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Research Project EASA.2012/03

COCAM - Comparison and harmonisation of Aircraft Collision Avoidance System (ACAS) event monitoring

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COCAM

Comparison and harmonisation of Aircraft Collision Avoidance System (ACAS) monitoring performed by National Aviation Authorities (NAAs), Air Navigation Service Providers (ANSPs) and Airlines

Final Report

Document review

Version	Date	Description of evolution	Modifications
0.1	30/07/2013	Initial draft	-
0.2	21/08/2013	Revised draft taking into account EASA comments at the Progress Review Meeting #3 held on the 31st of July 2013	All sections (including document structure)
0.3	30/08/2013	Revised draft taking into account EASA comments at the ad-hoc review meeting held on the 23rd of August 2013	All sections
0.4	11/09/2013	Revised draft including mature conclusions and recommendations	Chapter 5
1.0	04/10/2013	Proposed first issue version (taking into account EASA comments at the ad-hoc review meeting held on the 26th of September 2013)	All sections
1.1	20/12/2013	Minor changes in conclusions and recommendations (to take into account discussion outcomes from the COCAM final presentation held on the 18th of December 2013)	Chapter 5

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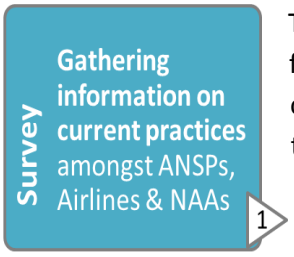
Executive Summary

Although international civil aviation organisations acknowledge the need to monitor ACAS operations, there is currently no harmonised regulation[1] nor standard practice or guidance[2] on how to perform ACAS monitoring, or to collate and analyse monitoring data inside different organisations at the European level.

In this general context, the EASA research section has launched the COCAM Project aiming at gathering information on existing practices amongst National Aviation Authorities (NAAs), Air Navigation Service Providers (ANSPs) and Aircraft Operators (AOs) and at identifying the possible options for harmonisation.



The COCAM project focused both on the operational[3] and technical[4] monitoring of ACAS occurrences.

The information-gathering exercise of the COCAM project was carried out through a thorough and wide survey of various organisations (from the three targeted categories[5] and from different geographical locations[6]) covering data collection methods, data analysis techniques, outcomes and occurrence reporting processes dedicated to ACAS monitoring.

[1] Except on the subject of occurrence reporting
[2] Apart from the general guidance material provided in the ICAO ACAS Manual
[3] Refers to the operational monitoring of ACAS events during flight operations
[4] Refers to the technical monitoring of the ACAS system (and its effect on 1030/1090 MHz telecommunication channels)
[5] I.e. ANSPs, Aircraft Operators and NAAs
[6] E.g. core Europe and areas with less traffic density

Building on a comparative analysis of the monitoring activities conducted by surveyed organisations, the COCAM project provided a better understanding of current practices, limitations and gaps in ACAS monitoring in EASA Member States.

It should be noted that mostly proactive organisations in the field of ACAS monitoring did participate to the survey which enabled the identification of effective practices that are to be considered in the light of the means such organisations did set in place. Therefore, the practices observed in such organisations were considered and generalised with caution.

The project has shown that, the main objective of ACAS monitoring activities by surveyed organisations is to collect and use ACAS monitoring data primarily in the context of investigation and prevention of accidents and incidents, but not only. The survey has also revealed that data collected through monitoring activities may as well be pertinent to perform change impact analyses[7] (e.g. for ANSPs), training and awareness programmes and collaboration with other organisations (e.g. between Airlines and ANSPs), or safety oversight and monitoring of national organisations[8] (e.g. for NAAs).

As a whole, the comparative analysis indicated that, operational monitoring of ACAS events is conducted by almost all surveyed organisations, regardless of their category (i.e. ANSPs, Airlines or NAAs). However, depending on the targeted objectives and the available means (e.g. financial and human resources, technical infrastructure, tools and data, etc…),

[7] In the context of risk assessment and mitigation with regards to changes in ATM
[8] I.e. ANSPs and Airlines

different extent of operational monitoring activities have been observed in the surveyed organisations.

In the contrary, the survey has highlighted that technical monitoring of the ACAS system (and its effect on 1030/1090 MHz channels) is not a very widespread activity. Indeed, the surveyed organisations tend to perceive no particular benefits to technical ACAS monitoring activities compared to the induced costs and structure required to set it in place. Moreover, organisations are lacking guidance material on the subject.

An appraisal of these current effective practices against target objectives for ACAS monitoring allowed identifying **"best (good) practices"**[9] (together with limitations and gaps) in the ACAS monitoring activities carried out by the different categories of organisation. Different topics are covered by these best (good) practices from the plans for monitoring activities, monitoring data availability and sharing across various organisations, to organisational structure for monitoring activities and the scope and extent of monitoring data analysis inside an organisation.

Building on the outcomes of this appraisal, high-level recommendations were drawn to promote these best (good) practices in the light to improve ACAS monitoring in Europe.

The complementarity of ACAS monitoring objectives of each category of organisations led to recommend that all organisations should monitor ACAS occurrences[10] at their level, with defined process and/or programme for maximum effectiveness of their ACAS monitoring activities.

The project also recommends to harmonise (at least) the use of commonly agreed taxonomy in the field of ACAS monitoring and to promote collaborations between various aviation organisations (e.g. ANSPs, Airlines and NAAs at national and supranational levels) for maximum effectiveness of ACAS monitoring activities over Europe.

Acknowledgments

This work was possible only thanks to the contributions of a number of people in ANSPs, Airlines and NAAs that agreed to take some time to respond to our survey, either through questionnaires or interviews. Without their inputs, it would not have been possible to obtain the necessary information to conduct this project.

EASA and Egis Avia wish to express their best appreciation for the support and assistance provided by participating organisations and staffs.

[9] Refers to a method, initiative, process, approach, technique or activity that is believed to be more effective (than other means) at delivering a particular outcome in support to the safety of ACAS operations and system by ANSPs, Airlines and NAAs – *This definition has been derived for the means of the project from the Commission Regulation N°390/2013 laying down a performance scheme for ANS and network functions, i.e. SKPIs IR*

[10] Refers either to an operational ACAS event, or a technical system failure related to the ACAS system (or its impact to 1030/1090 MHz channels)

1. Introduction

1.1. Background and context on ACAS monitoring

The carriage of an ACAS compliant equipment, defined by ICAO PANS-ATM [1] as "*an aircraft system based on secondary surveillance radar (SSR) transponder signals which operates independently of ground-based equipment to provide advice to the pilot on potential conflicting aircraft that are equipped with SSR transponders*" such as TCAS[11] [2], [3].

ICAO PANS-ATM recommends that the performances of the ACAS system are monitored and those significant ACAS events are reported as they can have a significant impact on ATC operations as shown in the extracts hereafter:

> "*15.7.3.5 ACAS can have a significant effect on ATC. Therefore, the performance of ACAS in the ATC environment should be monitored.*
> *15.7.3.6 Following a significant ACAS event, pilots and controllers should complete an air traffic incident report.*"

Similarly at the international level, Chapter 9 and 10 of ICAO ACAS Manual [4] (refer to Appendix A for relevant extracts from Chapter 9) explain the need for respectively ACAS and transponder monitoring and describes practical ways of conducting it and ACAS-related problems that should be detected.

However, even though international civil aviation organisations acknowledge the need to monitor ACAS operations, **there is currently no harmonised regulation nor standard practice / guidance on how to perform ACAS monitoring[12] or to collate and analyse monitoring data inside different organisations at the European level** (apart from the general guidance material provided in the ICAO ACAS Manual).

Data gathered through monitoring activities performed by ANSPs, NAAs and Aircraft Operators (AO) are indeed expected to have a significant role to play in:

- Understanding the relevance of ACAS in ATM operations;
- Identifying, investigating and correcting deficiencies in all areas of ACAS operations;
- Reducing or eliminating safety risks as well as minimising deviations from regulation and henceforth; and
- Ensuring that the ACAS system will continue to deliver the benefits expected.

[11] TCAS is aircraft equipment that is an implementation of an ACAS. Hereafter, TCAS refers to TCAS II – the only equipment so far that is compliant with the ACAS II standard.
[12] Except on the subject of occurrence reporting

1.2. Scope and objective of COCAM project

In this general context, the EASA research section has launched a project (COCAM) aiming at gathering information on existing practices amongst National Aviation Authorities (NAAs), Air Navigation Service Providers (ANSPs) and Aircraft Operators (AOs) and at identifying the possible options for harmonisation.

The COCAM project addresses both the operational monitoring of ACAS events as well as the technical monitoring of ACAS and Mode S transponders performance (including 1030/1090MHz telecommunication channels).

In that prospect, a survey was conducted with representative organisations involved in ACAS monitoring that constituted the basis for the analysis of the effective practices encountered.

In a first step, data were gathered and analysed, and conclusions were drawn to try and understand the aim of the monitoring activities carried out by the different organisations and what means, processes and structures these organisations have set in place to achieve their goal; but also, what gaps and limitations they have faced.

In a second step, a specific analysis on the subject of the use of monitoring data in support to change impact analyses was conducted and conclusions on the pros and cons of using monitoring data for change impact analyses were drawn using the results from the first step, but also from lessons learnt from past or current projects carried out at an international level.

This COCAM project is intended to provide a better understanding of current practices in ACAS monitoring in the EASA Member States and highlight the effective practices that would improve the effectiveness of ACAS monitoring by each category of organisation, including existing limitations and gaps that would need to be taken into account if envisaging further harmonisation in ACAS monitoring activities.

1.3. Methodology and surveyed organisations

As described in the previous section, **the information-gathering exercise was carried out through a comprehensive survey of representative organisations**.

This survey has been conducted mainly by means of questionnaires and interviews[13] (conducted following the outline of the questionnaire) covering the scope, nature and extent of the monitoring activities carried out by the surveyed ANSPs, NAAs and Aircraft Operators (e.g. data collection methods, data analysis techniques and event/occurrence reporting processes dedicated to technical monitoring of the ACAS system and operational monitoring of ACAS events currently in place within the surveyed organisations). Refer to Appendix B for a copy of the questionnaire.

[13] When possible

A number of organisations of each category were contacted[14] and eventually participated to the survey. Care was taken to ensure that the interviewees included representatives from different categories of organisations (e.g. ANSPs, Aircraft Operators, or NAAs) from different geographical locations. The category and geographical representativeness of the surveyed organisations is given in Figure 1 and Figure 2 respectively.

These following figures reflect the relatively satisfactory level of representativeness of the participants.

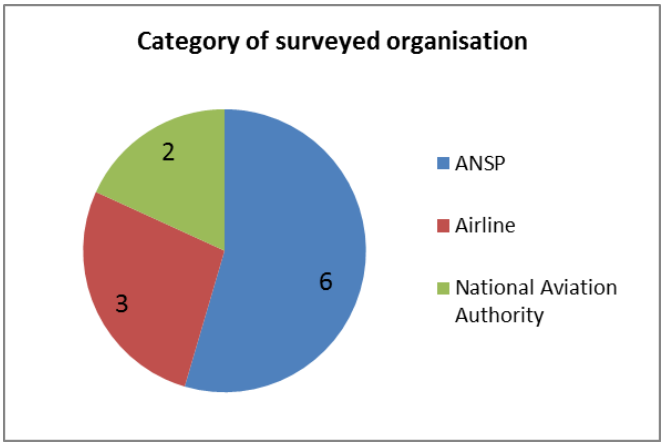


Figure 1: Category of surveyed organisations

Figure 2: Origin of surveyed organisations

[14] A total of 9 ANSPs, 9 Airlines and 4 NAAs were actually contacted, but only 11 organisations did participate to the survey.

As it can be seen in Figure 2, the surveyed organisations (regardless of whether they are representative of ANSPs, Airlines or NAAs) are mainly originated from core Europe, but also with some representative from less dense traffic areas.

The relatively low rate of participation, in particular among airlines and NAAs, is a limitation that has been taken into account when drawing conclusions from the survey. Indeed, practices observed in some organisations are to be considered and generalised with caution.

However, the number of organisations which participated in the survey can be considered representative enough for the identification of effective practices, limitations and gaps, which is the main objective of the COCAM project. Indeed, as depicted on Figure 3 below, **most surveyed organisations carry out both technical and/or operational ACAS monitoring.**

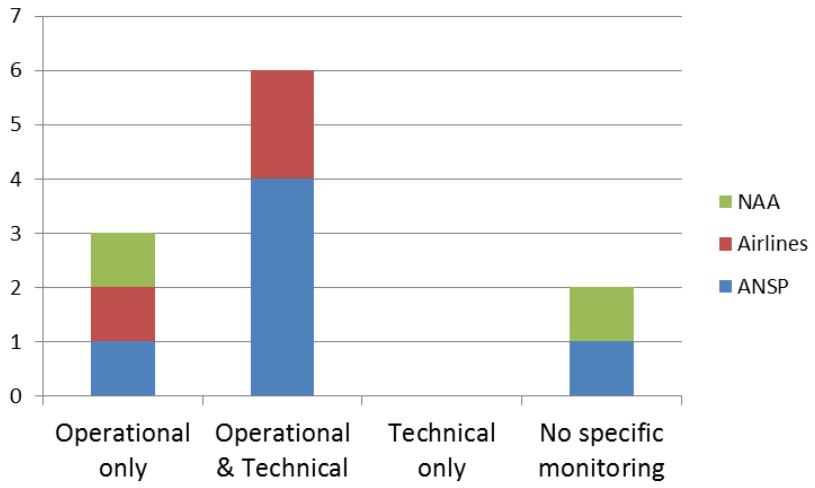


Figure 3: Kind of ACAS-related monitoring by surveyed organisations

It should be noted that a bias may exist in the survey results and conclusions that were consequently drawn, as **organisations extremely proactive in the field of ACAS monitoring participated to the survey**. However, this bias enabled the identification of effective practices that are to be considered in the light of the means such organisations did set in place.

1.4. Structure of the document

This document constitutes the COCAM final project report. It is organised into five Chapters as follows:

- **Chapter 1** presents the project's background and context, as well as the scope, objective and methodology used for the COCAM project;
- **Chapter 2** identifies effective current practices, limitations and gaps in ACAS monitoring activities by **surveyed ANSPs**;
- **Chapter 3** identifies effective current practices, limitations and gaps in ACAS monitoring activities by **surveyed Airlines**;
- **Chapter 4** identifies effective current practices, limitations and gaps in ACAS monitoring activities by **surveyed NAAs**; and
- **Chapter 5 draws general conclusions** on the best practices, limitations and gaps identified in ACAS monitoring activities in Europe and **some high level recommendations to promote effective current practices observed** in surveyed organisations (as guidance on what should be done, why and how).

Within each Chapter targeting a given category of organisation (i.e. Chapters 2, 3 and 4):

- The first section gives the **objectives of ACAS monitoring activities** for the studied category of organisation;
- The second section then focuses on **operational ACAS monitoring activities**; and
- The third section focuses on **technical ACAS monitoring activities**.

Additionally, the second and third sections of each Chapter (within Chapter 2, 3 and 4) are structured as follows:

- In the first two sub-sections a **summary of the survey's outcomes** is given (with details on the scope, nature extent and outcomes of ACAS monitoring activities conducted); and
- In the third and fourth sub-sections an **analysis of the survey's outcomes** is provided by identifying effective practices in ACAS monitoring activities, but also current limitations and gaps, for each targeted objectives.

1.5. Terminology

The following terminology is used throughout this report.

The term **"operational ACAS monitoring"** refers to the monitoring activities of ACAS events during flight operations, including the operational relevance of ACAS RAs and responses given by the flight crew.

The term **"technical ACAS monitoring"** refers to the monitoring activities related to the ACAS system (including its equipment, display, Mode S transponder, antennas …) and its effect on 1030/1090 MHz telecommunication channels.

The term **"best (good) practice"** *[in ACAS monitoring]* refers to a method, initiative, process, approach, technique or activity that is believed to be more effective (than other means) at delivering a particular outcome in support to the safety of ACAS operations and system – *This definition has been derived for the means of the project from the Commission Regulation N°390/2013 laying down a performance scheme for ANS and network functions, i.e. SKPIs IR.*

The term **"ACAS (operational or technical) occurrence"** refers either to a safety occurrence in which ACAS plays a role, i.e. an operational ACAS event, or a technical system failures related to the ACAS system (or its impact on 1030/1090 MHz channels).

2. Effective current practices, limitations and gaps in ACAS monitoring activities by surveyed ANSPs

This section focuses on surveyed ANSPs monitoring activities. The first sub-section details ANSPs targeted objectives for operational and technical ACAS monitoring. The second and third sub-sections focus respectively on operational versus technical ACAS monitoring activities carried out by the surveyed ANSPs by analysing and comparing the scope, nature, extent and outcomes of their monitoring activities.

The aim of this section is to understand what activities can be carried out by ANSPs and identify effective practices (as well as potential gaps), in relation with the targeted monitoring objectives.

2.1. Objectives of ACAS monitoring activities by ANSPs

Table 1 and Table 2 below gather the target objectives identified respectively for operational and technical ACAS monitoring activities that were used in the comparative analysis of current practices by surveyed ANSPs to identify effective practices, limitations and gaps on the matter.

Objective ID	Description of ACAS monitoring objective by ANSPs
OO_ANSP_1	**Operational monitoring of ACAS events as part of investigation and prevention of accidents and incidents** (in the context of ANSP's Safety Management System operation) in order to: • Analyse the performance of ACAS in the ATC environment (e.g. compatibility of ACAS with ATC procedures and working practices, effectiveness of ACAS as the last safety barrier against mid-air collisions); and • Identify issues in the ATC environment related to ACAS operations (e.g. hot spots, misuse of ACAS by pilots, inappropriate pilots' responses to RAs) and, as far as practicable, identify the main causal factors for these issues
OO_ANSP_2	**Operational monitoring of ACAS events as part of risk assessment and mitigation with regard to changes in ATM** (in the context of ANSP's Safety Management System operation) in order to: • Conduct change impact analyses of ACAS environment (e.g. safety-related and operational suitability of ACAS RAs following an airspace structure and/or local procedures change); and • Conduct Research & Development (R&D) activities related to ACAS operations (e.g. operational suitability of displaying ACAS RA information to controllers, support to evolution of ACAS provisions and standards, etc…)
OO_ANSP_3	**Operational monitoring of ACAS events in support to training and awareness programmes and collaboration with other organisations,** in order to: • Draw lessons learnt and report/inform management (e.g. identification of hot spots of RAs), staff (e.g. support to controller training and awareness on ACAS), and Airlines (e.g. feedback on misuse[15] of ACAS by pilots)

Table 1: Objectives of operational ACAS monitoring by ANSPs

[15] Misuse of ACAS by pilots : Use of ACAS traffic display to unnecessarily issue disruptive requests to ATC, to challenge ATC instructions or to perform unauthorized and unjustified manoeuvres

Objective ID	Description of ACAS monitoring objective by ANSPs
OT_ANSP_1	**Technical monitoring of ACAS system (and 1030/1090 MHz telecommunication channels) as part of the monitoring of the quality of Mode S surveillance system** in order to: • Analyse the impact of ACAS on the performance of the Mode S surveillance network (e.g. ACAS usage of spectrum) • Analyse the impact of Mode S surveillance system on the performance of ACAS (e.g. transponder occupancy)
OT_ANSP_2	**Technical monitoring of ACAS system (and 1030/1090 MHz telecommunication channels) as part of risk assessment and mitigation with regard to changes in ATM** (in the context of ANSP's Safety Management System operation) in order to: • Conduct change impact analyses of surveillance system change (e.g. deployment of Mode S technology including ADS-B); and • Support and/or conduct Research & Development (R&D) activities related to ACAS (e.g. technical feasibility of using ACAS RA information for operational purposes, use of transponder/ACAS on the ground)
OT_ANSP_3	**Technical monitoring of ACAS system in support to operational ACAS monitoring** (through automatic RA recordings) in order to: • Overcome the limitation of RA reporting rates; and • Identify technical issues explaining suspicious RA events (e.g. false RAs and surveillance issues)

Table 2: Objectives of technical ACAS monitoring by ANSPs

2.2. Operational ACAS monitoring activities by ANSPs

This section specifically analyses the operational ACAS monitoring activities carried out by the surveyed ANSPs. Observed monitoring activities are analysed and compared. Scope, nature and extent of operational monitoring activities performed by the surveyed organisations are presented, as well as the outcomes of their operational monitoring activities.

The aim here is to understand what activities can be carried out by ANSPs by identifying effective current practices, but also potential gaps that they are likely to face, in relation with the operational monitoring objectives presented in the previous section.

2.2.1. Scope, nature and extent of operational ACAS monitoring activities by surveyed ANSPs

This sub-section focuses on the scope, nature and extent of the processes set in place by surveyed ANSPs to conduct operational ACAS monitoring activities including data collection methods, data analysis techniques and data sources.

Almost all participating ANSPs reported conducting monitoring of ACAS events, generally integrated in the context of incident/accident investigation regardless of the data collection and analysis methods. Only one ANSP reported having a dedicated and independent unit in the organisation dedicated to the monitoring of ACAS events.

In general, ANSPs report monitoring continuously all the airspace under their responsibility and all RAs reported by either pilots or controllers. A major part of ANSPs' operational ACAS monitoring activities consists in carrying out investigation of ACAS events on an event-driven basis, using the severity and/or the rarity of the event as a trigger for the analysis. Many of them also report monitoring pilots' responses to RAs and computing statistics about RAs occurring in their airspace. It should be noted that systematic and statistical monitoring of ACAS events is rather used for specific projects and/or for annual operational reports.

Figure 4 hereafter presents statistics on the way surveyed ANSPs conduct operational ACAS monitoring.

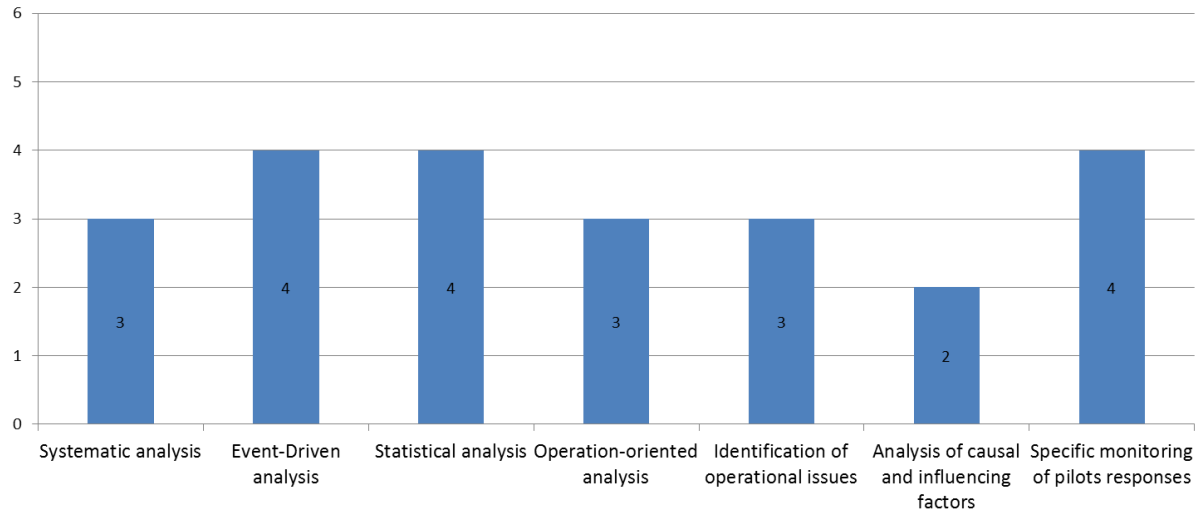


Figure 4: Nature of operational ACAS monitoring activities by ANSPs

Most surveyed ANSPs report potentially using several sources of data, including radar data and RA recordings, pilots and ATCO reports, R/T transcripts, voice recordings and STCA alerts, where appropriate.

Figure 5 hereafter present statistics on the sources of data used by surveyed ANSPs to conduct operational ACAS monitoring activities.

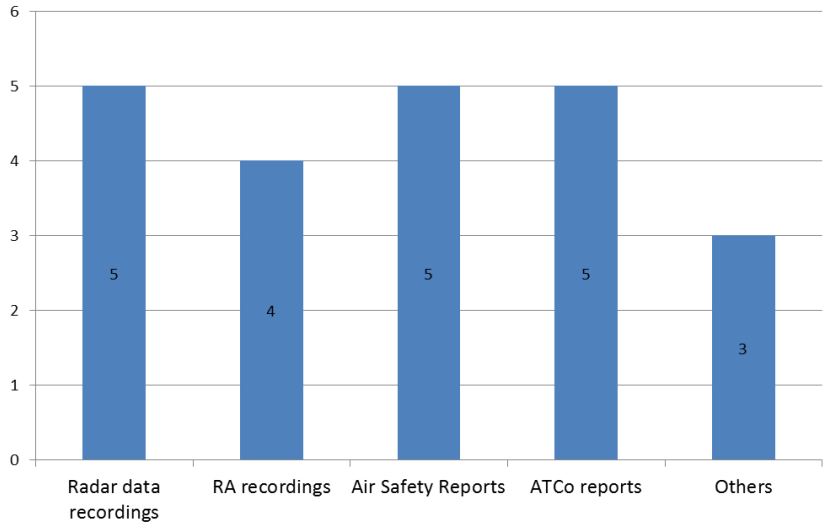


Figure 5: Sources of data used by ANSPs for operational ACAS monitoring activities

While most of the time, as mentioned in the previous paragraphs, operational ACAS monitoring activities are part of ANSPs Safety Managements System, some of them do use the data collected for the analysis of the impact of an operational change. For example, three ANSPs reported using ACAS monitoring data to assess the impact of a change in the airspace structure, including route network or specific procedures. For instance, issues on arrival and departure procedures at major airports were reported to have been identified through the monitoring of ACAS RAs.

Indeed, Safety Nets events (STCA and ACAS RA) collected by ANSPs may be used as a safety indicator of the airspace and to identify hotspots by measuring, quantifying and representing the density of such events in the airspace, to define the boundaries where the density significantly changes and to describe some of these high density areas characteristics (density magnitude, how and to what extent they are connected with each other, their temporal evolution and their topology).

However, it should be noted that such examples only show uses of ACAS monitoring data for a posteriori change impact analysis. Indeed, in most cases, it is the identification of hot-spots that allow the assessment of the impact of an operational change. For impact assessment prior to the change, often only models or simulated data can be used. For maximum realism, it is then preferable that these models are being developed and validated against relevant monitoring data.

It is also to be noted that only major ANSPs have the ability to gather ACAS monitoring data to the extent that is relevant for wide pan-European (or international) R&D projects.

2.2.2. Outcomes of operational ACAS monitoring activities by surveyed ANSPs

This sub-section is dedicated to the outcomes of the operational ACAS monitoring activities by surveyed ANSPs. The kinds of results that surveyed ANSP seek to obtain through their operational monitoring activities are presented first. The preventive and/or corrective actions that can be taken following the conclusions drawn from the operational monitoring of ACAS events are then described.

2.2.2.1. Issues identified by operational ACAS monitoring activities

The most common purpose of operational ACAS monitoring among surveyed ANSPs is the analysis of pilots' use of ACAS. Indeed, almost all organisations carrying out operational monitoring activities report monitoring pilots' responses to RAs. Some also mention that operational monitoring enable identifying inappropriate use of ACAS by flight crews (e.g. second guess the controller, acting on TA only, or using the ACAS display to determine separation or perceived lack of separation). It should be noted, as mentioned in the previous sub-section, that major ANSPs also use the operational monitoring to draw other conclusions such as the identification of hot-spots or the interaction between STCA and ACAS.

Figure 6 hereafter presents the main outcomes that resulted from ACAS operational monitoring by surveyed ANSPs.

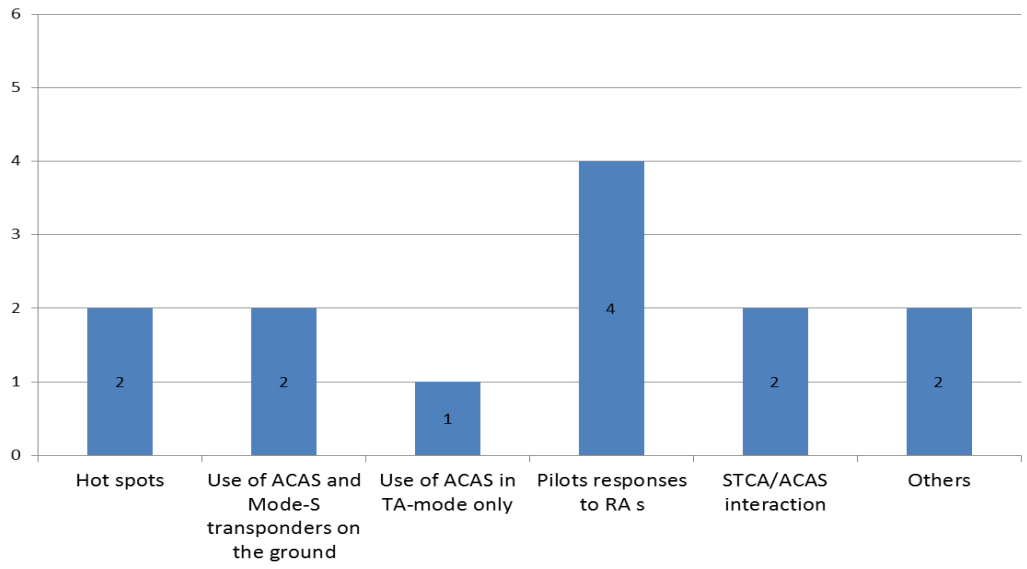


Figure 6: Outcomes of operational ACAS monitoring by ANSPs

For pioneer ANSPs that have implemented RA display on controller working positions, there is no obvious need to set in place a specific (off-line) operational monitoring of ACAS RAs to identify further operational issues (as the on-line display of RAs already allows raising awareness of controllers on potential safety issues).

2.2.2.2. Preventive/corrective actions taken following operational ACAS monitoring activities

It appears that the operational monitoring of ACAS events allows preventive and corrective actions to be taken. Indeed, most surveyed ANSPs report **communicating with Airlines on identified issues to improve the use of ACAS by pilots or using the conclusions drawn from ACAS monitoring to adjust local procedures and/or controller training**.

At a higher level, some major ANSP report using ACAS monitoring as a cornerstone of the evolution of ACAS standards. In that perspective, almost all participants collaborate with NAAs, EUROCONTROL or other national and international organisations.

2.2.3. Effective current practices in operational ACAS monitoring activities

This sub-section concentrates on the effectiveness of the current practices by surveyed ANSPs in the scope of their operational monitoring of ACAS events.

Table 3 hereafter consolidates the effective practices that have been identified from the analysis presented throughout section 2.2, in relation with the objectives of operational ACAS monitoring activities by ANSPs presented in section 2.1.

Objectives	Effective current practices
OO_ANSP_1 Operational monitoring of ACAS events as part of investigation and prevention of accidents and incidents	**Effective collaboration between ANSPs, Airlines and NAAs** allows a better access to specific monitoring data (e.g. flight data recordings and pilot reports for ANSPs) that are essential to undertake complete analysis of ACAS events
	Adapt the extent of the analysis (e.g. influencing factors, monitoring of pilots' responses, etc…) to the severity of the ACAS events for cost-effective operational ACAS monitoring
OO_ANSP_2 Operational monitoring of ACAS events as part of risk assessment and mitigation with regard to changes in ATM	**Collaboration between ANSPs and supranational organisations through R&D projects related to ACAS** (e.g. EUROCONTROL, EUROCAE, SESAR, etc…) to ensure comprehensive understanding of ACAS effect on ATC, and vice-versa, in Europe
	Number, type and density of ACAS RAs can be used as a safety indicator when changes in the airspace structure and/or local procedures (that can affect traffic patterns) are envisaged
	Number, type and density of ACAS RAs can be used as a local ATM compatibility indicator when a change of the ACAS system is envisaged
	Operational monitoring data can be used to develop and adjust realistic models of ATC / flight operations in a given airspace that can then be used for change impact analysis (when the change is so important that the impact analysis requires such modelling)

Objectives	Effective current practices
OO_ANSP_3 Operational monitoring of ACAS events in support to training and awareness programmes and collaboration with other organisations	**Statistical analysis of ACAS events allows the identification of general trends about safety and operational suitability of ACAS in the airspace**, that can then be shared with other organisations (e.g. Airlines and NAAs)
	Detailed analysis of ACAS events taking into account the configuration of the air traffic situations at the time of occurrence of the RAs is necessary to draw valuable lessons and conclusions, as opposed to purely statistical monitoring of ACAS events
All Objectives (OO_ANSP_1 to 3)	**Existence of a specific structure / resources inside the ANSP organisation dedicated to the operational monitoring of ACAS events** (e.g. ACAS monitoring cell under the responsibility of the department in charge of incident/accident operational analysis)
	Use of a wide range of sources of data for operational monitoring of ACAS events in order to gain a comprehensive picture of RA occurrences and a precise understanding of the factors that influence most these occurrences

Table 3: Effective practices in operational ACAS monitoring activities by ANSPs

2.2.4. Limitations and gaps in operational ACAS monitoring activities

This sub-section concentrates on the limitations and gaps encountered by surveyed ANSPs in the scope of their operational monitoring of ACAS events, potentially resulting in gaps. Surveyed ANSPs were particularly invited to react on the subjects of access to data, appropriate expertise and tools, as well as induced costs. They also had the possibility to comment any other limitation they might have encountered when setting in place operational monitoring activities related to ACAS.

It has been pointed out earlier that most ACAS monitoring activities conducted by surveyed ANSPs rely on reported RAs (identified using ASRs and/or controllers' reports) rather than recorded RAs; one reason (pointed out by one surveyed ANSP) is the difficulty of determining the correct mapping between RA data contained in BDS 3.0 and RA oral annunciation due to the lack of European guidance material on the matter.

Some ANSPs commented on the difficulty and associated costs necessary to acquire and maintain the operational expertise necessary to support a group of experts dedicated to the monitoring and analysis of ACAS events.

Although no difficulties seem to be encountered on the subject of access to data for ANSP, it has been highlighted that the sensitive nature of ACAS data could be a major issue in the setting in place of an international collaboration for operational ACAS monitoring[16].

[16] Outside authority-led incident investigations

Figure 7 hereafter summarises the type of limitations encountered by ANSPs for operational monitoring of ACAS events.

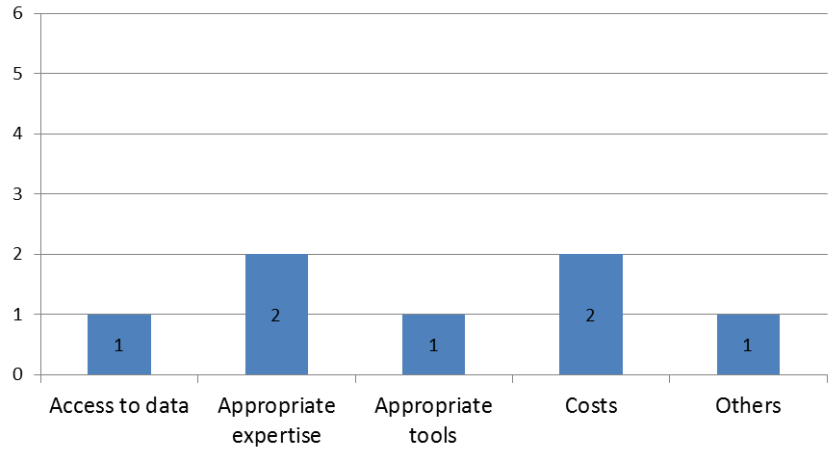


Figure 7: Type of limitations encountered by ANSPs for operational ACAS monitoring activities

Table 4 hereafter consolidates the limitations and gaps that have been identified from the analysis presented in the previous paragraphs, in relation with the objectives of operational ACAS monitoring activities by ANSPs presented in section 2.1.

Objectives	Limitations & Gaps
OO_ANSP_1 Operational monitoring of ACAS events as part of investigation and prevention of accidents and incidents	**Difficulty, and associated costs, for ANSPs to acquire and maintain the operational expertise** necessary to conduct thorough monitoring and analysis of ACAS events
OO_ANSP_2 Operational monitoring of ACAS events as part of risk assessment and mitigation with regard to changes in ATM	**ACAS related changes (e.g. introduction of a new ACAS version) are international and the impact analysis cannot be carried out at a local level only**
	When changes are too important (e.g. new aircraft fleet in the airspace), it is difficult to use monitoring data directly to assess the impact of the implementation of such changes. In this case models may enable to simulate scenarios representing as a whole the operations that one would observe in the future
	Operational monitoring data of ACAS events are not sufficient to determine the reduction of the risk of collision in the airspace
	Limited flexibility and adaptability of ASMT for specific ANSPs' needs

Objectives	Limitations & Gaps
OO_ANSP_3 Operational monitoring of ACAS events in support to training and awareness programmes and collaboration with other organisations	**Limited flexibility and adaptability of ASMT** for specific ANSPs' needs
All Objectives (OO_ANSP_1 to 3)	**Not all organisations have the ability to set in place automated operational monitoring of ACAS events** due to limited (or lack of) Mode S[17] monitoring infrastructure
	Anticipated difficulty to share operational monitoring data at a supranational level due to the sensitivity nature of ACAS events
	High costs (in terms of resources, efforts, means, expertise, infrastructure, etc… required) of an extended monitoring system deployment, maintenance and use

Table 4: Limitations and gaps in operational ACAS monitoring activities by ANSPs

[17] Active and/or passive surveillance

2.3. Technical ACAS monitoring activities by ANSPs

This section specifically analyses the technical ACAS monitoring activities carried out by the surveyed ANSPs. Observed monitoring activities are analysed and compared. Scope, nature and extent of technical monitoring activities performed by the surveyed organisations are presented, as well as the outcomes of their technical monitoring activities.

The aim here is to understand what activities can be carried out by ANSPs by identifying effective current practices, but also potential gaps that they are likely to face, in relation with the technical monitoring objectives presented in the previous section.

2.3.1. Scope, nature and extent of technical ACAS monitoring activities by surveyed ANSPs

This sub-section focuses on the scope, nature and extent of the processes set in place by surveyed ANSPs to conduct technical ACAS monitoring activities including data collection methods, data analysis techniques and data sources.

Although most surveyed ANSP report conducting both technical and operational monitoring, it appears that in practice **only approximately half of them have regular and structured technical monitoring activities with dedicated resources and processes**. Indeed, outside of R&D activities, or specific studies on demand of other entities carried out by major organisations, **ANSPs tend to perceive no particular benefits to carrying out technical monitoring compared to the induced costs and organisation required to set it in place**.

Moreover, among the organisations that do report conducting technical monitoring, even less have processes set in place for technical monitoring of 1030/1090 MHz telecommunication channels, outside of specific and one-shot or R&D studies.

Figure 8 and Figure 9 hereafter present statistics on the way surveyed ANSPs conduct technical ACAS monitoring of respectively ACAS system and 1030/1090 MHz telecommunication channels.

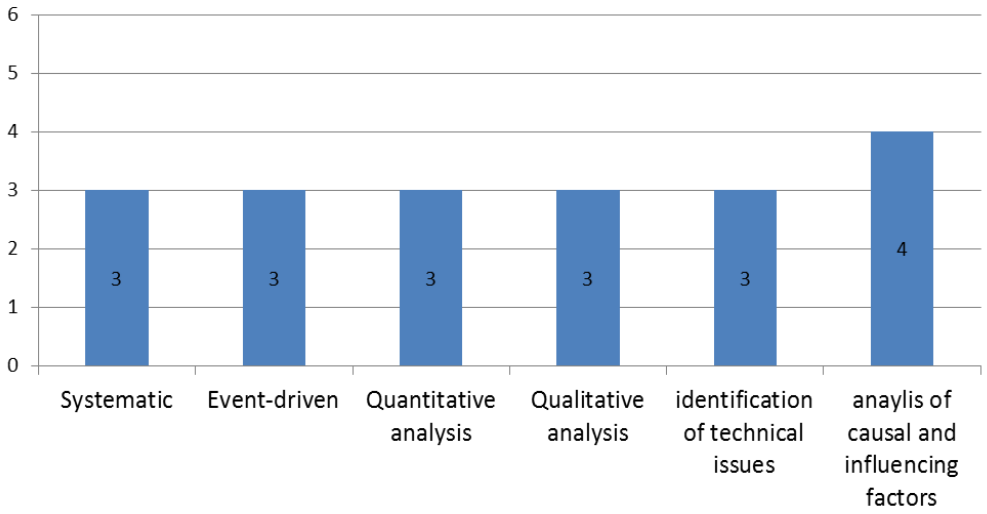


Figure 8: Nature of technical monitoring of ACAS system activities by ANSPs

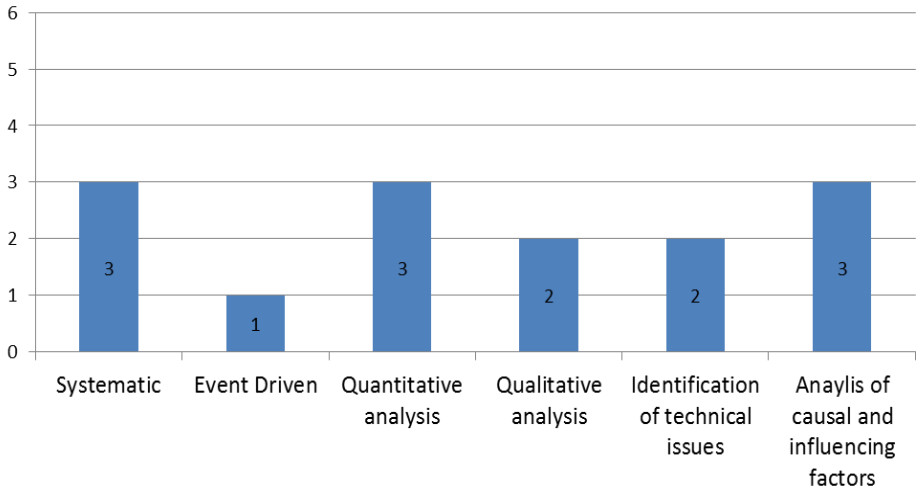
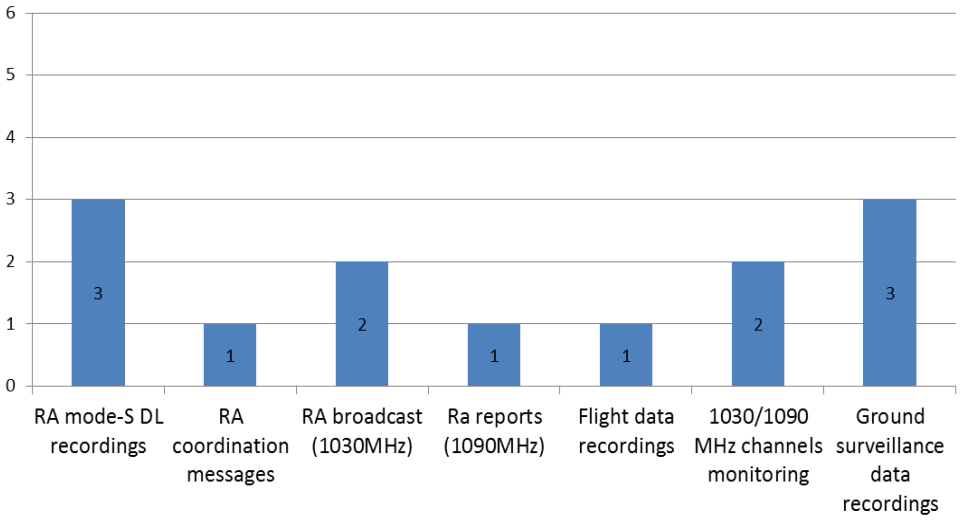


Figure 9: Nature of technical monitoring of 1030/1090 MHz telecommunication channels activities by ANSPs

All kinds of sources of data were reported to be used by the ANSPs that have technical monitoring activities with **particular emphasis on RA mode S Downlink recordings and surveillance data recordings which are exploited by all ANPs carrying out technical ACAS monitoring activities**.

Figure 10 hereafter present statistics on the sources of data used by surveyed ANSPs to conduct technical ACAS monitoring activities.



Note: Although standardised, automatic RA reporting on 1090MHz are not yet widely implemented on aircraft. Surveyed organisations that responded using RA reports most probably were referring to RA reports by pilots.

Figure 10: Sources of data used by ANSPs for technical ACAS monitoring activities

2.3.2. Outcomes of technical ACAS monitoring activities by surveyed ANSPs

In the scope of the limited monitoring activities described in the previous sub-section, ANSPs are nevertheless capable of detecting false RAs and ACAS surveillance issues (in particular thanks to the exploitation of RA downlink data). It should be noted that such technical issues might sometimes be detected through the detailed analysis of ACAS operational events.

Figure 11 hereafter presents the main issues that have been identified by surveyed ANSPs in the scope of their technical ACAS monitoring.

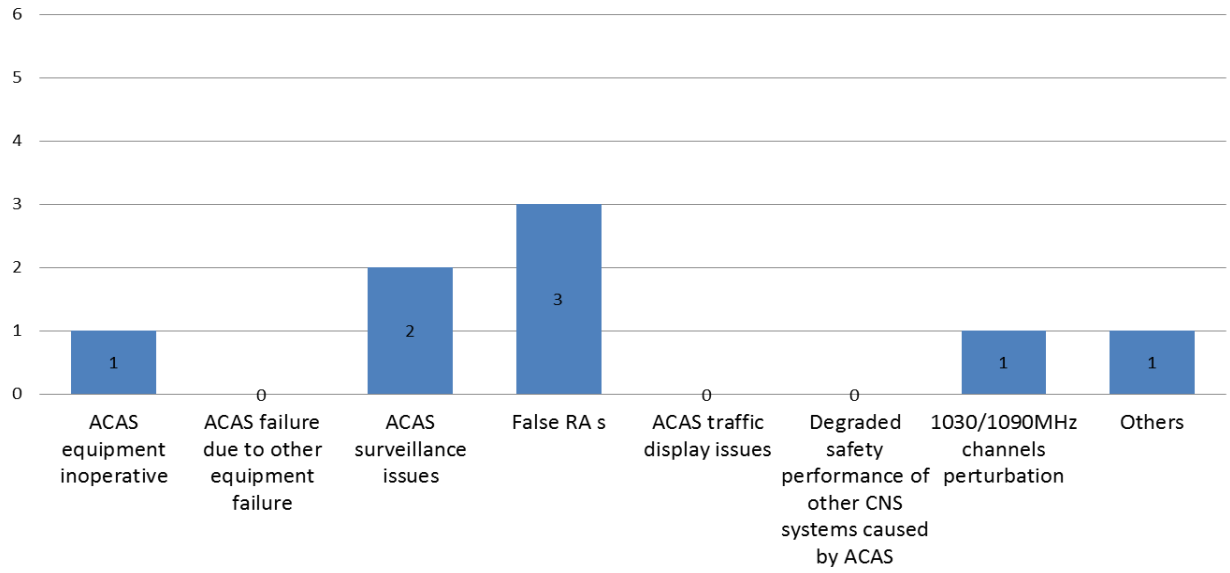


Figure 11: Outcomes of technical monitoring activities by ANSPs

The data collected through technical ACAS monitoring was also reported to be used at a national scale to look into technical and operational issues.

For instance, one ANSP particularly proactive in the field of ACAS monitoring reported using monitoring data to identify inappropriate retrofitting of TCAS versions and consequent misleading RA/DL report formats due to compatibility issues between TCAS and transponder versions. Two ANSPs reported using the data collected through the active monitoring of the 1030/1090 MHz channel to support the deployment of Mode S technology including ADS-B. And one ANSP reported having used Mode S monitoring data to assess the impact of the use of ACAS transponders on the ground (at a major airport) on the RF load. The aim was to assess the impact on ACAS surveillance performances due to this practice by local airspace users. Finally, a few ANSPs reported using surveillance monitoring data in order to assess the compatibility between ACAS and other surveillance and alerting systems, such as the STCA.

Amongst the organisations that report having technical monitoring activities, some of them **collaborate in the scope of these activities with supranational organisations** such as EUROCONTROL and/or European entities (e.g. SESAR, EUROCAE, …), in particular in the context of Airborne Monitoring Project or the ASMT (ATM Safety Monitoring Tool) user group. Indeed, **technical ACAS monitoring activities are rarely stand-alone local initiatives**. It should be noted that **only major organisations have the resources to conduct such activities**.

2.3.3. Effective current practices in technical ACAS monitoring activities

This sub-section concentrates on the effectiveness of the current practices by surveyed ANSPs in the scope of their technical ACAS monitoring activities (including ACAS system and/or 1030/1090 MHz telecommunication channels).

Table 5 hereafter consolidates the effective practices that have been identified from the analysis presented throughout section 2.3, in relation with the objectives of technical ACAS monitoring activities by ANSPs presented in section 2.1.

Objectives	Effective current practices
OT_ANSP_1 Technical monitoring of ACAS system (and 1030/1090 MHz telecommunication channels) as part of the monitoring of the quality of Mode S surveillance system	**Technical 1030/1090 MHz monitoring data can be used to assess the occupancy level of the frequencies** to get an insight into the performances of the overall Mode S surveillance system (including ACAS)
	Technical ACAS monitoring data can be used to assess the impact of Radio Frequency load on ACAS surveillance performances to identify potential shortcomings in the contribution of ACAS in the reduction of mid-air collision risk
OT_ANSP_2 Technical monitoring of ACAS system (and 1030/1090 MHz telecommunication channels) as part of risk assessment and mitigation with regard to changes in ATM	**Technical 1030/1090 MHz monitoring data can be used to support the deployment of Mode S technology** including ADS-B, while taking into account ACAS
	Technical (surveillance) monitoring data can be used to assess the interaction between ACAS and other surveillance and alerting systems, such as STCA or when envisaging the display of RA/DL on Controller Working Position
	Collaboration between ANSPs and other organisations at an international level (e.g. EUROCONTROL, SESAR, EUROCAE,…) ensures a comprehensive and efficient monitoring of the ACAS system
	Major ANSPs carry out technical monitoring activities as part of wide R&D projects to help justify and/or limit the costs and difficulties experienced in setting in place and maintaining the appropriate expertise
	Technical monitoring data can be used to develop and adjust realistic models of surveillance system behaviour (in particular with regard to 1030/1090 MHz radio Frequency load)
OT_ANSP_3 Technical monitoring of ACAS system in support to operational ACAS monitoring	**Collaboration between ANSPs and Airlines** in order to share technical data and expertise in support to operational analysis of incidents/accidents involving ACAS

Table 5: Effective practices in technical ACAS monitoring activities by ANSPs

2.3.4. Limitations and gaps in technical ACAS monitoring activities

This sub-section concentrates on the limitations and gaps encountered by surveyed ANSPs in the scope of their technical ACAS monitoring activities (including ACAS system and/or 1030/1090 MHz telecommunication channels), potentially resulting in gaps. Surveyed ANSPs were particularly invited to react on the subjects of access to data, appropriate expertise and tools, as well as induced costs. They also had the possibility to comment any other limitation they might have encountered when setting in place technical monitoring activities related to ACAS.

Through the answers of the surveyed ANSPs, it appears that **the limitations encountered to set in place a proper and dedicated technical ACAS monitoring process are numerous**.

Indeed, almost all of them report having **difficulties justifying such activities when not integrated into wider Research & Development projects, and/or defining dedicated processes** that could be set in place to conduct technical monitoring of ACAS system. This often results in difficulties experienced in terms of finding funds for appropriate staffing, tools and/or infrastructure.

Moreover, **the data processed in the scope of technical monitoring seem to represent a challenge in themselves**, due to their sensitive nature that prevent ANSPs from transmitting the data to other organisations, implying a strong restriction in the collaboration that can be envisaged at a higher level in this matter, but also to their complexity that requires specific infrastructure such as specific hardware and software facilities to collect and analyse monitoring data.

Figure 12 hereafter summarises the type of limitations encountered by ANSPs for technical monitoring of ACAS events.

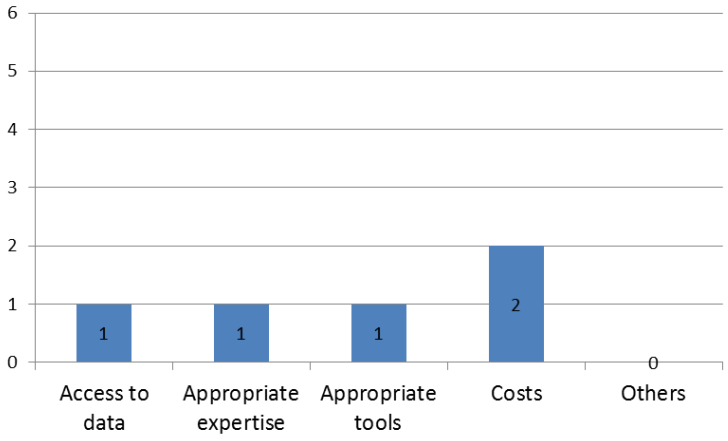


Figure 12: Type of limitations encountered by ANSPs for technical ACAS monitoring activities

In conclusion, ANSPs tend to perceive no particular benefits in carrying out technical monitoring activities compared to the induced costs and organisation (i.e. staffing, tools and/or infrastructure) required for establishing and conducting effective monitoring of the ACAS system.

Table 6 hereafter consolidates the limitations and gaps that have been identified from the analysis presented in the previous paragraphs, in relation with the objectives of technical ACAS monitoring activities by ANSPs presented in section 2.1.

Objectives	Limitations & Gaps
OT_ANSP_1 Technical monitoring of ACAS system as part of the monitoring of the quality of Mode S surveillance system	**Difficulty for ANSPs to find guidance material on how to set in place technical ACAS monitoring activities** that would help shaping the purpose, scope, nature and extent of such activities in Europe
	Difficulty to interpret and analyse data collected during technical ACAS monitoring resulting in issues for finding and maintaining knowledgeable staff inside the various organisations
OT_ANSP_2 Technical monitoring of ACAS system as part of risk assessment and mitigation with regard to changes in ATM	**Although local organisations might conduct technical monitoring at their level, changes of the surveillance system (e.g. introduction of ADS-B) are often Europe-wide and so the impact analyses cannot be carried out at a local level only**
	Although local technical monitoring data can be useful, ACAS related changes (e.g. introduction of a new ACAS version) has to be assessed at the international level and so the impact analyses cannot be carried out at a local level only
OT_ANSP_3 Technical monitoring of ACAS system in support to operational ACAS monitoring	**The sensitive nature of surveillance data makes it difficult for ANSPs to collaborate with other organisations** and therefore for Airlines to complement their flight monitoring data with ground-based technical monitoring data available to ANSPs
All Objectives (OT_ANSP_1 to 3)	**Difficulty for ANSPs to obtain/develop tools (hardware and software) dedicated to technical ACAS monitoring**, due in particular to the technicality of the data to be processed
	The scope and extent of technical ACAS monitoring activities observed in small and major ANSPs suggest that the smallest ones neither are in a capacity to carry out such activities nor do they see any benefit to it

Table 6: Limitations and gaps in technical ACAS monitoring activities by ANSPs

3. Effective current practices, limitations and gaps in ACAS monitoring activities by surveyed Airlines

This section focuses on surveyed Airlines monitoring activities. The first sub-section details Airlines targeted objectives for operational and technical ACAS monitoring. The second and third sub-sections focus respectively on operational versus technical ACAS monitoring activities carried out by the surveyed Airlines by analysing and comparing the scope, nature, extent and outcomes of their monitoring activities.

The aim of this section is to understand what activities can be carried out by Airlines and identify effective practices (as well as potential gaps), in relation with the targeted monitoring objectives.

3.1. Objectives of ACAS monitoring by Airlines

Table 7 and Table 8 below gather the target objectives identified respectively for operational and technical ACAS monitoring activities that were used in the comparative analysis of current practices by surveyed Airlines to identify effective practices, limitations and gaps on the matter.

Objective ID	Description of ACAS monitoring objective by Airlines
OO_AO_1	**Operational monitoring of ACAS events as part of investigation and prevention of accidents and incidents** (in the context of Aircraft Operator's Safety Management System) in order to: • Identify issues related to ACAS operations (e.g. level busts, hot spots, flight dynamics such as high vertical speed towards cleared level, inappropriate pilots' responses to RAs) and, as far as practicable, identify the main causal factors for these issues
OO_AO_2	**Operational monitoring of ACAS events in support to training and awareness programmes and collaboration with other organisations,** in order to: • Draw lessons learnt and report/inform management (e.g. feedback on misuse[18] of ACAS by pilots), staff (e.g. support to pilot training and awareness on ACAS), and ANSPs (e.g. identification of hot spots of RAs)

Table 7: Objectives of operational ACAS monitoring by Airlines

Objective ID	Description of ACAS monitoring objective by Airlines
OT_AO_1	**Technical monitoring of ACAS system as part of the monitoring of the technical performance of the ACAS system**, in order to: • Maintain high reliability of ACAS (and Mode S) systems; and • Comply with standards and applicable rules

Table 8: Objectives of technical ACAS monitoring by Airlines

3.2. Operational ACAS monitoring activities by Airlines

This section specifically analyses the operational ACAS monitoring activities carried out by the surveyed Airlines. Observed monitoring activities are analysed and compared. Scope, nature and

[18] Misuse of ACAS by pilots : Use of ACAS traffic display to unnecessarily issue disruptive requests to ATC, to challenge ATC instructions or to perform unauthorized and unjustified manoeuvres

extent of operational monitoring activities performed by the surveyed organisations are presented, as well as the outcomes of their operational monitoring activities.

The aim here is to understand what activities can be carried out by Airlines by identifying effective current practices, but also potential gaps that they are likely to face, in relation with the operational monitoring objectives presented in the previous section.

3.2.1. Scope, nature and extent of operational ACAS monitoring activities by surveyed Airlines

This sub-section focuses on the scope, nature and extent of the processes set in place by surveyed ANSPs to conduct operational ACAS monitoring activities including data collection methods, data analysis techniques and data sources.

Almost all participating Airlines mention having monitoring activities of ACAS operations with resources and processes integrated to their Flight Data Monitoring structure. They report continuously monitoring all reported and recorded RAs (sometimes after a validation process) for all airspace worldwide, all company fleet and during all phases of flight.

In order to do so, they report following an established process consisting in an analysis of the event, and in particular of the pilot's response to the RA, as well as a follow up of specific issues identified. Additionally, they draft statistics/trends of ACAS events experienced by their fleet. One surveyed Airline insists on the **role of operational monitoring of ACAS events in drawing lessons and conclusions** that serve the promotion of a safe operational use of ACAS aimed at their flight crews and at ATC when possible.

Figure 13 hereafter presents some numbers on the way surveyed Airlines conduct operational ACAS monitoring.

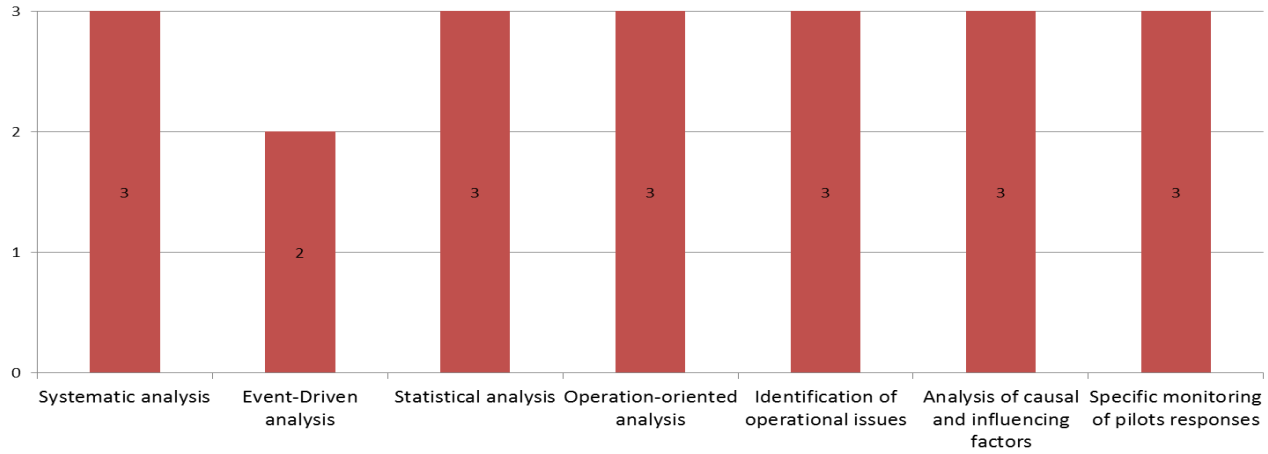


Figure 13: Nature of operational ACAS monitoring activities by Airlines

All Airlines reported using what can be considered as the most easily available data such as **RA recordings and Air Safety Reports (ASR)** for their operational ACAS monitoring activities. Only one of the three surveyed Airlines reported being able to use radar data recordings and ATCO reports (for serious ACAS events), which shows the difficulty of establishing effective collaboration with ANSPs outside authority-led incident investigations.

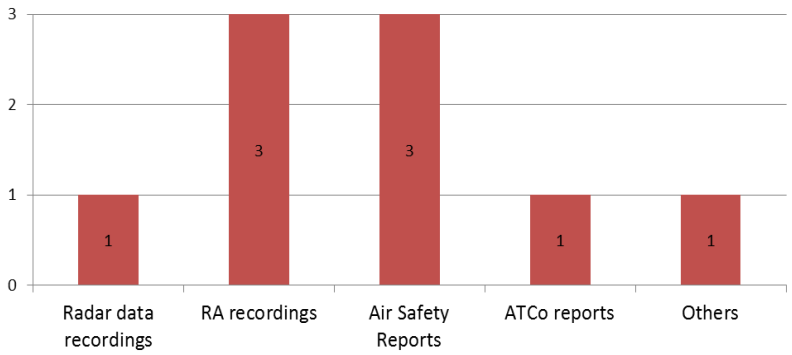


Figure 14: Sources of data used by Airlines for operational ACAS monitoring activities

3.2.2. Outcomes of operational ACAS monitoring activities by surveyed Airlines

This sub-section is dedicated to the outcomes of the operational ACAS monitoring activities by surveyed Airlines. The kinds of results that surveyed Airlines seek to obtain through their operational monitoring activities are presented first. The preventive and/or corrective actions that can be taken following the conclusions drawn from the operational monitoring of ACAS events are then described.

3.2.2.1. Issues identified by operational ACAS monitoring activities

The main concern of Airlines justifying the need for operational monitoring of ACAS events seems to be **acquiring a better understanding of the RAs experienced by the flight crews** (e.g. Hot-spots of RAs at specific locations, nuisance RAs due to high vertical rate when approaching cleared flight level, phantom RAs, …) and the way they respond to them.

Figure 15 hereafter presents the main outcomes that resulted from ACAS operational monitoring by surveyed Airlines.

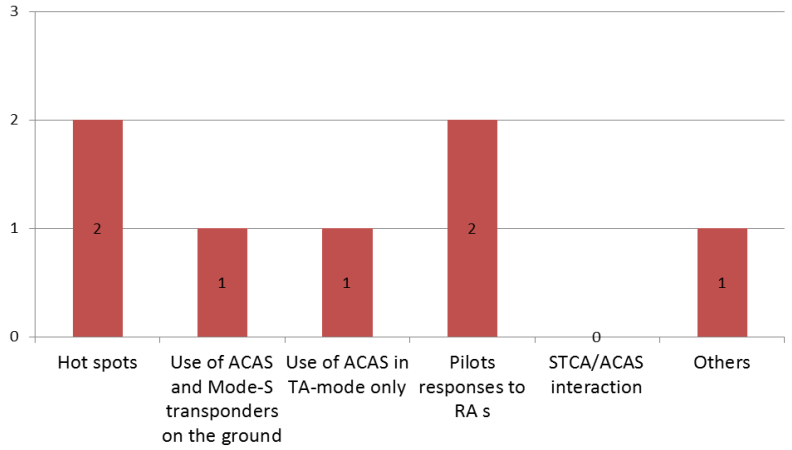


Figure 15: Outcomes of operational ACAS monitoring by Airlines

3.2.2.2. Preventive/corrective actions taken following operational ACAS monitoring activities

Not all surveyed Airlines report having taken preventive or corrective actions based on the outcomes of ACAS monitoring. The one that do so mainly concentrates on preventive actions by **adapting pilot training on ACAS** (e.g. feedback on the use of ACAS, simulator scenarios) and **improving understanding of ATC practices in relation with ACAS**. One surveyed Airline also mentions adapting

operational procedures, in particular regarding the high vertical speed towards cleared flight levels which remains one of the main operational issue observed by aircraft operators.

All survey participants collaborate with other Airlines, their national ANSP and/or with national or international safety bodies to ensure maximum effectiveness of operational ACAS monitoring.

3.2.3. Effective current practices in operational ACAS monitoring activities

This sub-section concentrates on the effectiveness of the current practices by surveyed Airlines in the scope of their operational monitoring of ACAS events.

Table 9 hereafter consolidates the effective practices that have been identified from the analysis presented throughout section 3.2, in relation with the objectives of operational ACAS monitoring activities by Airlines presented in section 3.1.

Objectives	Effective current practices
OO_AO_1 Operational monitoring of ACAS events as part of investigation and prevention of accidents and incidents	**Systematic and thorough monitoring of (reported) ACAS events following an established process** for maximum effectiveness of operational monitoring of safety occurrences
	Effective collaboration between ANSPs, Airlines and NAAs allows a better access to specific monitoring data (e.g. radar data and controller reports for Airlines) that are essential to undertake complete analysis of ACAS events
	Adapt the extent of the analysis (e.g. influencing factors, monitoring of pilots' responses, etc…) to the severity of the ACAS events for cost-effective operational ACAS monitoring
OO_AO_2 Operational monitoring of ACAS events in support to training and awareness programmes and collaboration with other organisations	**Statistical analysis of ACAS events allows the identification of general trends about safety and operational suitability of ACAS in the airspace**, that can then be shared with other organisations (e.g. ANSPs)
	Detailed analysis of ACAS events taking into account the configuration of the air traffic situations at the time of occurrence of the RAs is necessary to draw valuable lessons and conclusions, as opposed to purely statistical monitoring of ACAS events
All Objectives (OO_AO_1 to 2)	**Use of a wide range of sources of data** for operational monitoring of ACAS events in order to gain a comprehensive picture of RA occurrences and a precise understanding of the factors that influence most these occurrences
	Correlation between different sources of data to check the consistency of the ACAS events and to make sure that all events are captured (especially the rare ones). If any issue is encountered or if a serious airprox/inappropriate response to an RA comes up, a follow up of the event is set in place

Table 9: Effective practices in operational ACAS monitoring activities by Airlines

3.2.4. Limitations and gaps in operational ACAS monitoring activities

This sub-section concentrates on the limitations and gaps encountered by surveyed Airlines in the scope of their operational monitoring of ACAS events, potentially resulting in gaps. Surveyed Airlines were particularly invited to react on the subjects of access to data, appropriate expertise and tools, as well as induced costs. They also had the possibility to comment any other limitation they might have encountered when setting in place operational monitoring activities related to ACAS.

The survey highlighted that it can be an **issue for Airlines to have access to all the data they would need** (e.g. radar data, ATCO reports) when they do not have particular agreements with local ANSPs. Indeed, they then miss data from both involved aircraft to reconstruct the event which can only be provided by ANSPs. Moreover, a significant amount of data is needed to build realistic statistics, which can be tricky to gather.

One participating Airlines commented on the economic context implying cuts in Airlines budgets and consequent cost-related difficulties in maintaining up-to-date hardware and software and properly trained staff.

Figure 16 hereafter summarises the type of limitations encountered by Airlines for operational monitoring of ACAS events.

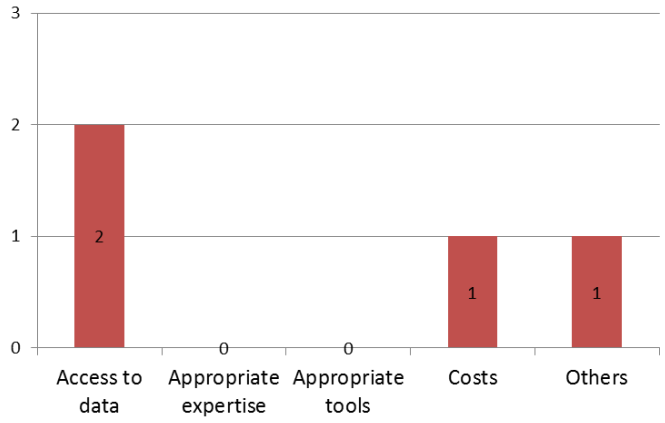


Figure 16: Type of limitations encountered by Airlines for operational ACAS monitoring activities

Table 10 hereafter consolidates the limitations and gaps that have been identified from the analysis presented in the previous paragraphs, in relation with the objectives of operational ACAS monitoring activities by Airlines presented in section 3.1.

Objectives	Limitations & Gaps
OO_AO_1 Operational monitoring of ACAS events as part of investigation and prevention of accidents and incidents	**Getting access to data**[19] such as radar data, controller reports and/or or data from the intruder aircraft (which are perceived as essential to have a thorough analysis of ACAS events) can be tricky if there is no collaboration between Airlines and local ANSPs, or among Airlines
OO_AO_2 Operational monitoring of ACAS events in support to training and awareness programmes and collaboration with other organisations	*No specific limitation or gaps identified for this particular objective*
All Objectives (OO_AO_1 to 2)	**Not all organisations have the ability to set in place automated operational monitoring of ACAS events** due to limited (or lack of) Mode S[20] monitoring infrastructure
	Anticipated difficulty to share operational monitoring data at a supranational level due to the sensitivity nature of ACAS events

Table 10: Limitations and gaps in operational ACAS monitoring activities by Airlines

[19] Outside authority-led incident investigations
[20] Active and/or passive surveillance

3.3. Technical ACAS monitoring activities by Airlines

This section specifically analyses the technical ACAS monitoring activities carried out by the surveyed Airlines. Observed monitoring activities are analysed and compared. Scope, nature and extent of technical monitoring activities performed by the surveyed organisations are presented, as well as the outcomes of their technical monitoring activities.

The aim here is to understand what activities can be carried out by Airlines by identifying effective current practices, but also potential gaps that they are likely to face, in relation with the technical monitoring objectives presented in the previous section.

3.3.1. Scope, nature and extent of technical ACAS monitoring activities by surveyed Airlines

This sub-section focuses on the scope, nature and extent of the processes set in place by surveyed Airlines to conduct technical ACAS monitoring activities including data collection methods, data analysis techniques and data sources.

Technical ACAS monitoring represents a very minor part of the ACAS monitoring activities conducted by Airlines, and is often integrated into other processes related to Flight Data Monitoring. Moreover, the monitoring of 1030/1090MHz telecommunication channels is not part of surveyed Airlines' ACAS monitoring activities at all.

For Airlines, the main sources of information seem to be **RA reports (by pilots) and Flight Data Recorders**.

3.3.2. Outcomes of technical ACAS monitoring activities by surveyed Airlines

As mentioned before, the **scope of Airlines technical monitoring of the ACAS system is quite limited**; their main concern that might justify the conduct of specific technical monitoring is to identify failures of the ACAS and Mode S systems, in order to maintain a high level of reliability of these systems.

However, all surveyed Airlines carrying out technical ACAS monitoring collaborate with other organisations such as EUROCONTROL or NAAs/ANSPs of their country.

3.3.3. Effective current practices in technical ACAS monitoring activities

This sub-section concentrates on the effectiveness of the current practices by surveyed Airlines in the scope of their technical ACAS monitoring activities.

Table 11 hereafter consolidates the effective practices that have been identified from the analysis presented throughout section 3.3, in relation with the objectives of technical ACAS monitoring activities by Airlines presented in section 3.1.

Objectives	Effective current practices
OT_AO_1 Technical monitoring of ACAS system as part of the monitoring of the technical performance of the ACAS system	**Collaboration between Airlines and other organisations such as EUROCONTROL or NAAs/ANSPs** in order to share technical data and expertise

Table 11: Effective practices in technical ACAS monitoring activities by Airlines

3.3.4. Limitations and gaps in technical ACAS monitoring activities

This sub-section concentrates on the limitations and gaps encountered by surveyed Airlines in the scope of their technical ACAS monitoring activities, potentially resulting in gaps. Surveyed Airlines were particularly invited to react on the subjects of access to data, appropriate expertise and tools, as well as induced costs. They also had the possibility to comment any other limitation they might have encountered when setting in place technical monitoring activities related to ACAS.

Table 12 hereafter presents the limitations and gaps that have been identified from the analysis presented in the previous paragraphs, in relation with the objectives of technical ACAS monitoring activities by Airlines presented in section 3.1.

Objectives	Limitations & Gaps
OT_AO_1 Technical monitoring of ACAS system as part of the monitoring of the technical performance of the ACAS system	**Difficulty to interpret and analyse data collected during technical ACAS monitoring resulting in issues for finding and maintaining knowledgeable staff inside the various organisations**
	The sensitive nature of surveillance data makes it difficult for ANSPs to collaborate with other organisations and therefore for Airlines to complement their flight monitoring data with ground-based technical monitoring data available to ANSPs
	The scope and extent of technical ACAS monitoring activities observed during the COCAM survey suggest that Airlines do not see any major benefit to it

Table 12: Limitations and gaps in technical ACAS monitoring activities by Airlines

4. Effective practices, limitations and gaps in ACAS monitoring activities by surveyed NAAs

This section focuses on surveyed NAAs monitoring activities. The first sub-section details NAAs targeted objectives for ACAS monitoring. The second sub-section focuses on operational monitoring activities carried out by the surveyed NAAs by analysing and comparing the scope, nature, extent and outcomes of their monitoring activities.

The aim of this section is to understand what activities can be carried out by NAAs and identify effective practices (as well as potential gaps), in relation with the targeted monitoring objectives.

4.1. Objectives of ACAS monitoring by NAAs

Table 13 below gathers the target objectives identified for operational ACAS monitoring activities that were used in the comparative analysis of current practices by surveyed NAAs to identify effective practices, limitations and gaps on the matter.

No specific objective has been identified for NAAs on the matter of technical ACAS monitoring activities since no surveyed NAA reported having specific technical monitoring activities related to ACAS.

Objective ID	Description of ACAS monitoring objective by NAAs
OO_NAA_1	**Operational monitoring of ACAS events as part of investigation and prevention of accidents and incidents**
OO_NAA_2	**Operational monitoring of ACAS events in the context of the monitoring of national aviation organisations** (e.g. analysis of specific ACAS events reported by Airlines or ANSPs)

Table 13: Objectives of operational ACAS monitoring by NAAs

4.2. Operational ACAS monitoring activities by NAAs

This section specifically analyses the operational ACAS monitoring activities carried out by the surveyed NAAs. Observed monitoring activities are analysed and compared. Scope, nature and extent of operational monitoring activities performed by the surveyed organisations are presented, as well as the outcomes of their operational monitoring activities.

The aim here is to understand what activities can be carried out by NAAs by identifying effective current practices, but also potential gaps that they are likely to face, in relation with the operational monitoring objectives presented in the previous section.

4.2.1. Scope, nature and extent of operational ACAS monitoring activities by surveyed NAAs

This sub-section focuses on the scope, nature and extent of the processes set in place by surveyed NAAs to conduct operational ACAS monitoring activities including data collection methods, data analysis techniques and data sources.

Only one NAA (out of the two surveyed organisations) reports conducting specific operational ACAS monitoring. For the other one, dangerous encounters can sometimes be more closely looked into but always in the scope of the surveillance of their national ANSP's activities.

The NAA conducting operational ACAS monitoring reports continuously monitoring all national airspace, including airspace delegated by surrounding countries, and all reported RAs (with a specific process dedicated to ACAS events that lead to Airproxes) using mainly radar data recordings, air safety reports and controllers' reports. Building upon the outcomes of these activities, the NAA delivers regular safety reports. These processes are integrated into a wider Safety Management System structure (e.g. as part of investigation and prevention of accidents and incidents).

4.2.2. Outcomes of operational ACAS monitoring activities by surveyed NAAs

This sub-section is dedicated to the outcomes of the operational ACAS monitoring activities by surveyed NAAs. The kinds of results that surveyed NAA seek to obtain through their operational monitoring activities are presented first. The preventive and/or corrective actions that can be taken following the conclusions drawn from the operational monitoring of ACAS events are then described.

4.2.2.1. Issues identified by operational ACAS monitoring activities

The NAA with active operational monitoring of ACAS events reports mainly looking for hot-spots of ACAS events and pilots' misuse of ACAS, including inappropriate responses to RAs and the use of ACAS as a separation tool in VFR environment.

4.2.2.2. Preventive/corrective actions taken following operational ACAS monitoring activities

It seems that, even for the NAA that reports conducting only ad-hoc operational ACAS monitoring, preventive and corrective actions can be taken in the context of their surveillance of the national ANSP.

Additionally, the NAA that reports conducting operational ACAS monitoring activities uses the outcomes of these activities to communicate with aircraft operators of the safe operational use of ACAS through newsletters and/or participation to aircraft operators' conferences.

4.2.3. Effective current practices in operational ACAS monitoring activities

This sub-section concentrates on the effectiveness of the current practices by NAAs in in the scope of their operational monitoring of ACAS events.

Table 14 hereafter consolidates the effective practices that have been identified from the analysis presented throughout section 4.2, in relation with the objectives of operational ACAS monitoring activities by NAAs presented in section 4.1.

Objectives	Effective current practices
OO_NAA_1 Operational monitoring of ACAS events as part of investigation and prevention of accidents and incidents	**Effective collaboration between ANSPs, Airlines and NAAs** allows a better access to specific monitoring data (e.g. ATCO reports and Air Safety Reports for NAAs) that are essential to undertake complete analysis of ACAS events
	Detailed analysis of ACAS events taking into account the configuration of the air traffic situations at the time of occurrence of the RAs is necessary to draw valuable lessons and conclusions, as opposed to purely statistical monitoring of ACAS events
	Adapt the extent of the analysis (e.g. influencing factors, monitoring of pilots' responses, etc…) to the severity of the ACAS events for cost-effective operational ACAS monitoring
OO_NAA_2 Operational monitoring of ACAS events in the context of the monitoring of national aviation organisations	**Require that significant ACAS events are being reported** as part of the reporting process of safety hazards or potential hazards involving national registered aircraft or aircraft flying in national airspace
All Objectives (OO_NAA_1 to 2)	**Use of a wide range of sources of data** for operational monitoring of ACAS events in order to gain a comprehensive picture of RA occurrences and a precise understanding of the factors that influence most these occurrences

Table 14: Effective practices in operational ACAS monitoring activities by NAAs

4.2.4. Limitations and gaps in operational ACAS monitoring activities

This sub-section concentrates on the limitations and gaps encountered by surveyed NAAs in the scope of their operational monitoring of ACAS events, potentially resulting in gaps. Surveyed NAAs were particularly invited to react on the subjects of access to data, appropriate expertise and tools, as well as induced costs. They also had the possibility to comment any other limitation they might have encountered when setting in place operational monitoring activities related to ACAS.

The major difficulty encountered by the NAA conducting operational ACAS monitoring activities is related to the access to data. Indeed, monitoring data are only available through mandatory and voluntary reporting system, but NAAs have no direct access to it and rely on aircraft operators and/or ANSPs to provide them with what is needed, which is not always simple.

Additionally, induced costs are also an issue for this NAA.

Table 15 hereafter consolidates the limitations and gaps that have been identified from the analysis presented in the previous paragraphs, in relation with the objectives of operational ACAS monitoring activities by NAAs presented in section 4.1.

Objectives	Limitations & Gaps
OO_NAA_1 Operational monitoring of ACAS events as part of investigation and prevention of accidents and incidents	**Airlines might be reluctant to share data with NAA**, in particular when their fleet is not registered in the same country
OO_NAA_2 Operational monitoring of ACAS events in the context of the monitoring of national aviation organisations	*No specific limitation or gaps identified for this particular objective*
All Objectives (OO_NAA_1 to 2)	**Not all organisations have the ability to set in place automated operational monitoring of ACAS events** due to limited (or lack of) Mode S[21] monitoring infrastructure
	Anticipated difficulty to share operational monitoring data at a supranational level due to the sensitivity nature of ACAS events

Table 15: Limitations and gaps in operational ACAS monitoring activities by NAAs

[21] Active and/or passive surveillance

5. Conclusions and recommendations

Building on a survey on ACAS monitoring (operational and technical) by concerned aviation organisations (i.e. ANSPs, Airlines and NAAs), the COCAM project **provided a better understanding of current practices in ACAS monitoring** in the EASA Member States.

Comparing ACAS monitoring practices conducted by surveyed organisations (in terms of activities, data collection methods, data analysis techniques and outcome) led notably to **highlighting best (good) practices** in relation with targeted objectives by each category of organisation. Existing limitations and gaps have also been identified that would need to be taken into account if envisaging further harmonisation in ACAS monitoring activities in Europe.

To conclude the project, **high-level recommendations were drawn to promote these best (good) practices** to improve ACAS monitoring in Europe.

Figure 17 hereafter provides an overview of the COCAM project.

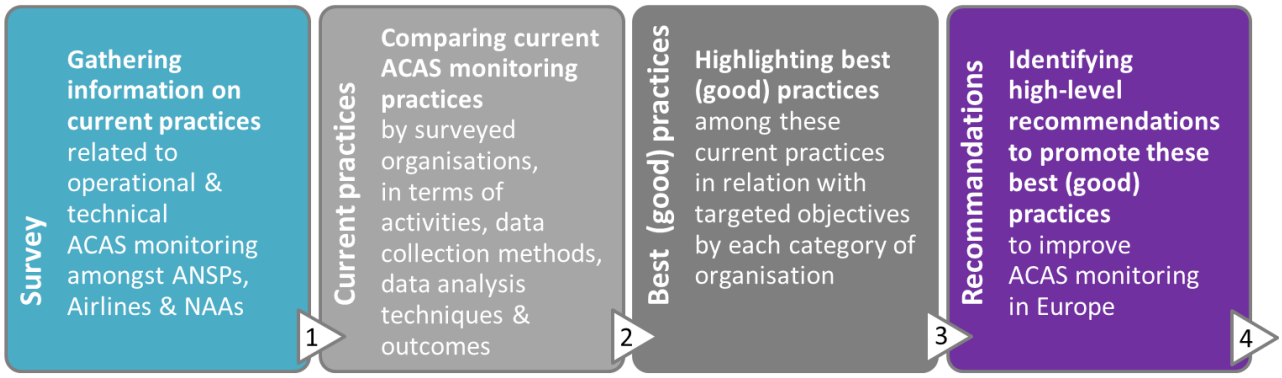


Figure 17: COCAM project overview

Each section of this Chapter focuses on each boxes of Figure 17:

- Section 5.1 details the survey on ACAS monitoring activities conducted in the COCAM project;
- Section 5.2 summarises the outcomes of the comparison of ACAS monitoring activities by surveyed organisations in Europe;
- Section 5.3 highlights best (good) practices, limitations and gaps identified in ACAS monitoring activities in Europe; and
- Section 5.4 identifies high-level recommendations for ACAS monitoring in Europe.

5.1. Survey of ACAS monitoring activities

The information-gathering exercise of the COCAM project was carried out through a thorough and wide survey of various organisations covering data collection methods, data analysis techniques and occurrence reporting processes dedicated to operational and technical ACAS monitoring.

Organisations from the three targeted categories (i.e. ANSPs, Aircraft Operators and NAAs) participated in the survey (either through the questionnaire or interviews) and care was taken to ensure that the interviewees included representatives from different geographical locations (e.g. core Europe and areas with less traffic density).

It should be noted that the relatively low rate of participation (in particular among Airlines and NAAs) and the fact that **most of proactive organisations in the field of ACAS monitoring participated to the survey** are limitations and biases that have been taken into account when drawing conclusions from the survey. Indeed, effective current practices observed in some organisations were considered and generalised with caution.

In summary, the organisations which participated in the survey are considered representative enough for the identification of effective practices[22], limitations and gaps – which was the main objective of the COCAM project.

5.2. Comparison of ACAS monitoring activities, data collection methods and data analysis techniques by surveyed organisations

A comparative analysis of ACAS monitoring activities, data collection methods, data analysis techniques and data sources supporting operational and technical ACAS monitoring in the surveyed organisations has been performed.

As a whole, operational monitoring of ACAS events is conducted by almost all surveyed organisations, regardless of their category (i.e. ANSPs, Airlines or NAAs). It should however be noted that depending on the targeted objectives and the available means (e.g. financial and human resources, technical infrastructure, tools and data, etc…), different extent of operational monitoring activities have been observed in the surveyed organisations.

In the contrary, the survey has highlighted that technical monitoring of the ACAS system (and its effect on 1030/1090 MHz channels) is not a very widespread activity. Indeed, the surveyed organisations tend to perceive no particular benefits to technical ACAS monitoring activities compared to the induced costs and structure required to set it in place. Moreover, organisations are lacking guidance material on the subject.

[22] The more proactive organisations enabled the identification of practices that are to be considered in the light of the means such organisations did set in place

Table 16 hereafter summarises current ACAS monitoring activities in Europe by category of organisation and type of ACAS monitoring performed.

Category of organisation	Operational monitoring of ACAS events	Technical monitoring of ACAS system (and its effect on 1030/1090 MHz channels)
ANSPs	**Widespread activity (yet limited to significant RA events)** generally integrated to ANSPs' Safety Managements System primarily in the context of investigation and prevention of accidents and incidents (**OO_ANSP_1**) Some major ANSPs also use the data collected (through ACAS / Mode S monitoring) to perform change impact analyses in the context of risk assessment and mitigation with regards to changes in ATM (**OO_ANSP_2**) Operational monitoring data may also be used by ANSPs in support to training and awareness programmes and collaboration with other organisations (i.e. ANSPs, Airlines, NAAs) to improve the safety of ACAS operations (**OO_ANSP_3**)	**Limited activity** typically as part of R&D or specific studies carried out by major ANSPs within the framework of their Mode S related programmes (**OT_ANSP_1** & **OT_ANSP_2**) Technical monitoring of ACAS system (e.g. RA downlink recordings) may also be used by ANSPs in support to operational ACAS monitoring for some specific RA events (**OT_ANSP_3**)
Airlines	**Common activity (yet limited to significant RA events)** usually integrated to Airlines' Flight Data Monitoring programme in the context of investigation and prevention of accidents and incidents (**OO_AO_1**) Some Airlines also use operational monitoring data in support to training and awareness programmes and collaboration with other organisations (e.g. ANSPs) to promote a safe operational use of ACAS (**OO_AO_2**)	**Very limited activity** usually integrated to Airlines' Flight Data Monitoring programme allowing to identify failures of the ACAS and Mode S systems and thus contributing to maintain a high level of reliability of these systems (**OT_AO_1**)
NAAs	**Limited activity (yet not specific to ACAS events)** by some NAAs in the context of: a) investigation and prevention of accidents and incidents in the national airspace (**OO_NAA_1**); or b) safety oversight and monitoring of national organisations (i.e. ANSPs and Airlines) (**OO_NAA_2**)	**No specific activity** identified

Table 16: Comparison of ACAS monitoring activities by category of organisation

5.3. Summary of best (good) practices, limitations and gaps in ACAS monitoring

An appraisal of current practices (as observed through the survey) against target objectives for ACAS monitoring allowed identifying best (good) practices, limitations and gaps in the ACAS monitoring activities carried out by the different categories of organisation.

The term **"best (good) practice"** *[in ACAS monitoring]* refers to a method, initiative, process, approach, technique or activity that is believed to be more effective (than other means) at delivering a particular outcome in support to the safety of ACAS operations and system – *This definition has been derived for the means of the project from the Commission Regulation N°390/2013 laying down a performance scheme for ANS and network functions, i.e. SKPIs IR.*

And, in this context, the term **"ACAS (operational or technical) occurrence"** refers either to a safety occurrence in which ACAS plays a role, i.e. an operational ACAS event, or a technical system failure related to the ACAS system (or its impact to 1030/1090 MHz channels).

Table 17 hereafter summarises these best (good) practices, as well as limitations and gaps. Current practices by surveyed organisations are further detailed in Chapters 2, 3 and 4 for ANSPs, Airlines and NAAs respectively.

Topics	Best (good) practices	Limitations & Gaps
Plans for monitoring activities	**It is essential that monitoring data be collected and used:** • **Primarily in the context of investigation and prevention of accidents and incidents**; but not only • **Data collected through monitoring activities may also be very useful to**: a) Perform **change impact analyses** in the context of risk assessment and mitigation with regards to changes in ATM (for ANSPs); b) Support **training and awareness programmes and collaboration** with other organisations (for Airlines and ANSPs); or c) **Perform safety oversight and monitoring** of national organisations (i.e. ANSPs and Airlines) (for NAAs).	**Monitoring data are essential but due to the relatively low frequency of (operational or technical) ACAS occurrences, problems may sometimes be spotted too late** (i.e. after a major issue or incident/accident) when using monitoring data only. To compensate for this limitation, wide R&D studies[23] can be used to anticipate some issues before their actual observation in real life. It has also to be noted that although local organisations might conduct technical monitoring at their level, ACAS system failures (or possible side-effect on 1030/1090 MHz channels) cannot be addressed at a local level only.

[23] That may also include the encounter-model based methodology

Topics	Best (good) practices	Limitations & Gaps
Organisational structure for monitoring activities	**Monitoring is facilitated when the activities are structured inside the organisation within a specific process and/or programme (with identified resources and means) dedicated to ACAS monitoring** (e.g. ACAS monitoring cell under the responsibility of the department in charge of incident/accident operational analysis).	**Not all organisations have the ability to set in place a specific internal ACAS monitoring process and/or programme** due to: • The high costs (in terms of resources, efforts, means, expertise, infrastructure, etc…) of an extended monitoring system deployment, maintenance and use (**economical constraint**); and • To a lesser extent, the limited (or lack of) Mode S[24] monitoring infrastructure in some States (**technical constraint**).
Monitoring data availability and sharing	**The benefits afforded by ACAS monitoring to aviation organisations is increased if data and expertise are shared**, through: • **Effective collaboration between ANSPs, Airlines and NAAs** to allow a better access to complementary monitoring data (e.g. **reported versus recorded data**); and • **Effective collaboration between national and supranational organisations** to: a) Ensure **comprehensive understanding** of ACAS effect on ATC (and vice-versa) at the European level; b) Help **justify and/or limit the costs and difficulties** experienced in setting in place and maintaining an appropriate expertise; and c) Enhance awareness on ACAS – related issues throughout the aviation community.	**Due to the sensitivity nature of ACAS and surveillance data, it may be difficult (in the absence of legal framework) to share monitoring data[25] at supranational level but also between different categories of organisations**, e.g.: • Difficulty for ANSPs to collaborate with other organisations and therefore for Airlines to complement their flight monitoring data with ground-based monitoring data available to ANSPs; and • Airlines might also be reluctant to share data with NAAs (outside mandatory reporting), in particular when their fleet is not registered in the same country.

[24] Active and/or passive surveillance
[25] Outside authority-led incident investigations

Topics	Best (good) practices	Limitations & Gaps
Scope and extent of monitoring data analysis	**For maximum relevance of the analyses performed within ACAS monitoring activities, it is essential to**: • **Use and correlate a wide range of sources of data** in order to: a) Check the **consistency** of monitoring data to gain a comprehensive and accurate picture of ACAS occurrences; b) Make sure that maximum ACAS occurrences are **captured**; and c) Allow a **precise understanding** of the factors that influence most these occurrences; • **Perform statistical analysis in order to identify general trends** about safety and operational suitability of ACAS in the airspace and/or fleet[26], as well as ACAS (and transponder) systems failures; • **Perform thorough analysis of (at least) the most significant ACAS occurrences** in order to draw valuable lessons and conclusions that takes into account the local circumstances and influencing factors (as opposed to purely statistical ACAS monitoring); and • **Develop cost-effective approach** that adapts the extent of the analysis to the severity of ACAS occurrences.	**Difficulty for aviation organisations to:** ▪ **Acquire and maintain the operational and technical expertise**; and ▪ **Obtain/develop tools (hardware and software) dedicated to ACAS monitoring** that are necessary to conduct thorough analysis of ACAS occurrences (due in particular to the technicality of the data to be processed).

Table 17: Summary of best (good) practices, limitations and gaps in ACAS monitoring activities in Europe

[26] For example the number, type and density of ACAS RAs can be used as a safety indicator when changes in the airspace structure and/or local procedures are envisaged and as a local ATM compatibility indicator when a change of the ACAS system is envisaged

5.4. Recommendations for best (good) practices on ACAS monitoring in Europe

Building on the outcomes of the COCAM project, the following recommendations have been drawn that aims at promoting best (good) practices in the field of ACAS monitoring.

COCAM_R1	Operational and technical ACAS occurrences should be monitored **by different categories of aviation organisation**, each of them at their level

ACAS monitoring by different categories of aviation organisation is key for continuous effectiveness of ACAS system and operations throughout Europe.

In this context, appropriate consideration should be given by the different aviation organisations to ensure that:

- **For ANSPs,** ACAS occurrences should be monitored in **their area of responsibility**, primarily in the context of investigation and prevention of accidents and incidents, but also to perform change impact analyses in the context of risk assessment and mitigation with regards to changes in ATM.
  For example, ACAS events collected by ANSPs could be used as a safety indicator of the airspace, yet with caution having in mind that **:**

  a) not all significant RAs might be collected if reporting culture is not encouraged, and

  b) not all recorded RAs might be safety significant (e.g. false or spurious RAs, operationally undesired RAs during managed air traffic situations, intentional RAs by military or flight test aircraft, etc.)

- **For Airlines,** ACAS occurrences should be monitored over **their whole fleet**, primarily in the context of investigation and prevention of accidents and incidents, but also to support training and awareness programmes and collaboration with other organisations (e.g. ANSPs and NAAs).
  For example, preventive actions could be taken by Airlines by adapting their pilot training on ACAS following monitoring activities outcomes.

- **For NAAs,** ACAS occurrences should be monitored in **their national airspace**, primarily in the context of investigation and prevention of accidents and incidents, but also to perform safety oversight and monitoring of national organisations (i.e. ANSPs and Airlines).
  For example, NAAs could require that significant ACAS events be reported as part of the reporting process of safety hazards or potential hazards involving national registered aircraft or aircraft flying in their national airspace.

COCAM_R2	ACAS monitoring activities should be performed as part of **defined process and/or programme**, with identified and adequate resources and means

Structured ACAS monitoring (in the planning and execution phases) permits to ensure maximum effectiveness of ACAS monitoring activities inside a given organisation.

In this context, appropriate consideration should be given by the organisation to ensure that the defined process and/or programme enable to:

- **Identify** most significant ACAS occurrences and **immediately investigate** those which are considered to have safety implications, by guaranteeing an open climate for reporting and investigation of ACAS occurrences inside the organisation;
- **Involve the adequate subject matter expertise** from the ATM/ANS domain in the processes of investigation of ACAS occurrences, **include the appropriate data and level of detail** and **develop a cost-effective approach** that adapts the extent of the analysis to the severity of ACAS occurrences;
- **Use the results of ACAS occurrence investigation in the identification of deficiencies and safety concerns and their resolution**. For example, the conclusions drawn from ACAS monitoring can help to adjust local procedures and/or training (controller and/or pilot); and
- **Monitor** the process and/or programme for ACAS monitoring itself in order to ensure continuous improvements.

COCAM_R3	ACAS monitoring activities should use **commonly agreed taxonomy** for the description and analysis of ACAS occurrences

The use of standard definition, terms and metrics should allow a **meaningful comparison of the monitoring outcomes** and **facilitates sharing of monitoring results** between various aviation organisations in a number of different airspace over Europe.

ICAO ACAS Manual ([4]) could be a starting point for common definitions and terms. Yet, more work is needed to provide guidance on relevant metrics and/or indicators to assess the safety and performance of ACAS operations and system.

COCAM_R4	**Collaboration between aviation organisations** (e.g. ANSPs, Airlines and NAAs) involved in ACAS monitoring should be encouraged

In this context, appropriate consideration should be given by aviation organisations to elaborate processes and **legal framework** for data-sharing between different organisations (when possible).

Indeed, an effective collaboration between ANSPs, Airlines and NAAs may allow a **better access to complementary monitoring data** (e.g. reported versus recorded data, radar data recordings versus on-board recorded data) and **share expertise** on ACAS operations and system.

Also, an effective collaboration between national and supranational organisations may allow ensuring a comprehensive understanding of ACAS effect on ATC (and vice-versa) at the European level and help **justifying and/or limiting the costs and difficulties** experienced in setting in place and maintaining an appropriate expertise inside a given organisation.

Finally, collaboration between aviation organisations involved in ACAS monitoring is also key to **enhance knowledge on ACAS-related issues** (and possible solutions) more easily and efficiently than with isolated ACAS monitoring activities.

List of Acronyms

ACAS	Aircraft Collision Avoidance System
ADS-B	Automatic Dependent Surveillance - Broadcast
ANSP	Air Navigation Service Provider
ASMT	ATM Safety Monitoring Tool (of EUROCONTROL)
ASR	Air Safety Report
AO	Aircraft Operator
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATM	Air Traffic Management
COCAM	Comparison and harmonisation of Aircraft Collision Avoidance System (ACAS)monitoring performed by National Aviation Authorities (NAAs), Air Navigation Service Providers (ANSPs) and Airline
EASA	European Aviation Safety Agency
EUROCAE	European Organisation for Civil Aviation Equipment
EUROCONTROL	European Organisation for the Safety of Air Navigation
ICAO	International Civil Aviation Organisation
MOPS	Minimum Operational Performance Standards
NAA	National Aviation Authority
RA	Resolution Advisory (from ACAS)
RA/DL	RA Downlink
RF	Radio Frequency
R&D	Research & Development
R/T	Radio/Telephony
SESAR	SESAR Joint Undertaking (Agency of the European Commission)
SKPIs	Safety Key Performance Indicators
SSR	Secondary Surveillance Radar

STCA	Short-Term Conflict Alert
TA	Traffic Advisory (from ACAS)
TCAS	Traffic alert and Collision Avoidance System

References

[1] ICAO, *Doc 4444 PANS-ATM - Procedures For Air Navigation Services - Air traffic Management.*

[2] EASA, “Certification Specifications - European Technical Standard Orders (CS -ETSO), TCAS II, referenced ETSO-C119c,” [Online]. Available: http://easa.europa.eu/agency-measures/certification-specifications.php.

[3] EUROCAE, “ED-143 - TCAS Minimum Operational Performance Standards (MOPS) for Traffic Alert and Collision Avoidance System II (TCAS II),” latest edition. [Online]. Available: http://boutique.eurocae.net/catalog/product_info.php?products_id=300.

[4] ICAO, *Doc 9863 - Airborne Collision Avoidance System (ACAS) Manual.*

Appendix A –Guidance on ACAS monitoring at the International level

Chapter 9 of the ICAO ACAS Manual explains the need for ACAS monitoring and then describes practical ways of conducting it.

Extracts from Chapter 9 of ICAO ACAS Manual [4] on ACAS performance monitoring

9.1 Need for ACAS Monitoring Programmes

9.1.1 Operational evaluations conducted worldwide to identify operational and technical issues have been extremely valuable in the development and updating of ACAS provisions.

9.1.2 These operational evaluations have also contributed to the improvement of ACAS II equipment. When modifications have been made to the ACAS II logic, or ACAS II has been introduced into new types of airspace, or changes have been made to airspace configuration and operation, some operational issues have been identified and resolved. Therefore, it is prudent to continue monitoring the operational performance of ACAS and to retain the expertise and tools to analyse any questionable circumstances that may be observed and, if required, to develop solutions.

9.1.3 Monitoring via controller reports is typically mandated by a State, e.g. based on an AIC. Aviation authorities may place requirements on operators for pilot-reporting of ACAS encounters. Data provision from Mode S, ACAS recordings and other means is on a voluntary basis.

9.1.4 In the longer term ACAS monitoring can become part of overall safety monitoring regulations. Harmonized procedures are developed for reporting all incident types, including ACAS. In particular, ACAS analysis should become a normal part of Airprox analysis, and statistics about ACAS during Airproxes can be fed into ACAS monitoring. Whenever a standard set of tools is available for safety monitoring, ACAS monitoring tools should be included. This approach is supported in Europe.

9.2 Monitoring Programme Objectives

The ACAS monitoring programmes of States should have the following key objectives:

a) Continuing the validation of the safety benefits and operational acceptability of ACAS

b) Assessing the impact of ACAS, airspace, and ATC procedure modifications on collision avoidance system performance and the identification of any new issues

c) Ensuring sufficient surveillance performance exists for both ACAS and ATC purposes

d) Identifying pilot/controller training issues

e) Assessing the operational and technical performance of ACAS in a current and future ATM environment

f) Maintaining an adequate level of expertise in the areas of ACAS significant event analysis and problem resolution

9.3 Description of Current Monitoring Programmes Data Sources

9.3.1 Many States and organizations have conducted ACAS monitoring programmes for a number of years. These existing programmes have identified multiple sources of data that can be used to effectively monitor and assess the performance of ACAS. (…)

Sources of Data	Discussion
9.3.2 Pilot and controller reports	*(…) The use of pilot and controller reports has been demonstrated to be an effective means of obtaining data related to the operation and performance of ACAS II*
9.3.3 Observer reports	*The use of observer reports has also been demonstrated to be an effective means of complementing the data obtained from pilot and controller reports*
9.3.4 ACAS surveys	*When data are required on a particular subject, a survey may be conducted. This is most valuable when standard pilot or controller reports do not capture the data or opinions. Where written ACAS surveys are utilized, their effectiveness is increased if short, pointed questions are used*
9.3.5 Airborne recorded data	*(…) The use of data recorders has been demonstrated as an effective means of obtaining reliable, factual information that allows unbiased performance analysis of ACAS surveillance and logic. Onboard quick access flight recorders and optional ACAS internal recorders may also provide data about ACAS events. Equipment manufacturers have incorporated an internal data recording capability into their ACAS hardware*
9.3.6 Mode S RA downlink	*Mode S ground stations can obtain RA downlink messages from aircraft. (…) This provides objective information about the nature of the RA, ACAS equipage, and the intruder's position or identification. These types of data can be used to identify problems with ACAS operation, to identify geographic areas where ACAS operations are impacting ATC operations, and to identify geographic areas where ATC operations and procedures adversely affect ACAS performance*
9.3.7 RF environment recorders	*Specialized omnidirectional receivers exist, that record all 1030 MHz and 1090 MHz signals. These can be used to detect RAs, to verify air-to-air ACAS messages, and to assess EMI*
9.3.8 ATC radar data	*Any of the data sources described above may show that an ACAS RA has occurred. In these cases, it is often useful to obtain ATC radar data associated with the event. This can be used to replay and simulate the event for better understanding, even in cases where the RA information was not captured via the RA downlink. ATC radar data have been shown to be important in assessing the performance of ACAS II and in assessing any impacts of an RA on ATC operations*
9.3.9 Flight plans	*The flight plans for the aircraft involved in an RA may also help investigations, especially when used in conjunction with the radar data for a specific event*
9.3.10 ATC/pilot voice communication tapes	*Pilot and controller voice communication tapes can provide additional information regarding the event. These data have been very important in the analyses of certain RAs*

9.4 Methods of Data Analysis

9.4.1 Existing monitoring programmes have developed and validated a number of effective methods for analysing the aforementioned data. (…)

Methods of Data Analysis	*Description*
9.4.2 ACAS logic-based simulations	*There are several software tools available that take radar data and allow the replay of an event. They can also simulate standard responses by pilots. For a single event this is invaluable for operational understanding and also for validation of the ACAS logic. Several simulations have been developed that allow the positions of the aircraft involved in the event to be altered slightly so that multiple variations of the same event can be analysed. By combining the results of many such events, statistics about ACAS performance and pilot responses can be obtained*
9.4.3 Database analysis	*Data obtained from pilots, controllers, observers, recorders and other sources are often put into a database to facilitate analyses of the data. This may be supplemented by manual assessment of the issues involved with each event. These data are then used for highlighting issues of concern and completing statistical evaluation of ACAS performance*
9.4.4 ACAS performance simulations and flight trials	*Simulation models are available for analyses of recorded data. These evaluations may discover problem areas that require further evaluation and possible flight trials*
9.4.5 ACAS RF compliance and interference measurements	*Measurements are first made to estimate parameters in electromagnetic environment models. Further measurements are made to validate these environmental models and ensure that electromagnetic interference is suitably limited*

9.5 Products of Monitoring and Analysis Programmes

9.5.1 The results of analyses conducted by monitoring programmes need to be shared between States, the States' regulatory authorities, and other monitoring programmes. This sharing of information is most effective when there is some consistency in the types of reports produced by the monitoring and analyses programmes. The following two types of reports are produced by numerous States' monitoring activities and have been found to be valuable.

Types of reports	*Description*
9.5.1.1 Statistical reports of ACAS performance	*In the past, several States have produced reports which were based on the data collected via their monitoring programmes. These reports provided key information that allowed for the identification and resolution of technical and operational problems*
9.5.1.2 Event reports	*When pilots or controllers report an RA, further data are often collected. All data are then analysed and a report on the event is created. This gives feedback to operational staff, operators, civil aviation authorities and ATC authorities about incidents they have experienced.*

9.5.2 Existing monitoring programmes have used these initial analyses to develop more detailed analyses of identified problems and issues. These analyses have resulted in the following types of reports or actions being completed. State regulatory authorities and air traffic service providers often use these reports to implement mandatory changes to procedures, regulations, and in some rare cases, to the ACAS logic:

- *Procedural changes (ATC and aircraft) to alleviate difficulties with ACAS noted in operational reports*
- *ACAS performance reports, noting difficulties with the logic, surveillance, displays or any other part of the ACAS system.*
- *Reports on the ACAS surveillance performance in the SSR environment and reports on impacts of ACAS operation on the existing SSR environment*
- *Technical non-compliance reports. Sometimes analysis will detect technical faults in aircraft, e.g. faulty transponders. The reports are sent to the operator concerned and the appropriate regulatory authority*
- *Training issues. The overall effectiveness of ACAS depends heavily upon pilots and controllers correctly following their procedures during an RA. As the result of analysis, particularly when procedures are not well followed, training topics for pilots and controllers are identified*

9.6 Harmonization of monitoring data

9.6.1 For monitoring programmes to achieve their maximum potential for monitoring and evaluating ACAS performance, ***they must be harmonized to allow for the comparison of the data collected by the various States in a number of different airspaces****. Past experience in monitoring the performance of ACAS II has shown that it is highly desirable for States to share the results of data collected in these programmes. It is expected that monitoring ACAS performance will result in the desire or necessity to share similar information as the use of ACAS becomes more widespread. In order to compare the results in a meaningful manner, it is recommended that States follow the following standards:*

9.6.1.1 ***Pilot report form****. Appendix 3 contains the recommended list of items to be included on the pilot report form. This form, along with the controller report form, provides the basis for identifying ACAS issues, frequency of occurrences, and amplifying information relating to an ACAS event. Appendix 1 is a Sample Pilot Report, ACAS Event Form.*

9.6.1.2 ***Controller report form.*** *Appendix 4 contains the recommended list of items to be included in the controller report form. This form, along with the pilot report form, provides the basis for identifying ACAS issues, frequency of occurrences, and amplifying information relating to an ACAS event. Appendix 2 is a Sample Controller Report, ACAS Event Form.*

9.6.1.3 ***ACAS recorders****. ACAS recorders have been valuable in the past when addressing technical issues related to ACAS performance. Appendix 5 contains the recommended list of data to be provided by dedicated ACAS recorders. All known ACAS recorders support the recording of the data shown in this list.*

9.6.1.4 ***Definitions for ACAS monitoring programmes****. To allow a meaningful exchange of the results of monitoring programmes, it is highly desirable to use standard definitions and terms in the description of the events examined by the programmes. This recommended list is contained in Appendix 6.*

9.7 Recommended ACAS problem review process

9.7.1	***Step 1***	***Collection of data and analysis at State level****. This process has been described in the previous sections of this chapter.*
9.7.2	***Step 2***	***Identification of significant trends and events for potential international discussion****. National analyses will identify problems that may be relevant for other States, or where more information or assistance is required from other States to assess their significance. Two types of data will identify these problems:* • *Statistical data will show trends of known issues.* • *Individual events will identify new problems.*
9.7.3	***Step 3***	***Exchange of data and discussion of specific problems at an international level.*** *When issues of international importance are known, data will be exchanged internationally and the problems discussed through the appropriate ICAO fora. Individual contacts between States' experts outside of these fora will be necessary, especially when urgent action is required.*
9.7.4	***Step 4***	***Dissemination of information about international problems to all relevant authorities****. The experts from the appropriate ICAO fora will inform their States' authorities and other relevant organizations about problems found and resolutions proposed. This information will also be disseminated to all Contracting States through ICAO.*

9.8 Example of a comprehensive ACAS Monitor System Implementation

Refer to [4] for further details.

Appendix B – COCAM survey questionnaire

This questionnaire is divided into four main parts:

1. Identification
2. ACAS monitoring activities (in general)
3. Technical monitoring of ACAS system and Mode S transponders
4. Operational monitoring of ACAS events

The first two parts aim at gathering further information on your organization and the kind of ACAS monitoring you carry out (please fill both).

The last two parts are respectively dedicated to technical and operational monitoring of ACAS system / events (please fill the relevant section(s)).

For each question, please tick the box corresponding to the answer you wish to give. Please do not hesitate to develop your ideas or add any further explanation or information in the dedicated boxes placed at the end of each sub-part when you deem it necessary.

Thank you very much for your participation.

1. Identification

1.1 Please indicate the name of your organisation(s):

1.2 Can you please provide us with further information about yourself?

1.2.1 Name:

1.2.2 Position held in the company:

1.2.3 Involvement in activities related to ACAS monitoring:

1.3 Please indicate the category corresponding to your organisation:

☐ Air Navigation Service Provider
☐ Airline
☐ National Aviation Authority
☐ Other:

2 ACAS monitoring activities

This subsection aims at understanding how aviation organisation monitor ACAS (and transponders) system(s) and operations – that is to say the structures and means they have put in place – and what limitations or obstructions you have encountered to set these monitoring activities in place.

In this section and in the rest of the questionnaire, distinction is made between technical and operational monitoring of ACAS performance:

- The term "**technical ACAS monitoring**" refers to the monitoring activities related to the ACAS system (including its equipment, display, Mode S transponder, antennas …) and its effect on 1030/1090 MHz telecommunication channels.
- The term "**operational ACAS monitoring**" refers to the monitoring activities of ACAS events during flight operations, including the operational relevance of ACAS RAs and responses given by the flight crew.

2.1 Which kind of ACAS-related monitoring is being conducted in your organisation?

☐ Both technical and operational ACAS monitoring
☐ Technical monitoring of ACAS system and/or Mode S transponders, only
☐ Operational monitoring of ACAS events, only
☐ No ACAS monitoring activities

2.2 In your organisation, is there a defined process dedicated to the technical monitoring of ACAS system and/or Mode S transponders?

☐ Yes ☐ No (if no, please proceed to question 2.2.3)

2.2.1 If yes, what resources are allocated to this process?

2.2.2 If yes, what procedures are being defined for this process?

2.2.3 If no, why?

2.3 Do you collaborate with other organisations for technical monitoring related to the ACAS system?

☐Fully ☐ Partly ☐Not at all

If "Fully" or "Partly", with whom?

2.4 When setting in place technical ACAS monitoring, did your organization encountered any limitations or obstructions regarding in particular:

2.4.1 Data accessibility:

☐ Yes ☐ No

If yes, please describe the difficulties you have encountered, the consequences on the way ACAS system is technically monitored in your organisation:

2.4.2 Data protection:

☐ Yes ☐ No

If yes, please describe the difficulties you have encountered, the consequences on the way ACAS system is technically monitored in your organisation:

2.4.3 Confidentiality issues:

☐ Yes ☐ No

If yes, please describe the difficulties you have encountered, the consequences on the way ACAS system is technically monitored in your organisation:

2.4.4 Appropriate expertise:

☐ Yes ☐ No

If yes, please describe the difficulties you have encountered, the consequences on the way ACAS system is technically monitored in your organisation:

2.4.5 Appropriate monitoring tools:

☐ Yes ☐ No

If yes, please describe the difficulties you have encountered, the consequences on the way ACAS system is technically monitored in your organisation:

2.4.6 Costs (infrastructure, staffing…):

☐ Yes ☐ No

If yes, please describe the difficulties you have encountered, the consequences on the way ACAS system is technically monitored in your organisation:

2.4.7 Other(s):

☐ Yes ☐ No

If yes, please describe the difficulties you have encountered, the consequences on the way ACAS system is technically monitored in your organisation:

2.5 In your organisation, is there a defined process dedicated to the operational monitoring of ACAS events?

☐ Yes ☐ No (if no, please proceed to question 2.5.3)

2.5.1 If yes, what resources are allocated to this process?

2.5.2 If yes, please describe the procedures followed in case of a ACAS event:

2.5.3 If no, why?

2.6 Do you collaborate with other organisations for operational ACAS monitoring?

☐Fully ☐Partly ☐Not at all

If "Fully" or "Partly", with whom?

2.7 When setting in place operational ACAS monitoring, did your organization encountered any limitations or obstructions regarding in particular:

2.7.1 Data accessibility:

☐ Yes ☐ No

If yes, please describe the difficulties you have encountered, the consequences on the way ACAS system is operationally monitored in your organisation:

2.7.2 Data protection:

☐ Yes ☐ No

If yes, please describe the difficulties you have encountered, the consequences on the way ACAS system is operationally monitored in your organisation:

2.7.3 Confidentiality issues:

☐ Yes ☐ No

If yes, please describe the difficulties you have encountered, the consequences on the way ACAS system is operationally monitored in your organisation:

2.7.4 Appropriate expertise:

☐ Yes ☐ No

If yes, please describe the difficulties you have encountered, the consequences on the way ACAS system is operationally monitored in your organisation:

2.7.5 Appropriate monitoring tools:

☐ Yes ☐ No

If yes, please describe the difficulties you have encountered, the consequences on the way ACAS system is operationally monitored in your organisation:

2.7.6 Costs (infrastructure, staffing…):

☐ Yes ☐ No

If yes, please describe the difficulties you have encountered, the consequences on the way ACAS system is operationally monitored in your organisation:

2.7.7 Other(s):

☐ Yes ☐ No

If yes, please describe the difficulties you have encountered, the consequences on the way ACAS system is operationally monitored in your organisation:

2.7.8 Do you have any additional comment(s) on the generic subject of ACAS monitoring?

3 Technical monitoring of ACAS system and Mode S transponders

This sections aims at understanding **how your organisation monitors technical performance of ACAS (and Mode-S transponder) system(s)** and their effect on 1030/1090 MHz telecommunication channels, including identification of system failures, analysis of the technical /operational environment and the notification of operators and competent authorities.

3.1 In the past few years has your organization carried out any kind of technical monitoring activities related to the ACAS system (including equipment, display, Mode S transponder, antennas, …):

3.1.1 Systematic monitoring:

☐ Yes ☐ No (If no, please proceed to question 4.1)

3.1.2 Event-driven monitoring:

☐ Yes ☐ No

If "Yes", please detail the **criteria** applied to select the events to be investigated:

3.1.3 Quantitative analysis:

☐ Yes ☐ No

3.1.4 Qualitative analysis:

☐ Yes ☐ No

3.1.5 Identification of technical issues:

☐ Yes ☐ No

3.1.6 Analysis of causal and influencing factors:

☐ Yes ☐ No

9.1 In the past few years has your organization carried out any kind of technical monitoring activities of the effect of ACAS on the 1030 MHz/1090 MHz telecommunication channels services?

3.1.7 Systematic monitoring:

☐ Yes ☐ No

3.1.8 Event driven monitoring:

☐ Yes ☐ No

If yes, please detail the **criteria** that are being used to select areas to be investigated:

3.1.9 Quantitative analysis:

☐ Yes ☐ No

3.1.10 Qualitative analysis:

☐ Yes ☐ No

3.1.11 Identification of technical issues:

☐ Yes ☐ No

3.1.12 Analysis of causal and influencing factors:

☐ Yes ☐ No

3.2 In the scope of the technical ACAS monitoring activities carried out by your organisation as stated in questions 3.1 and/or 9.1, which source(s) of data is being used by your organisation?

3.2.1 RA Mode S downlink (1030/1090 MHz) recordings:

☐ Yes ☐ No

3.2.2 RA coordination messages (on 1030/1090 MHz):

☐ Yes ☐ No

3.2.3 RA broadcast (on 1030 MHz):

☐ Yes ☐ No

3.2.4 RA reports (on 1090 MHz):

☐ Yes ☐ No

3.2.5 Flight data recorders:

☐ Yes ☐ No

3.2.6 1030/1090 MHz channels monitoring:

☐ Yes ☐ No

3.2.7 Ground surveillance data recorders:

☐ Yes ☐ No

3.3 For the technical monitoring of ACAS performance, what were your organisation's objectives when setting up the kind of monitoring activities you described in the previous section?

3.4 In the scope of the technical ACAS monitoring activities carried out by your organisation as stated in questions 3.1 and/or 9.1, which of these technical issues have been identified?

3.4.1 ACAS equipment inoperative:

☐ Yes ☐ No

3.4.2 ACAS failure due to other equipment failure (e.g. transponder, radio-altimeter, altitude source…):

☐ Yes ☐ No

3.4.3 ACAS surveillance issues:

☐ Yes ☐ No

3.4.4 False RAs:

☐ Yes ☐ No

3.4.5 ACAS traffic display issues:

☐ Yes ☐ No

3.4.6 Degraded safety performance of other CNS systems caused by ACAS (including issues related to ground surveillance equipment e.g. SSR, A-SMGCS):

☐ Yes ☐ No

3.4.7 1030/1090MHz channels perturbation:

☐ Yes ☐ No

3.4.8 Others (Please describe):

3.5 Has your organisation notified operators and/or competent authorities of ACAS system issues following the conclusions of technical monitoring in the past few years?

☐ No event notified ☐ Few events notified ☐ Many events notified

If any, please give examples:

3.6 Do you have any additional comment(s) on the subject of technical monitoring of ACAS system?

4 Operational monitoring of ACAS events

This sections aims at understanding how you and your organization monitor the performance of ACAS in an operational environment and used by a flight crew, including the operational relevance of ACAS RAs and responses given by the flight crew.

4.1 Does your organisation carry out an operational monitoring of ACAS events?

☐ Yes ☐ No (If no, please proceed to the end of the questionnaire)

4.2 If yes, can you please give further information on the following items:

4.2.1 Scope of the monitoring activity (e.g. all airspace, TMA and/or en-route operations, specific fleet, etc.):

4.2.2 Timing / frequency of the monitoring activity (e.g. continuously, on a periodic basis, occasionally, etc.):

4.2.3 Type of ACAS RAs monitored (e.g. all reported / recorded RAs, airproxes, significant RAs, etc.):

4.3 In the scope of operational monitoring of ACAS events, has your organisation carried out the following monitoring activities in the past few years:

4.3.1 Systematic monitoring:

☐ Yes ☐ No

4.3.2 Event-driven monitoring:

☐ Yes ☐ No

If yes, please detail the **criteria** applied to select RAs to be investigated:

4.3.3 Statistical monitoring:

☐ Yes ☐ No

4.3.4 Operational-oriented monitoring:

☐ Yes ☐ No

4.3.5 Identification of operational issues (e.g. level busts, hot spot of ACAS events, interaction STCA/ACAS, …) :

☐ Yes ☐ No

If yes, please give examples:

4.3.6 Analysis of causal and influencing factors (e.g. airspace design, ATC procedures, misuse of ACAS by pilot, etc.):

☐ Yes ☐ No

If yes, please give examples:

4.3.7 Specific monitoring of pilot's response to RAs:

☐ Yes ☐ No

4.3.8 Others (Please detail):

4.4 In the scope of operational monitoring activities carried out by your organisation as stated in question 4.3, which source(s) of data is being used by your organisation?

4.4.1 Radar data recordings:

☐ Yes ☐ No

4.4.2 RA recordings:

☐ Yes ☐ No

4.4.3 Air safety reports:

☐ Yes ☐ No

4.4.4 ATCO reports:

☐ Yes ☐ No

4.4.5 Other (Please detail):

4.5 In the scope of operational monitoring activities carried out by your organisation as stated in question 4.3, what kind of operational and/or safety issues have been identified by your organisation?

4.5.1 Hot-spots of ACAS events:

☐ Yes ☐ No

4.5.2 Use of ACAS and Mode-S transponders on the ground:

☐ Yes ☐ No

4.5.3 Use of ACAS in TA-only mode:

☐ Yes ☐ No

4.5.4 Incorrect and/or lack of pilots' response to ACAS RAs:

☐ Yes ☐ No

4.5.5 STCA/ACAS interaction issues:

☐ Yes ☐ No

4.5.6 Other (please detail):

4.6 Has your organisation taken preventive and/or corrective actions following the conclusions of operational monitoring of ACAS events in the past few years?

☐ Yes ☐ No

If yes, please give examples:

4.7 Has your organisation notified operators and/or competent authorities of ACAS events following the conclusions of operational monitoring in the past few years?

☐ No event notified ☐ Few events notified ☐ Many events notified

If any, please give examples:

4.8 Do you have any additional comment(s) on the subject of ACAS operational monitoring?

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