM class. (cf. page 57-58)*

HF Issues (Nr. 45):
Same as previous (Nr. 42, Nr. 43, Nr. 44). The ground support aspects of non-normal operations need further development in the ConOps. The content and the procedures of ground support have to be elaborated by possible classes of non-normal operations.

2.7.8.1 HF issues raised to Subsection 8.11.3*"Emergency Operations"*

- *An emergency occurs when an unforeseen event creates a hazard to the passengers, the crew, or the aircraft, which requires immediate action. In the context of the A^3 ConOps, an emergency is considered to be any situation in which the safety levels for the aircraft cannot be maintained under the assumptions made.*
- ***Main rule:** Emergency aircraft will obtain the highest priority level and will be required to exit SSA and reach Managed Airspace as soon as they are able.*
- *When an aircraft crew believes it's aircraft is in an emergency situation then that aircrew will be able to declare an emergency through all communication means available:*
  - ○ *Throught the aircraft emergency frequency (International Air Distress (121.5 MHz) for civil aircraft, Military Air Distress (243.0 MHz) for military aircraft).*
  - ○ *Throught the enabled voice communication frequency in that particular sector.*
  - ○ *Throught Air-Air DL and SWIM (emergency/priority status message).*

> - ○ *Adjusting the SSR transponder to reply on Mode 3/A Code 7700.*
> - *The aircraft emergency status will also be made known to all actors through SWIM.*
> - *The emergency aircraft will in collaboration with the governing ANSP be able to choose a preferred route into Managed Airspace.*
> - *Separation responsibility from aircraft which have declared an emergency will fall upon nearby traffic.*
> - *The SM classification used for the emergency aircraft will take into account:*
>   - ○ *Possible deviations from the aircraft declared trajectory.*
>   - ○ *A possible surveillance capabilities degradation.*
>   - ○ *The aircraft actually not providing any surveillance information, which will mean having to rely upon SWIM data, which will be less accurate and with a lower update rate*
>   - ○ *The hazard that an emergency aircraft presents to nearby traffic, by itself.*
> - *The procedures (which will involve ATC) concerning the transition of an emergency aircraft from SSA to MA are not considered.*
> - *In order to prioritize the entrance of the emergency aircraft into MA, the governing ANSP may have to issue a new set of CTAs to all other aircraft. CTA changes to other aircraft, as a result of an emergency, will not be subjected to negotiation between the other aircraft and the ANSPs.*
>   *(cf. page 58-59)*

HF Issues (Nr. 46):
Development of ground support concept in the refined A^3 ConOps requires elaboration of the content and procedures of ground support in emergency operations. The main purpose of the ground support in emergency should be to help the crew in emergency, alleviate the situation of crews in vicinity of emergency aircraft and to prevent the escalation of emergency situation in a more dense, less separated context.

2.8 HF issues raised to Section 9 “A³ Systems”

2.8.1 HF issues raised to Subsection 9.1 ”Communications”

HF Issues (Nr. 47):
A^3 concept in D1.3 is based on the absence of ground-based ATC which obviously effects the nature of communication in general. Today high effort is put into frequency changes and reporting to the ATCo via the voice channel. Almost all information about the environment is currently taken from this source. iFly aims to remove this communication completely. It is proposed in the concept to maintain a voice channel for emergency situations only. This will result – assuming that there will be few emergency situations – in a very quiet cockpit. Thus the aircrew might feel isolated.
But such feelings might diminish and the issues may only relate to the transition phase.

There would be nobody to confer the data with – this might affect the trust in the system. It might also lead to a higher rate of private conversations just to breach the silence but also to more discussions on the traffic situation, on-board systems, etc. to have a common picture and prepare a common strategy for the ongoing flight. New cockpit procedures shall be developed in order to solve the question ‘who is doing what? When? And how? So the inter-crew communication, content and quantity could change according to the new tasks. This possible effect may be reduced by well designed conversion training.

In the above mentioned discussion also the FOCs might play an important role (see also D1.2). They have an overview of the whole fleet and probably of some other aircraft which invested in their services. They might be included into the conflict resolution task in terms of ‘what is the best solution taking the whole fleet into account’. So the communication might also increase on the ground side.

FOC will have such considerations all the time, but it should not be something to discuss on the radio when working out a CR (assuming a dedicated frequency). And it should not be expected to happen either.

The voice channel today is also used to receive some additional data regarding the weather situation. Today the crews receive accurate data from aircraft flying ahead. It is not clear, if in the future the loss of this information channel will be adequately replaced by, e.g. SWIM.

In case of an emergency iFly proposes to have a voice communication channel. Two main questions appear there: will all the aircraft operating in the SSA have to monitor this frequency or will this frequency only be accessible for involved and neighbouring aircraft. In the first case many aircraft will be bothered with emergency situations they are not involved in. And in the latter case some aircraft involved might be excluded because of a failure in calculating ‘who needs to receive this information – who not’. Radio communication procedures shall be adjusted and renewed according to SSA users’ needs in case of emergencies as well as for normal operations.

Several problems which might occur as a result of changes in the communication might be covered by new rules, regulations, procedures… but crew resource management will be of equal importance.

2.8.2 HF issues raised to Subsection 9.2 ”Automated Ground Surveillance Support”

HF Issues (Nr. 48):
While developing the concepts of the ground support, more elaboration will be needed for automated ground surveillance functions together with prognosis, where the boundaries between ground based (or gathered) data (SWIM) and airborne gathered data lie.

2.8.2.1 HF issues raised to Subsection 9.2.1 *”Information Sharing System”*

HF Issues (Nr. 49):
It is stated in the ConOps that some data will be available “upon request” and some will be periodically sent to the aircraft. The question comes up to what extent the aircrew is involved in this process. What does “upon request” mean for the aircrew? Could they ask for additional data (“upon request”) which is not included in the periodical update?

2.8.2.2 HF issues raised to Subsection 9.2.2 *”Traffic Proximity Detection”*

HF Issues (Nr. 50):
See the next comment (Nr. 51).

2.8.2.3 HF issues raised to Subsection 9.2.3 *”Complexity Predictor”*

HF Issues (Nr. 51):
The work of these two tools should be undetectable for the flight crew.

2.8.2.4 HF issues raised to Subsection 9.2.4 *”Information Communication Structure”*

HF Issues (Nr. 52):
The table doesn’t include the information how far the aircrew will be involved or even informed about the information exchange. And it doesn’t indicate which information is in the end presented to the aircrew and which is not. It just mentions “aircraft” as one possible acknowledgement. Does that mean that only the airborne automated system is informed with no indication to the aircrew? It might be interesting to have a table where the information presented to the aircrew is indicated, where this information comes from…

2.8.3 HF issues raised to Subsection 9.3 "Cockpit/airborne System"

2.8.3.1 HF issues raised to Subsection 9.3.2 "Airborne separation Assistance System (ASAS)"

HF Issues (Nr. 53):
As stated above (see comments Nr. 31 and Nr. 32 on the pages 25-26), it may happen, that contrary to the current A^3 ConOps views the main burden of CD&CR will fall onto short term CD&CR module and timing because of data precision problems. It will put higher strain on the crews in short term period before the predicted conflict compared to the initially planned comparatively comfortable approach, which is oriented mainly to medium term CD&CR. In this case LT CD&CR and MT CD&CR generated warnings will serve mainly as SA enhancing means to prepare the crew for quick decision making and immediate actions in short term time frame.

So from HF point of view, we might want to pose a hard requirement to the A^3 system which may look something like: 95% of the shared data needs to be provided within 15 seconds. 100% of the shared data needs to be provided within 30 seconds. Or whatever makes sense and is measurable.

2.8.3.1.1 HF issues raised to Subsection 9.3.2.1 "Conflict Detection"

- *If a conflict is detected by any of the conflict detection modules, it passes through to the Conflict Processing module, which will process the information and send it to the resolution modules and via the HMI to the flight crew. (cf. page 68)*

HF Issues (Nr. 54):
The maneuvering options will need to be presented in a way that is intuitive to the crew such that they understand the options and can act within the time limits.

2.8.3.1.2 HF issues raised to Subsection 9.3.2.2 "Conflict Processing"

- *Situations which would only become dangerous if failures occur (e.g. FMS failure to follow lateral path), also known as blunder conflicts, one or both of the following actions will be taken:*
  - *The situation is registered and further analyzed during following iterations.*
  - *A **caution** indication is provided through the HMI to make the crew aware of the situation.*

  . . . .
- *When a conflict is to be presented to the flight crew, it must be given in a timely and effective manner. The amount and content of information which is needed by the flight crew to enter the decision making process regarding conflict resolution is subject to investigation. (cf. page 69)*

HF Issues (Nr. 55):
The options will need to be presented in a way that is intuitive to the crew such that they understand the options and can act within the time limits.

*2.8.3.1.3 HF issues raised to Subsection 9.3.2.3 "*Conflict Resolution*"*

- *Depending on the urgency of the conflicting situation there are two different CR modules. They differ in the time that is required for action and in the form and execution of the CR manoeuvre(s):*
  - ***Short term CR** addresses conflicts with a short time to Loss of Separation (LoS) – (up to ~3-5 min) In this context immediate action is required (research parameter, typically about 30 s). The module generates only an isolated CR manoeuvre, not a consistent RBT update (this is resolved subsequently by Trajectory Synthesizer). The pilot will decide to execute the manoeuvre manually or via the mode control panel of the autopilot.*
  - ***Medium Term CR** addresses conflicts with a longer time to Loss of Separation (LoS) – (up to ~10-20 min). In this context timely action is required (research parameter, typically 1-2 minutes). Within Medium Term CR manoeuvres are generated in the form of a consistent RBT updates that can be provided to the FMS and executed. In this way strategic constraints are taken into account as well as the manoeuvre optimization. (cf. page 69)*

HF Issues **(Nr. 56):**
See the comments to the sections 8.6.2., 8.6.3 and 9.3.2 (comments Nr. 31 and Nr. 32 on the pages 25-26 and comment Nr. 53 on the page 38).

1 Short term CR algorithm characteristics

- *The CR module may generate several possible manoeuvres.*
- *The CR manoeuvre(s) is/are immediately presented to the pilot and at his/her discretion either executed through the autopilot (Mode Control Panel) or by manually execution.*
- *The information about the manoeuvre is also provided to Trajectory Synthesizer (see 9.3.2.4). (cf. page 70)*

2 Medium term CR algorithm characteristics

- *Both state and intent information will be used in the CR algorithm.*
  . . . .
- *The CR module will internally generate several possible manoeuvres and will prioritize them. It is a subject of research how (and how many of them) they will be presented to the crew. (cf. page 70)*

HF Issues **(Nr. 57):**
The manoeuvering options will need to be presented in a way that is intuitive to the crew such that they understand the options and can act within the time limits.

2.8.3.1.4 HF issues raised to Subsection 9.3.2.4 "Trajectory Synthesizer (TS)"

- *This module will ensure that after all tactical and/or strategic trajectory changes a new consistent (complete) conflict and areas-to-avoid free RBT respecting AFR exit condition (if possible) is constructed and inserted to the FMS. For these purposes it may call other functions. The typical scenarios are:*

> ○ ***Short Term (state) CR manoeuvre.*** *As this manoeuvre must be executed without delay, it is directly sent to the pilot for execution. At the same time the information about the manoeuvre is also sent to the TS, which will generate a connecting conflict free trajectory taking into account the constraints and some level of optimization. This new trajectory is then (after pilot's input) inserted into the FMS.*
> . . . .
>
> • *In addition, the trajectory synthesizer should also handle the RBT changes initiated by the flight crew. In particular, a modified route inserted into the FMS will be automatically provided to the TS, which can call relevant CD functions to verify that the route is free of conflicts. After this verification, the flight plan may be safely activated. (cf. page 71)*

HF Issues (Nr. 58):
The conditions, under which the RBT changes need to be initiated by flight crew, have to be defined in a more detailed way.

2.8.3.2 HF issues raised to Subsection 9.3.4" Human Machine Interface – Recommended design guidelines"

> • *The effect of the introduction of advanced tools to support the flight crew during the separation manoeuvre related to situational awareness, team situational awareness and vigilance must be addressed. Safety impacts that may result from changes in these areas also have to be addressed.*
>
> • *Concerning the design of supporting tools (conflict detection and resolution) and its HMI (display) the guidelines as stated in the ICAO circular 249-AN/149 must be followed:*
> ○ *The human must be in command.*
> ○ *To command effectively, the human must be involved.*
> ○ *To be involved, the human must be informed.*
> ○ *Functions must be automated only if there is a good reason for doing so.*
> ○ *The human must be able to monitor the automated system.*
> ○ *Automated systems must, therefore, be predictable.*
> ○ *Automated systems must be able to monitor the human operator.*
> ○ *Each element of the system must have knowledge of the other's intent.*
> ○ *Automation must be designed to be simple to learn and operate.*
>
> *While the calculations will be automated, the decision making process will be left to the human. (cf. page 72)*

HF Issues (Nr. 59):
The HMI for the many new systems and components that will be added for SESAR and A^3 should be worked out in an integral way. Information should be presented, removed or integrated smoothly. There exist some very good, but admittedly preliminary, guidelines for this effort from programs like NASA's Advanced Air Traffic Technology research and several unclassified military programs like the US Air Force Super Cockpit program. While these ideas and guidelines are still preliminary, they can be used to provide designers with a good place to start.

This issue is also fully applicable to Subsection 9.3.4.1 "Mode awareness".

2.8.3.2.1 HF issues raised to Subsection 9.3.4.3 "Conflict resolution"

- *The airborne decision support tools assist the flight crew in their new self separation task. CD&R advisories shall have the following desirable characteristics:*
  - *CD&R advisories should be inline with flight crews' way of thinking.*
  - *Resolution manoeuvres should be straightforward and especially Short Term CR advisories should be designed according to existing flight rules;*
  - *The ability to specify priorities (e.g. fuel, time, weather, comfort, etc) in the calculation of conflict resolution advisories should be investigated (the flight crew must be kept in the loop. They have to know how accurate the information within the algorithm is, and if this information reflects the actual situation).*
  - *In case of missing/wrong information (e.g. no weather information available, no information of congested areas, etc) the flight crew must be informed.*
    (cf. page 73)

HF Issues (Nr. 60):
For the flight crew to remain in the loop they will need at least a 3D solution and preferably a 4D solution. For example, passing 1000 ft vertically is easier, faster and cheaper than long level diversions. A completely intuitive display format will be needed.

2.8.3.2.2 HF issues raised to Subsection 9.3.4.4 "CDTI – basic functionality"

- *To perform airborne self separation, the cockpit crew must have accurate information on the surrounding traffic.*
- *A CDTI shall assist the flight crew in performing their self separation task. Information requirements for the HMI and CDTI concerning the following subtasks have to be defined:*
  - *Traffic monitoring*
  - *Conflict prevention*
  - *Conflict detection*
  - *Conflict resolution*
  - *Replanning*
  - *Inter-traffic/ traffic-FOC communication*

Some of the information requirements needed in order to accomplish each of the subtasks are explained in the following points:

- ***Traffic Monitoring (to assist Perception).*** *The CDTI should include the following functions:*
  - *Indicate traffic position.*
  - *Indicate traffic speeds.*
  - *Indicate identification of traffic: call sign or SSR code.*
  - *Indicate aircraft future state: based on intent or state information.*
  - *Indicate direction and attitude: track, climb/descent rate.*
  - *Traffic information shall be in the same frame as the navigation information.*
  - *An indication shall be given concerning the level of accuracy of the data (state or intent based information shall be indicated).*
  - *The crew should be able to de-clutter (deselect) the traffic information manually.*
  - *The capability of selecting of altitude bands should be provided for conflict de-clutter.*

- ***Conflict Prevention.*** *Conflict Prevention tools should assist the crew in the decision making process. The system predicts which manoeuvres will lead to a conflict before these manoeuvres are executed. Several studies have shown the usability of presenting the information of such a system in the form of "no-go" bands* *on speed, heading and vertical speed tape. Indications of such "no-go" bands must not conflict with other alerts/information and must not lead to confusion which could have impact on safety. Other implementations include FMS integrated prevention systems that poll for conflicts on the modified route. Some of the information that might be displayed for the purpose of Conflict Prevention will:*

- ○ *Show unsuitable headings, climb/descent sense and rates, speed ranges so as to avoid short term conflicts.*
- ○ *Show conflict zones.*
- ○ *Show high density traffic areas (overloaded areas in SSA) – Congestion Prediction.*
- ○ *Show hazardous areas.*
- ○ *Show specific areas in SSA: segregated areas, density of traffic in entry/exit points/areas.*
- ○ *Show SSA boundaries.*
- ○ *Show projected information (e.g. separation requirements along route for aircraft, objects and airspace; deviation between separation and prescribed limits; relative projected aircraft routes; relative timing across routes).*

- ***Conflict detection (to assist Comprehension):***
  - ○ *In case of conflicts the flight crew shall be alerted in a way which will also be effective when the flight crew is not monitoring a specific display (e.g. aural alert).*
  - ○ *Information about the conflict shall be provided: when, where, who and nature of conflict.*
  - ○ *In case of multiple simultaneous conflicts a priority order should be indicated (for use by 1-on-1 conflict resolution algorithms – mainly at Medium Term CD&R).*
  - ○ *A clear indication as to which of the aircraft involved in the conflict has priority will be provided (i.e. when using priority rules or due to an emergency).*
  - ○ *It is necessary to provide transparency as to why the system predicts the conflict.*

- ***Conflict Resolution (to assist Projection):*** *The CD&R system shall:*
  - ○ *Provide the crew with the means to be informed about and choose among various CR options.*
  - ○ *Assist the crew in the execution of resolution manoeuvres (the flight crew shall always be in command).*
  - ○ *The final decision making in CD&R is up to the flight crew.*
  - ○ *If required, the CDTI must show:*
    - ▪ *The resolution manoeuvres of other aircraft*
    - ▪ *Back-up options (fail-safe), in order to increase safety*
    - ▪ *The impact of potential route changes (e.g. amount of changes required; aircraft capabilities to perform changes; increase/decrease in length of route; cost/benefit of changes; impact of proposed change on: aircraft separation, arrival requirements, number of potential conflicts, aircraft fuel and comfort)*
    - ▪ *The time limit to perform a manoeuvre*

- ***Replanning (assists Projection):*** *the tools for replanning the trajectory after a CD&R situation (Trajectory Synthesizer) will enable the flight crew to determine the best moment of recovery, i.e. when they can return to their original intended path, if this is required, taking into account that the recovery manoeuvre should be part of the conflict solution.*

- ***Inter-traffic/ traffic-FOC communications:***
  - ○ *Data Link and SWIM interfaces will be the primary means for communication for flight crews. Operations are designed in a way that direct communication between flight crews is not necessary in regular operations, but there is the provision for establishing contact through these means in case of need. Radio will*

be preserved as a backup for aircraft- aircraft communications.
- ○ *Communications with FOC and ANSP (to negotiate CTAs) are also performed through data link, with radio as a backup.*
- ○ *The messages will make extensive use of the interaction between FMS, CDTI and the communications equipment in order to allow for a quick and easy transfer of RBT parameters and other data.*
- ○ *The call sign/SSR code will be provided on the traffic information display to identify other aircraft and to enable the crew to contact them in case of need (the call sign is also useful for crew coordination within own ship).*
- ○ *In addition to Air-Air Data Link, a R/T frequency band will be devoted to flight crew contingency and emergency communications, with the development of the specific rules regarding the use of this R/T frequencies falling outside the scope of the A^3 ConOps. (cf. page 73-76)*

HF Issues (Nr. 61):
Complete and intuitive cognitive integration will be necessary.

2.8.3.2.3 HF issues raised to Subsection 9.3.4.5 "General requirements for the CDTI design"

- *Minimize impact on cockpit (cockpit layout, new hardware, changes in existing equipment, etc).*
- *Minimize clutter; traffic symbols should present as much information as possible (necessary) without clutter.*
- *Provide crew with means to configure display with respect to:*
  - ○ *Displayed information;*
  - ○ *Selected range (e.g. long range can be used for conflict detection, and short range could be used for conflict resolution).*
- *Minimize training demands.*
- *Minimize human misunderstanding and action errors by an ergonomic study of the display and the interfaces, e.g.:*
  - ○ *The CDTI might be located in the pilots' primary scan zone.*
  - ○ *The CDTI shall have an acceptable size, resolution, visibility… etc.*
- *Minimize crew actions.*
- *Keep consistency in the display of information of different sources (e.g. Surveillance vs. ACAS data)*
- *Concerning collision alerts:*
  - ○ *Display Traffic Alerts (TA) with the relevant associated trajectories.*
  - ○ *Clearly indicate when passing from Separation Assurance to Collision Avoidance mode in ASAS.*
- *Congested areas, weather development and conflict information has to be integrated in a way that pilots can collect all relevant data and make a proper decision.*
- *Supporting tools shall enable the comprehension of emergencies/equipment malfunctions and alerts from both, ownship and other traffic operating in the SSA (e.g. equipment affected, flight time on remaining fuel, etc).*
- *Effects of false alarms on the flight crew and their decisions have to be kept in mind (cf. page 76)*

2.8.3.2.4 HF issues raised to Subsection 9.3.4.6 "General issues regarding Flight Deck integration of Airborne Traffic Management systems"

- *The airborne system will be integrated with the avionics system of the aircraft in such a way that the system has access to current aircraft state, autoflight mode, aircraft configuration and performance, surveillance information, navigation capabilities, constraints, and programmed trajectory information when available and relevant.*

- *The ASAS system, up to ASAS level, is independent from any Aircraft Collision Avoidance System (ACAS), and yet the two systems are designed to be inter-operable and non-conflicting, due to the fact that the ACAS functions are integrated seamlessly in the last ASAS layer. (cf. page 77)*

HF Issues (Nr. 62):
Complete and intuitive cognitive integration will be necessary.

2.8.3.2.5 HF issues raised to Subsection 9.3.4.7 "Workload"

- *Pilot's workload shall be kept within acceptable limits. Therefore it is needed to:*
  - *Correctly define the procedures (covering normal procedures in SSA and contingency & emergency events);*
  - *Develop reliable systems including safety and warning tools;*
  - *Develop emergency and recovery procedures for Emergency and Non-Normal Events;*
  - *Assess and formulate task distribution within the cockpit crew;*
  - *In order to minimize the additional demands required to gather and process the additional information, the choice of contents and the mode of display are crucial concerns that need to be taken into account at an early stage of the HMI design, and;*
  - *Self separation shall be easy to handle; for instance, input of new data into the system should be as easy as possible, should not create an increase in workload, should not lead to long head down time.*
  - *False alarms have to be considered. (cf. page 77)*

HF Issues (Nr. 63):
The development of procedures for contingency and emergency situations will be very critical to safety.

2.8.3.2.6 HF issues raised to Subsection 9.3.4.8 "Training"

- *Pilots as well as Air Traffic Controllers must be familiarized with all changes that will arise due to their new or changed responsibilities and tasks. This familiarization shall include changes in operational procedures as well as the usage of new or changed equipment.*
- *In order to ensure a high level of safety all identified stakeholders have to be provided with suitable trainings to strengthen their confidence in and deepen their knowledge of new procedures and supporting tools. (cf. page 77)*

HF Issues (Nr. 64):
Familiarisation training is almost an understatement. Many old habits will interfere with the new procedures and systems. It takes a lot of practice to ensure that the new procedures really overrule the old ones. This already is the case for a single new system component that looks alike the old one, but now we deal with completely new way of operation. It has to be remembered that part of the old procedures will still be in place outside the SSAs.

Zero flight time training will be possible, but with considerable exposure to realistic situations.

2.9 Concluding remarks

This section summarizes the objective of this report, the human factor issues identified during the critical review of the A^3 ConOps, and the proposed subject areas which might due to further elaboration lead to a refinement of the A^3 ConOps within the iFly project.

2.9.1 Issues for improvement of A^3 ConOps identified in this report

This report has performed a critical human factors oriented review of the A^3 ConOps developed in D1.3. As a result of this several issues for improvement of A^3 ConOps have been identified. The current report serves as the basis for a follow-up WP2 deliverable which takes the herein identified bottlenecks of the developed system and conceptualizes proposals for improvement of the A^3 ConOps.

2.9.2 Classification of HF issues

Most of the identified issues are related to A^3 ConOps design, and a few only are related to A^3 application. In order to systematize the results of the HF critical review performed for the A^3 ConOps, presented in WP1 D1.3, the HF issues identified in the preceding sections are categorized in Table 1.

Although there may be several options to form the categories and several approaches for categorization were preliminarily tested, the final choice was to use seven categories below related to A^3 system design:

Ground support issues (2, 3, 6, 13, 17, 19, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47)

SWIM-related issues (2, 3, 20, 21, 22, 23, 25, 26, 28, 31, 34, 35, 36, 41, 47, 48, 49)

Minimal operational requirements (4, 8, 9, 12, 27)

Transition issues (2, 3, 7, 11, 13, 24, 37, 41)

Human/ automation relationships issues (5, 12, 17, 28, 31, 32, 47, 50, 51, 52, 53)

HMI and communication issues (10, 17, 28, 41, 47, 54, 55, 57, 59, 60, 61, 62)

FOC/flight crew relations issues (14, 15, 16, 17, 18, 25, 29, 33, 35, 36, 41, 47, 58)

There were also two HF issues, mostly related to A^3 system applications (14, 63) and two general HF issues, named as “other” (1, 63) in the present classification.

Issues related to A^3 system design are mainly directed to the system designers. These issues are very critical to quality characteristics of the A^3 ConOps and need serious attention during further developments of the ConOps.

Issues related to A^3 system applications are mainly concerning organizational factors. These issues are not time-critical to the system design or its implementation at the present stage of development of ConOps.

Table 1. **Results of classification of review HF issues** *

No	Relevant grouping	No	Relevant grouping	No	Relevant grouping	No	Relevant grouping
1	other	17	A, F, G, H	33	F	49	S
2	G, S, T	18	F	34	S	50	A
3	G, S, T	19	G	35	F, S	51	A
4	O	20	S	36	F, S	52	A
5	A	21	S	37	T	53	A
6	G	22	S	38	G	54	H
7	T	23	S	39	G	55	H
8	O	24	T	40	G	56	A
9	O	25	F, S	41	F, G, H, S, T	57	H
10	H	26	S	42	G	58	F
11	T	27	O	43	G	59	H
12	A, O	28	A, H, S	44	G	60	H
13	G, T	29	F	45	G	61	H
14	F, apl	30	A	46	G	62	H
15	F	31	A, S	47	A, F, G, H, S	63	other
16	F	32	A	48	S	64	apl

Note: The letters in the Table 1 correspond to the categories of review issues:

- A – human/ automation relationships issues
- F – FOC/ flight crews relations issues
- G – Ground support issues
- H – HMI and communication issues
- O – Minimal operational requirements
- S – SWIM-related issues
- T – Transition issues
- apl – issues related to A^3 system applications
- other – not directly related to above grouping

Some review issues may contribute to several categories.

2.9.2.1 Issues related to A^3 System design

Ground support issues

The special and the planned feature of A^3 ConOps is the lack of ATC in the system. In the A^3 ConOps this feature has been followed strictly for the enroute phase of flight in Self Separating Airspace. At the same time several ground support agents participate in providing the necessary information and feedback for A^3 aircraft and flight crews. There will be SWIM, FOC-s and a kind of ground surveillance (probably from the side of ANSP). For the normal self separated flights in normally functioning Self Separating Airspace the role of ground support described in ConOps seems appropriate. But under vague or ambiguous, non-normal and emergency situations the specifics of emergency ground support need to be improved without jeopardizing the intended ATC free basis of the A^3 ConOps.

Some examples of possible vague or ambiguous situations are related to dynamic allocation of airspace boundaries, possible military operations in SSA, transitions from/to SSA to/from TMA, use of voice communication channel and the need for renegotiations if flow management constraints will not be met.

SWIM-related issues

SWIM will be an important agent in the future air traffic system and in A^3 ConOps because it provides the necessary information to support the adequate situation awareness of the flight crews, which is needed for handling their new responsibilities. Until the concept of SWIM is under development, the A^3 needs to SWIM should be formulated, to get the necessary information support at necessary occasions. Demands for SWIM information have to be specified for normal, non-normal and emergency situations. The capabilities of SWIM (the rate of information renewal, the response speed etc.) belong to these needs, together with the differentiation between those ground support functions, provided through SWIM (e.g., providing the weather data) and the others, provided directly to the airborne system (e.g., verbal communication). It would be helpful to create a kind of "A^3 wish-list" to be taken into account during SWIM development in the SESAR framework.

Minimal operational requirements

Defining the minimal operational requirements, which enable the A^3 system to operate in Self Separating Airspace, is needed. This will minimize vagueness in some aspects of the A^3 ConOps, may facilitate the acceptance of the concept, helping to open the scene for further discussions and elaboration.

Transition issues

Although it is stated in the A^3 ConOps, that the transitions from SSA to TMA and vice versa are not considered in detail, the limited introduction of transition operations proves, that these issues are important.

From HF point of view the transition operations are safety-critical, because besides the high task load and high demands to situation awareness of the flight crews they have to hand over their self separation responsibility to ATC in transitions from SSA to TMA and take the responsibility over from ATC while leaving TMA. For the flight crews these processes are real transitions, which need time and situation awareness for preparation and cannot be accomplished momentarily.

The A^3 ConOps in D1.3 neither provides specific solutions for the case that due to an emergency a transition from SSA to controlled irspace happens

Due to dynamically changing airspace boundaries it may also be possible to enter SSA from Unmanaged Airspace, which is another kind of transitions, worth of considering theoretically.

Human/ automation relationships issues

Automation must be implemented in a smart way to improve situation awareness, since both the level of automation and the kind of automation are crucial for situation awareness and safety. Implementing more automation does not necessarily mean that it effectively assists to gain an appropriate level of situation awareness. This means that the level of automation may need to vary as a function of environment and the crew workload, being supportive, not burdening. It is appropriate to think of the airborne system as a joint (man-machine) cognitive system, where the function congruence between man and machine would be the aim of the automation.

HMI and communication issues

Although at the present level of maturity of A^3 concept it is premature to discuss HMI and communication human factors issues in detail, some of them have been risen in the review process. First the information needs of the crew have to be assessed and then the solutions offered. The HMI for many new systems and components should be worked out in an integral way. Different modalities for display of information should be considered, the voice channel in normal situations among the others. It also has to be considered, how far the crew will be involved or even informed about the information exchange between different actors in the SSA.

FOC/ flight crew relations issues

In the A^3 ConOps FOC will provide extensive support to the flight crews, especially by the processes of preparing the flights. Several issues like in-flight traffic monitoring, communication with the crews in normal and non-normal situations, participating in renegotiations if the aircraft has failed to meet the flow management constraints etc. will remain to be solved within the FOC and crew communications during the flights.

2.9.2.2 Issues related to A^3 system applications

Training of all actors involved will be a serious issue, but definitely manageable even without expensive in-flight trainings. Aircrews will have to build trust in all new onboard tools as well as in their “controller abilities” without becoming “believer pilots”. It would be desirable to focus on training issues already during the early stages of the system development to get a better idea of specific issues which will remain to be solved at the stage of A^3 system implementation.

A^3 concept will support a change in the reporting culture in the A^3 environment. Most probably it will become more difficult and will need specific tools. These possible changes in reporting culture may need special attention and specific tools.

All the conclusions related to system design have the highest priority in the advanced concept design process, they will help to alleviate several barriers to design found in the present version of A^3 ConOps and they fit into E-OCVM phase 1 (see iFly 2007a p. 12):

> ***V1 Scope*** *– The phase where the concept should be described in sufficient detail to enable identification of the potential benefits mechanism (i.e. the change to systems and/or operations that will enable a known barrier to be alleviated). Some aspects of the concept will be unknown or unclear at this stage.There may exist a number of options to be assessed during the further validation process.*

The identified HF issues will be taken as the foundation for the development of D2.4. Possible mitigation strategies will be proposed to overcome the barriers found in the present version of A^3 ConOps from the HF point of view.

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Appendixes

Appendix 1 HF issues raised to Section 10 "Operational Scenarios"

A1.1 HF issues raised to Subsection 10.3 "Event Driven Scenarios"

HF Issues (Nr. 65):
All the event driven scenarios put the crew performance under test, which can reveal a range of human factor related problems in implementation of A ^{3} ConOps. These could be expected to be, but not necessarily limited to:

- Reduced situation awareness of the flight crew
- Reduced conflict detection performance
- Reduced decision-making ability of the flight crew
- Increased manoeuvre execution time
- Reduced quality and update rate of traffic trajectory information.

A1.1.1 HF issues raised to Subsection 10.3.1 *"TMA closure Scenario"*

To test the transitory performances and flexibility of the A^3 ConOps ATM system, this operational scenario is designed to stage a massive shift in traffic flows, by suddenly closing an important TMA. All aircraft that were flying towards a designated TMA have to be redirected to neighbouring TMAs, which results in a massive new CTA/RTA assignment.

The goal of this scenario is to assess the airspace structure in terms of strategic flow restructuring, and how aircraft cope with sudden appearances of congested and/or complex areas.
The scenario configuration will follow the principles outlined in the baseline operational scenario, but place greater importance to the TMA configuration design. Some factors that may have a relative high significance in the design of the scenario include:

- *Geographical location and area coverage of the TMAs.*
- *Aircraft's time to react. How they re-route to the newly assigned TMAs?*
- *Airport capacity (which will have an impact on CTA assignment).*
- *TMA entry and exit configurations.*
- *Introduction of multiple airport TMAs.*

A^3 ConOps related factors that can be analyzed include:

- *Assess flight crew and on-board systems performance to deal with the changing situation*
- *CTA and RTA compliance.*
- *Interaction with scheduled aircraft arriving at the "open" TMAs, and disturbance produced by the additional re-scheduled aircraft.*
- *Traffic flows time-dependent structure, and the appearance of complex and/or congested areas*
- *Additional conflict rate, compared to baseline levels.*

The A^3 functionalities that will be put to the test in this scenario include:

- *Trajectory management and FMS, operating at all time frames (from the long*

term to the short term) to allow for trajectory modifications while maintaining CTA/RTA compliance.
- *SWIM and Data Link communications.*
- *ATM Ground Based scheduling tools.*
- *Flight crew abilities to assess and react to a changing situation.*

(cf. page 86-88)

HF Issues (Nr. 66):
This event driven scenario puts the crew performance under test, which can reveal a range of human factor related problems in implementation of A^3 ConOps. These could be expected to be, but not necessarily limited to:
- Reduced situation awareness of the flight crew
- Reduced conflict detection performance
- Reduced decision-making ability of the flight crew
- Increased manoeuvre execution time
- Reduced quality and update rate of traffic trajectory information.

A1.1.2 HF issues raised to Subsection 10.3.2 *"Sudden publication of a RAA Scenario"*

HF Issues (Nr. 67):
This event driven scenario puts the crew performance under test, which can reveal a range of human factor related problems in implementation of A^3 ConOps. These could be expected to be, but not necessarily limited to:
- Reduced situation awareness of the flight crew
- Reduced conflict detection performance
- Reduced decision-making ability of the flight crew
- Increased manoeuvre execution time
- Reduced quality and update rate of traffic trajectory information.

A1.2 HF issues raised to Subsection 10.4 "Intruder Based Scenarios"

HF Issues (Nr. 68):
All the intruder based scenarios put the crew performance under test, which can reveal a range of human factor related problems in implementation of A^3 ConOps.

A1.2.1 HF issues raised to Subsection 10.4.1 "Air defence fighter interception Scenario"

HF Issues (Nr. 69):
The assumption of the system is that all aircraft and their crews are actively participating in the iFly system. However, it is reasonable to assume that there will need to be some exceptions (e.g., military aircraft on secret missions or weather balloons or other normal not controlled traffic) that will necessarily use part of an SSA but may not be able to play according to the "normal rules". Such operations will need to be addressed in a way that are intuitive to the normal user but yet recognize the special needs of the nonparticipating aircraft.

This intruder based scenario puts the crew performance under test, which can reveal a range of human factor related problems in implementation of A^3 ConOps. These could be expected to be, but not necessarily limited to:
- Reduced situation awareness of the flight crew

- Reduced conflict detection performance
- Reduced decision-making ability of the flight crew
- Increased manoeuvre execution time
- Reduced quality and update rate of traffic trajectory information.

A1.2.2 HF issues raised to Subsection 10.4.2 *"Fast- moving RAA Scenario"*

That area will (instead of not moving at all, or moving relatively very slowly) move at the aircraft's speed but, unlike an aircraft, will not provide trajectory information.
(cf. page 89)

HF Issues (Nr. 70):
Moving special use airspace is considered, which is not allowed to be entered into SWIM. Recently because of concerns raised by terrorists, vehicles (both flying and non-flying) that are carrying highly valued personnel (e.g., high government officials) are being assigned restricted airspace that moves with that individual. In addition, because the exact location of the individual can be a secret, the restricted airspace may move but without anyone in the system knowing that it is moving. Again these special operational limits will need to be addressed in a way that is intuitive to the normal user while maintaining the required security.

This intruder based scenario puts the crew performance under test, which can reveal a range of human factor related problems in implementation of A ^{3} ConOps. These could be expected to be, but not necessarily limited to:

- Reduced situation awareness of the flight crew
- Reduced conflict detection performance
- Reduced decision-making ability of the flight crew
- Increased manoeuvre execution time
- Reduced quality and update rate of traffic trajectory information.

A1.2.3 HF issues raised to Subsection 10.4.3 *"Emergency operation Scenario"*

HF Issues(Nr. 71):
There are a variety of system component failures which will require the flight crew to declare an emergency. An emergency aircraft by rule has the right away and depending on the emergency can have a variety of performance and communication problems that may or may not be able to be communicated.

There will be two distinct sets of operational and human factors issues. The first set will involve the aircraft with the emergency and the second set will involve those aircraft arround the emergency aircarft who will need to manoeuvre to assure that the emergency aircraft can perfrom all of its necessary tasks and possibly manoeuvres, e.g., emergency descent due to loss of cabin pressurization.

This intruder based scenario puts the crew performance under test, which can reveal a range of human factor related problems in implementation of A ^{3} ConOps. These could be expected to be, but not necessarily limited to:

- Reduced situation awareness of the flight crew
- Reduced conflict detection performance
- Reduced decision-making ability of the flight crew
- Increased manoeuvre execution time
- Reduced quality and update rate of traffic trajectory information.

A1.2.4 HF issues raised to Subsection 10.4.4 *"Rogue aircraft Scenario"*

HF Issues (Nr. 72)**:**
The assumption of the system is that all aircraft and their crews are actively participating in the iFly system. However, it is reasonable to assume that there may be an aircraft which will on occasion enter into the protected airspace either intentionally (e.g., hijacked aircraft) or unintentionally that will use part of an iFly airspace but may not be able to play according to the "normal rules." Such operations will need to be addressed in a way that are intuitive to the normal user but yet recognize the special needs of the nonparticipating aircraft.

This intruder based scenario puts the crew performance under test, which can reveal a range of human factor related problems in implementation of A^3 ConOps. These could be expected to be, but not necessarily limited to:

- Reduced situation awareness of the flight crew
- Reduced conflict detection performance
- Reduced decision-making aability of the flight crew
- Increased manoeuvre execution time
- Reduced quality and update rate of traffic trajectory information.

A1.3 HF issues raised to Subsection 10.5 "Reduced Performance Scenarios"

HF Issues (Nr. 73)**:**
The reduced performance scenarios have been selected not to intentionally investigate human performance issues but rather to test the A^3 concept and then to identify what contribution human factors issues could give to that scenario. All reduced performance scenarios will put the crew under increased stress. As such the scenarios have been designed to investigate a range of system performance, specifically human factors issues, that need to be addressed in the implementation of the A^3 ConOps.

A1.3.1 HF issues raised to Subsection 10.5.1 "Reduced air-air communication range Scenario"

HF Issues (Nr. 74)**:**
A variety of cognitive, perceptual, motor and situation awareness consequences are possible. These could be expected to be, but not necessarily limited to:

- Reduced situation awareness of the flight crew
- Reduced conflict detection performance
- Reduced decision-making ability of the flight crew
- Increased manoeuvre execution time
- Reduced quality and update rate of traffic trajectory information.

A1.3.2 HF issues raised to Subsection 10.5.2 "Loss of long/medium term information Scenario"

This scenario assumes aircraft are not receiving long term traffic and area information. Aircraft will only be aware of traffic inside Air-Air DL range. Other medium term ground functions may still be regarded operative. The loss of long term information will imply degradations in the following aspects:

- *Flight crew situational awareness.*
- *Conflict Detection performances.*

- *Restrictions placed upon CR algorithms due to the lack of reliable longer term information.*
- *Flight crew decision-taking and manoeuvre execution time.*
- *Quality and update rate of traffic trajectory information.*

The problem is furthermore complicated by the lack of consistency in situational awareness that will arise; traffic inside air-air communication range will still be broadcasting their full intent information, providing reliable information up to the 15 – 20 minutes time frame, while trajectory information for traffic just outside Air-Air DL range may not be available.

This scenario, together with the "Reduced air-air communication range Scenario", can be useful to:

- *Evaluate the relative performances of Air-Air DL and SWIM.*
- *Assess CD&R performance when fed with different kinds of traffic trajectory information.*
- *Evaluate flight crew workload levels in different conditions.*

(cf. page 93-94)

HF Issues (Nr. 75):
The loss of long/medium term information will imply the degradations in the following:

- Situation awareness of the flight crew
- Conflict detection performance
- Restrictions placed upon CR algorithms due to the lack of reliable long/medium term information
- Flight crew decision-making ability and manoeuvre execution time
- Quality and update rate of traffic trajectory information.

A1.3.3 HF issues raised to Subsection 10.5.3 *"Diminished Ground Support Scenario"*

HF Issues (Nr. 76):*Inability to assess the track of other traffic*

What will be the minimum data necessary for a pilot to be able to recognize the potential for an in-flight hazard with another aircraft from their displays? Will the pilot be able to transfer learning from traditional Visual Metrological Conditions (VMC) operations or will there need to be additional cues presented to the pilots if they are to be able to recognize potential future hazards? If cues are necessary, what will they be, and how should they be presented to the pilot(s) to support the selection of the best, optimal, or at least an acceptable solution that meets the minimum required standards?

Aircraft damage that FMS does not recognize

A normally stable aircraft can become unstable due to in-flight damage (e.g., bird strike hail damage). In such cases the pilot(s) can be completely busy just trying to keep the aircraft right-side up. In the current system a highly experienced ground-based air traffic controller would take over part of the pilot's tasks (e.g., basic navigation and traffic clearance). What additional capability will need to be provided to both the aircraft that has been damaged as well as those who are around it? Will some additional form of operational standards need to be put in place and how will the SWIM know which ones are appropriate to the situation.

A variety of cognitive, perceptual, motor and situation awareness consequences are possible. These could be expected to be, but not necessarily limited to:

- Reduced situation awareness of the flight crew
- Reduced conflict detection performance
- Reduced decision-making ability of the flight crew
- Increased manoeuvre execution time
- Reduced quality and update rate of traffic trajectory information

A1.3.4 HF issues raised to Subsection 10.5.4 *"Other Scenarios"*

HF Issues (Nr. 77):*Nonparticipating aircraft in the iFly airspace*
The assumption of the system is that all aircraft and their crews are actively participating in the iFly system. However, it is reasonable to assume that there will need to be some exceptions (e.g., military aircraft on secret missions or weather balloons or other normal not controlled traffic) that will necessarily use part of an iFly airspace but may not be able to play according to the "normal rules." Such operations will need to be addressed in a way that are intuitive to the normal user but yet recognize the special needs of the nonparticipating aircraft.

Cultural operational differences

Not only will there be significant differences between military and air carrier type of operations, but the operational philosophies of different airlines should be expected to influence how flight crews from different airlines will utilize the system. Will the airborne software need to be modifiable to meet these operational differences?

A variety of cognitive, perceptual, motor and situation awareness consequences are possible. These could be expected to be, but not necessarily limited to:

- Reduced situation awareness of the flight crew
- Reduced conflict detection performance
- Reduced decision-making ability of the flight crew
- Increased manoeuvre execution time
- Reduced quality and update rate of traffic trajectory information.

HF Issues (Nr. 78):*Spatial disorientation*
While flight experience reduces the probability of a pilot being susceptible to ordinary spatial disorientation (e.g., the leans) it does not eliminate susceptibility to spatial disorientation. Therefore, particularly in cases of single pilot operations, some design consideration will need to be made. Because even if the experienced pilot can adequately control the aircraft and keep it right-side up when disoriented, there maybe little or no attention for other pilot tasks.

A variety of cognitive, perceptual, motor and situation awareness consequences are possible. These could be expected to be, but not necessarily limited to:

- Reduced situation awareness of the flight crew
- Reduced conflict detection performance
- Reduced decision-making ability of the flight crew
- Increased manoeuvre execution time
- Reduced quality and update rate of traffic trajectory information.

HF Issues (Nr. 79):*Passenger comfort related to RTA (Requested Time of Arrival)*

A significant fraction of airline passengers are “nervous fliers,” who become upset with certain quick changes in the aircraft’s speed, bank, or pitch. Quick changes are perceived as an abnormal event and reason for concern. Thus, airline flight crews often tend to want to take the path requiring the least rate of change. Because of this bias, manoeuvring decisions will need to be made as early as possible so that the rates of change will be low and passengers remain comfortable.

A variety of cognitive, perceptual, motor and situation awareness consequences are possible. These could be expected to be, but not necessarily limited to:

- Reduced situation awareness of the flight crew
- Reduced conflict detection performance
- Reduced decision-making ability of the flight crew
- Increased manoeuvre execution time
- Reduced quality and update rate of traffic trajectory information.

Appendix 2 Acronyms

Acronym	Definition
A^3	Autonomous Aircraft Advanced
ACARS	Aircraft Communication Addressing and Reporting System
ACAS	Airborne Collision Avoidance System
ADS-B	Automatic Dependant Surveillance – Broadcast
ADS-C	Automatic Dependant Surveillance – Contract
AFR	Autonomous Flight Rules
AIS	Aeronautical Information Service
AMAN	Arrival Manager
ANSP	Air Navigation Services Provider
AOM	Airspace Organisation & Management
ASACAS	Airborne Separation Assurance and Conflict Avoidance System
ASAS	Airborne Separation Assistance System
ASEP	Airborne Separation
ASP	Aeronautical Surveillance Panel
ATC	Air Traffic Control
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
ATN/CLNP	Air Traffic Network/Connectionless Network Protocol
ATS	Air Traffic Services
ATSEP	Air Traffic Safety Electronics Personnel
CD	Conflict Detection
CD&R	Conflict Detection and Resolution
CDM	Collaborative Decision Making
CDTI	Cockpit Display of Traffic Information
CNS	Communication, Navigation and Surveillance
ConOps	Concept of Operations
COTS	Commercial Off-The-Shelf
CP	Conflict Prevention
CR	Conflict Resolution
CTA	Controlled Time of Arrival
CZ	Comfort Zone
DCB	Demand and Capacity Balancing
DL	Data Link
DST	Decision Support Tools
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

Acronym	Definition
ICAO	International Civil Aircraft Association
IFR	Instrumental Flight Rules
IOC	Initial Operational Capability
IP	Implementation Package
LoC	Lines of Change
LoS	Loss of Separation
LTACD	Long Term Area Conflict Detection
LTAZ	Long Term Awareness Zone
MA	Managed Airspace
MET	Meteorological Service
MOC	Minimum Obstacle Clearance
MTAZ	Medium Term Awareness Zone
MTCD&R	Medium Term CD&R
NFU	Non-FOC Airspace User
NVFR	Night Visual Flight Rules
OI	Operational Improvement
OPSP	Operations Panel
PANS	Procedures for Air Navigation Services
PAZ	Protected Airspace Zone
R/T	Radio Telecommunications
RAA	Restricted Airspace Area
RBT	Reference Business Trajectory
RNP	Required Navigation Performance
RNPC	RNP Capability
RSP	Required Surveillance Performance
RTA	Required Time of Arrival
RTD	Research, Technology and Development
RVSM	Reduced Vertical Separation Minima
S&M	Sequencing and Merging
SA	Situation Awareness
SARP	Standards and Recommended Practices
SASP	Separation and Airspace Safety Panel
SBT	Shared Business Trajectory
SES	Single European Sky
SESAR	SES Advanced Research
SFM	Strategic Flow Management
SI	Spacing Interval
SM	Separation Minima
SSA	Self Separated Airspace
SSEP	Airborne Self Separation
SSR	Secondary Surveillance Radar
STAZ	Short Term Awareness Zone
STCD&R	Short Term CD&R
SVFR	Special Visual Flight Rules
SWIM	System Wide Information Management System
SZ	Safety Zone
TA	Traffic Alert
TBD	To Be Defined

Acronym	Definition
TCAS	Tactical Collision Avoidance System
TIS-B	Traffic Information Service - Broadcast
TIS-C	TIS-Contract
TMA	Terminal Area
TS	Trajectory Synthesizer
TTF	Traffic To Follow
UA	Unmanaged Airspace
UAV	Unmanned Air Vehicle
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
WHA	Weather Hazard Areas
WP	Work Package

Appendix 3 References

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