Operational assessment of co-operative ASAS applications

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Abstract

The ASAS concept wants to address operational requirements to improve the capacity and the efficiency of Air Traffic Control through the definition of ASAS (Airborne Separation Assurance System) applications. CENA is particularly interested in studying the operational impact of co-operative ASAS applications in the future European Air Traffic Management System.

This paper presents the approach followed-up by CENA for the operational assessment of ASAS applications and the initial results about the assessment of the ASAS Crossing Procedure (ACP) as an example of a co-operative ASAS application.

Introduction

The ASAS concept was proposed by CENA in 1995 as an alternative way to address the task given to SICASP (SSR Improvements and Collision Avoidance System Panel) by ICAO on other uses of ACAS (Airborne Collision Avoidance System). The ASAS concept proposes to transfer the responsibility for maintaining aircraft separation from the ground to the airborne side under specific conditions [1]. All the technical, operational and economic issues related to ASAS applications need to be assessed before implementing the ASAS concept.

In order to study the operational impact of specific ASAS applications in the future European Air Traffic Management System [2], CENA has planned to follow a stepwise approach including:

- **concept of ASAS operations assessment**: to identify potential benefits and constraints through off-line simulations and case studies for ASAS procedures and logics refinement. These simulations should permit to study the compatibility of ASAS applications with Air Traffic Control (ATC) and ACAS.
- **feasibility assessment**: to conduct cost/benefit analysis through fast-time simulations of significant traffic samples; these simulations should permit to statistically assess the pertinence of ASAS applications, the ASAS logic performances and the ATC capacity and efficiency improvement.
- **operational acceptability assessment**: to evaluate the operational adequacy of the ASAS procedure through demonstrations using ATC and cockpit real-time simulations; these simulations should permit to validate the procedures and to assess the ASAS applications conformance to the pilot and controller requirements.

The approach also makes provision for possible reiterated steps depending on the results obtained at each stage.

This paper is organised as follows: the first part introduces the generic issues related to the ASAS applications and presents the ASAS Crossing Procedure; the second part is devoted to the operational assessment of the ACP conducted at CENA. Initial results about the operational concept assessment are presented. Concerning the feasibility and the operational acceptability assessment, this paper presents the means under development at CENA and the objectives of the studies to be performed.

Scope of ASAS applications

Generic ASAS applications

The definition of ASAS was discussed by ICAO/SICASP members [3]. They agreed on the following definition: « the equipment, communications, protocols, airborne surveillance and other aircraft state data, flight crew and ATC procedures which enable the pilot to exercise responsibility, in agreed and appropriate circumstances, for separation of his aircraft from one or more aircraft ».

The implementation of the ASAS applications assumes the availability of new technologies on board such as ADS-B (Automatic Dependent Surveillance - Broadcast) and Air-to-Air datalink.

The European project EMERALD (EMErging Research and technical development Activities of reLevance for ATM concept Definition) has identify potential application scenarios for ADS-B/ASAS [4]. The EMERALD partners proposed to classify the ASAS applications into three different classes:

- **Traffic Situation Awareness applications** related to the use of a Cockpit Display of Traffic Information (CDTI) with no responsibility delegation. Such applications provide the pilot with data on his traffic environment for safety improvement.
- **Tactical Co-operative applications** with limited responsibility delegation from controller to the pilots of aircraft in close proximity to each other. Such applications help the pilot to manage the relative movement between his own aircraft and another aircraft. Such applications correspond either to **distancing applications** where the two aircraft are close to each other for a very short duration, or to **shadowing applications** where the two aircraft are required to stay at some distance for some time.
- **Strategic Co-operative applications** with full separation responsibility transferred to the pilot for the time he flies in the airspace reserved for such ASAS applications. In this case, the pilot is intended to manage his own route over a long time horizon taking into account the separation constraints with other traffic.

CENA is particularly interested in studying tactical co-operative ASAS applications [5] and the operational impact of such ASAS applications in the future European Air Traffic Management System (EATMS). The ASAS Crossing Procedure proposed by CENA is an example of a distancing co-operative ASAS application [6].

Co-operative ASAS applications

New share of separation responsibility

The major issue of co-operative ASAS applications is the new share of separation responsibility between the ground and the airborne side. This assumption implies changes in both pilot and controller actual practices depending on the level of responsibility delegation. This delegation should concern either the detection of conflict, i.e. potential loss of separation, or the execution of the separation itself:

- the first alternative implies the definition of ASAS clearances asking pilot for **monitoring airborne separation**; it should be noted that conflict is associated to the risk of loss of separation which is different from the risk of collision currently taken into account by the pilot.
- the second alternative assumes the existence of ASAS clearances asking pilot for **maintaining separation under specific conditions**; these clearances could correspond to the extension under Instrument Meteorological Conditions (IMC) of existing visual clearances, but could also be another alternative to current ATC practices like spacing operations between two aircraft.

Such tactical ASAS clearances should be applicable within the « Managed Airspace » of the future EATMS. Expected benefits are conflict workload reduction for the controller in order to increase the airspace capacity and to optimise the conflict resolution with respect to aircraft performances.

Pilot and controller requirements

In order to facilitate operational acceptability of tactical co-operative ASAS applications, pilot and controller requirements need to be taken into account when defining ASAS operational procedures.

From the controller's point of view, the main issues are:

- explicit initial requirements for the ASAS procedure and visibility of airborne solutions for maintaining separation. This last issue could be addressed either through the application of some rules of the air known by both the ground and the airborne sides or through specific constraints defined by the controller when initialising the ASAS procedure.
- compatibility with the ATC system capabilities in order to allow safe operations in all conditions, including degraded modes; This issue is not

necessarily compatible with the definition of reduced airborne separation standards.
- compatibility with Short-Term Conflict Alert (STCA) ground systems.

From the pilot's point of view, there is a strong requirement for the availability of onboard ASAS capabilities. The pilot's main issues are:
- improvement of the pilot's traffic situation awareness, together with explicit ASAS procedures to use CDTI within managed airspace.
- limitation in pilot workload increase; this objective could be achieved by the enhancement of current auto-pilot functionality in order to permit efficient and safe relative movement of an aircraft with respect to another.
- compatibility with the efficiency of flight management; this issue could be addressed by the design of new airborne systems taking into account separation constraints together with navigation and performance constraints.
- compatibility with the collision avoidance function provided by ACAS. This is essential as the mandatory carriage of ACAS II is planned in Europe for the year 2000.

The availability of airborne system for separation assurance seems to be essential for both pilot's and controller's acceptability of co-operative ASAS applications.

The ASAS Crossing Procedure

Operational purpose

The ASAS Crossing Procedure was initially presented during the ATM-97 seminar [6]. It is intended to enable the pilot to assure himself his separation from another traffic in specific conditions. The procedure would be very similar to the visual separation clearance currently performed in France except that it could be applied under IMC. In a first step, the procedure should be applied only to Instrument Flight Rules (IFR) within en-route controlled airspace.

Expected benefits and constraints

The benefits expected from this procedure are:
- ATC capacity improvement due to the controller workload reduction with respect to the conflicts where pilots are responsible of maintaining airborne standard separation.
- more efficient conflict resolution with limited trajectory alteration and improved compatibility with the current flight profile.

The procedure constraint are the following:
- ASAS equipage of the aircraft performing the ACP. This is absolutely necessary to limit the pilot workload increase and to maintain the same level of safety.
- early conflict detection in order to allow the procedure initialisation. As a matter of fact, the pilot and controller communications could be a limitation to the procedure applicability.

Operational procedure

The procedure requires common agreement between the actors for the object of the contract, i.e. the crossing, and for its duration as well. It also requires positive identification of the other aircraft involved in the conflict.

During the execution of the ACP clearance, the pilot is responsible for maintaining his airborne standard separation. The conflicting aircraft is informed by the controller and is supposed not to deviate from its current clearance.

When the ACP is performed, the pilot reports to the controller who issues an after ASAS clearance to allow the normal IFR continuation of the flight.

Safety rationale

The contingency procedure relies on possibility for the controller to re-establish IFR standard separation. When this is not possible, ACAS II equipment would act as the last resort for collision avoidance. As a consequence, ACAS and ASAS should carry out independent surveillance.

Operational concept assessment of the ASAS Crossing Procedure

Applicability of ACP

The ASAS Crossing Procedure is likely to be daily applicable within the European high density airspace. However, the operational need for such ASAS application has to be demonstrated. To assess the potential applicability of ACP in the French en-route airspace, radar data recordings have been processed to extract real conflicts within the current controlled airspace. However, not all the conflicts have required an ATC intervention to maintain separation.

Set of conflicts extracted from radar data

The real conflicts have been extracted from about one day of radar data recordings spread over four French Area Control Centres (ACC). The resulting data base contains about 300 encounters involving two aircraft in conflict. Almost all these conflicts are situated over FL140 (93%) with a majority over FL290 (55%).
The conflicts have been classified according to the geometry of the encounter in the horizontal plane:

- head-on situation: the two aircraft are in opposite direction where the angle of convergence is more than 150 degrees.
- crossing situation: the two aircraft are in the same or opposite direction where the angle of convergence is equal to or greater than 30 degrees.
- overtaking situation: the two aircraft are in the same direction where the angle of convergence is less than 30 degrees.

The proportion of each geometry is similar for all the ACC: there is about one half (55%) of crossing situations and another half of head-on and overtaking situations.
In the vertical plane, the following situations are distinguished:

- level situation: the two aircraft are maintaining the same flight level.
- non-level situation: at least one of the two aircraft is in vertical evolution with altitude crossing.
- level-off situation: at least one of the two aircraft in vertical evolution is performing a level-off, or one aircraft is leaving its flight level with altitude crossing.

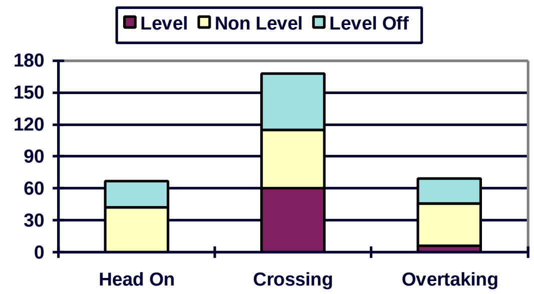

Figure 1: Data base of real conflicts

The great number of crossings provides confirmation that the ASAS Crossing Procedure is likely to be applied many times per day in French en-route airspace.

Airborne separation assurance by ATC

The final separation between the two aircraft in conflict depends on the encounter geometry. In the majority of level or non-level aircraft, and whatever the situation in the horizontal plane, the controller decided to maintain an horizontal separation. On the contrary, in case of level-off geometry, ATC intervention aimed at assuring vertical separation between the two aircraft.
The following figure shows the horizontal distance at the closest point of approach of the two aircraft depending on the encounter geometry in the vertical plane.

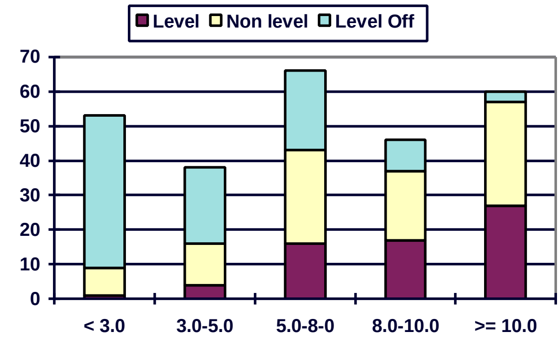

Figure 2: Horizontal separation distribution with ATC

In a majority of conflicts, aircraft horizontal separation assured by ATC is greater than the radar separation minima of 5 NM. In some conflicts, it is even greater than the radar separation standard of 8 NM.

Conflict resolution by ATC

The **case by case analysis** of each conflict has allowed to determine the proportion of conflict which have required an ATC intervention to assure aircraft separation. The ATC intervention is supposed to be either an heading alteration, a flight level alteration, a level-off instruction or a vertical speed alteration.

The conflict resolution by ATC takes into account the aircraft flight phase constraints as often as possible (e.g. heading alteration in case of level aircraft). However, the controller not always ensures either minimum trajectory alteration or minimum delay before the resume navigation instruction. In a few conflicts, the necessity of the ATC instruction itself is not obvious. This could be explained by a lot of factors like the controller's trend to anticipate the conflicts, the controller's workload limitation or the

difficulty to dynamically adjust the solution.
In almost all the conflicts with an ATC resolution, there is only one manoeuvring aircraft. This is particularly the case in 97% of the crossings with at least one level aircraft. This proportion is lower in case of level-off clearances with 8% of double level-off. In case of head-on situations, the proportion of double manoeuvres goes up to 13%.

ASAS logic for ACP

In order to identify the issues related to the ASAS Crossing Procedure and its implementation using an ASAS logic, CENA has conducted initial simulations with a basic conflict detection and resolution algorithm. These simulations have been performed on the set of real conflicts extracted from radar data where the controller's actions have been suppressed in order to assess the ACP logic ability to maintain separation. The ROSALIE test bench (Required Off-line Simulator for ASAS Logic Implementation and Evaluation) has been used to modify the initial encounters, to simulate both the ASAS and ACAS logics and to analyse the resulting aircraft trajectories.

Basic ACP logic

The basic ACP logic aims at preserving a fixed protection volume around the aircraft and issues Separation Advisories in case of potential loss of separation.
The conflict detection is based on the prediction of the airborne separation standard infringement together with time infringement. The trajectory prediction is based on an extrapolation technique, where the aircraft speed remain constant. The ADS-B data have been supposed to be available in a range of 90 NM.
Depending on the simulations, the alert time threshold is changed from one to 4 minutes, the horizontal standard separation is either 3 NM, 5 NM or 8 NM while the vertical standard separation is always 1000 feet.

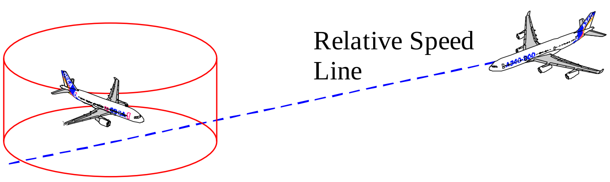

Figure 3: Conflict detection for ACP

The main drawback of such conflict detection method is that unnecessary alarms could be raised if aircraft manoeuvre. Besides, the less the closure rate is, the closer the aircraft are at the time of conflict detection.
The conflict resolution is limited to horizontal manoeuvres. It consists in computing a discontinuous heading objective in order to avoid the protected zone around the intruder aircraft while limiting the own track excursion. The crossing ends with either range divergence detection or vertical separation detection.
Some priority rules have been introduced to limit the number of manoeuvring aircraft to only one depending on their vertical profiles.

Example of the ACP logic behavior

Let's illustrate the ACP logic behaviour in a typical crossing situation extracted from the radar data recordings. One level aircraft (# 12) at FL 270 is crossing another aircraft (# 325) climbing towards its requested flight level FL 280. In the real conflict, the controller has issued a level-off instruction to the climbing aircraft 1000 feet below the conflicting aircraft.
The following figure presents the horizontal tracks of both aircraft before and after the ASAS simulation.

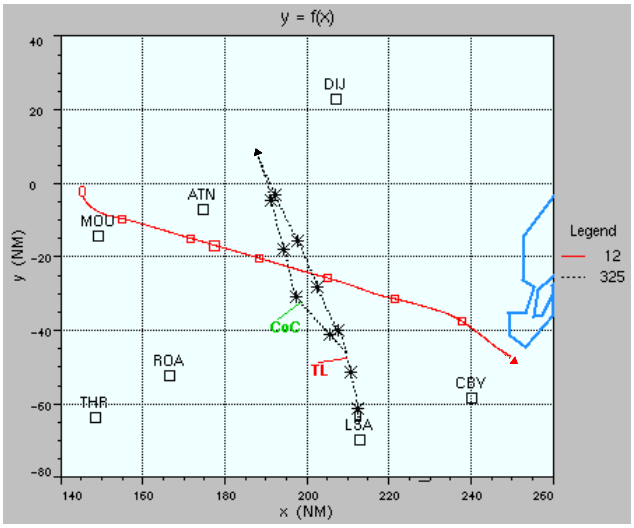

Figure 4: Tracks of the aircraft in conflict

Only the climbing aircraft (# 325) is manoeuvring due to the priority rules which give advantage to the level aircraft. The « Turn Left (TL) » advisory issued by the ACP logic ensures the horizontal separation of both aircraft. The « Clear Of Conflict (COC) » is issued with divergence detection.

Conflict detection efficiency

In order to assess the conflict detection efficiency, let's consider the set of conflicts where the ACP logic issues at least one separation advisory despite the fact

that the airborne separation is assured without any intervention.
The following figure presents the number of crossings with such **unnecessary separation advisories** depending on the time threshold for conflict detection and with an horizontal separation standard of 5 NM.

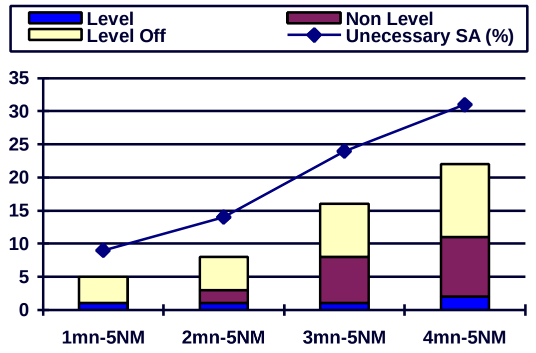

Figure 5: Unnecessary Separation Advisories

The high proportion of unnecessary separation advisories from 9% to 31% depending on the time threshold highlights how much the trajectory prediction is significant for conflict detection.
Actually, the conflict detection is likely to be degraded by the uncertainty on aircraft performances and the lack of intents processing in trajectory prediction.

Conflict resolution efficiency

The ACP logic aims at minimising the trajectory alteration while maintaining airborne separation.
The following figure presents the distribution of the horizontal separation obtained on the set of crossings with an ASAS resolution in case of a separation standard of 5 NM.

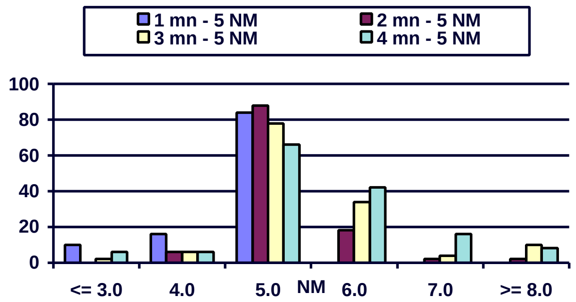

Figure 6: Horizontal separation distribution with ASAS

In the majority of the conflicts (81%), the resulting horizontal separation is close to the standard with a tolerance of 1 NM. In a few conflicts, an early clear of conflict due to vertical separation assurance permits to limit the horizontal deviation. On the other hand, inaccuracy when predicting the relative location of the conflicting aircraft leads to an excessive distancing of the aircraft.

The trajectory alteration highly depends on the look-ahead time for conflict detection and the airborne separation standard. As illustrated by the following figure, the average heading excursion varies from 10 degrees in case of a separation standard of 3 NM up to 50 degrees in case of a separation standard of 8 NM and alert time of 4 minutes.

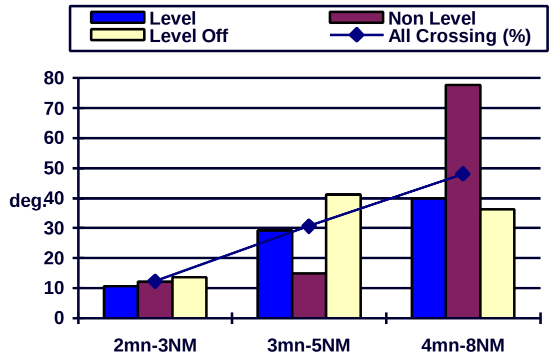

Figure 7: Average heading excursion with ASAS

Nevertheless, the average of the heading excursion is not fully representative. In case of an horizontal manoeuvre in the opposite direction from the intended flight plan, the heading excursion increases rapidly during the crossing.
As a matter of fact, the conflict resolution efficiency relies on the ability of the ASAS logic to take into account the navigation constraints.

ACAS compatibility

The following figure presents the correlation between the Separation Advisories (SA) and the TCAS II (Version 7.0) Traffic Advisories (TA) issued on the set of crossings depending on the airborne standard separation and with an alert time of 3 minutes.

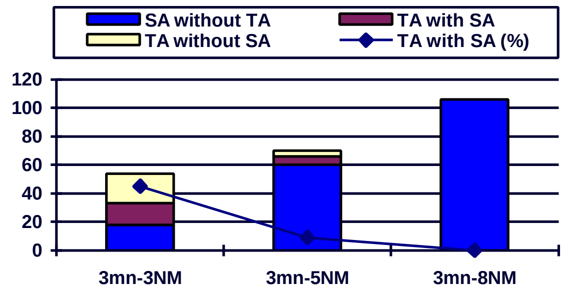

Figure 8: Traffic Advisories issued by TCAS II

Furthermore, in a few conflicts Resolution Advisories have been triggered by the TCAS II logic. These results point out the constraints induced by ACAS concerning the definition of reduced airborne separation standard.

Operational issues for ACP

The case by case analysis of each conflict, together with the measure of the basic ACP logic performances, point out a set of issues discussed hereafter:

Domain of applicability

The ASAS Crossing Procedure was initially evaluated on the crossing geometries involving only two aircraft. The possible extension to non-crossing geometries (head-on and overtaking) and multi-aircraft conflicts depends on the ACP logic performances and the potential use of ACP by both the controller and the pilot in such situations.
In case of head-on geometries, initial results let expect greater efficiency of the ASAS resolution with respect to ATC resolution. On the contrary, the ACP logic appears to be rather inadequate in case of overtaking geometries.
The extension to multi-aircraft conflicts brings out the issue of the procedure feasibility and acceptability by the controller and the pilots. As a matter of fact, the procedure initialisation might take a long time with high VHF load and the procedure development might require a greater reserved airspace for conflict resolution.
Another possible extension of the ACP could be the procedure application within Terminal Manoeuvring Areas, particularly in case of arrival and departure crossings.

Controller and pilot requirements

The main issues for both the controller and the pilot are **visibility and stability** of the ASAS conflict resolution.
In the previous simulations, the priority rules have been integrated in the ACP logic. In practice, the manoeuvring aircraft might have been defined by the controller when initialising the ASAS Crossing Procedure. This hypothesis permits to prevent any misunderstanding between the actors while limiting the radio-communication exchanges.

Concerning the conflict resolution itself, limiting Separation Advisories to heading alteration permits to easily keep the controller informed about the ASAS solutions. However, this restriction might not be necessarily optimal with respect to the flight management. In the example used to illustrate the ACP logic, the vertical speed regulation of the climbing aircraft could be more efficient than the current horizontal resolution.
The same applies with the choice to maintain the new heading objective all along the conflict resolution. This hypothesis allows the validation by the pilot of the Separation Advisories, but might result in aircraft separation somewhat larger than the minimum applicable. However, from the pilot's point of view, allowing continuous relative motion of his aircraft from another aircraft (i. e. in auto-pilot mode) would require a great confidence in the ASAS system.

Airborne Separation Assurance System requirements

With regard to the initial results on the previous ACP logic performances, the following set of issues needs to be considered when designing ASAS applications like the ASAS Crossing Procedure:

- Horizontal versus vertical conflict resolution taking into account ATC and ACAS II compatibility constraints.
- Discrete conflict resolution (e.g. discrete heading instruction) for pilot validation versus reactive automatic conflict resolution (e.g. continuous heading instruction) for minimum trajectory alteration.
- Risk of disruptive conflict detection without aircraft selected parameters processing (e.g. conflict detection during a level-off clearance).
- Risk of loss of separation with conflict detection without intents processing (e.g. conflict at a Top Of Descent).
- Risk of inefficient conflict resolution without taking into account navigation constraints (e.g. conflict at a Trajectory Change Point) and aircraft performances.
- Risk of incompatibility with ATC or ACAS in case of reduced airborne separation standards.

Feasibility assessment of ASAS Crossing Procedure

In order to assess the feasibility of the ASAS Crossing Procedure, CENA has planned to conduct cost/benefit analysis of the procedure using fast-time simulations of significant traffic samples.

Air traffic simulator

Architecture

The BASILE (Basic Aircraft Simulator for Logic Evaluation) air traffic simulator uses three servo systems based on simplified equation for the transitional motion of aircraft to model lateral and longitudinal movement. In other words, the aircraft is guided by the difference between the current state vector and the intent, which are calculated by a pseudo Flight Management System (FMS). This intent might be changed by the ASAS logic under evaluation.

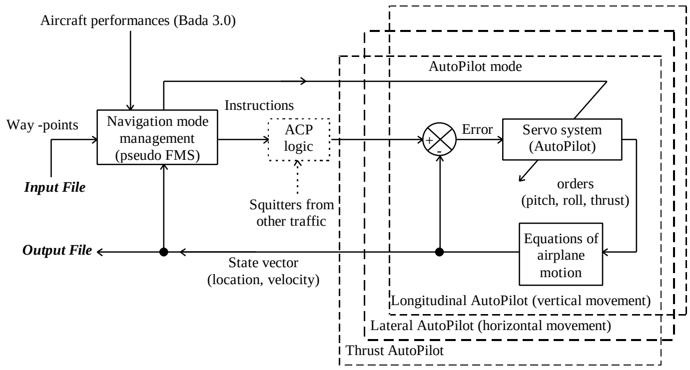

Figure 9: BASILE air traffic simulator

The inputs of the air traffic simulator are a list of successive way points for each flight. Those data come either from radar data recordings or from flight plan archives.

Navigation mode management

For each aircraft, the navigation mode module is in charge of selecting:

- the current way-point in the list of successive way points,
- operating modes and instructions for the longitudinal and lateral auto-pilots. Operating modes are chosen using geometric considerations between the current position of the aircraft, and the three dimensions position of the current way-point. Instructions come from BADA (Version 3.0) tables for aircraft data performances [7].

Aircraft motion management

Three servo systems control the motion of the aircraft:

- the longitudinal auto-pilot controls the motion of the aircraft in the vertical plane through the angle of attack. Two operating modes can be selected: vertical speed acquisition or level acquisition.
- the lateral auto-pilot controls the motion of the aircraft in the horizontal plane through the bank angle. Two operating modes can be selected: heading acquisition or axis acquisition.
- the thrust auto-pilot controls the ground speed of the aircraft.

Those auto-pilots have been calculated using a first order closing loop model [8].

Initial cost/benefit analysis of ACP

The BASILE air traffic simulator is intended to be used to statistically assess the ACP applicability, ASAS logic performances and possible improvement of ATC capacity and efficiency.

ACP applicability

To assess the applicability of the procedure, the air traffic simulator should use an implementation of the rules for the ACP application including:

- the initial conditions required which could be related to the geometry of the encounter and the number of conflicting aircraft, and
- the controller clearance constraints, for instance the choice of the manoeuvring aircraft.

Afterwards, fast-time simulations of significant traffic samples should permit to measure the **potential use of the procedure** by ATC through alternative scenarios of ASAS equipage and increasing traffic conditions.

ASAS logic performances

These simulations should also permit to evaluate the ability of the ACP logic to maintain separation in the conflicts where it is supposed to operate.

For that purpose, the following statistics are intended to be performed:

- the proportion of conflicts with effective loss of separation despite the ASAS equipment of the aircraft. These conflicts could either concern the two aircraft involved in the ACP or another aircraft in close proximity. The proportion of **unresolved** conflicts and that of conflicts **induced** by the ACP logic need to be distinguished.
- the proportion of conflicts with **unnecessary** resolution by the ACP logic, i.e. the conflicts where airborne separation is assured without the ASAS intervention.

- the proportion of conflicts with TCAS II advisories.

Besides, the cost of the airborne separation assurance is intended to be evaluated through the following statistics:

- the distribution of the **heading alteration** defined as the maximum heading excursion all along the conflict resolution by the ACP logic.
- the distribution of the track alteration defined as the maximum « **cross track distance** » all along the conflict resolution (i.e. the maximum lateral distance to the initial track) which should be no more than the horizontal separation standard.
- the distribution of the « **conflict duration** » defined as the period from the beginning of trajectory excursion to the « resume navigation » issued by the ACP logic.
- the distribution of the **delay** induced by the ASAS resolution measured at the last way point of the flight plan.

ATC capacity improvement

In order to assess the ATC capacity improvement expected from the ASAS Crossing Procedure, the air traffic simulator should be extended with sector description. Airspace capacity is mainly constrained by sector capacity which is human capability dependent. Punctually reducing the controller workload by setting up the ASAS Crossing Procedure should permit to increase the overall sector capacity while maintaining the controller workload at the same level.

Future fast-time simulations using various airspace and traffic management conditions should permit to perform the following statistics:

- **instantaneous aircraft count** per sector,
- **average rate of aircraft flow** through sectors,
- **conflicts** statistics including the geometry and the duration of conflicts. The distinction between the conflicts handled by the onboard ASAS application and those handled by the controller is essential for the controller workload assessment.

The sector capacity analysis would be performed using a model based on weighted sum of these indicators like in the MBB model [9]. Iterative simulations with traffic sample increase would be used to estimate sector capacity increase. This simulation based approach has already been carried out at CENA for the assessment of advanced EATMS concepts [10].

Operational acceptability assessment of the ASAS Crossing Procedure

In order to assess the operational acceptability of the ASAS Crossing Procedure, CENA has planned to demonstrate the procedure through real-time simulations. These simulations should permit to validate the procedure and to assess the ASAS application conformance to the pilot and controller requirements.

Real-time demonstrator

The CESAR project (Concept of Electronic Separation Assurance in Real-time environment) aims at developing a real-time demonstrator for ASAS applications using the real-time simulation capabilities of CENA. The project is on going and an initial version of the demonstrator has already been developed regardless of the design of the logics for airborne separation assurance.

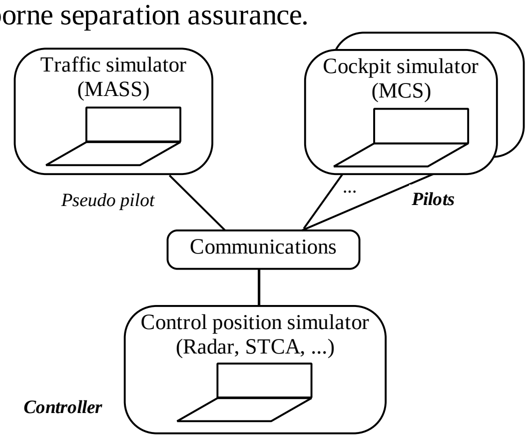

Figure 10: CESAR real-time demonstrator

The CESAR real-time demonstrator includes the following components:

- the Multi-Aircraft Simplified Simulator (MASS) which should control the main part of the traffic involved in the simulations.
- one or more instances of the Multi-aircraft Cockpit Simulator (MCS) developed by NLR and Eurocontrol which is intended to be the pilot interface for each remaining aircraft not handled by MASS.
- the ASAS server for the ACP logic simulation for all the aircraft, i.e. those controlled by MASS and those managed through MCS, together with the ACAS server for the TCAS II logic simulation.
- the Control position simulator available in the

Distributed ATM Architecture based on Rnav, Workstations, Intelligent tools and Networks (DAARWIN) developed at CENA. This component is supposed to be the controller interface during the simulations. It offers among others radar and STCA simulations.

The communication between all components uses the DIS (Distributed Interactive Simulations) standard. Radio communications are performed through pseudo VHF.

Validation scenarios for ACP

The CESAR real-time demonstrator should permit to evaluate the pilot and controller acceptability of the ASAS Crossing Procedure.

For that purpose, alternative operational scenarios should be defined concerning:

- the development of the procedure under **normal conditions** with the controller or the pilot taking the initiative of the procedure. The controller should initiate the ACP as often as possible regardless of the geometry (e.g. level crossing, unrestricted climb near a conflicting traffic). Whereas the pilot's demand for ACP could be associated with a trajectory change (e.g. at the time of his Top Of Descent). In order to facilitate the procedure applicability, full ASAS equipage of the fleet would be simulated.
- the application of the ASAS procedure with **environmental constraints**; these constraints should act upon the normal development of the procedure and could correspond to: mixed ASAS equipage of the fleet, activation of military areas, ground proximity or bad weather conditions, controller's or the pilot's workload. In particular, alternative scenarios with high density traffic, conflict with traffic following Standard Instrument Departure or Standard Arrival Route procedures could be defined.
- the **degraded modes** of the procedure; the possible scenarios for the ACP interruption include the simulation of non co-operative traffic, the ASAS failure on the airborne side, the radar failure on the ground side or the VHF failure.

The objectives of the real-time simulations are the evaluation of:

- the **operational need** for the ASAS Crossing Procedure. In particular, the controller and the pilot should actually use the procedure in the situations where it is supposed to operate.
- the improvement of the pilot's **traffic situation awareness** and the coherence with the controller's image of the traffic. In particular, no misunderstanding should occur during the development of the procedure from the pilot's point of view and between both actors.
- the **adequacy** of the ASAS functions on board and the CDTI facilities. This implies the correct use of the ASAS equipment by the pilot and his acceptability of the ASAS solutions with respect to the flight management. Besides, no ACAS resolution should occur during the normal development of the procedure.
- the **efficiency** the ASAS functions on board. In particular, no increase in pilot's workload should be noticed under normal conditions. At the same time, the conflict workload of the controller should be reduced.
- the **compatibility** with Air Traffic Control. This implies the controller's correct understanding and acceptability of the solutions set up by ASAS . In particular, no disruptive events like STCA or induced conflicts should issue during the normal development of the procedure.
- the **adequacy** of the contingency procedure during the simulation of degraded situations.

The prerequisite of all these real-time simulations are the controllers and pilots briefing about the ASAS Crossing Procedure and the Man-Machine Interface of the CESAR demonstrator, in particular the CDTI and the ASAS functions on board.

Finally, the operational evaluation of the ACP would be performed through immediate debriefing with controllers and pilots and the analysis of written reports.

Conclusion

CENA has participated to the definition of the ASAS concept at the ICAO level (SICASP, ADS-Panel) and at the European level (EMERALD project). Generic issues related to ASAS applications have been identified by the EMERALD partners and a Research and Technical Development Plan for the ASAS Concept Development has been proposed to the European community. However, operational requirements for each ASAS application need to be precisely defined. On this subject, CENA is

participating to the ODIAC/AIRSAW Task Force in charge of identifying operational needs related to AIRborne Situation Awareness in Europe.
A basic iterative process for the assessment of ASAS applications has been defined by CENA. Simulation means and objectives have been specified and developments are on-going. CENA has already started an initial assessment of the ASAS Crossing Procedure presented in this paper. The design of logic for airborne separation assurance has been initiated and should continue. Some issues related to an ASAS logic for ACP have already been identified. Airborne separation standards are still to be defined.
Initial results about the applicability of ACP let except substantial use of the procedure in en-route controlled airspace. Further results about the feasibility and the operational acceptability assessment of ACP are required and CENA has planned to perform related studies described in this paper.

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