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EUROCONTROL Guidance Material for Short Term Conflict Alert

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Abstract

This document contains comprehensive guidance material to assist in implementing the EUROCONTROL Specification for Short Term Conflict Alert. It covers the full STCA lifecycle, including definition of objectives; implementation or change; tuning and validation; as well as operating and monitoring.

Keywords

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1.0	14-12-2006	06/12/14-23	Formatting changes	All

CONTENTS

Note: Appendices are contained in separate documents

EXECUTIVE SUMMARY

This document contains comprehensive guidance material to assist in implementing the EUROCONTROL Specification for Short Term Conflict Alert. Specifically, the document contains guidance related to the STCA lifecycle, including:

- Definition of objectives
- Implementation or change
- Tuning and validation
- Operating and monitoring

1. INTRODUCTION

1.1 Purpose of this Document

The European Convergence and Implementation Plan (ECIP) contains a pan-European objective (ATC02.2) for ECAC-wide standardisation of STCA in accordance with the EUROCONTROL Specification for Short Term Conflict Alert.

The EUROCONTROL Specification for Short Term Conflict Alert contains specific requirements, many of which must be addressed at an organisational or managerial level and others, more system capability related, which need to be addressed with significant input from technical staff.

The purpose of this document is to provide practical guidance material to assist in implementing the EUROCONTROL Specification for Short Term Conflict Alert. The guidance material covers the full STCA lifecycle.

1.2 Structure of this Document

Chapter 2 contains a general introduction and overview of the STCA lifecycle, including definition of objectives; implementation or change; tuning and validation; and operating and monitoring.

Chapter 3 elaborates organisational issues regarding STCA, including definition of roles and responsibilities, consideration of the Reference STCA System, definition of operational requirements, and development of a policy and a safety case.

Chapter 4 contains a guide to STCA System procurement and improvement.

Chapter 5 addresses STCA System tuning and validation aspects.

Chapter 6 highlights STCA System management and training issues.

This document contains the following appendices, most of which can be used as stand-alone documents for particular purposes:

Title	**Purpose**
Appendix A: Reference STCA System	Detailed technical explanation of typical implementation details of STCA with emphasis on parameterisation and performance optimisation. Optimisation concepts are also covered in detail.

Appendix B: Safety Assurance	A set of three documents that can be used as starting point for STCA safety assurance work in a particular local context.
Appendix B-1: Safety Argument for STCA System	ANSPs may find it convenient to present the safety argument as a stand-alone document initially, as is the case with this document. However, the argument will ultimately become part of the safety case document and the stand-alone version will then become defunct.
Appendix B-2: Generic Safety Plan for STCA Implementation	Describes what safety assurance activities should be considered at each lifecycle phase, who should do them, and what the criteria for success are.
Appendix B-3: Outline Safety Case for STCA System	Addresses in detail the assurance and evidence from the System Definition stage and outlines the likely assurance and evidence for the later stages.
Appendix C: Cost Framework for the Standardisation of STCA	Assists in identifying potential financial implications of standardisation of STCA in compliance with the EUROCONTROL Specification for Short Term Conflict Alert.
Appendix D: Case Study	A set of two documents describing the (partial) application of the optimisation and safety assurance guidance material in a demanding environment.
Appendix D-1: Optimisation of STCA for ATCC Semmerzake	Identifies potential solutions for handling military formation flights and a large number of primary tracks in STCA whilst keeping the number of nuisance alerts to an effective minimum.
Appendix D-2: Functional Hazard Assessment of STCA for ATCC Semmerzake	Describes the Functional Hazard Assessment of the identified potential solutions for optimisation of STCA, performed as initial step of safety assurance activities.

1.3 Relevant Material from the EUROCONTROL Specification

The EUROCONTROL Specification for Short Term Conflict Alert should be referred to for conventions regarding terms and abbreviations, and for a description of the STCA concept of operations.

Furthermore, chapter four of the EUROCONTROL Specification for Short Term Conflict Alert contains specific requirements, which are referred to in relevant sections of this document.

2. THE STCA LIFECYCLE

2.1 Overview of the STCA Lifecycle

The STCA lifecycle represents an ideal process followed by ANSPs to assure a solid and consistent development of STCA from the initial procurement to and during the operational use.

Figure 2-1 is a synthetic representation of the whole lifecycle. Each phase is covered by appropriate guidance in the document.

2.1.1 Definition of objectives

The initial step of the lifecycle is the *definition of roles and responsibilities* inside the organisation, to establish who has the responsibility for the management of STCA. Roles are made clear and well known inside the organisation to assure a consistent development of the system (section 3.1)

Then, the core issue is the definition of the *operational requirements* of STCA, based on a careful consideration of the local needs and constraints of the operational context in which the STCA is being introduced (section 3.3). Other two strictly interrelated processes are: the *consideration of a reference STCA* (section 3.2) and the *development of a policy and safety case* (section 3.4).

In performing the whole phase, representatives from different kinds of roles in the organization should be involved: the safety management, the technical staff and the operational experts.

2.1.2 Implementation or change

The previous steps are all needed to take an appropriate decision about the *STCA procurement*, either when the product is purchased from an external manufacturer (section 4.2) or when STCA is *enhanced* (section 4.3).

This phase is mostly performed by engineers and technical staff.

System verification (section 4.6) is performed either when implementing a new system from scratch or when enhancing an existing system.

Based on a verification methodology, an appropriate feedback loop assures that the phase is not terminated if the STCA is not functioning according to the technical specifications previously established.

2.1.3 Tuning and validation

The third phase is aimed at optimising the system in order to meet the operational requirements identified in the first phase. It also addresses validating the system before making it fully operational. The most essential steps are STCA system tuning and validation (chapter 5).

This phase relies on close collaboration between technical staff and operational experts.

Based on acceptance tests with controllers and/or on the use of optimisation tools, an appropriate feedback loop assures that the phase is not terminated if the STCA does not meet the established operational requirements.

2.1.4 Operating and monitoring

When the STCA is deemed validated or optimised, adequate *training* is provided to both ATCOs (section 6.2) and engineers (section 6.3).

Once the system is fully operational, a set of parallel processes are put in place:

- Collection of feedback from ATCOs
- Analysis of Pilots/ATCOs reports (section 6.4)
- Monitoring of STCA performance (section 6.5)
- System maintenance (section 6.6)

Also this phase requires a close collaboration between operational experts and technical staff. Safety management should also be involved, to ensure that the STCA role is adequately considered in evaluating the whole safety performance of the ANSP.

Based on the parallel processes described above, an appropriate feedback loop ensures that the system will revert to a tuning process, every time the STCA is not providing the required operational benefits.

It is to be noted that the whole STCA lifecycle is not a linear process, due to the ever-changing nature of the operational context in which the system is embedded. Thus iterations are still possible not only within each phase, but also between the different phases.

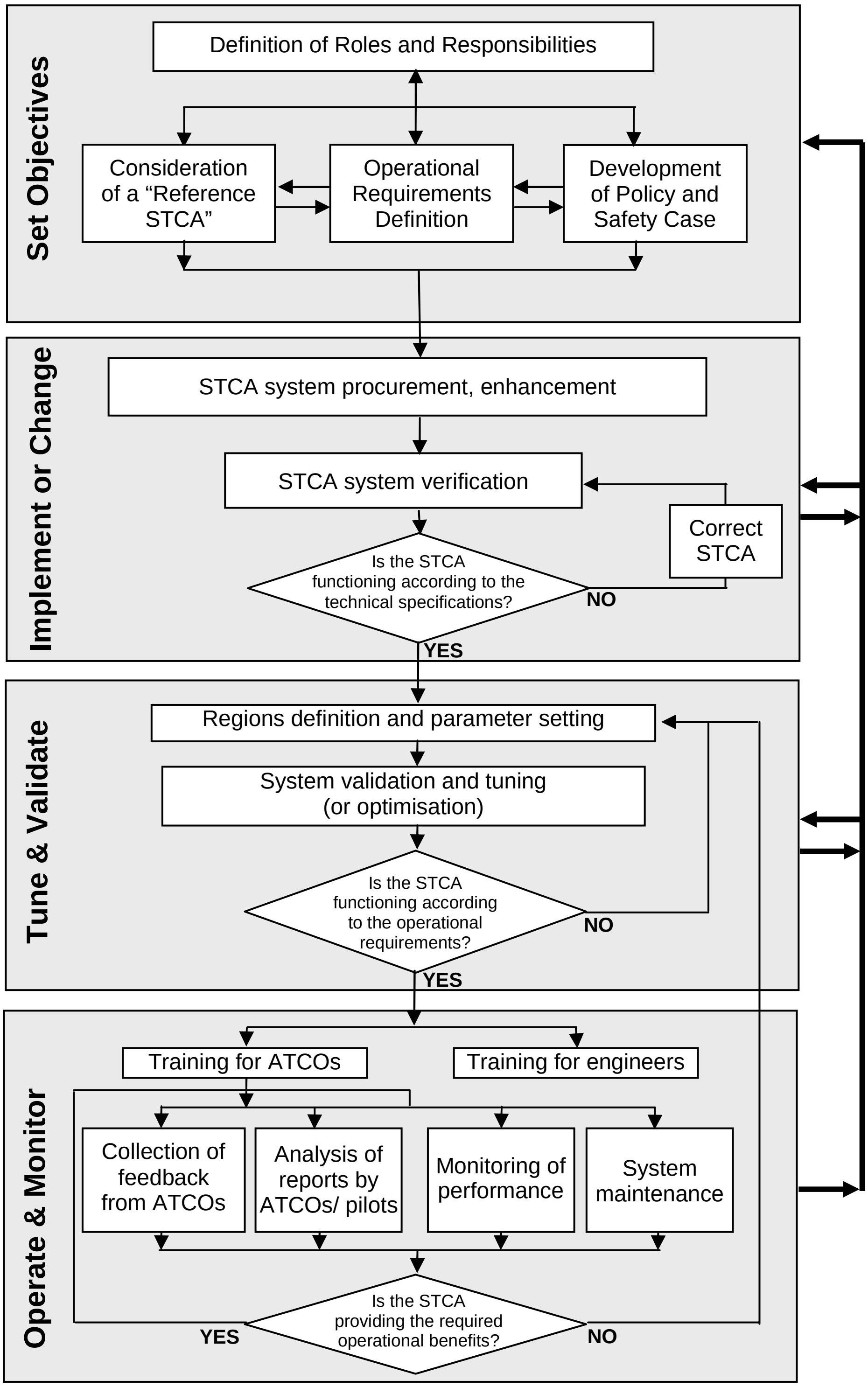

Figure 2-1 The STCA Lifecycle

3. ORGANISATIONAL ISSUES (SET OBJECTIVES)

3.1 Definition of Roles and Responsibilities

The EUROCONTROL Specification for Short Term Conflict Alert requires that:

STCA-02: The ANSP shall assign to one or more staff, as appropriate, the responsibility for overall management of STCA.

It should be possible for other staff in the organisation to identify the assigned staff. The assigned staff should seek advice from the STCA manufacturer, as appropriate.

Management of STCA can be addressed in different ways, according to the specific characteristics and constraints of the ANSP. Nevertheless, through various phases of the STCA lifecycle, a mix of different staff will be required, including technical, operational and safety specialists. Despite that fact that developing an STCA may appear as a purely technical exercise, it is of paramount importance that the system is fit for the purposes of the specific operational context and consistent with the safety policy established inside the ANSP.

In all ANSP organisations an adequate flow of information between engineering and operational staff is constantly required, especially in the tuning and validation phases.

The operational staff should have experience in the various areas where STCA will be active. For example, en route, approach and (where relevant) military controllers should be consulted when gathering operational requirements for an STCA system that is to function in both an en route and a TMA environment.

Finally, an adequate involvement of Safety Management should be assured both when developing the Policy and Safety Case and when monitoring STCA performance. For example, the role of STCA should be adequately considered when evaluating the overall safety performance of the ANSP[1].

Note that roles and responsibilities can change or be adapted as far as new needs emerge in following phases of the lifecycle. However roles should remain clear and well established inside the organisation, to assure reliable management of the system.

[1] Even if STCA is not considered when calculating the Target Level of Safety of the ATM, it is deemed necessary that the Safety Managers are aware of the actual safety benefit provided by the STCA.

3.2 Consideration of the Reference STCA System

The most essential parts of the reference STCA system are summarised in this chapter, to allow an understanding of how STCA fits into the ATC system, and the main technical features and options.

For a more in depth description of STCA, please refer to chapter two of *appendix A: Reference STCA System*.

3.2.1 STCA in the ATM System Environment

The inputs to and outputs from the reference STCA system are best understood in the STCA context diagram, shown in Figure 3-1 below:

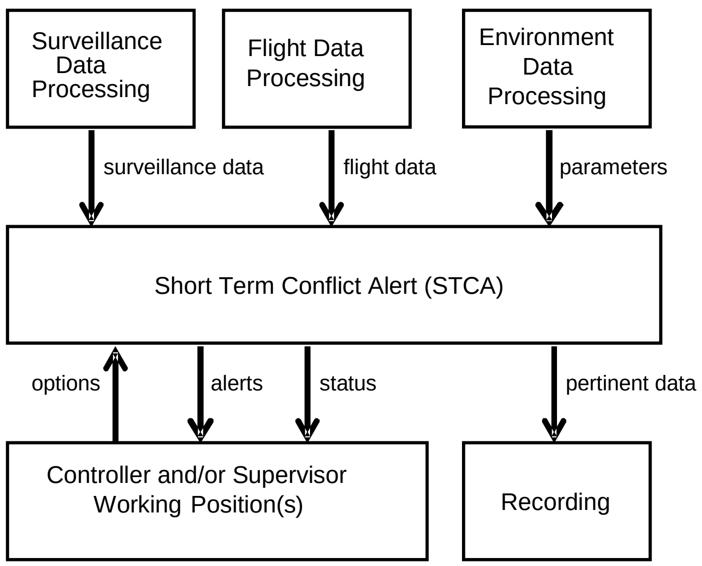

Figure 3-1 STCA Context Diagram

As illustrated in Figure 3-1, the reference STCA system obtains information from Surveillance Data Processing and Environment Data Processing. As an option, the reference STCA system can additionally make use of data from Flight Data Processing.

Surveillance track data including tracked mode C is used to predict conflicts.

Environment Data Processing supplies the reference STCA system with the necessary parameters for a number of user-defined volumes of airspace.

Flight data may be used to provide additional information, such as:

- Type/category of flight: to determine the eligibility for alert generation
- RVSM status: to apply appropriate parameters in RVSM airspace
- Concerned sector(s) of: to address alerts
- Cleared/Block Flight Levels: to increase the relevance of conflict prediction
- Type of aircraft/wake turbulence category
- Number of aircraft: to apply appropriate parameters for formation flights
- Manually entered Flight Levels: to compensate for missing Mode C data

In any STCA system, alerts should be generated at least at the Controller Working Position(s) of the control sector(s) controlling the aircraft.

Status information regarding the technical availability of STCA is to be provided to Supervisor and Controller Working Positions. Selectable options of STCA related to eligibility and configuration may be available at Supervisor Working Positions.

All pertinent data for offline analysis of STCA should be recorded.

3.2.2 System Track Eligibility

Most essentially, the STCA system must recognise which tracks belong to aircraft under the responsibility of the control centre. Normally, if at least one of the tracks in a potentially conflicting pair is under ATC, then STCA processing will be performed.

Determination of whether an aircraft is under ATC or not, may be done in a variety of ways. In some STCA systems, the system track is correlated with a flight plan in a flight plan database. In other systems, the SSR code of the track is used to look up a list of “controlled” codes (i.e. those SSR codes normally assigned to aircraft under control of the ATC centre). One possible advantage of a SSR code look-up list is that it makes the STCA system more independent of the rest of the ATC system. However, the list of “controlled” codes would need to be kept up to date with the actual SSR code allocations.

3.2.3 STCA Regions and Parameters

STCA reads user-defined regions (volumes of airspace). In most systems, a particular parameter group is associated to a region. This allows the selection of different sets of STCA parameters depending on the aircraft’s location in the airspace. Note that several regions may be associated with the same parameter group. For example several stack regions could be assigned the same parameter group number.

The purpose of parameter groups is to allow STCA to be optimised for the type of aircraft behaviour in the various types of airspace. e.g.

- En route airspace
- Terminal areas
- Departure regions
- Stacks

In addition, exclusion regions may be defined where no conflict tests are done; for example, to cover exercise areas.

3.2.4 Conflict Detection

The most common and effective conflict detection mechanism used in STCA is the linear prediction filter.

The purpose of the linear prediction filter is to determine whether the track pair will simultaneously violate certain lateral and vertical separation criteria within a given look ahead time. The prediction is made by a linear (straight-line) extrapolation of each aircraft's 3D track vector. In some STCA systems cleared flight levels are used to increase the relevance of conflict prediction.

If the lateral and vertical separation criteria will be violated within the look-ahead time then a conflict "hit" is registered, otherwise a conflict "miss" is registered.

3.2.5 Alert Confirmation

The final stage of STCA processing, called the alert confirmation stage, has a number of objectives:

- To test if a conflict is imminent and an alert is required immediately
- To suppress an alert which might be caused by spurious track data
- To test whether an alert is required at this time, or should be delayed, with the hope that the situation will become resolved before an alert is necessary
- To continue an alert when there are temporary perturbations in the track data

Essentially, the alert confirmation stage determines whether to issue an alert based upon the number of conflict "hits" from previous track cycles and the time of violation (the time remaining until the separation criteria will be violated).

3.2.6 Optional Features for STCA

The complexity of operational STCA systems varies between states. The reference STCA system describes not only the basic type of STCA system, but also describes a number of optional features.

These optional features are summarised in Table 3-1 below:

Option	Description	Effects on STCA Performance
A	Split Track Alert Suppression	Suppresses alerts from split tracks
B	Military Formation Alert Suppression	Suppresses alerts from military formations
C	Fast Diverging Conditions to suppress Fine Filters	Switches off the alert soon after aircraft are diverging
D	Use of uncertainty in conflict prediction	Takes account of uncertainty of future aircraft position. Can give extra warning time, as well as adding to the nuisance alert rate.
E	Cleared Flight Level used for Vertical Prediction in Linear Prediction Filter	Reduces nuisance alerts, particularly for level off situations. Can give extra warning time, but reduces warning time in the event of level bust.
F	Block Flight Levels used for Vertical Prediction in Linear Prediction Filter	Usually used in military training areas. It reduces nuisance alerts, particularly for level off situations. Can give extra warning time, but reduces warning time in the event of level bust.
G	Current Proximity Filter and Alert Confirmation	Can provide extra warning time for close proximity tracks
H	Turning Prediction Filter and Alert Confirmation	Can provide extra warning time for turning tracks – requires stable turn information.
I	Time for Standard Manoeuvre Test (vert. + lat.)	Allows fine tuning of the timing of alerts and the nuisance alert rate
J	Safe Crossing Test in Current Proximity Alert Confirmation	Suppresses some unwanted alerts in relatively safe crossing situations

Table 3-1 Summary of STCA Optional Features

For a more detailed description of the reference STCA system and its various options, see *appendix A: Reference STCA System*.

3.3 Operational Requirements Definition

In general terms, operational requirements are qualitative and quantitative parameters that specify the desired capabilities of a system and serve as a basis for determining the operational effectiveness and suitability of a system prior to deployment.

This part of the STCA lifecycle is very important, since time spent defining a set of high quality operational requirements is time spent reducing the risk of partial or complete project failure.

For STCA systems, the scope of the operational requirements covers both functional and non-functional requirements, including, but not limited to, the following:

Functional requirements:

1. capabilities or features of the system (e.g. prediction methods, use of CFL, RVSM etc)

2. system capacities (e.g. number of regions)

3. requirements on environment data (both on-line and off-line)

4. HMI requirements (as far as is relevant for the system)

5. data recording requirements

Non-functional requirements:

1. usability requirements (e.g. visibility of visual alerts, ease of Cleared Flight Level input)

2. quality attributes (e.g. reliability, maintainability, supportability, testability, safety, standards and availability requirements)

3. constraining factors imposed externally (e.g. cost, legislation, policy)

4. interoperability/interface requirements (e.g. physical, process, support and information interfaces to other capabilities/systems)

Defining the operational requirements of a new or modified STCA system can be a challenge, especially for individuals who have had no previous experience in either STCA or operational requirements definition. Therefore, this section is focussed on the process of defining operational requirements.

The convention is to consider the definition of operational requirements as a three-stage process.

1. Initial Requirements capture - gather an exhaustive list of requirements.

2. Requirements Analysis - analyse the list to address ambiguous, incomplete or contradictory requirements.

3. Requirements Recording - record the final requirements in an operational requirements document.

3.3.1 Initial Requirements Capture

The aim of the requirements capture stage is to produce a list of requirements, but to refrain from analysing them closely. The list of requirements should be refined later during requirements analysis. During the capture stage, too narrow a focus can result in costly oversight, which can only be pre-empted through engagement with all key stakeholders early on in the process.

There are a number of techniques and tools that can be used to derive requirements. Some of the more widely used ones are:

- Key Stakeholder Workshops for the resolution of discrepancies by consensus
- Re-use of requirements *(requirements from previous STCA systems)*
- Product research *(product surveys, web searches, ANSP feedback)*
- Use of guidance material *(Reference STCA System)*
- Interviews with stakeholders, usually on a one-to-one basis, to facilitate detailed consultation (ATCOs, technical specialists)
- Use of a requirements checklist *(see section 3.3.4)*
- Brainstorming techniques are particularly suited to where requirements are considered vague *(In groups of six or fewer domain specialists)*
- Hazard Analysis *(finding potential hazards can generate requirements for mitigation)*
- System Modelling *(real time or fast time, as appropriate)* may be used as a facilitating mechanism
- Capability gap analysis *(a study comparing the current capability to the desired future capability).*
- Prototyping
- Lessons learned *(from previous projects or programs)*
- Use of an STCA demonstrator to show example situations and alerts. *An STCA demonstrator can be downloaded from the EUROCONTROL safety nets web site:* http://www.eurocontrol.int/safety-nets

It is suggested that a number of these techniques/tools be employed, depending on the amount of effort that is available, and the anticipated complexity of the requirements.

The people involved in the requirements capture depends to some extent on the methods employed. Nevertheless, it is always essential to involve both operational and technical experts in the process. The experience of operational staff should cover the entire airspace in which the STCA system will be active (e.g. both approach and en route controllers). Important input into the requirements capture will also come from a number of technical experts who should have knowledge of STCA, other associated ATM functions (e.g. flight data processing, surveillance data processing, data recording) and issues related to system interfacing.

The requirements checklist is a non-exhaustive list of areas that should be considered in the requirements capture, and may be used to give structure to interviews and brainstorming sessions.

Models and prototypes can be powerful tools for establishing both functional and non-functional requirements. However, the model or prototype may require a significant amount of resources to produce.

The output of the previous activities is typically a loose collection of lists of requirements and related issues. These need to be engineered into one cohesive database.

3.3.2 Requirements Analysis

Requirements analysis should be undertaken by a small group of qualified staff with both operational and technical expertise.

The purpose of the exercise is to sort through the list of requirements obtained from the previous stage to check that each is complete and unambiguous, and does not contradict other requirements. It may be necessary to clarify some requirements with the originator.

It is also useful to organise the requirements into groups of related requirements or categories.

3.3.3 Requirements Recording

The final stage is to record the requirements in an operational requirements document.

This is a living document. In discussion with manufacturers or other ANSPs, it is likely that requirements will change or be added that were not foreseen in the original requirements capture.

Requirements may also be removed. To avoid unnecessary repetition of effort, it is important that a permanent record of the each removed requirement is kept, as well as the reason for its removal.

It should also be agreed with the manufacturer at which point in the development of the STCA system the requirements will be frozen.

Each requirement should be:

- Correct
- Unambiguous
- Complete
- Consistent
- Ranked for importance
- Verifiable
- Atomic
- Modifiable
- Traceable

3.3.3.1 Correct

It is recommended that each requirement be reviewed for correctness, if necessary, tracing back to the originator, or originating document that lead to the requirement. Ask whether the requirement is strictly true, and whether it is necessary. If the answer to either question is “no”, then the requirement should be reworded, re-ranked (for importance), or deleted.

3.3.3.2 Unambiguous

Each requirement should have as far as possible only one interpretation. Requirements need to be contractually taut. If not, then the supplier might misinterpret what was asked for and the recipient cannot know if they have received what was meant to be delivered and so may not know whether to accept it. An independent review of the requirements can help identify ambiguous use of language.

3.3.3.3 Complete

Consider whether, given the operational requirements document alone, the product developers would be able to deliver a suitable system.

3.3.3.4 Consistent

Each requirement should neither contradict nor repeat any other requirement.

3.3.3.5 *Ranked for Importance*

Some requirements may be essential, whereas others may simply be desirable, so it is important to assign a priority to each one. This may help decision-making if, at a later date, it becomes apparent that some requirements are difficult to achieve within the anticipated budget. Requirements can be prioritised as follows;

- Key requirements are critical to the capability and the satisfaction of the operational need. They bound the contract and encapsulate the characteristics of the capability
- Priority 1, Priority 2 and Priority 3 requirements in decreasing importance. The ability to trade these requirements is to be defined within the project
- Mandatory requirements are compulsory but not unique to the capability (e.g. legislation/safety)

3.3.3.6 *Verifiable*

It is important to consider whether reasonable means exists to check that the product meets the requirement. If a method cannot be devised to determine the product meets the requirement, then it should be reworded or removed.

To satisfy the need for testability, the requirement should also defined in precise terms. For example, replace phrases such as “immediately” and “appropriate HMI” with phrases like “within 3 seconds of the event 99% of the time”, and “pop-up menu, realised by a click of the right mouse button”.

3.3.3.7 *Atomic*

There should be only one action or concept per statement.

3.3.3.8 *Modifiable*

Avoid duplication of requirements and structure the operational requirements document to be easily modifiable.

3.3.3.9 *Traceable*

It is often useful to be able to determine the original reason for a requirement. A requirement is traceable if its origin is clear.

3.3.4 The STCA Requirements Checklist

Table 3-2 below outlines a number of questions that an ANSP will find useful to address in order to help define the requirements for an STCA system. The list is not exhaustive, and ANSPs will no doubt need to define requirements that are not covered in the list.

The ANSP may also use parts of the checklist as a basis for compiling a list of questions for STCA system manufacturers.

1. Current and Future Operational Environment

1.1 Within which classifications/types of airspace will STCA be adopted?

Airspace Classification (e.g. UK Class A – G), en route, off-route, TMA, RVSM, non-RVSM, approach, departure, stacks, military airspace, danger areas

1.2 What aerial activity is conducted in the proposed STCA airspace?

Straight Flight, vertical transitions, aerobatics, Military formations (joins/splits), high energy manoeuvres, gliders

1.3 What types of flights are of concern?

Civil, Military, General Aviation, IFR, VFR, GAT, OAT

1.4 What is the nature of the traffic?

Traffic hotspots, crossing traffic, frequent stacking, parallel approaches, busy periods

1.5 How is the Airspace used?

FUA either now or in the future, Civil/Military sharing airspace, uncontrolled flights

1.6 What is the impact of ATM Procedures?

Standing agreements? Silent co-ordination? RVSM?

2. Current and Future ATM System Components

2.1 Flight Data Processing System

Correlation used for STCA eligibility? Flight plans available over area of interest?

STCA function in FDPS Failure Modes?

2.2 Data Recording System

Recording of Tracks and Alerts? Recording of internal STCA values?

Sufficient to allow verification of STCA, or alert analysis?

2.3 Other Data Inputs

QNH, Region activation/deactivation

3. Current and Future Surveillance

3.1 Surveillance Coverage

Coverage sufficient? Even at lower altitude? Known problem areas? What is the operational requirement?

3.2 Track Quality

Reliability of lateral and vertical track? Tracking blunders? Split tracks? Reflections?

3.3 Data Content

Turn information? Track Age? Track Quality? Mode S Data? SFL?

4. Track Eligibility, STCA Regions and Parameters

4.1 Eligibility

Between all aircraft or selected?

Eligibility based on tracks correlated to a flight plan and/or SSR code lists?

Tracks without Mode C?

Use of track quality? Track Age?

Are some tracks to be Inhibited (manually or automatically)?

4.2 Regions

Number of regions required (now and in future)? Number of exclusion regions?

Automatic linking of STCA exclusion regions with APW (TSAs)?

Region shapes?

STCA should use actual region shape or superimpose on a grid?

Region activation (on and off) either manually or automatically?

Rules for determination of parameter group when regions overlap?

Rules for determination of parameter group when aircraft in different regions?

4.3 Parameters

Which parameters must be tuneable (e.g. sensitivity, false alerts)?

Parameter ranges sufficient for optimisation?

5. STCA System Features (see reference STCA System for more information) 5.1 RVSM Rules 5.2 Coarse Filter 5.3 Treatment of Special Conditions (Split tracks, military formations) 5.4 Conflict Detection Mechanisms (Linear Prediction, Turning Prediction, Uncertainty etc) 5.5 Use of CFL/SFL/BFL. 5.6 Alert Confirmation Stage (Time of Violation Tests, Conflict Counts, Crossing Test, Standard Manoeuvre Tests) 5.7 Conflict Alert Message Supports Multi-level alarms? Contains pertinent data (TOV, LMD)?
6. Issues related to HMI (where HMI requirements are an issue) 6.1 Effective use of colour, flashing etc for an alert? 6.2 Effective use of aural alarms 6.3 Conflict Alert Box used? Appropriate information in the box? 6.4 Display of Multilevel (multi-severity) alarms? 6.5 Alert acknowledgement (the suppression of a current STCA alert)? 6.6 Alert inhibition (the suppression of one or more tracks from STCA processing)? 6.7 Display of STCA status (to controller(s), supervisor)?

7. Tools and Support
7.1 Tools
Data Recording and Playback?
Display of internal STCA values?
STCA analysis and tuning tools?
Plot/Track/Flight generator to create test scenarios?
Other Display tools for regions, encounters or hot spots?
7.2 After Sale Support
Support for set up and optimisation?
Training / documentation for technical staff and controllers?

Table 3-2 STCA Requirements Checklist

3.3.5 The Number of STCA Regions

The EUROCONTROL Specification for Short Term Conflict Alert states:

STCA should be adaptable for the procedures in use in all distinct volumes of airspace at any moment in time.

For STCA systems that use regions (user defined volumes) the question may arise as to how many regions an ANSP will need. There is no definitive answer to the question, since it depends heavily on how much the ANSP wishes to divide and optimise the airspace. Nevertheless, the following list provides a rough guide.

- One region for each volume of en route airspace: potentially two regions for each, to allow 1000ft and 2000ft vertical separation to be applied.
- One or more regions for each TMA volume, as appropriate.
- For each major airport, one approach/departure region. Alternatively, two approach and two departure regions may be defined and switched on/off according to the runway operating direction.
- One region for each holding stack (possibly switched on only when the stack is in use).
- Where applicable, a region for an area of special use, such as a military danger area.
- Regions to allow a graduation in parameter values between volumes of airspace (e.g. between en route and TMA, or between departures and stacks).
- Regions to apply appropriate parameters in areas of airspace where RVSM data is not available to the control centre.
- A region for any area where a specific type of traffic or aircraft behaviour can be distinguished.
- An exclusion region for each airport with significant traffic.

The above list will help an ANSP to arrive at an initial estimate of the number of regions required.

Investing significant time and using an STCA model or prototype can help the ANSP refine the estimate further. Even in this case, it is recommended to double the estimate, since the number of regions needed may be much more than originally anticipated. If no model or prototype is used, it is recommended to at least triple the initial estimate to allow for fine division of the airspace for optimisation.

3.3.6 The Use of Cleared Flight Level (CFL)

Use of CFL in STCA increases the relevance of conflict prediction. However, use of CFL in STCA should only be considered if the controller is required to systematically input CFL for other purposes. A user-friendly HMI should be provided to facilitate those inputs.

The following effects of the use of CFL in STCA should be fully considered in the safety case:

	CFL not used in STCA	**CFL used in STCA**
Missing or wrong CFL input	No effect	Dependent on geometry of the situation
Level bust	All situations in which level bust will cause conflict are alerted	Level busts that cause conflict are alerted only when they occur
Conflicting traffic at CFL	Dependent on geometry of the situation	Alerted early

3.3.7 Manual input of Flight Level (FL)

STCA relies on Mode C data to predict conflicts in the vertical plane. Depending on local factors it may be appropriate to discard tracks without valid Mode C data from processing by STCA. Alternatively it may be appropriate to cater for manual input of FL.

The following effects of manual input of FL in STCA should be fully considered in the safety case:

	Manual input of FL not used in STCA	**Manual input of FL used in STCA**
Missing or wrong FL input	No effect	Dependent on geometry of the situation
Level bust	No effect	Levels busts are not detected

3.3.8 Interdependencies between STCA and Area Proximity Warning (APW)

It may be necessary to inhibit alerts for predefined volumes of airspace (e.g. exercise areas) to suppress unnecessary alerts. However, if an aircraft unintentionally penetrates such a volume of airspace, conflicts with aircraft that are legitimately inside the volume of airspace are not alerted.

APW is an effective safety net to prevent such situations from occurring.

Therefore, if APW is to be available, in the operational requirements phase, consideration should be given as to whether the definition and activation/deactivation of volumes of airspace in APW should be automatically linked to the exclusion regions in STCA.

3.4 Development of a Policy and a Safety Case

3.4.1 Development of a Policy

The EUROCONTROL Specification for Short Term Conflict Alert requires that:

The ANSP shall have a formal policy on the use of STCA consistent with the operational concept and SMS applied.

The policy should be consistent with the following generic policy statements:

STCA IS A SAFETY NET; ITS SOLE PURPOSE IS TO ENHANCE SAFETY AND ITS PRESENCE IS IGNORED WHEN CALCULATING SECTOR CAPACITY.

STCA IS DESIGNED, CONFIGURED AND USED TO MAKE A SIGNIFICANT POSITIVE CONTRIBUTION TO THE EFFECTIVENESS OF SEPARATION PROVISION AND COLLISION AVOIDANCE.

STCA is only effective if the number of nuisance alerts remains below an acceptable threshold according to local requirements and if it provides sufficient warning time to resolve the situation.

The policy should be developed in collaboration with controllers who have experience of using STCA operationally, as well as staff who understand the specific operational environment. Local factors, such as the density and type of air traffic, may be taken into account when developing the policy.

The ANSP’s policy statements define how the STCA system is to be used. Consequently, these statements should steer much of the STCA lifecycle, including operational requirements definition, system specification, parameter settings and controller training.

3.4.2 Development of a Safety Case

It is Safety Management best practice and an ESSAR4 requirement to ensure that all new safety related ATM systems or changes to the existing system meet their safety objectives and safety requirements. ANSPs and National Safety Authorities will need documented assurance that this is the case before putting the new or changed system into operation. Typically, the assurance is presented as a safety case.

Comprehensive guidance on how to develop a safety case for STCA is available in the following three documents:

Appendix B-1: Safety Argument for STCA System

Appendix B-2: Generic Safety Plan for STCA Implementation

Appendix B-3: Outline Safety Case for STCA System

An ANSP's own documented assurance should contain the evidence, arguments and assumptions as to why a system is safe to deploy. The process of developing and acquiring the necessary safety assurance is considerably enhanced if the activities to obtain it are planned from the outset, ideally during the system definition phase of a project.

Appendix B-1: Safety Argument for STCA System is a generic document intended for use by ANSPs in developing their own safety assurance for STCA. Like the generic safety argument, the ANSP's own safety argument should follow a logical structure and be complete regarding the scope of the system, its environment and any assumptions that have to be taken into account.

Appendix B-2: Generic Safety Plan for STCA Implementation covers all the system lifecycle phases. It describes what activities should be considered at each phase, who should do them, and what the criteria for success are. The output of the activities in the safety plan should provide the evidence necessary to complete the safety case.

Finally, *appendix B-3: Outline Safety Case for STCA System* follows the EUROCONTROL Safety Assessment Methodology (SAM). It addresses in detail the assurance and evidence from the System Definition stage within the SAM lifecycle and it outlines the likely assurance and evidence for the later stages.

4. GUIDE TO STCA SYSTEM PROCUREMENT AND IMPROVEMENT

4.1 Reference Documents

Appendix A: Reference STCA System describes a generic or reference STCA system, with a number of optional features. This document can provide useful information for those making decisions related to system procurement or enhancement.

A cost framework is provided in *appendix C: Cost Framework for the standardisation of STCA*. This gives guidance to the cost of implementing or enhancing an STCA system to meet the requirements prescribed in the EUROCONTROL Specification for Short Term Conflict Alert.

4.2 Procurement of an STCA System

The aim of any purchase is that the delivered product is fit for purpose.

Manufacturers of STCA systems have a responsibility to ensure that the products they sell are fit for operational use. Conversely, the ANSP also has a duty to inform the manufacturer of any specific requirements at an early stage.

STCA, like other safety nets systems, is often included as part of a manufacturer’s ATM system. If this is the case, it is important to make sure that the STCA system is appropriate.

At a very early stage in the purchase decision, it is essential that the manufacturer supplies a specification of the proposed STCA system so that the purchaser can assess if the system will be appropriate for their needs. It is also helpful if at the earliest opportunity, the manufacturer is able to demonstrate the STCA system, and explain the functional aspects of the system. If the STCA system is part of an ATM system to be purchased, then the HMI and visual/aural aspects of the STCA alerts should also be demonstrated.

The purchaser should review the STCA specification in detail to ensure that the system will not only be fit for current use, but can be configured to meet anticipated future needs (such as changes to airspace, or new input data). The purchaser should also seek the manufacturer’s advice, to check whether the system will meet the purchaser’s needs. It is likely that several meetings between the respective experts will be required specifically to discuss requirements, system capabilities and capacities.

If the STCA system is not being designed from a set of operational or user requirements, it will be useful at the outset for representatives from both the manufacturer and the purchaser to compile a list of relevant questions. An example list is given in Table 4-1 below:

What is the extent of the airspace to be covered by STCA?
What is the nature of the air traffic (TMA, en route, approaches, departures, stacking)?
What are the main features of the STCA system, and are they in accordance with aircraft behaviour, tracker behaviour and local operational procedures? (Perhaps think about how much manoeuvring occurs, the number of split tracks, and whether reliable CFL or SFL data is available)
What SDP (tracking) data will be provided to STCA, and is it of sufficient quality?
What other data will be supplied to STCA? Flight plan data? Data input by the controller?
How will STCA alerts be presented to the controller?
Does the facility exist for the controller to be able to manually inhibit alerts?
How are parameters set, and regions defined?
How many regions of airspace can be defined in the operational system?
Is the maximum number of regions/parameter groups sufficient for current and future needs?
Can regions be dynamically activated / deactivated?
How many exclusion regions can be defined?
Are other STCA capacities sufficient for both current and future needs?
Do the parameters (or range of values) allow the STCA system to be optimised for the airspace?
What STCA analysis tools are provided?
Is the STCA capable of recording its internal values, and are they sufficient for testing?
Who will test the STCA system? And how will it be tested?

Table 4-1 Example List of Relevant Questions

The answers to these questions will help both the purchaser and the manufacturer determine whether the purchaser's requirements can be met.

The purchaser may wish to ask the manufacturer for specific features, such as those outlined in section 3.2.6, and the manufacturer could offer a number of other extra features. With any of the advanced features, it is important to make sure that it is relevant in the airspace of interest and local operational procedures.

STCA systems should be subject to factory acceptance testing (FAT) and site acceptance testing (SAT).

It is normal practice for not only the manufacturer to perform tests on the system but also the purchaser. The purchaser in particular will want to test the system to make sure that:

- It behaves as specified
- It is fit for operational use

The manufacturer should be able to supply tools and, if necessary, human resources to help the purchaser test the STCA system.

4.3 Enhancement of an Existing STCA System

4.3.1 Introduction

This section provides guidance on how to manage the enhancement of an existing STCA system.

The need to enhance the STCA system is very often driven by a need to solve performance issues with the system. In particular, it is not unusual for one or more of the following problems to exist:

- STCA is giving irrelevant alerts (e.g. alerts for aircraft not under ATC)
- STCA is producing too many false or nuisance alerts
- STCA is not providing sufficient warning time, or provides sufficient warning time only in a limited number of situations

As well as improving alerting performance, the STCA system can also be enhanced by making improvements to the presentation of the alert, or the controllers HMI. A number of HMI options are described in section 6.

Enhancing the STCA system is normally less expensive than buying a new one from scratch. In any case, a new STCA system may not necessarily solve the original problem(s). Furthermore, the ANSP is generally familiar with how their system operates, and can often foresee how the system will perform after improvements have been implemented.

Nevertheless, in order to make the improvements, the ANSP must commit some resources to the task, and must either already have a good technical understanding of the STCA system, or draw on external technical expertise.

A practical example of STCA system enhancement is given in *appendix D-1: Optimisation of STCA for ATCC Semmerzake*.

4.3.2 The Improvement Process

The improvement process can be broken down into a number of essential steps:

- Identifying and understanding the nature of the problem(s).
- Designing appropriate solution(s)
- Implementing the change to the system
- Measuring the effect of the change

Identifying and understanding the nature of the problem is the crucial first step to designing an appropriate solution. In some cases, the precise nature of the problem will be revealed simply by looking at a controller display.

However, in many other cases, the only way to fully comprehend the problem is to record a sample of traffic, and analyse in detail the situations that trigger the problem. This analysis is greatly aided by the availability of a complete and accurate specification of the STCA algorithms.

It is important at the analysis stage to involve both technical and operational staff. This is because technical staff alone may identify solutions that would not be operationally appropriate.

If a number of problems are present, it may be appropriate to implement one solution at a time, in order to test it and measure its effect separately.

An STCA model is an ideal instrument for testing many proposed improvements to the STCA system, and allows the effect of the change to be measured before it is put into the operational system. However, if a model is not available, an alternative could be to use an STCA system running on a non-operational partition of the ATC system.

When adding new logic to the STCA system, it is essential to include parameters that will allow the new logic to be fully tuned, and bypassed in the event that the solution does not work as foreseen.

If the solution is complex, ANSPs should consider how risk can be reduced, perhaps by implementing the solution in stages, or by introducing it at a smaller ATC centre first for a trial period.

4.4 Guidelines for Improving the Alerting Performance of STCA

The most important step is to identify and fully understand the nature of any deficiencies with the STCA system.

It is not always necessary for the STCA system to be technically enhanced. Many problems can be overcome or reduced either by changing the STCA parameters, or by breaking the airspace up into a number of regions. Further, making parameter and region changes might provide a temporary solution to a problem, whilst a better long-term solution is being investigated.

Similarly, some problems could be resolved simply by updating a list of SSR “controlled” codes. It is important to review these codes regularly and make sure they are up to date.

Sometimes, a very simple solution may be found which can make a significant contribution to the performance of the STCA system. In particular, some deficiencies may be discovered by carefully inspecting the code or the system specification. For instance, some things to check for are:

- Check that both the eligibility criteria and the coarse filter are finding all the pairs of interest (i.e. they are not removing relevant conflict pairs)
- If using a step-wise prediction method, check that the step time is sufficiently short so that no conflicts are missed
- Make sure that the alert confirmation stage gives priority to alerting when the situation is imminent. (Any tests for imminent conditions must not wait for a count of conflict hits to build up)

Certain problems, such as unwanted alerts from split tracks or military formations, are not usually solved by parameter tuning and are likely to need specific logic. For example, trying to avoid alerts from split tracks by increasing the conflict count is inappropriate, and reduces the overall performance of the STCA system. Instead, problems with split tracks or military formations require the introduction of new logic to detect and suppress such situations from alerting.

Furthermore, STCA performance may be masked if there are an overwhelming number of false alerts from split tracks. Therefore it is best to deal with these types of unwanted alerts before trying to tune the parameters for optimum alerting performance.

Once most of the problems have been resolved, further improvements to STCA may be made, for example, by the introduction of new conflict detection algorithms or the use of cleared or block flight levels. The optional features for STCA outlined in section 3.2.6 are described in detail in *appendix A: Reference STCA System*. The effect of each of these features is already well established, and all can make a contribution to improve STCA performance.

ANSPs should select enhancements that are in accordance with how aircraft behave in the airspace and local operational procedures. For example, a turning prediction filter is likely to be more relevant in TMA airspace than en route, and the use of CFL or SFL is best considered only if the CFL is input as part of normal ATC procedures or if SFL is available from mode S enhanced surveillance.

The ANSP should review the overall effect of any changes to the STCA system on alerting performance, and should consider whether some of the other parameters need re-tuning to redress the balance between warning time and nuisance alert rate. For example, if a turning prediction is added, the linear prediction parameters might be slightly reduced; if CFL or SFL is used, some parameters may be increased, since there may be more scope to increase the warning time with little effect on the nuisance alert rate.

The order of priority for improving STCA performance is given in Figure 4-1 below:

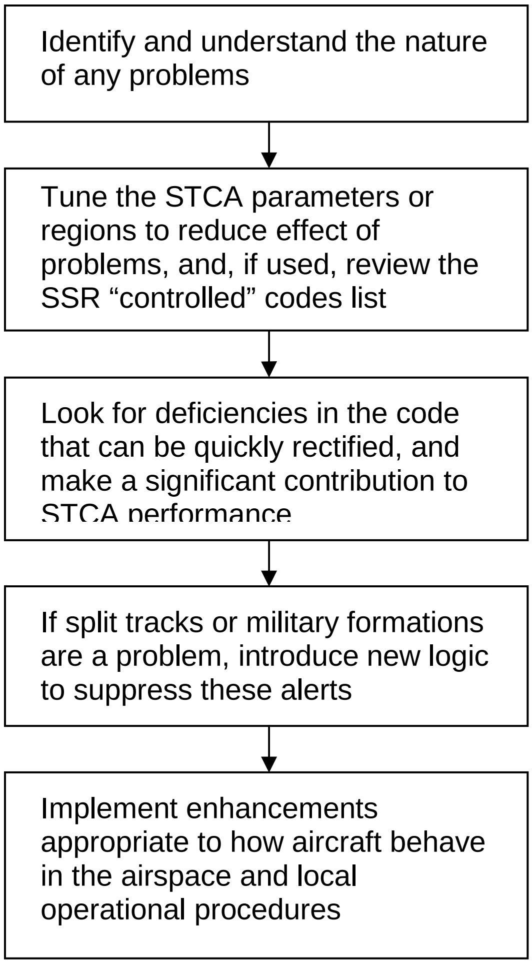

Figure 4-1 The Order of Priority for STCA System Improvement

4.5 HMI Options for STCA

4.5.1.1 Introduction

Controller’s displays vary between the ECAC states, and likewise so does the presentation of STCA alerts, and STCA related information.

The purpose of this section is not to promote one type of presentation over another, but to describe a number of options and explain what needs to be considered when deciding on an appropriate HMI.

The most important aspect of an alert is that is should be clear and unambiguous. Even if STCA is the only source of alerts, the HMI should be designed bearing in mind that other sources may be added in the future.

4.5.1.2 Requirement for Presentation of Alerts

The EUROCONTROL Specification for Short Term Conflict Alert requires that:

STCA-10 STCA shall provide alerts that attract the controller's attention and identify the aircraft involved in the conflict; STCA alerts shall be at least visual.

It continues:

An audible element may be included to improve the systems ability to draw the controller's attention to the alert. If a continuous audible element is included, an acknowledgement mechanism may be provided to silence an alert.

4.5.1.3 Visual Presentation

An alert is usually indicated visually either by flashing track labels, or a change of the track label colour. Other mechanisms include a change to the border of the track label, or a short string ("STCA" or "CA") in the track label.

A conflict vector may be used to indicate where the aircraft will be after a particular period of time, or at the minimum lateral separation.

In order to help identify which pair of aircraft are in conflict, joining lines are sometimes used between the two relevant tracks.

Note that too many lines on the display may be distracting to the controller. This may be the case if there are a very large number of alerts from aircraft in close proximity (such a split tracks and military formations).

A conflict alert box in a separate area of the display is sometimes used to show additional information for the alerting track pair. The box may also help if the tracks are overlapping, and the track labels become illegible.

Additional information on the display should help the controller to distinguish between urgent and non-urgent alerts. A conflict severity measure can be computed (perhaps high and low severity) and is quick and easy to understand. Time to conflict will also give a reasonable indication of severity. Other measures such as the lateral separation, and particularly the lateral miss distance are less reliable measures to provide the controller (because there is little correlation between urgency and the lateral miss distance).

Note, however, that too much information on the display may not be helpful to the controller.

4.5.1.4 Audible Presentation

An audible element to the alert can help draw the controller's attention to a conflict.

The alarm should be clear and unambiguous, and should be audible to the relevant controller.

On the other hand, alarms that are too frequent, too loud or unpleasant will become a nuisance. Continuous alarms may also be a nuisance, and furthermore may overlap with controller's RT instructions to pilot, causing alarm and confusion in the cockpit.

The precise characteristics of the audible alarm must be carefully engineered, taking into consideration other competing noises in the control room and the frequency of STCA alerts.

4.5.1.5 Alert Acknowledgement

Some systems allow the alert to be acknowledged by the controller at the CWP. This can be useful if the controller has already issued an instruction to the aircraft that will resolve the conflict.

When acknowledged, the visual and/or audible aspects of the alert are suppressed or reduced. Thus an acknowledged alert will not continue to grab the controller's attention.

STCA systems that compute alert severities (e.g. high and low severity) may allow only low severity alerts to be acknowledged, with the alert reappearing again if it becomes a higher severity.

4.5.1.6 Alert Inhibition

Alert inhibition is different to alert acknowledgement.

Alert inhibition can be applied to one or more aircraft, not necessarily those that are currently alerting, and suppress them from alerting.

Tracks are selected for inhibition by the controller on his display, usually based upon SSR codes or call signs. It should be clear to the controller whether one or both aircraft in a pair must be inhibited, in order to suppress the STCA alert.

Note the requirement from the EUROCONTROL Specification for Short Term Conflict Alert:

STCA-16 Alert inhibitions shall be made known to all controllers concerned.

4.5.1.7 *Controller Inputs*

The HMI for controller inputs, such as cleared flight levels (CFL), block flight levels (BFL) or any other information should be as user-friendly and efficient as possible.

4.5.1.8 *STCA Status Information*

STCA-17 Status information shall be presented to supervisor and controller working positions in case STCA is not available.

It should be immediately clear to controllers and supervisors when STCA is not fully functioning.

4.6 STCA System Verification

4.6.1 Verification Methods

The aim of verification is to check that the system is behaving as described in the specification. Therefore, verification relies on the availability of a detailed and accurate specification.

The level of verification that can be done will also depend fundamentally on the data recording capabilities of the system. Guidelines for recording STCA data are described in detail in chapter 5 of *appendix A: Reference STCA System*.

It is normally the responsibility of the manufacturer to make sure the STCA system is working as specified. Nevertheless, it is likely that the purchaser will want to check the same, and may either require evidence of verification, or the facility to make their own checks.

4.6.2 Verification Using an STCA Model

A model of the STCA system (written to the same specification as the operational system) can be an invaluable tool for system verification.

For an accurate STCA model to be produced, it is absolutely essential that the specification is complete and unambiguous. The specification should include the algorithms, parameters, trace message formats, and timing characteristics of the system.

When using an STCA model, the steps that should be followed are:

- Produce or acquire a detailed and accurate specification of the STCA algorithms.

- Produce the operational STCA system – the operational system should be made capable of outputting trace (or debug) messages containing pertinent internal values, and flags at decision points

- At the same time as the operational STCA system is under production, other engineers should produce an STCA model to the same specification. The STCA model should be made capable of producing the same trace messages.

- Design and produce test scenarios (ideally as track pairs) to exercise all aspects of the STCA logic. The parameters and region definitions required must also be specified as part of each test. A number of example test scenarios are given in *appendix A: Reference STCA System*.

  (Note that for test scenarios, the parameters and regions do not have to be realistic, or even close to those that will be used operationally. The purpose of the tests is to ensure that all aspects of the STCA logic are provoked. For some tests it may be convenient to use extreme parameter values).

- Input the test scenarios into the operational STCA system, recording the system tracks used by STCA, the alerts and trace messages.

- Input the same test scenarios into the STCA model, recording the alerts and trace messages. To ensure the tracks are identical to those used by the operational STCA system, it may be necessary to use the system tracks recorded from the operational STCA in the previous step.

- Compare the alerts and trace messages from the operational system and the model. In principle, this could be done manually – however, if there are a number of tests automatic comparison tools will be invaluable at this stage. Any differences between the two must be investigated to check the reason for the difference. If the model is incorrect, this can be quickly fixed. If the operational system is incorrect it will have to be fixed and the tests rerun. Note that it is also possible that a difference between the STCA system and the model highlights an ambiguity in the specification, which should be corrected

- Repeat the previous three steps until all the differences have been resolved.

- Input opportunity traffic into the operational STCA system, recording the system tracks used, the alerts and trace messages.

  (Opportunity traffic is useful because it contains aircraft geometries and conditions that may have been missed in the design of the test scenarios)

- Input the same opportunity traffic into the STCA model, recording the alerts and trace messages. Again, to ensure the tracks are identical to those used by the operational STCA system, it may be necessary to use the system tracks recorded from the operational STCA in the previous step

- Compare the alerts and trace messages from the operational system and the model, resolving any differences.

- Repeat the previous three steps until all the differences have been resolved.

4.6.3 Verification without an STCA Model

It is clear that the use of an STCA model for verification requires a significant investment of time and resources, and this is particularly true if the manufacturer or ANSP has to build an STCA model from scratch.

Fortunately verification can be done without an STCA model. However, the level of verification does still rely very much on a detailed specification and sufficient recording capabilities of the operational STCA system.

Without an STCA model, one approach to verification is:

- Produce or acquire a detailed and accurate specification of the STCA algorithms.

- Produce the operational STCA system – the operational system should be able to produce trace (or debug) messages containing pertinent internal values, and flags at decision points.

- Design and produce test scenarios to exercise all aspects of the STCA logic. The parameters and region definitions required must also be specified as part of each test. (Note that some tests, can be designed such that the passing of the test is indicated by the presence or absence of an alert)

- Input the test scenarios into the operational system, recording the system tracks used, the alerts and trace messages.

- Check that the expected alerts are present, and there are none that are not expected.

- For a selection of the tests, manually check that pertinent values (e.g. time of violation) are correctly computed. (As an option, it may be useful to use tools which compute pertinent values, given a set of input system tracks)

- For a selection of the tests, manually check the alerts and trace messages against the specification. It should be possible to follow the logical path by comparing the computed values and flags to the algorithms in the specification.

- Repeat the previous four steps (as necessary) until all issues have been resolved.

5. STCA SYSTEM TUNING AND VALIDATION

5.1 The Objective of Parameter Optimisation

The objective of parameter optimisation is to tune the STCA parameters to meet the requirements laid out in the EUROCONTROL Specification for Short Term Conflict Alert:

STCA-08 STCA shall detect and alert operationally relevant conflicts involving at least one eligible aircraft.

STCA-11 The number of nuisance alerts produced by STCA shall be kept to an effective minimum.

STCA-13 When the geometry of the situation permits, the warning time shall be sufficient for all necessary steps to be taken from the controller recognising the alert to the aircraft successfully executing an appropriate manoeuvre.

STCA-14 STCA shall continue to provide alert(s) as long as the alert conditions exist.

5.2 Overview of Parameter Optimisation

At the most basic level, parameter optimisation requires two things:

1. The capability to quantitatively measure the performance of the STCA system, given certain track data as input.

2. The capability to alter the parameter settings, so the results of various parameter values can be compared.

Comprehensive Guidance to parameter optimisation is given in *appendix A: Reference STCA System*.

The material includes guidance to appropriate parameter values for the reference STCA system, optimisation concepts, and the optimisation procedure.

The method presented in *appendix A* is highly recommended because it includes quantitative measures of STCA performance, and once in place is fast and efficient. However, the method does also require the use of large samples of recorded data, the use of various tools for STCA modelling, visualisation and encounter classification. All in all, the process requires a significant commitment of resources to the task.

5.3 Overview of the Parameter Optimisation Method

5.3.1 Overview of Parameter Optimisation Tools and Files

The diagram below shows the tools and data files that are appropriate for STCA parameter optimisation. Tools are indicated in bold type, files are shown in normal type.

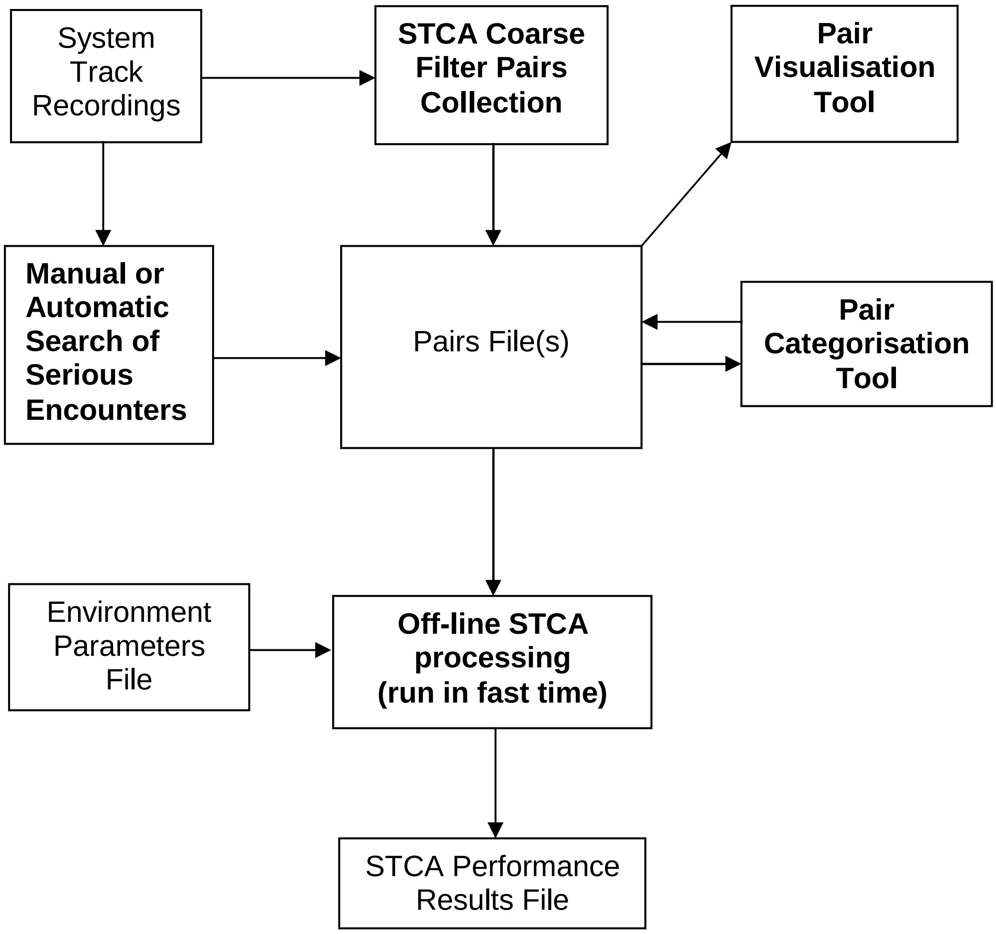

Figure 5-1 Tools and Files Required for Parameter Optimisation

5.3.2 Pairs Collection

The first stage of the optimisation process is the collection of situations of interest in one or more "pairs files". The purpose is to compose a set of encounters suitable for STCA performance analysis. To this end, the pairs file must contain encounters that give rise to both “wanted” and “unwanted” alerts. The unwanted alerts are relatively simple to find, since these will occur in any sample of general traffic system tracks. However, the wanted alert encounters are much less common and may need to be extracted from historical system track recordings.

5.3.3 Pairs Files

The pairs files comprise the essential system track information (3D state vector, mode A code, track ages etc), for pairs of system tracks that have passed an STCA coarse filter. The file is organised in order that individual pairs of trajectories can be input into the off-line STCA model or viewed using visualisation tools.

5.3.4 Pair Categorisation Process

The purpose of pair categorisation is to classify the situations in the pairs file into one of the following categories:

Category 1	ALERT NECESSARY – the situation involved a serious loss of separation or avoided such a loss by a late manoeuvre.
Category 2	ALERT DESIRABLE – although there was no serious loss of separation, the situation was such that an alert would have been useful in drawing the attention of the controller to a potential conflict
Category 3	ALERT UNNECESSARY – An alert was unnecessary for the satisfactory resolution of the situation but would be “predictable” or understandable by the controller.
Category 4	ALERT UNDESIRABLE – the situation presented little threat of separation loss and an alert would be distracting or unhelpful.
Category 5	VOID – This situation is not to be used for optimisation. For example. It may be a false situation caused by erroneous track data, or it may occur in a region of airspace not covered by STCA.

Table 5-1 Definition of Encounter Categories

The pair categorisation process needs to be done before inputting the pairs file into the STCA model.

5.3.5 Pair Visualisation and Manual Categorisation

Because the pair categorisation process is somewhat subjective, some means of examining individual encounter pairs will be required, in order to do a manual categorisation. Software that generates a printed diagram showing the situation in lateral and vertical view is recommended. An assessment may then be made of the borderline situations to assign an appropriate category. For manual categorisation, it may also be useful to take advice from controllers as to whether an STCA alert is desirable for particular borderline pair situations.

5.3.6 The Off-Line STCA processing

Having categorised all the pairs, they are input into an off-line STCA process.

The off-line STCA process must be functionally identical to the operational system. Also, the process should be able to run in fast time, so that several weeks worth of traffic may be processed very quickly; during optimisation the same data sets will need to be processed by the model many times with varying environment parameter sets.

The off-line STCA process will record various data, such as described in *appendix A*.

5.3.7 STCA Performance Results

The STCA performance results file contains details of the performance test run, overall performance statistics as well as the timing and details of each of the alerts.

The test run details must include:

- The names of all environment and track pairs files input into the model.
- Identification of pairs that have been processed.

The overall statistics must include the following measures:

- The number of pairs of each category
- The number and percentage of alerts of each category
- The mean warning times for wanted alerts

The details of each alert must include:

- Identification of the pair of aircraft
- The time and duration of the alert

- The STCA filter that initially detected the alert
- The STCA regions and parameter group at the start of the alert

5.3.8 Requirements for STCA Performance

In essence, the purpose of the optimisation process is to maximise the number of wanted alerts, providing as much warning time as possible whilst keeping the number of unwanted alerts to an acceptable level.

Possible requirements for STCA performance are listed in Table 5-2, below:

Performance Indicator	**Maximise / Minimise**	**Required Performance**	**Preferred Performance**
% of Category 1 encounters alerted	Maximise	≥95%	100%
% of Category 2 encounters alerted	Maximise	≥80%	≥90%
% of alerted encounters which are Category 3, 4 & 5	Minimise	≤75%	≤50%
% of Category 3 encounters alerted	Minimise	-	≤30%
% of Category 4 encounters alerted	Minimise	-	≤1%
% of Category 5 encounters alerted	Minimise	-	-
% of Category 1 and 2 encounters where adequate warning time exists which give less than adequate warning time	Minimise	≤45%	≤35%
Mean warning time achieved for Category 1 and 2 encounters where adequate warning time exists	Maximise	≥90% of adequate	≥95% of adequate
Mean achieved warning time for Category 1 and 2 encounters where adequate warning time does not exist	Maximise	≥70% of mean objective warning time	≥75% of mean objective warning time

Table 5-2 Possible STCA Performance Requirements

In order to maximise performance, repeated runs with different STCA parameters are generally required. Guidance for parameter settings is given in *appendix A*.

5.4 Alternative Parameter Optimisation Strategies

There are a number of strategies that may be adopted by ANSPs to ease the burden of full parameter optimisation.

5.4.1 Using Artificial Scenarios

Firstly, it may be possible to generate a large number of artificial scenarios, including wanted alerts and unwanted alerts. This would avoid the need to collect real data, or search for serious encounters. Suitable encounter models exist for the generation of many thousands of scenarios that could be used for STCA parameter optimisation.

Scenario generators may also be available for producing individual encounters, using track script files (These scripts include track start positions, turns, climbs etc). If scenarios are generated individually, then encounters can be designed that are either definitely “wanted alerts” or definitely “unwanted alerts”. This approach would avoid the need for an encounter categorisation tool.

No matter how the scenarios are generated, they will need to include a large variety of different geometries and manoeuvres in all the airspace of interest.

Ultimately, the success of this approach will depend on how well the scenarios simulate the real traffic.

5.4.2 Adapting Existing Visualisation Tools

Visualisation tools that allow tracks to be displayed are already available to ANSPs.

With a small amount of effort it may be possible to modify track display tools to include STCA alerts. If this is not possible, the timing of each alert could still be marked on a picture using commonly available software.

5.4.3 Using Real STCA Systems

If a version of the STCA system is available that isn’t running on the operational partition of the ATC system, then this could be used, instead of producing an STCA model. This STCA system must be functionally the same as the operational one.

For example, in some ATC systems, STCA is available in a test partition.

Whereas a model can run in fast time, a test STCA system will be limited to (more or less) real time. To save manual effort, all the encounters may be best injected into the STCA system as track data in one large data sample. There is no reason why a large number of aircraft encounters could not be compressed into a fairly short timeframe, reducing the time between each test run to a tolerable level.

The STCA system must be capable of taking user-defined parameters and recording the alerts that are produced, and these alerts must be attributable to each encounter for later analysis.

As part of the optimisation, it is essential that the recorded alerts can be presented in a form that allows the user to assess the performance of the STCA system. It may be necessary to produce a tool that takes the recorded alert file and summarises the results in a text file. The information presented should include as a minimum the identity of each encounter, whether the encounter has alerted and the time and duration of each alert. Other useful information would include, positions and heights of the aircraft at the start of the alert, the regions of airspace that each aircraft occupies, and if possible, an identification of whether the alert is wanted.

5.4.4 Warning Time Measures for STCA

Appendix A: reference STCA System describes the calculation of warning time for measuring STCA performance. This is quite a complex process requiring calculation of the point of risk, as well as an analysis of the situation to determine the maximum possible warning time.

As a simple alternative, it is often sufficient to compare the timing of the alerts between different runs (of the STCA model or the test STCA system). Although this will not give an absolute measure, it will provide a very useful comparative measure of the warning time performance, allowing the system to be optimised.

6. STCA SYSTEM MANAGEMENT AND TRAINING

6.1 Introduction

This chapter provides guidance to ANSPs in the operation and monitoring of STCA, and also in appropriate training.

6.2 Training for ATCOs

STCA-03 The ANSP shall ensure that all controllers are given specific STCA training, relevant to the STCA system that the controller will use.

The primary goal of the training is to develop and maintain an appropriate level of trust in STCA, i.e. to make controllers aware of the likely situations where STCA will be effective and, more importantly, situations in which STCA will not be so effective (e.g. sudden, unexpected manoeuvres).

Training should include, amongst other things:

- How STCA detects conflicts (indicating the main features of the STCA filters)
- Which aircraft are eligible for STCA
- The volumes of airspace in which STCA is active, and differences in performance in various parts of airspace
- How STCA alerts are displayed and acknowledged
- How STCA performs in various situations (play back of STCA situations helps here)
- What action to take in the event of an alert
- What action to take in the case that STCA is not available
- Procedures for feedback of STCA performance (this helps further optimisation)

Controller training on STCA should be given before using the operational STCA system, and again after significant changes to the system.

A number of tools, such as ATC test partitions, ATC simulators, STCA models or various types of situation replay media (e.g. video) are all relevant, and may be used to show example situations to controllers.

6.3 Skill Development for Engineers / Operational Analysts

In this context engineers are the operational analysts responsible for the setting up, optimisation and maintenance of the STCA system.

Most importantly, engineers should understand how their STCA system works; requiring that they become familiar with their STCA specification. If no specification is immediately available, then the manufacturer should be able to supply one.

Some description of algorithms is essential for teaching new technical staff about the STCA system. Therefore, if the specification is of poor quality, or is not available from the manufacturer, then it may be necessary for an engineer to examine the source code, and to precisely document the STCA algorithms.

Engineers should then be provided with the tools and take time to become skilled in STCA alert analysis and parameter optimisation.

It is a useful exercise to collect and analyse all STCA alert situations, not only to aid parameter tuning, but to provide informative examples than can be shown to engineers, ATCOs and other staff.

The more the engineer analyses alerts, the more the engineer will understand the specification, and how the STCA parameters affect performance.

It is a useful exercise to compare the specific STCA system with the reference STCA System in *appendix A*, and furthermore *appendix A* provides detailed advice on parameter setting, and optimisation.

6.4 Analysis of Pilot/ATCO reports

It is good practice to analyse performance STCA for all reported incidents and safety significant events. The analysis of individual situations can help the user to choose suitable parameters and identify potential improvements to the STCA algorithms.

Furthermore, it is useful to keep as large a sample as possible of historical incidents for parameter optimisation.

6.5 Monitoring of STCA Performance

It is good practice to analyse all safety significant events regardless of whether they result in an STCA alert. During an analysis of such events, STCA parameters and regions (and if necessary, algorithms) should be carefully considered, since it may be that some changes to the STCA settings are identified that could potentially improve STCA performance. Nevertheless, any changes to the settings are best tested with an off-line STCA model before implementation in the operational system.

Monthly alert rate figures over the course of a year can help ensure that the alert rate stays within a tolerable level.

6.6 System Maintenance

STCA system regions and SSR code files should be updated to reflect changes in airspace and SSR code allocations, otherwise STCA performance is likely to gradually degrade. It may be necessary to update these files several times a year.

Regular parameter optimisation is recommended to ensure that the STCA performance improves rather than degrades following changes to airspace.

Note: Appendices are contained in separate documents.

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