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(Feasibility of ACAS RA Downlink Study)

Close-out Report

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Abstract

This Report presents the background and the results of the Feasibility of ACAS RA Downlink Study (FARADS).

Following a summary of the findings, a way forward is outlined.

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EXECUTIVE SUMMARY

This Report presents the background and the results of the Feasibility of ACAS RA Downlink Study (FARADS).

The FARADS Project was launched following a number of safety recommendations to address an issue of controller's limited situational awareness when pilot reports of RA are delayed, missing or incomplete.

RA Downlink is an automatic notification to the controller about Resolution Advisories (RAs) generated in the cockpit by the Airborne Collision Avoidance System (ACAS). The Study has found that RA Downlink is technically feasible and may deliver safety benefits. However, at this stage these benefits could not be quantified due insufficient data.

As a FARADS follow-up and in order to quantify the foreseen safety benefits, a study to develop the overall, coordinated concept for airborne and ground-based safety nets has been proposed and it expected to commence mid 2007. The study will perform a number of monitoring activities to assess the number and severity of ACAS encounters and to improve the understanding of the ACAS and STCA interactions in Europe.

1. INTRODUCTION & BACKGROUND

1.1 Purpose & Contents

The purpose of this Report is to present the background and the results of the Feasibility of ACAS RA Downlink Study (FARADS). Following a summary of the findings, a way forward is outlined.

1.2 ACAS RA Downlink

RA Downlink is an automatic notification to the controller about Resolution Advisories (RAs) generated in the cockpit by the Airborne Collision Avoidance System (ACAS).

Currently, air traffic controllers are only aware that an RA has been issued if and when notified by the pilot by radio. Being unaware about an RA, the controller might instruct the aircraft to manoeuvre in a sense contrary to the RA. Although specifically mandated not to, pilots in some cases follow the ATC clearance rather than the RA. Compliance with the contradictory ATC clearance severely degrades the effectiveness of ACAS.

RA Downlink has been proposed as a possible method of improving controller awareness of ACAS events, thereby reducing the probability of the controller intervening during an RA.

1.3 Safety Recommendations

Safety recommendations concerning RA downlink have been made by a number of organisations and advisory groups. Some of them are listed below.

In 2001, following an incident in Copenhagen, the Danish Accident Investigation Board recommended that it should be considered whether controllers should have access to Mode S transponder RA information [19].

In 2003, the High-Level European Action Group for ATM Safety (AGAS) advised to investigate the feasibility of RA Downlink [5].

In the Überlingen accident report, BFU (German Federal Bureau of Aircraft Accidents Investigation) recommended the initiation of RA Downlink development [13].

1.4 Feasibility of ACAS RA Downlink Study (FARADS) Objectives

In 2003 EUROCONTROL launched the Feasibility of ACAS RA Downlink Study (FARADS).

The FARADS study was conducted by the ATC Domain in cooperation with the Mode S & ACAS Programme, the EUROCONTROL Experimental Centre in Brétigny, and the European Safety Programme.

The objective of the FARADS study was to assess the technical and operational feasibility of displaying ACAS RA information on the Controller Working Position (CWP).

2. RESULTS OF RA DOWNLINK STUDIES

2.1 RA Downlink Technical Study

The RA Downlink Technical Study, conducted in 2004 by Helios Technologies, concluded that RA Downlink is technically feasible. Within the Mode-S coverage area, Mode-S RA reports are the best solution. These Mode-S RA reports are already specified in ICAO Annex 10 [21]. Outside the Mode-S coverage area, the 1090 Extended Squitter can potentially be used for RA Downlink. The study also concluded that setting up a dedicated infrastructure for RA Downlink is economically not justifiable [9].

2.2 RA Downlink Latency Study

Any potential benefit of RA Downlink will depend on the delay with which the message is delivered. In order to investigate the impact of delays, an RA Downlink Latency Study was conducted in 2005 by QinetiQ [8]. The study considered both technologies established as suitable by the Technical Study [9], that is Mode-S and 1090 Extended Squitter.

A mathematical model was developed that decomposed overall latencies into individual sequential delays. These delays included technical latencies (e.g. associated with detection by the rotating radar antenna and data transmission) and human latencies (e.g. associated with the perception and interpretation of the message by the controller). Distributions were defined and delays were sampled stochastically to build up a statistical distribution of the overall latencies.

One of the events investigated concerned the point in time at which the controller would be aware of the RA. In the current situation, an en-route controller, on average, will be aware of an RA 30 second after the RA has been presented to the pilot. With Mode-S RA reports, the controller will be aware about the RAs in 95% of the cases within 9 seconds of their occurrence.

Thus, the downlink of RA information was found to be sufficiently timely to allow for a significant increase in the controller's awareness of the RA encounter.

2.3 Operational Concept

In order to consider RA Downlink, a number of potential operational concepts have been considered. These operational concepts differed with respect to (a) type of RAs displayed, (b) the level of detail provided for every RA [4].

Operational concepts were assessed against a number of criteria, such as minimal changes to current operating procedures and display of operationally relevant information only. On the basis of these criteria, one Operational Concept was chosen for the RA Downlink Experiments (Simulations) and RA Downlink Safety Assessment.

The retained Operational Concept involved the downlink of all types of RAs, required the pilot to report RAs verbally, and maintained the current pilot/controller responsibilities.

The Operational Concept will need to be reviewed if/when the implementation decision has been made and ICAO standards regarding RA Downlink are developed.

2.4 RA Downlink Experiments (Simulations)

2.4.1 RADE-1

The first RA Downlink Experiment (RADE-1) was conducted in November 2003 at the EUROCONTROL Experimental Centre [7] in Brétigny, France. The aim of the experiment was to gather controller feedback on the concept of RA Downlink as well as on the different implementations of RA Downlink HMI. Also, the effect of RA information on controllers' understanding of the traffic situation was investigated.

The majority of the participants saw clear operational benefits in the provision of RA information to the controller. RA Downlink can support the controller's anticipation of aircraft manoeuvres. Most participants also expected RA Downlink to decrease the likelihood of contradictory ATC clearances to the conflict aircraft.

As the experiment was limited to playback of non-interactive scenarios, it was difficult to assess objective benefits (such as differences in controller performance), rather than just anticipated benefits.

2.4.2 RADE-2

To fully assess the operational utility of RA Downlink, an interactive real-time RA Downlink Experiment (RADE-2) was conducted between October 2005 and January 2006 at the EUROCONTROL Experimental Centre.

The general aim of the RADE-2 experiments was to analyse the impact of RA Downlink on controller performance, situational awareness, and workload. In particular, it was investigated whether RA Downlink can prevent controllers from issuing contradictory clearances. In the experimental runs, RA Downlink was either present or absent, and pilot reports were either timely or delayed.

The experiment was conducted in two parts – RADE-2A for area control (12 participants) and RADE-2T for terminal control (4 participants). The latter was intended as a prototype experiment to assess the feasibility of such simulation in the terminal control environment. It was found that the simulation of RA Downlink in the terminal control environment is challenging as the extreme aircraft proximity required to obtain an RA in the lower airspace is difficult to achieve and may render the simulation unrealistic [18]. For that reason, the results reported below pertain only to the RADE-2A simulation.

The number of contradictory clearances issued to aircraft involved in an RA was too small to support any statistically sound conclusions. Nevertheless, it needs to be pointed out that all contradictory clearances to RA aircraft (i.e., 2 in a total during 48 simulation runs) occurred without RA Downlink.

There was also evidence that RA Downlink increased the controllers' understanding of the RA situation. However, this benefit potentially occurred at the expense of attending to other (lower priority) aircraft in the sector [17].

2.5 RA Downlink Safety Assessment

The RA Downlink Safety Assessment was launched to assess whether RA Downlink can provide a substantial net safety benefit compared to the current situation [3]. The study was conducted by HVR Consulting Ltd.

Perceived hazards and risks associated with an RA Downlink situation were captured during a workshop, attended by ATM operational, technical, safety experts, and representatives from the commercial pilot community [2]. Also, Cognitive Task Analysis and Human Reliability Assessment were carried out in order to identify likely errors and potential mitigation with and without RA Downlink [1].

The following benefits were identified in the study: RA Downlink can prevent the controller from issuing a clearance to an aircraft responding to RA; it reduces the amount of R/T during the RA encounter; it improves controller's awareness of the RA encounter; and it supports the prevention of follow-up conflicts.

On the other hand, the study identified a number of safety issues. Most of them can be mitigated by Safety Requirements; however, there are some issues that cannot be easily mitigated. These are: occurrence of false downlinks (undermining trust in the RA Downlink system), downlink of RAs that do not require a deviation from the ATC clearance, and occurrence of conflicting voice and RA Downlink reports.

From the evidence gathered, the safety analysis identified a net benefit of RA Downlink if the proposed Safety Requirements can be satisfied. Nevertheless, the identified benefits and drawbacks are based on subjective perception of the participants rather than on objective operational data. The Study concluded that further analyses, based on empirical data, are required to quantify the perceived benefits.

3. DISSEMINATION OF RESULTS

3.1 RA Downlink Workshop

The RA Downlink Workshop was held at EUROCONTROL Headquarters in Brussels on 31st May 2006. The purpose of the workshop was to share with Stakeholders the results of the FARADS project and begin a consultation process on the future direction of FARADS. The workshop was attended by 69 participants, representing several ANSPs, regulators, professional organisations, and research institutes.

Most of the participants concluded from the presentations that RA Downlink is technically feasible and provides operational benefits. It was felt that there are open issues that need to be further investigated. Some of these open issues are not restricted to RA Downlink, but exist in the same way in today's ATM system [16].

3.2 Workshop Recommendations

Taking into account the recommendations from the studies as well as the feedback received from Stakeholders during the May 31st Workshop, the following work is proposed to conclude the assessment of RA Downlink.

3.2.1 Monitoring of RA Events

At present, there is insufficient information concerning the frequency and severity of RAs (in terms of risk of collision). The existing information about RA events is fragmented, selective, and incomplete and not well adapted to RA Downlink study requirements. That is mainly due to the collection techniques (e.g. voluntary reporting).

In order to fully establish the potential impact of RA Downlink on ATC operations, information on RA events needs to be collected in a more systematic and comprehensive manner. Therefore, it has been proposed that RA information should be collected using the existing Mode-S radar stations and recording tools. That would involve the combined analysis of Mode-S RA reports, radar data, and ATC operational data.

That will allow analysis of links between different influencing parameters (e.g., severity of events vs. timing of pilot reporting, RA compliance vs. timing of events).

The monitoring would be performed in selected locations (to cover various traffic patterns, e.g. high level, low level, etc). The monitoring and analysis of events will be done by a qualified team of experts to produce a comprehensive picture of RA events as described above.

3.2.2 Review of ICAO Procedures

The RA Downlink Safety Assessment [3] concluded that the existing ICAO procedures are inconsistent and should be reviewed. The issue of unclear controller responsibilities before and – even more – after the potential implementation of RA Downlink was also discussed during the RA Downlink Workshop [16]. Current ICAO procedures do not contain provision for operational use of RA Downlink.

It has been recommended that current ICAO procedures are reviewed as soon as possible, and, if required, action is taken to rectify any existing inconsistencies. The review should also identify how the existing procedures could be changed to accommodate operational use of RA Downlink.

3.2.3 Economic Assessment

Before making a decision on whether to implement RA Downlink, ANSPs inevitably will have to assess the financial impact of such a decision. Costs associated with the radar equipment should be negligible, as RA Downlink messages are a part of the existing Mode S standard.

However, the ATC systems will require modifications. The scope of such modifications will depend on system architecture and local implementation details. A study should be conducted to assess the cost of implementation in various systems.

3.3 Presentations to Stakeholder Teams

A paper summarizing FARADS results as well as outlining the above mentioned recommendations (see 3.2) was presented to the following Stakeholder consultation Teams:

- Safety Team,
- Operational Requirements and Data Processing Team,
- Mode S & ACAS Programme Steering Group,

- Airspace and Navigation Team.

The views of the teams are noted below:

3.3.1 Safety Team (ST) – 20 September 2006

"[…] before any support is given further research is needed. The ANSPs present agreed that research is continued especially in the areas which yellow flags are still present (one being the clarification of legal responsibility of ATCOs once the RA will be displayed on their screens). It is expected that the remaining research to take at least one year." [20]

3.3.2 Airspace and Navigation Team (ANT) – 26 October 2006

ANT commented that the proposed revision of ICAO procedures in the recommendation were not desirable and objected to them. This recommendation was removed. Otherwise, the ANT members noted the contents of the paper [6].

3.3.3 Operational Requirements and Data Processing Team (ODT) – 9 November 2006

"The ODT meeting expressed reservation and advised caution for a number of reasons (i) more work was considered necessary to quantify the problem and the cost/benefit aspects; (ii) operational benefits are not clear to all; (iii) the reliability of the tool in dense traffic is not proven; (iv) the area of applicability is not clear; (v) ICAO review not yet available; and finally (vi) the temptation to react to market forces/products is to be avoided.

Early implementation is not supported as no work has been conducted on procedures and potential safety risks could result.

The ODT requested that the Agency limit expenditure and give an estimate of the resources planned on FARADS.

Further work in the areas of monitoring RA events and CBA were supported." [15]

3.3.4 Mode S & ACAS Programme Steering Group (MAPSG) – 23 November 2006

The Steering Group noted the results and supported the recommendations of FARADS as presented in the Working Paper [14].

4. WAY FORWARD – ESTABLISH AN OVERALL, COORDINATED CONCEPT FOR AIRBORNE AND GROUND-BASED SAFETY NETS

The FARADS project has identified the need for further research that was supported by the Stakeholder consultation Teams.

The finding of FARADS indicated that RA Downlink cannot be considered in isolation from existing ground-based safety nets (i.e. STCA). Therefore, an overall, coordinated concept for airborne and ground-based safety nets needs to be developed, taking into account the interactions between them. A systemic approach will ensure that the safety nets are not in 'competition' and provide the maximum benefit.

Consequently, a full study to develop the overall, coordinated concept for airborne and ground-based safety nets is expected to commence mid 2007. The study will perform a number of monitoring activities to assess the number and severity of ACAS encounters and to improve the understanding of the ACAS and STCA interactions in Europe. This will supply the data for quantifications required by the RA Downlink Safety Assessment (see 2.5).

The proposed Economic Assessment (see 3.2.3) is deferred pending the results of the monitoring activities and the Safety Assessment quantification.

The findings of FARADS project will be taken into account in the development of the overall, coordinated concept for airborne and ground-based safety nets and RA Downlink would be consider, if found appropriate, in the context of the overall concept.

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ABBREVIATIONS & TERMS

ACAS	Airborne Collision Avoidance System – ACAS II provides "Resolution Advisories" in the vertical plane advising the pilot how to regulate or adjust his vertical speed so as to avoid a collision.
AGAS	European Action Group on ATM Safety.
ANSP	Air Navigation Service Provider.
ATC	Air Traffic Control.
CWP	Controller Working Position.
Extended Squitter	The broadcast of an event driven extended squitter message containing RA information to a passive ground network.
FARADS	Feasibility of ACAS RA Downlink Study.
ICAO	International Civil Aviation Organization.
Mode S RA Report	The downlinking of RA information from the aircraft in reply to an interrogating Mode S SSR radar station.
RA	Resolution Advisory – an ACAS alert advising the pilot how to regulate or adjust his vertical speed so as to avoid a collision.
R/T	Radio-telephony.
SARPs	ICAO Standards and Recommended Practices.
STCA	Short Term Conflict Alert
TCAS	Traffic alert and Collision Avoidance System – a specific implementation of the ACAS concept. TCAS II Version 7 is currently the only available equipment that is fully compliant with the ACAS SARPs.