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EUROCONTROL Guidance Material for Area Proximity Warning
Appendix D-1: Enhancement of APW for ATCC Semmerzake

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Abstract

ATCC Semmerzake is the Belgian Military ATC Unit. It is equipped with a modern ATC system that contains amongst others an APW application. However, there are a number of deficiencies in the APW system, which reduces its effectiveness as a safety net.

In February and March 2008, ATCC Semmerzake and EUROCONTROL, supported by QinetiQ and Deep Blue, collaborated to address these deficiencies.

This document describes the actions undertaken and the results achieved. It forms a Case Study in applying the guidance material that supports the EUROCONTROL Specification for APW, and as such is guidance material in its own right.

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FOREWORD

ATCC Semmerzake is the Belgian Military ATC Unit. It is equipped with a modern ATC system that contains, amongst other things, an APW application. However, there are a number of deficiencies in the APW system that reduces its effectiveness as a safety net.

In February and March 2008, ATCC Semmerzake and EUROCONTROL, supported by QinetiQ and Deep Blue, collaborated to address these deficiencies.

This document describes the actions undertaken and the results achieved. It forms a Case Study in applying the guidance material that supports the EUROCONTROL Specification for APW, and as such is guidance material in its own right.

Note however that specific solutions identified in the document should not be adopted without performing similar analysis to determine their applicability in the target environment.

1. INTRODUCTION

1.1 Overview of the Study

The APW system at ATCC Semmerzake is known locally as RAI – Restricted Area Intrusion. The function is embedded in the Semmerzake Radar Operating System, SEROSII, which went operational in 2003.

In this document the system is referred to by the more generic name – APW.

The APW function is in daily use by controllers at ATCC Semmerzake. However, it suffers from a number of deficiencies, some more problematic than others, which compromises the effectiveness of the alerts.

This report describes these deficiencies, the process that was carried out to identify the solutions and the resulting operational requirements.

1.2 Report Structure

The key elements of the current APW system are described in chapter 2 of this study.

The analysis method is described in chapter 3 and the results of the study are presented in chapter 4.

Conclusions are drawn in chapter 5, and recommendations are made in chapter 6.

Pictures that are too large to fit easily next to the relevant text can be found in chapter 7.

A list of abbreviations is included in chapter 8, and references in chapter 9.

2. APW AT ATCC SEMMERZAKE

2.1 Introduction

ATCC Semmerzake has participated in EUROCONTROL's SPIN task force since its conception in 2005 and it has been keen to share its experience of safety nets, and in particular the issues related to operating safety nets (in their case STCA, MSAW and APW) in a military environment.

The military operational environment is somewhat different to the civil environment in which APW and other safety nets are more often used. The particular issues described in this document will apply to a specific local environment to a lesser or greater degree.

Figure 7-1, Figure 7-2, Figure 7-3, and Figure 7-4 in chapter 7 show an outline map of Belgium and surrounding countries, and the predefined APW areas.

These areas are not necessarily permanently activated, but they are defined in the ATM system, ready to be activated when the specific airspace is in military use.

2.2 Overview of Alerting Function

In the current APW system, an alert is generated to the relevant controller for aircraft about to enter an APW area. If the alerting aircraft is under the controller's jurisdiction, the controller can remove the alert from the display by acknowledging it.

An APW alert is also generated on exit of an APW area, giving the controller a warning that the aircraft is leaving the specific military area, and rejoining the neighbouring civil airspace. Again, in this case, the controller responsible for the aircraft may acknowledge the alert.

2.3 Key APW Parameters

APW parameters are defined off-line, and modifiable by the user.

The key parameters in the APW system are those that control the prediction time for detection of conflicts. For entry to an APW area, the prediction time is currently set to 60 seconds. For exit, the prediction time is set to 0 seconds

2.4 Presentation of APW alerts

When an APW alert is generated, the letters "AS" are shown in the track data block.

At the controller working position and sector that has jurisdiction over the track, “AS” is shown in red, and the controller is able to acknowledge the alert by clicking on the “AS” text. See Figure 2-1 below.

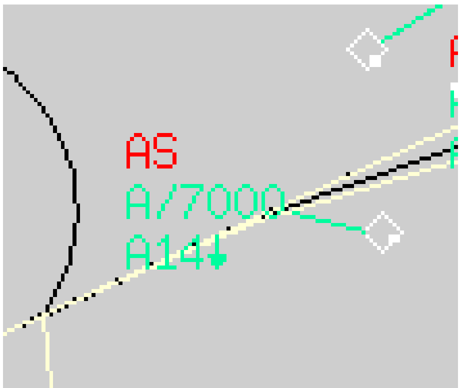

Figure 2-1 An APW alert on the situation display for the ATCO controlling the aircraft.

At other controller working positions the “AS” is shown in yellow, and the alert can not be acknowledged.

2.5 Control of APW

The APW function may be switched on/off at system level by the supervisory staff. It is their responsibility to make sure that the safety nets, including APW, are enabled during day-to-day operations. The controller can enable/disable the APW alerts at CWP level.

2.6 Use of track data

Surveillance tracks are used for conflict detection. Pressure altitude data and cleared flight levels are used when available to compute whether the track is in vertical conflict with an active APW area. If pressure altitude is not available for a track then the APW function considers that the aircraft may be anywhere from the ground upwards, and the conflict calculation is then only done in the horizontal dimension.

2.7 APW Areas and Volumes

There are two types of APW area in the system; Predefined (defined off-line) and temporary (defined on-line).

Each APW area (whether predefined or temporary) consists of up to nine individual volumes. Each volume is defined using polygons and arcs or cylinders with an upper and lower altitude.

Each APW area has an associated activation schedule, which is defined on-line, and controls when APW processing is executed for the area.

2.8 Presentation of APW Areas

When an APW becomes active, the boundary of the area is forced onto the situation display, along with a label for the area, called the APW label. See below.

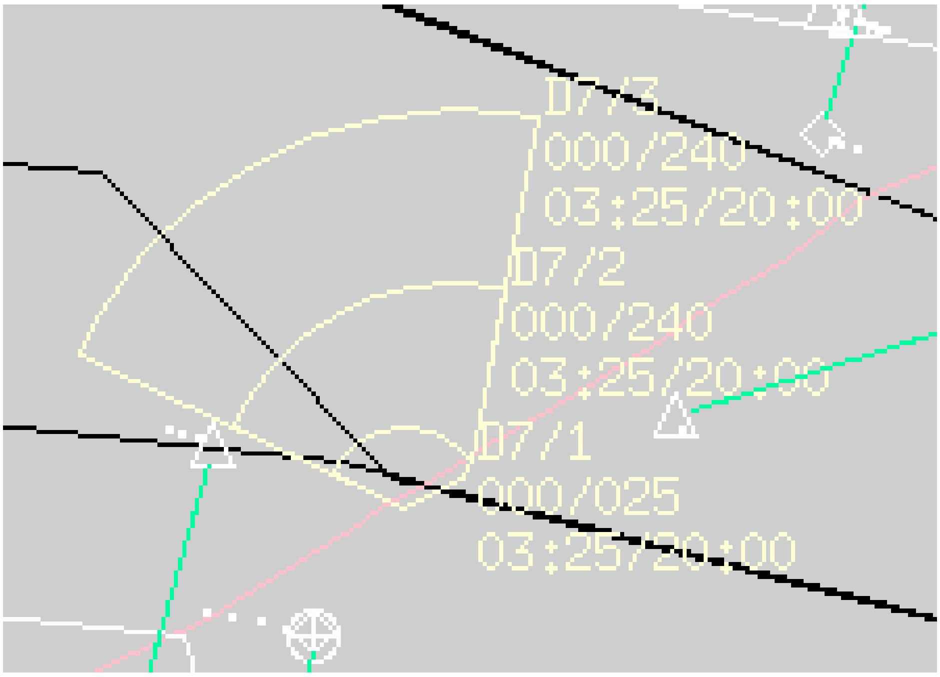

Figure 2-2 Three APW areas shown on the situation display

The APW area boundary is shown in eggshell white. The APW label is always drawn on the most easterly vertex of the shape. It comprises the name of the area, the lower and upper limits and the active time frame, in this example 3:25 to 20:00 for each APW area.

2.9 The Operational Environment

The APW areas define the volumes of airspace that are reserved for military operations, including prohibited/danger areas (such as gunnery and bombing areas) and Temporary Segregated Areas (TSAs).

Each morning, before the flying window, a representative of the Aeronautical Information Services (AIS) enters activation time blocks for the predefined and temporary APW areas for that day, based on the booking made in the airspace management program (AMPII) and received NOTAMs.

If areas are booked or cancelled during the day, then the supervisor must modify the appropriate activation time schedules.

2.10 Deficiencies with the APW function

In broad terms, the APW function suffers from deficiencies in three areas.

- Unnecessary or nuisance alerts
- The controllers' HMI
- Management of time schedules

The deficiencies are described in detail in chapter 4.

3. ANALYSIS METHOD

This chapter describes the brainstorming process that was used to identify deficiencies in the APW system as well as potential solutions. The specific problems and identified solutions are described in detail in chapter 4.

The main part of this study was undertaken on the ATCC Semmerzake site, with the invaluable assistance of staff at the control centre.

The analysis that was undertaken resulted in a capture of requirements for an improved APW system. In essence, effort was made to understand the deficiencies with the current APW system, and through brainstorming operational requirements were derived for the APW system.

The steps involved were:

- Nomination of the team
- Dissemination of material
- Understanding of deficiencies
- Examination of the operational HMI
- Brainstorming of solutions

3.1 Nomination of the Team

The team that was to participate in the brainstorming sessions was nominated.

The team consisted of specialists covering the various areas of expertise:

- Two operational experts from ATCC Semmerzake
- A technical expert in the safety nets domain
- A safety and human factors expert playing the role of facilitator

The number of people and expertise of the participants was ideal for this exercise because brainstorming sessions involving more than seven participants risk being insufficiently focussed.

Although the inclusion of a safety expert was not absolutely critical to the discussions, it was useful to have a participant who could address any safety issues.

3.2 Dissemination of Material

Before the participants met for the brainstorming meeting, material on the APW function and the operational environment was distributed to the team.

This material comprised:

- A technical description of the APW system
- A description of the HMI
- A description of the operational use of APW
- An overview of some of the known deficiencies

The technical and operational description that was provided was very similar in scope to chapter two of this report, except at a finer level of detail. This information was invaluable, allowing all participants in the brainstorming sessions to rapidly grasp the basic functionality of the APW function as well as the operational environment.

The HMI was described in words and pictures, showing amongst other things, the presentation of APW alerts, APW area creation/editing and activation windows, and the presentation of the APW areas on the situation display.

The descriptions of the known deficiencies were also particularly useful, since these allowed the problems to be considered before the brainstorming sessions began.

3.3 Understanding of the Deficiencies

The team met in ATCC Semmerzake premises. The first objective was to obtain a clear understanding of the deficiencies in the current APW system. This relied very much on the experience of the local operational experts, who described the problems to the technical and safety experts in the team.

Many of the shortcomings were reasonably easy to understand, such as those related to the alerting behaviour and the use of activation time schedules.

However, other deficiencies related to display aspects and HMI. For these, it proved beneficial to witness the deficiencies on the actual operational system.

3.4 Examination of the operational HMI

The team proceeded into the operational control room, where fortunately it was possible to interact with the HMI without affecting ATC operations.

Problems related the display of APW boundaries and labels were demonstrated, and some possible solutions were discussed.

3.5 Brainstorming of Solutions

The final session involved brainstorming. Each of the deficiencies was discussed in detail and brainstorming carried out to arrive at requirements for an enhanced APW system.

It was imperative that each deficiency and potential solution was analysed from an operational perspective. For example, if a proposed solution was technically feasible, yet would have a less than desirable effect on operations, then the solution was readily dropped.

Nevertheless, some of the proposed enhancements were born out of technical considerations. It was found that technical solutions applied in other safety nets (STCA and MSAW) would be likely to have a positive impact on APW performance. These enhancements include suppression of nuisance alerts, detection of formation flights and flexible parameterisation.

Finally, each deficiency and proposed solution was categorised as “short term”, “medium/long term” and “longer term”, depending on the technical complexity of the proposed solution.

4. DEFICIENCIES AND SOLUTIONS

The deficiencies are presented here together with the proposed solution(s), starting with the “short term” solutions first.

4.1 Short Term Solutions

4.1.1 Basic Alerting Behaviour for OAT and GAT

Currently, the APW system alerts for all aircraft tracks regardless of flight status (assumed by the controller or not) and SSR code. Furthermore, the system alerts on predicted entry into an APW area as well as on exit.

The result is that too many alerts are addressed to controllers who are not working the aircraft. These appear on the screen with a yellow “AS” symbol. These are unnecessary alerts that the controller cannot acknowledge.

The general principle of alerting on entry and exit of an area is sound, since the controller would wish to know when a military aircraft is about to enter civil airspace (i.e. exit an APW area). However, since GAT flights are not authorised to proceed into restricted airspace in the first place, a second alert on exit of an APW area is unnecessary for these types of flight.

The requirements are:

Requirement 1-1:

For GAT flights, alerts shall only be generated on predicted entry into an APW area.

Requirement 1-2:

For OAT flights, alerts shall be generated on predicted entry into and exit from an area, but in both cases only if a controller has assumed control of them.

Requirement 1-3:

Alerts for OAT flights shall be suppressed automatically after entry and exit as defined by off-line parameters (e.g. 20s after entry, 10s after exit).

Requirement 1-4:

For all flights, the controller shall be able to acknowledge the alert if it is in his sector.

4.1.2 Presentation of APW Maps and Labels

Currently, the polygons that define the APW areas are stored in SEROS II as selectable objects of two different types: APW areas and TSA maps.

The APW area is automatically drawn on the screen in eggshell white when it becomes active. On the other hand, the controller is able to manually select TSA maps for display, which are shown in pink.

Unfortunately, if a TSA map is displayed, it overrides the corresponding APW area, hiding the APW area boundary – the area will go pink. This behaviour means that if a controller is already displaying the TSA map for an APW area on his screen, there is no visual cue when the APW area activates or deactivates.

Furthermore, the APW label is always drawn at the most easterly corner of the defined shape. Because some of the polygons share the same co-ordinates, this leads to the overlapping of APW labels, which are then unreadable.

The requirements are:

Requirement 2-1:

When an APW area is on the screen, the APW area characteristics (colour and line style) shall have priority over any overlapping TSA maps.

Requirement 2-2:

The APW label position shall be definable by the user (off-line for predefined areas, and on-line for temporary areas).

Requirement 2-3:

The controller shall be able to remove an APW label by a mouse click, or drag it to another location, using the mouse.

4.1.3 Pre-activation / pre-deactivation of APW areas

Currently, the APW areas change between the active and non-active state with no visual pre-warning for the controller. The APW area simply appears on the screen when it becomes active, and automatically disappears on de-activation.

The requirements are:

Requirement 3-1:

The system shall support each APW area being in one of four states; pre-activation, active, pre-deactivation, inactive.

Requirement 3-2:

In the pre-activation state the APW area shall be shown with a dashed border, and the APW label shall be shown.

[Note requirement 2-1: The APW area overrides any overlapping TSA maps].

Requirement 3-3:

In the active state the APW area border shall become solid.

Requirement 3-4:

In the pre-deactivation state the APW area border shall change to a "pre-deactivation" colour and the APW label shall appear in the "pre-deactivation" colour.

Requirement 3-5:

In the deactivation state the APW area and APW label shall be removed from the display.

Requirement 3-6:

The pre-activation and pre-deactivation times shall be defined off-line by parameters.

4.1.4 Improvements to the APW activation time schedule

The APW activation time schedule window is shown in Figure 4-1 below:

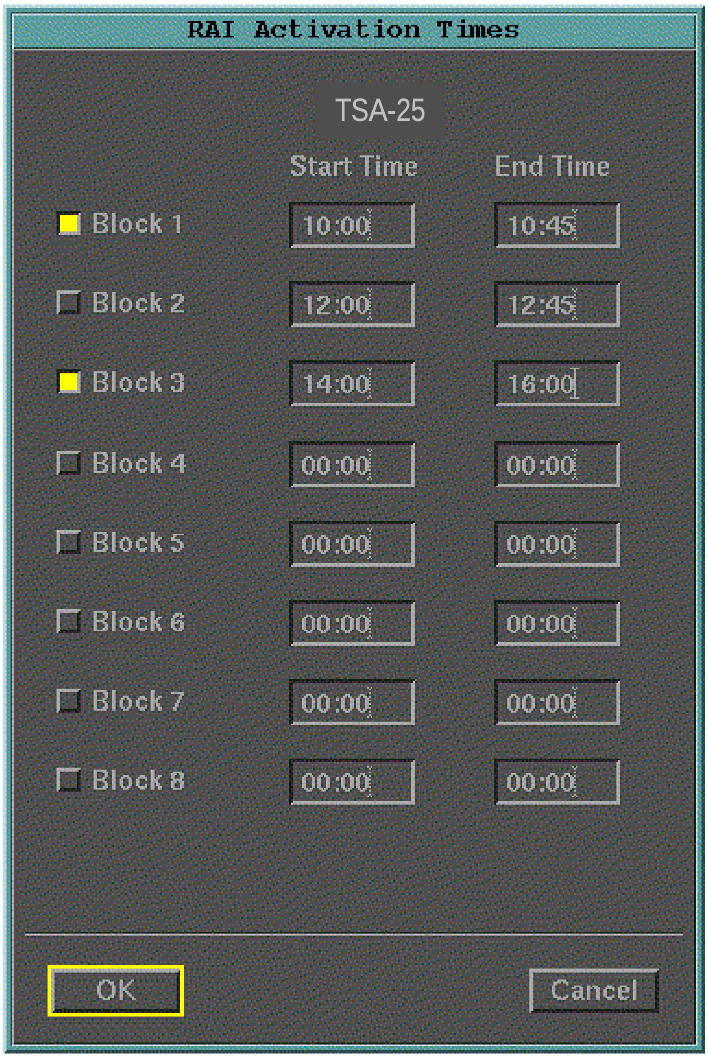

Figure 4-1 APW activation time schedule window

The supervisor sets up the time blocks in the morning, and will update this window during the day as required for each APW area.

The number of time blocks that can be defined is limited to eight. Unfortunately, this is not always sufficient, which means that sometimes the time blocks have to be re-programmed in the middle of the day. Furthermore, the time schedule can not be set to carry over into the next day, so new time schedules have to be input each morning.

In summary, the capabilities and capacities of time schedules must be enhanced.

The requirements are:

Requirement 4-1:

The SEROSII system shall allow the activation time schedule for each APW area to be defined by up to twenty time blocks.

Requirement 4-2:

The SEROSII system shall allow the user to specify dates as part of the activation time schedule.

4.1.5 Suppression of Nuisance Alerts

Inevitably there are a small number of situations, where an alert is generated even though the aircraft is not going to proceed into the area. These nuisance alerts are a distraction for the controller. As in all safety nets, it is important that the nuisance alert rate is reduced in order to enhance controllers trust in the generated alerts.

When examined, some of these nuisance alert situations would be predicted to clip the corner or edge of an APW area. So, the desired capability is for no APW alert to be generated if the aircraft is predicted to clip the APW area.

The requirements are:

Requirement 5-1:

The APW conflict detection algorithm shall check to see how long the aircraft is predicted to remain inside an APW area after initial entry.

Requirement 5-2:

If the aircraft is predicted to be outside all APW areas a parameterised time after predicted initial entry into an APW area, then no alert shall be generated.

See Figure 4-2 below for clarification:

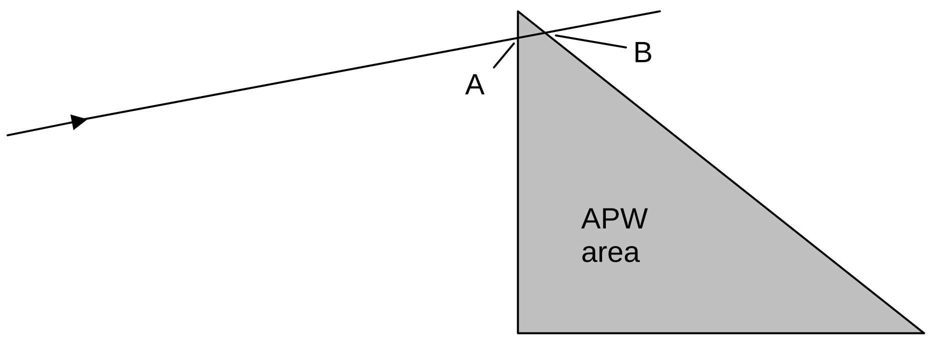

Figure 4-2 Example situation where an aircraft is predicted to clip an APW area

In the example above the aircraft is predicted to enter the APW area at point A, and to exit at point B.

If the time between point A and B is less than a parameterised time, it is assumed that the aircraft will just clip the area and no alert is raised on this processing cycle. This is permissible if the buffer zone around the area is larger than the worst case penetration of the APW area within the parameterised time.

4.2 Medium/long Term Solutions

4.2.1 Integration with AMP/LARA

In current operational practice, airspace is reserved for military operations by using an airspace booking system known as Airspace Management Program, or AMPII.

Unfortunately, the required exchange of airspace data between AMPII and SEROSII is not present. This means that the same time schedules have to be input into the SEROSII system by the supervisor in order for APW to function correctly.

This procedure is time consuming, as well as prone to error.

In the framework of Flexible Use of Airspace (FUA) and Functional Airspace Blocks (FAB), a new tool is being developed by EUROCONTROL, called LARA (Local and Regional Airspace Management). ATCC Semmerzake intend the replace AMPII with LARA.

The requirements are:

Requirement 6-1:

SEROSII shall receive appropriate data to allow the automatic set up of APW time schedules from the Airspace Management tool.

Requirement 6-2:

SEROSII shall make use of the data from the Airspace Management tool and update the time schedules automatically.

4.2.2 Treatment of Formation Flights

Formation flights can be problematic for a number of reasons:

- They tend to induce split (false) tracks
- There are a lot of nuisance STCA alerts between the leader and wingmen in the formation
- When entering and exiting an APW area, the wingmen trigger an APW alert. An alert is really only necessary for the leader.

In a previous study of STCA in the military environment (reference 1), algorithms were developed which detected aircraft flying in military formation, and suppressed these from alerting in STCA.

It was considered that these algorithms could be easily adapted to identify the leader and wingmen in a formation and to prevent APW alerts being generated for the wingmen.

The military formation detection algorithms are most easily applied to pairs of aircraft, such as those that are considered in STCA. Therefore, rather than implement a military formation detection algorithm in APW, it was proposed to adapt the algorithm designed for STCA so that it would identify the leader and the wingman, and then make this information available to APW.

The requirements are:

Requirement 7-1:

STCA formation flight detection logic shall identify the leader and the wingman in a pair of aircraft, for use outside of the STCA function.

Requirement 7-2:

APW shall make use of the leader and wingman identifications to suppress APW alerts for wingmen.

4.3 Longer Term Solution

4.3.1 Flexible Parameterisation of APW Areas

During the course of the brainstorming session, thought was given to how an APW system would be designed if one were given a blank slate.

There were several arguments that led the brainstorming team to conclude that a future APW system should allow much more flexible parameterisation of the individual APW areas. These were:

- The wider application of Flexible Use of Airspace (FUA)
- Various types of activity may be undertaken in APW areas, such as aerobatics, gunnery, bombing etc. These present varying amounts of danger to infringing aircraft.
- The nominal distances between civil traffic and an APW area can vary, as well as the traffic patterns. This means that the most appropriate parameter tuning (look-ahead time) for each area may be different.
- In principle APW should be configurable to alert not only when an unauthorised aircraft enters a prohibited area, but also on exit of the area, or when a civil aircraft is about to leave controlled airspace. Flexible configuration of entry/exit alerts for different types of flight would be desirable.
- Currently, aircraft without pressure altitude are treated as though they could be in any vertical position from the ground upwards. With this assumption, high level TSAs may have an unjustifiable number of nuisance alerts. Therefore, it is desirable to allow flexibility in the assumption that is made for each APW area.
- Controllers may want a varying amount of warning of activation (pre-activation time) and deactivation (pre-deactivation time) depending on the APW area.

Requirement 8-1:

For each APW area the user shall be able to define:

- *Up to nine volumes as polygons or cylinders*
- *A default timetable to apply if an operational one is not provided.*
- *A list of selected SSR codes*
- *Display of alerts on entry [None, Warning or Alert]*
- *Display of alerts on exit [None, Warning or Alert]*

- *Eligibility criteria for entry, based on a combination of:*
    - *“Assumed” status (from the flight plan)*
    - *GAT/OAT (from the flight plan)*
    - *SSR code requirement with respect to the SSR code list*
- *Eligibility criteria for exit, based on a combination of:*
    - *“Assumed” status (from the flight plan)*
    - *GAT/OAT (from the flight plan)*
    - *SSR code requirement with respect to the SSR code list*
- *The assumption to be made in the absence of pressure altitude [defined height band, no APW processing]*
- *The applied prediction time and other parameters related to conflict criteria*
- *Activation pre-warning time*
- *Deactivation pre-warning time*

5. CONCLUSIONS

5.1 The Method

The method used in this study was essentially brainstorming.

The study demonstrates that the brainstorming sessions were an effective way to arrive at meaningful requirements.

Furthermore, it demonstrates the importance of access to:

- High quality preparatory information
- Relevant equipment, such as the controller working positions
- Expert participants, including operational and technical experts
- A person playing the role of facilitator

It is recommended that the brainstorming session is facilitated by a person having a third party role with respect to operational and technical expert representatives. This helps ensure that all the relevant points of view are considered and that the resulting output is not biased towards one participant.

When available, the role of facilitator may be played by a safety expert. This is desirable for two reasons. Firstly, the safety expert makes sure that the most important safety issues are considered when new ideas or solutions are proposed.

Secondly, a number of safety activities, such as a Functional Hazard Assessment (FHA), are normally required after a significant change to the system. When conducting these activities, the safety expert will already be aware of the most relevant domain issues discussed during the brainstorming, thus saving valuable time and resources.

5.2 The Results

The main output of this study is a set of 22 operational requirements for an enhanced APW system for ATCC Semmerzake. These are presented in chapter 4.

It should be noted that specific solutions identified in this study should not be adopted by other ANSPs without first performing a similar analysis to determine their applicability in the target environment.

5.3 Further Requirements

EUROCONTROL Guidance material for APW (reference 2) suggests that various other techniques for requirements capture may be used, including product research and system modelling. In this case, it is considered that most of these techniques would probably not provide significant information or lead to new requirements.

However, it is anticipated that further requirements might be derived by using other techniques, such as:

- Interviews with ATCOs
- Hazard Analysis

In these cases, an experienced interviewer or a specialist in hazard analysis can best lead the exercises.

6. RECOMMENDATIONS

It is recommended that ATCC Semmerzake should seek to ensure that all the operational requirements for APW have been captured.

It is considered that the proposed changes to the HMI will affect the way controllers work, and therefore it would be worthwhile consulting a small group of ATCOs on the proposed changes.

Further, since it is intended to change the essential alerting behaviour of APW, a functional hazard analysis of the proposed system may reveal some additional requirements. A functional hazard analysis should, if possible, be led by a safety expert.

Once all the requirements are gathered, the next step will be to check each one for completeness and consistency. The current grouping of the requirements may be retained, or if appropriate another grouping system could be used.

It will also be useful to rank each requirement for importance, since it may be that some requirements will need to be removed at a later date for financial, or other practical reasons.

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

This is a living document. It should be expected that 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.

7. PICTURES

Figure 7-1 Picture showing the predefined APW areas (in yellow)

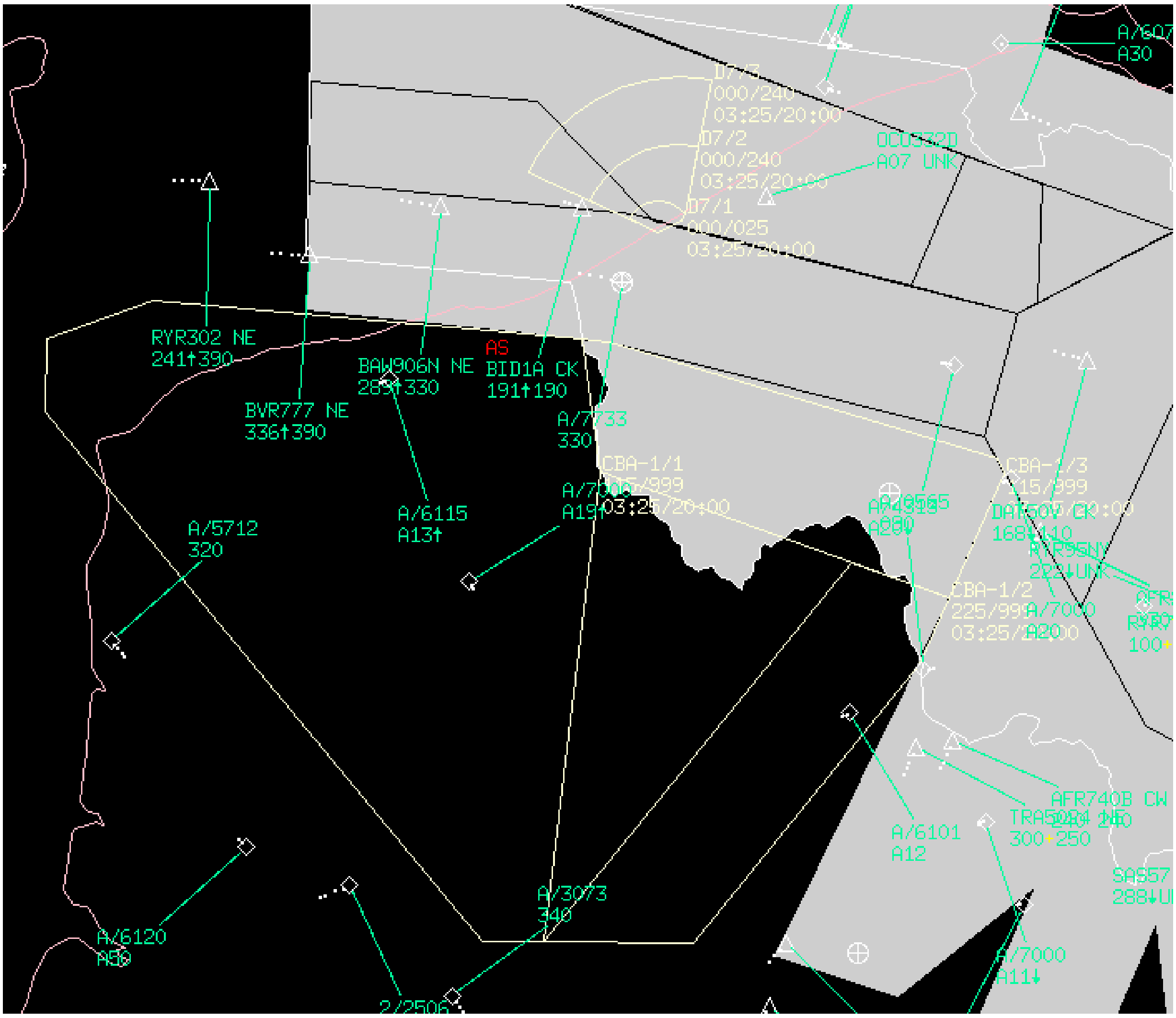

Figure 7-2 Picture showing the predefined APW areas (in yellow), zoomed in on the West

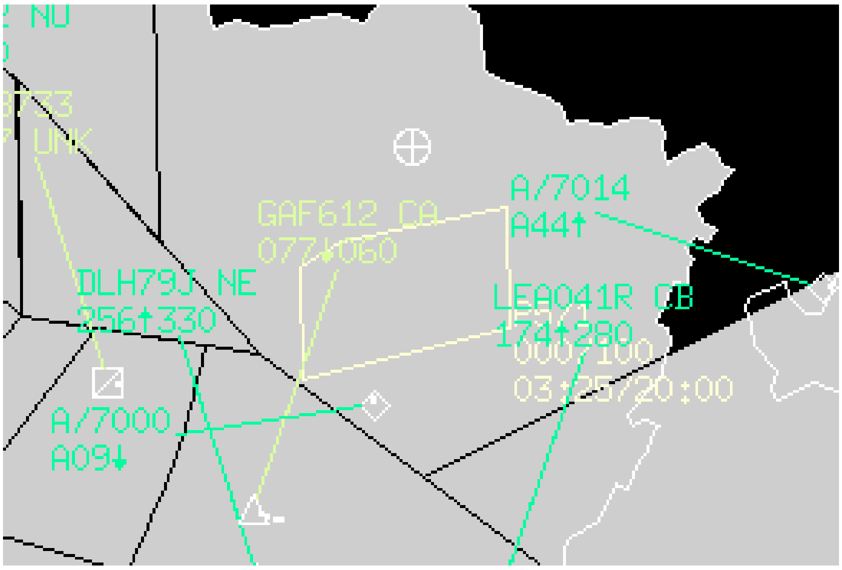

Figure 7-3 Picture showing the predefined APW areas (in yellow), zoomed in on the North East

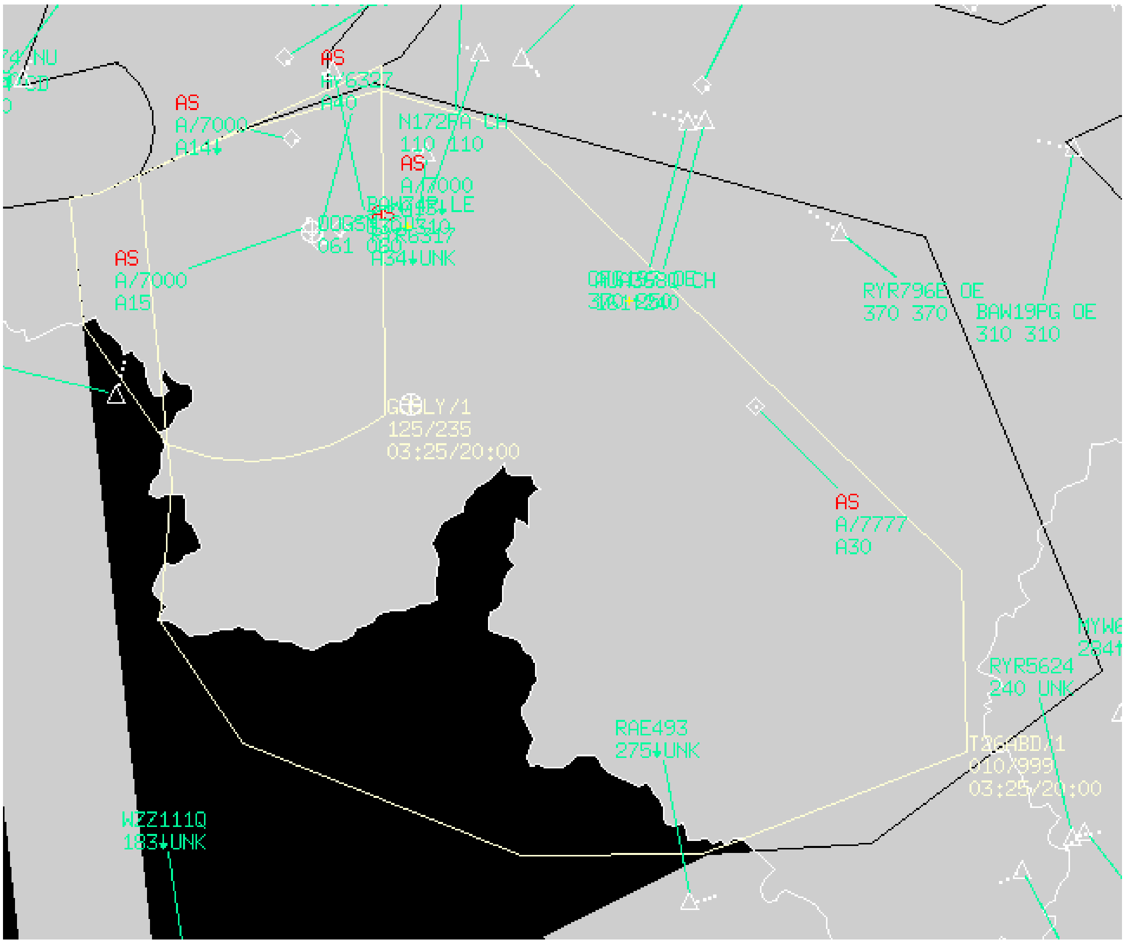

Figure 7-4 Picture showing the predefined APW areas (in yellow), zoomed in on the South East

8. LIST OF ABBREVIATIONS

AIS	Aeronautical Information Services
AMP	Airspace Management Program
APW	Area Proximity Warning
FAB	Functional Airspace Blocks
FUA	Flexible Use of Airspace
GAT	General Air Traffic
HMI	Human Machine Interface
MSAW	Minimum Safe Altitude Warning
NOTAM	Notice To Airmen
OAT	Operational Air Traffic
RAI	Restricted Area Intrusion
SEROS	Semmerzake Radar Operating System
SPIN	Safety nets: Performance, Implementation and eNhancements
STCA	Short Term Conflict Alert
TSA	Temporary Segregated Area

9. REFERENCES

1. EUROCONTROL Guidance Material for Short Term Conflict Alert Appendix D-1: Optimisation of STCA for ATCC Semmerzake
2. EUROCONTROL Guidance Material for Area Proximity Warning

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