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The EUROCONTROL SURVEILLANCE STRATEGY

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Abstract - This paper presents the EUROCONTROL Surveillance Strategy, comprising 3 pillars of surveillance: Primary Surveillance Radar together with Co-operative Independent systems; i.e. Mode S, Multilateration and Co-operative Dependent system; i.e. Automatic Dependent Surveillance-Broadcast. The current Surveillance Standard requires, for en-route and Terminal Manoeuvring Areas, two independent layers of surveillance to satisfy the necessary safety arguments. However, which surveillance options are chosen is left to individual States or Service Provider choice, based on economic or geographic considerations. The paper also presents the European Commission Implementing Rule for Surveillance Performance and Interoperability.

Keywords: Surveillance, ADS-B, Multilateration.

I. INTRODUCTION

This paper introduces the EUROCONTROL Air Traffic Management Surveillance Strategy for ECAC [1]. The Strategy has been developed by the EUROCONTROL Surveillance Division in cooperation with its stakeholder forum, the Surveillance Team.

The objective of the Surveillance Strategy is to define an evolutionary path for surveillance which promotes safety, security, interoperability and cost effectiveness of the infrastructure to enable the future Air Traffic Management (ATM) concepts in a timely manner. It has been developed in cooperation with stakeholders to agree the future direction of the surveillance infrastructure within the European Civil Aviation Conference (ECAC) area, for both the ground and the airframe components. A goal of the Surveillance Strategy is a seamless surveillance infrastructure that will permit an aircraft to fly throughout ECAC airspace in an interoperable, cost effective manner.

The current Surveillance Strategy is presented in four steps, namely:
Until 2010;
From 2010 to 2015;
From 2015 to 2020;
From 2020 onwards;

The Surveillance Strategy recognizes that the ATM community is extremely safety conscious. Therefore it presents a set of 'evolutionary' rather than 'revolutionary' changes, encouraging a gradual transition from the current Surveillance infrastructure to a future infrastructure comprising:

- Independent Cooperative Surveillance (Classical SSR and/or SSR Mode-S and/or Wide Area Multilateration {WAM}).
- Dependent Cooperative Surveillance (ADS-B);
- Independent Non Cooperative Surveillance (PSR or equivalent), where required.
- The Surveillance Strategy provides a link between the ICAO operational concept [2], future ATM concepts as defined in the EUROCONTROL Air Traffic Management Strategy for the Years 2000+ [3] and regional strategies (such as national strategies).

The ATM Surveillance Strategy provides:

- A link between the EUROCONTROL Operational Strategy [3] and surveillance specific aspects;
- Guidance to stakeholders for local surveillance implementation;
- Guidance to EUROCONTROL for their activities;
- Guidance to the aeronautics industry for product development.

A key driver for the Surveillance Strategy is to provide the 'glue' between the EUROCONTROL Operational Strategy [3] and other strategies to ensure interoperability both from

the air/ground perspective and across national borders, as illustrated in Figure 1.

In due course the SESAR Master Plan will become the new defining document and the Surveillance Strategy will be updated to be totally aligned with the Master Plan timeline (mid 2009).

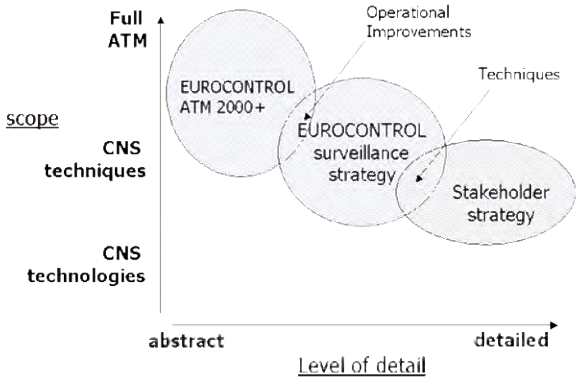

Figure 1 - Relationship between the ATM Surveillance Strategy and other strategies

Safety and Security are two of the key drivers within Air Traffic Management, no systems shall be allowed to be operated which are not considered 'safe'. It is the responsibility of all stakeholders; Air Navigation Service Providers (ANSPs), airlines and the aeronautics industry to meet their safety and security requirements (e.g. availability or reliability).

The Surveillance Strategy document directs the standardisation activities necessary to implement the strategy. These activities include:

- Application Standards (e.g. Safety/Performance Interoperability Requirements from EUROCAE, supported by groups such as the Requirement Focus Group (RFG) with key roles from EUROCONTROL and FAA);
- Equipment specifications, MASPS and MOPS, from EUROCAE;
- EUROCONTROL formal standardisation activities; (e.g. ASTERIX)
- SARPS (e.g. ICAO).
- European Commission Surveillance Performance and Interoperability Implementing Rule (SPI IR).

The dates illustrated in the ATM Surveillance Strategy define when surveillance systems are expected to become operational 'on a widespread basis'. This means that the document defines strategies that apply to large areas of ECAC (typically expressed in terms of, for example, 'Core Europe'). It is anticipated that some of the surveillance systems described in this strategy will be used on a 'local' basis, prior to the timescales in this document and thereby supports the operational roll-out from pioneer areas into widespread use.

II. STRATEGY FROM TODAY TO 2010

En-Route and TMA

Non Co-operative Independent Surveillance in the form of Primary Surveillance Radar is widely used within ECAC by Air Traffic Management for Approach and TMA surveillance. In some regional areas, Primary Surveillance Radar has been implemented to provide En-Route coverage, based on local requirements;
Co-operative Surveillance, in the form of SSR or SSR Mode-S, is still the principal means of surveillance in 2010 and is extensively used for air traffic surveillance by civil and military agencies. In particular, SSR is widely used operationally in ECAC for TMA and En-Route services, SSR Mode-S Elementary Surveillance has been implemented in the core area of Europe and SSR Mode-S Enhanced Surveillance has been implemented in parts of the core area of Europe.
Limited operational use of WAM has taken place in ECAC as a cost effective alternative to SSR (Mode-S).
Greater operational use of Air Derived Data (ADD) obtained via the surveillance infrastructure has been gradually introduced and delivered in the core area of Europe through Mode-S Enhanced Surveillance or through WAM. Limited, local pockets of ADS-B implementation (for ground based surveillance applications) have taken place based on SSR Mode-S Extended Squitter or (locally) based on VDL Mode 4. ADS Contract (ADS-C) is used to supply information over the oceanic regions.
Surveillance Data Processing and Distribution systems (SDPD) based on radar server technology are now widely implemented. The SDPD uses ADD to improve track quality and also distributes ADD with the track message. The SDPD has the capability to process multi-sensor position information derived from SSR (Mode-S), WAM and ADS-B.
There is increasing surveillance data sharing using IP v6 (e.g. through Radar Networks and civil/military exchanges).

Aerodrome Operations

The enabling technology for calculating the position of mobiles (both aircraft and vehicles) is the Surface Movement Radar (primary) and Airport Multilateration using SSR (Mode-S) transponder replies and Mode-S Extended Squitter messages. Active Mode-S interrogation of the avionics and a limited use of ADS-B (via Mode-S Extended Squitter) are also used to deliver aircraft identification to the ground controller. Airport vehicles may be equipped with broadcast surveillance squitter transmitters.
Advanced Surface Monitoring and Ground Control Systems (A-SMGCS Level I and II) will provide the benefits at the aerodrome. With the gradual introduction of Arrival Manager and Departure Manager functions, additional information (e.g. ADD) may be required by the ground systems.
Airport SDPD is implemented providing ground controllers

with an improved airport situation picture. Although many Airport Multilateration systems are configured with their own data fusion trackers as standard, a possible upgrade to existing SDPDs to support Aerodrome operations, is foreseen.

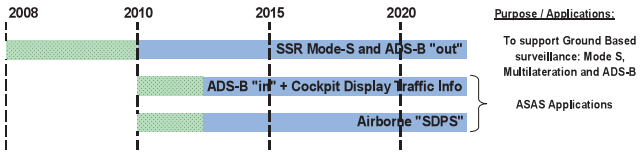

Figure 2 – Airborne Surveillance Strategy

Aircraft systems

In accordance with ICAO requirements, all aircraft flying within ECAC controlled airspace are required to be equipped with a pressure altitude reporting device. The majority of aircraft are fitted with a SSR Mode-S transponder.
If aircraft are operating in airspace where ADS-B ground based surveillance applications are in use, then the avionics configuration will require certificated 1090 MHz Extended Squitter equipage to deliver the Aircraft positional data.
If ADS-B is mandated then aircraft flying in such airspace need to be adapted to accommodate this technology.
Otherwise, it is not foreseen that there will be significant changes for aircraft systems prior to 2010. (See Figure 2)

III. STRATEGY FROM 2010 TO 2015

The ATM Surveillance Strategy from 2010 to 2015 is based on the continued need for the ground system to monitor targets and the need for the aircrew to have a traffic situation picture in the cockpit.

En-Route and TMA

It is predicted that by 2015 some SSR and SSR Mode-S systems may be approaching the end of their operational life and might be considered for replacement by other (mature) surveillance techniques. Therefore the ATM Surveillance Strategy for the ground system is to:

- Maintain an independent surveillance system (PSR or other means not relying upon the aircraft avionics) where required;
- Maintain a cooperative independent surveillance system like WAM or SSR Mode-S, as appropriate, including the delivery of ADD to ground systems. Monopulse SSRs are foreseen to be replaced by SSR Mode S in this timeframe;
- Deploy dependent cooperative surveillance based on ADS-B (using 1090 MHz Extended Squitter);
- Upgrade the SDPD to use the additional ADD in the tracking process;
- Upgrade the ground communications infrastructure to distribute additional surveillance information;
- ADS-C continues to be used in remote or oceanic areas.

Aerodrome Operations

At appropriate airports the ATM Surveillance Strategy is:

- The continued development of A-SMGCS level I and II enabled by Surface Movement Radar (SMR) and Airport Multilateration;
- To implement an ADS-B sensor infrastructure (alone or combined with Multilateration) required to support airport applications and the ADS-B-APT application;
- The arrival of aerodrome ground based surveillance systems will provide a correct and reliable situation picture to pilots and drivers.
- To upgrade the airport Surveillance Data Processing to deal with multi sensor data and to store and forward additional ADD (in particular to the Flight Data Processing and Safety Nets);

Aircraft systems

The ATM Surveillance Strategy for the aircraft component is:

- Mode-S transponders are expected to be widely implemented to provide Mode-S Elementary and Enhanced Surveillance including ADS-B “out” (1090 Extended Squitter);
- To develop ADS-B “in”, to provide the aircrew with a complete and reliable situation picture in support of ASAS (Airborne Situation Awareness and Spacing) applications and advanced A-SMGCS;
- To implement an airborne Surveillance Data Processing System (SDPS) to integrate ADS-B “in” for presentation of the air situation picture on a graphical display to the aircrew in the cockpit.

IV. STRATEGY FROM 2015 TO 2020

The ATM Surveillance Strategy from 2015 to 2020 is based on the continued need for the ground system to monitor targets and the need for aircrew to have an enhanced traffic situation picture in the cockpit.

En-Route and TMA

Non Co-operative Independent Surveillance in the form of Primary Surveillance Radar remains widely used.
It is predicted that by 2020 the majority of the SSR and SSR

Mode-S systems currently installed have reached the end of their operational life and will require replacement by other (mature) surveillance techniques. Therefore the ATM Surveillance Strategy for the ground system is to:

- Maintain an independent surveillance system (PSR or other means not relying upon the aircraft avionics) where required;
- Maintain a cooperative independent surveillance system like WAM or SSR Mode-S, as appropriate, including the delivery of ADD to ground systems;
- Deploy dependent cooperative surveillance based on ADS-B (using 1090 MHz Extended Squitter, including the delivery of ADD to ground systems);
- Upgrade the ground communications infrastructure to distribute additional surveillance information as necessary;
- ADS-C continues to be used in remote or oceanic areas.

(See Figure 3).

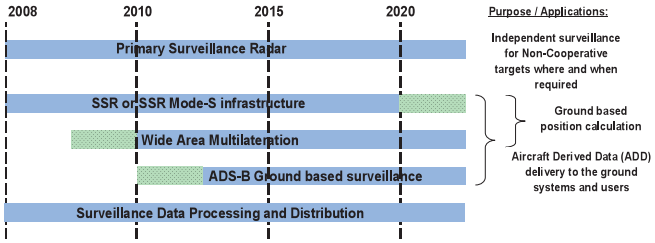

Figure 3 – Ground based infrastructure for En-Route and TMA

Aerodrome Operations

At appropriate airports the ATM Surveillance Strategy, as shown in Figure 4 is:

- The continued deployment of A-SMGCS enabled by SMR and Airport Multilateration;
- To continue the implementation of Airport Multilateration or ADS-B sensor infrastructure to receive ADD for airport applications and the ADS-B-APT application;
- To continue the implementation of A-SMGCS Level III and IV (which will include the ATSA-SURF application). The impact on the advanced aerodrome ground based surveillance systems will be to provide a correct and reliable situation picture to pilots and drivers.
- To upgrade the airport SDPD to store and forward additional ADD.

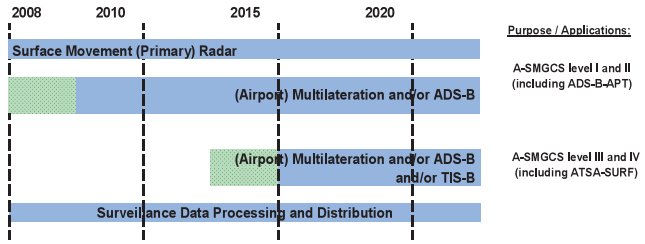

Figure 4 – Surveillance Strategy at the Aerodrome

Aircraft systems

The ATM Surveillance Strategy for aircraft systems is:

- Mode-S transponders are expected to be widely implemented to provide Mode-S Elementary and Enhanced Surveillance and ADS-B "out" (1090 Extended Squitter);
- To develop ADS-B "in", to provide the aircrew with a complete and reliable situation picture in support of ASAS (Situation awareness, Spacing and Separation) applications and A-SMGCS Level III/IV;
- To implement an airborne Surveillance Data Processing System (SDPS) to integrate ADS-B "in" for presentation of the air situation picture in the cockpit.
- To implement ASAS Separation tools.

V. STRATEGY FROM 2020 ONWARDS

Beyond 2020 it is anticipated that new forms of Non Co-operative Independent Surveillance will be provided by alternative techniques other than the current high powered, rotating Primary Radars. Investigations are already underway regarding passive surveillance and Multi Static Radars. Working along similar lines to Multilateration, these new systems should offer a cost effective replacement for the future.

It is foreseen that there will be a more general move away from SSR Mode S towards the use of ADS-B in combination with WAM. However SSR Mode S will be retained in those special areas where it remains cost effective, especially for the provision of ADD.

VI. SPI IR

The Surveillance Performance and Interoperability Implementing Rule (SPI IR) is the means by which the European Commission can regulate the performance requirements for the provision of ground based surveillance. EUROCONTROL has been formally requested to draft the Implementing Rule, on behalf of the European Commission. The SPI IR will describe, at a high level, what requirements have to be met to be legally compliant. The aim of the IR is to ensure that aircraft carry the appropriate avionics to support all currently known forms of ground based surveillance. i.e. SSR, SSR Mode S, ADS-B and Multilateration. The first IR will only cover ground based surveillance, later IRs may cover provision

of ADD and air-air applications. The SPI IR has been released for industry wide consultation. It is anticipated that all systems will have to be compliant by about 2015.

VII. IMPLEMENTATION

EUROCONTROL, through its implementation Programmes for Mode S, ADS-B and WAM, supports ANSPs and Aircraft Operators in the implementation of the various Surveillance techniques. This work includes developing appropriate Standards for avionic and ground based systems, safety and security assessments, performs trials and investigates the cost benefit arguments. Armed with such information, Users can then make their own implementation decisions based on sound, best practice information. Support is also provided through the implementation period in assisting in resolving issues and problems, especially in the aircraft transponders.

SSR Mode S

Over 100 Mode S interrogators have already been installed within the core area of Europe. Many are operating full Mode S, some still transmit a mixed mode to enable Mode A/C replies to also be received. The EUROCONTROL SDPD, ARTAS (ATM suRveillance Tracker And Server) is now capable of producing a multi sensor fused track using Mode S and is already operational in over 20 European Air Traffic Control Centers.

Almost 100% of all European flights, flying IFR/GAT, carry a Mode S transponders thus allowing Mode S services to start. DFS has flown the very first Mode S only service flight, between Frankfurt and Munich. Further city-pair services will commence later this year

ADS-B

Implementation of "ADS-B out" has already started locally, in "pocket" areas. The following implementation sites are currently foreseen by the corresponding ANSPs for the period 2009-2011:

- Netherlands (North Sea)
- Portugal (Azores)
- Italy (Pescara and Alghero)
- Greece (Rhodos)
- Sweden (Kiruna)
- Turkey (Trabzon)

Then, a wider implementation of "ADS-B out" is expected based on the Implementing Rule.

In parallel, "ADS-B in", for air to air applications, will be introduced from 2011 onwards initially on a voluntary basis, driven by the benefits to be acquired by the implementing airlines. The first application is expected to be the ATSAW In Trail Procedure (ATSA-ITP) in oceanic airspace.

Multilateration

Multilateration has been operational for over 10 years in the Reduced Vertical Separation Monitoring stations (RVSM) across Europe. Multilateration at Airports is widespread, being used to provide surface related data into A-SMGCS.

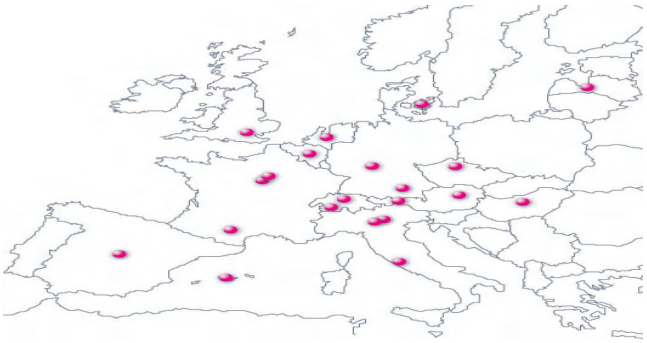

Figure 5 - MLAT at Airport sites in Europe

Wide Area Multilateration is already operational in Armenia, Austria, Czech Republic Latvia and Spain. Many more are being procured; The Netherlands, Germany, Switzerland, UK and Romania, just to name a few. Multilateration systems are also operational worldwide, Tasmania, Canada, China, New Zealand, USA and Mongolia.

VIII. REFERENCES

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[2] ICAO, Global Air Traffic management Operational Concept Doc 9854 AN/458
[3] EUROCONTROL, "Air Traffic management Strategy for the years 2000+."

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