Although widely deployed Primary and Secondary Surveillance Radars are considered to be mature, highly proven equipment, new technologies such as Automatic Dependent Surveillance - Broadcast (ADS-B) and Wide Area Multilateration (WAM) are proving to be advanced and effective alternatives.

Choosing a surveillance solution adapted to your current and future operational needs, your ATM environment and your budget is therefore not easy.

The objective of this booklet is to concisely present the different surveillance sensors currently available on the market, their interfaces with automation systems and real case studies to help you develop a truly Global Surveillance Solution, conceptualised by Thales. This booklet will show you how the Global Surveillance concept can help you meet tomorrow’s traffic demands and your objectives for even higher safety, enhanced efficiency and lower costs while meeting all future requirements too.

www.thalesgroup.com
A GUIDE TO GLOBAL SURVEILLANCE

AIR TRAFFIC MANAGEMENT
Air surveillance is not what it used to be a few years ago. It has been evolving in many ways and major factors now influence the choice of air navigation service providers concerning surveillance.

New solutions exist today that make surveillance possible even in the most difficult environments, solutions that are making air traffic control more accurate, safer and efficient. New technologies such as terrestrial or space-based ADS-B, Multilateration, Multi-Static Primary Surveillance Radar or Flat Panels using electronic scanning antenna offer, at a lower cost, identical or better performance than other mature technologies, with the capability of covering complex areas of the globe – remote deserts, oceans, mountains – where a radar can’t be installed because of environmental, operational or economic reasons. Depending on the situations some solutions outweigh others. The truth is that no one solution fits all. And combining different surveillance technologies is often the best way of achieving optimal results.

Environment has become increasingly complex with different new phenomena:
- the arrival of 4G/5G wireless communication using the same frequency range as radars thus generating saturation and/or intermodulation surveillance issues
- the increasing use of wind farm fields as renewable energy creating disturbing radar interference
- the low performance of non-cooperative radar technologies in detecting Unmanned Aerial Vehicles (UAVs) such as Drones which are yet becoming new integral tools in military and government operations
- the increasing cyber security threats that can affect surveillance integrity

These environmental features plus different weather related issues like wake vortex turbulence must be taken into account as constraints in implementing efficient surveillance solutions.

Regulatory changes in the way that Air Navigation Services Providers (ANSPs) assess and monitor the performance of their surveillance systems – a shift from procuring a specific sensor technology to procuring a cost effective performance-based solution while addressing the above listed environmental constraints.

Procurement of surveillance solution is also evolving from the delivery of sensors to the surveillance managed services. The FAA, for instance, is buying ADS-B data from a third party supplier.

The best surveillance solution needs to be adapted to your environment, your traffic (current and forecast) and your budget. A solution ready to meet tomorrow’s traffic flows while meeting your quests for higher safety, enhanced efficiency and lower costs.

This booklet is designed for anyone working in the Air Traffic Management (ATM) surveillance domain, and specifically Air Navigation Service Providers (ANSPs) that are considering their options for future surveillance solutions. Our guide will introduce you to global surveillance and the different technologies out there, what they do well and what they are not so good at. You can also take a look at the way some countries are already getting the best from their surveillance solutions in the references section. And rest assured, this booklet has been produced in plain English, with helpful diagrams and pictures to give you a good understanding of the domain without technical jargon. In reading this guide to global surveillance, you can ensure all your choices are wise ones.
1 SURVEILLANCE NEEDS & REGULATIONS
1.1 Surveillance: a key pillar for efficient ATM
1.2 Regulation: who says what?
1.3 Perform Based Surveillance

2 SURVEILLANCE TECHNOLOGIES
2.1 Primary Surveillance Radar (PSR)
2.2 Secondary Surveillance Radar (SSR)
2.3 Multilateration
2.4 Automatic Dependent Surveillance – Broadcast (ADS-B)
2.5 Automatic Dependent Surveillance – Contract (ADS-C)
2.6 Summary of Surveillance Technologies
2.7 Applications of Surveillance Technologies
2.8 Data provided by each Surveillance Technology
2.9 Tracking system

3 GLOBAL SURVEILLANCE
3.1 Why Global Surveillance?
3.2 Global Surveillance Solutions
3.3 Rationalisation
3.4 Simulation and Validation tools

4 CASE STUDIES
4.1 Frankfurt am Main TMA, WAM system
4.2 USA, Nationwide ADS-B coverage
4.3 Australia
4.4 Hong-Kong
4.5 United Kingdom

5 SUPPORT SERVICES

6 MAJOR R&D PROGRAMMES: SHAPING TOMORROWS’ SKIES

7 INNOVATIVE FEATURES
7.1 Windfarm Compliant Radars
7.2 Foreign Object Debris Detection
7.3 Wake Vortex Detection
7.4 Weather Hazards Detection
7.5 MultiStatic Primary Surveillance Radar

Acronyms and Terminology
1 SURVEILLANCE NEEDS & REGULATIONS

1.1 Surveillance: a key pillar for efficient ATM ................ 8
1.2 Regulation: who says what? ............................... 9
1.3 Perform Based Surveillance ................................. 10
1.1 Surveillance: a key pillar for efficient ATM

The main objective of Air Traffic Control (ATC) is the regulation of air traffic, preventing collisions between aircraft, obstructions on the ground and expediting and maintaining the orderly flow of traffic. The service is provided by air traffic controllers working for ANSPs, who rely on ATC systems to safely and efficiently guide aircraft from gate to gate.

ICAO identifies the fundamental uses of ATS Surveillance Systems:

- in the Area Control Service within ACC (Area Control Centre),
- in the Approach Control Service within APP (Approach Control Centre),
- in the Aerodrome Control Service within Tower,
- for surface movement control within Tower,
- in the Flight Information Service within FIC (Flight Information Centre).

Surveillance is a key function of air traffic control. Surveillance systems are the “eyes” of the controllers; they show who is in the sky, where they are and when they were there. They are the foundation of air traffic control. Surveillance systems detect aircraft and send detailed information to the ATC system which fuses the date from each surveillance before displaying on the Air Situation display and also used to feed the ATM system safety nets, enabling controllers to safely guide them. Air traffic control is not possible without surveillance systems, especially in highly busy airspaces. Air traffic control is not possible without surveillance systems, especially in highly busy airspaces.

Nowadays, surveillance is most widely provided by primary and secondary radars. However, new surveillance technologies such as GNSS-based ADS systems and multilateration are progressively being deployed. New technology, such as Multi-Static Surveillance Primary radars (MSPSR) are also under development as complement to tradition PSR. Depending on the environment and requirements of an ANSP, these solutions can be tailored to create the most optimal global surveillance solution possible.

The Fundamentals of Surveillance:

**Operational Aim**
- E.g. 5 nautical miles (NM) separation for En-Route surveillance areas, 3NM separation for Approach, 50 NM in Oceanic/Remote & desertic areas without means of surveillance.

**Technical Requirements**
- With a given probability: e.g. > 97%
- With a given horizontal accuracy: e.g. < 50m
- With a specified update rate: e.g. < 4 sec

1.2 Regulation: who says what?

The International Civil Aviation Organization (ICAO) defines an aeronautical surveillance system as one that “provides the aircraft position and other related information to ATM and/or airborne users” (ICAO Doc 9924 [Ref Doc. 25]).

The main ICAO requirement is to “define the signal in space for various technical systems to ensure interoperability and leave to States to decide which system(s) should be implemented in their airspace.”

In addition to this, the International Air Transport Association (IATA) has outlined the following:

- There is no airline requirement for using Primary Surveillance Radar (PSR) technology, should transponder aircraft equipage is sufficient to ensure relevant separations
- Multilateration is a superior replacement for Secondary Surveillance Radar (SSR) in terminal airspace
- SSR Mode S is preferred over SSR Mode A/C where radar must be installed or replaced
- Support for the implementation of Advanced Dependent Surveillance-Broadcast (ADS-B) OUT based on Mode S Extended Squitter (1090ES) data-link to supplement and eventually replace radar, and in non-radar airspace if traffic could benefit from ATC surveillance.

---

1 Refer to Chapter 2.1 2 Refer to Chapter 2.2 3 Refer to Chapter 2.4 4 Refer to Chapter 2.4
Perform Based Surveillance

Aviation System Block Upgrades (AS-BUs) presented in ICAO Document 9750 offer a structured approach to planning ATM modernisation and define everything that might be needed. Technology roadmaps for surveillance exist for surface, ground-based and air to air surveillance and are depicted in the following table.

The ICAO ASBUs and roadmaps establish a common framework for harmonisation and interoperability, but requirements are not set on individual states. It is a local or regional responsibility to define what is actually needed, taking account of the performance requirements and the cost pressures of airspace users.

### Technology Roadmap Table

<table>
<thead>
<tr>
<th>SURVEILLANCE</th>
<th>BLOCK 0</th>
<th>BLOCK 1</th>
<th>BLOCK 2</th>
<th>BLOCK 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GROUND-BASED</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSR</td>
<td>B0-84, B0-102</td>
<td>B1-102, B1-40</td>
<td>B1-102, B1-40</td>
<td></td>
</tr>
<tr>
<td>MultiStatic PSR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SSR/Mode-S</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ENABLERS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WAM</td>
<td>B0-40</td>
<td>B1-40</td>
<td>B1-40</td>
<td></td>
</tr>
<tr>
<td>ADS-B In/Out (ICAO Ver.2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Future ADS-B In/Out System</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CAPABILITIES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ground-based Surveillance</td>
<td>B0-84</td>
<td>B1-40</td>
<td>B1-40</td>
<td></td>
</tr>
<tr>
<td>Surveillance Data Fusion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SURFACE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SMR</td>
<td>B0-75</td>
<td>B1-75, B1-81</td>
<td>B2-75</td>
<td></td>
</tr>
<tr>
<td><strong>ENABLERS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MLAT</td>
<td>B0-75, B1-75, B1-81</td>
<td>B1-75, B1-81, B1-81</td>
<td>B1-75, B1-81, B1-81</td>
<td></td>
</tr>
<tr>
<td>Cameras</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CAPABILITIES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SMGCS Level 1 and 2</td>
<td>B0-75</td>
<td>B1-75, B1-81</td>
<td>B2-75</td>
<td></td>
</tr>
<tr>
<td>SMGCS Level 3 and 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>AIR-AIR</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADS-B In/Out (ICAO Ver.2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ENABLERS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In-Trail Procedures (ITP)</td>
<td>B0-85</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airborne Situational Awareness during Flight Operations (AIRB)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CAPABILITIES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airborne Spacing Application (ASPA) Interval Management</td>
<td>B0-85</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic Surface Situation Awareness (SURF)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface Situation Awareness with Indications and Alerts (SURF-IA)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: ICAO ASBU Framework
Regional requirements as follows

**EUROPE**
- In accordance with the ECAC Implementation Objective, the cooperative surveillance coverage required to support both terminal and en-route air traffic services is to have a duplicated cooperative surveillance coverage for en-route airspace and major terminal areas. PSR is required in TMAAs (Terminal Manoeuvring Areas) for safety.
- By 2020, at least one layer of ATM ground surveillance must be use co-operative independent surveillance to meet safety requirements.
- By 2020, all IFR/GAT aircraft > 5.7 t and True Air Speed > 250 knots shall have Mode-S transponder level 2 and ADS-B OUT capabilities.

**NORTH AMERICA**
- Existing surveillance infrastructure will remain in place until 2020
- ADS-B to be the primary means of surveillance by 2020
- All aircraft have to be ADS-B out capable for 2020.
- Reduced secondary surveillance network (after 2020)
- Retain limited set of terminal beacons at Operational Evolution Plan (OEP)/High density terminals
- Terminal primary radars are retained as safety backup
- Retain all en-route beacons

**CARIBBEAN & SOUTH AMERICA**
- **Medium term (2010-2015)**
  - SSR Mode S surveillance in high density air traffic areas
  - Increase of Ground implementation for ADS-B to fill en-route and terminal areas not covered with radar and to strengthen surveillance in areas covered with SSR Modes A/C and S
  - Wide Area Multilateration (WAM) implementation to speed up transition to ADS-B environment in a shorter timeframe
  - Automatic Dependent Surveillance - Contract (ADS-C) in all oceanic and remote airspace
- **Long term (until 2015-2025)**
  - Old SSR Mode A/C radars are no longer to be replaced
  - ADS-B or multilateration systems will replace all decommissioned SSRs

**ASIA PACIFIC**
- Maximise the use of ADS-B on major air routes and in terminal areas, use of ADS-B for ATC separation service
- Reduce the dependence on PSR for area surveillance
- Use ADS-B and Mode S SSR across air routes based on operational requirements
- Make full use of SSR Mode S capabilities where radar surveillance is used
- Make use of ADS-C where technical constraint or cost benefit analysis does not support the use of ADS-B, SSR or multilateration
- Make use of multilateration for surface, terminal and area surveillance where appropriate as an alternative or supplement to other surveillance systems
2 SURVEILLANCE TECHNOLOGIES

2.1 Primary Surveillance Radar (PSR) ........................................ 16
2.2 Secondary Surveillance Radar (SSR) ................................. 18
2.3 Multilateration .......................................................... 20
2.4 Automatic Dependent Surveillance – Broadcast (ADS-B) . 22
2.5 Automatic Dependent Surveillance – Contract (ADS-C) .. 24
2.6 Summary of Surveillance Technologies ......................... 26
2.7 Applications of Surveillance Technologies ...................... 28
2.8 Data provided by each Surveillance Technology .......... 29
2.9 Tracking system ...................................................... 30
Primary Surveillance Radar (PSR)

PSR is mainly used for approach and occasionally for en-route surveillance. It detects and localises aircraft. It is a non-cooperative system in the way that no electronic equipment is needed in the aircraft.

Think of a PSR as working in the same way as an echo. Equipped with a continuously rotating antenna, the PSR sends out a beam of energy. When that beam of energy hits an aircraft, the skin of the aircraft reflects it back to the radar, like an echo. By measuring the time it takes for the beam to be reflected back and the direction the reflection comes from (provided by the azimuth of the antenna), the primary surveillance radar can determine the position of the aircraft. The position is sent to the ATC system where it is displayed to the air traffic controller as a radar blip.

Only the position of the aircraft can be determined. The aircraft is not identified.

It is used around airports for safety (mainly for mitigation to support ATC in the event of a transponder failure and detection of infringement by non-cooperative (non-transponding) aircraft flying at low altitude and/or higher altitudes) or where there is not a sufficient percentage of aircraft equipped with transponder. The PSR radar is also used in certain countries for en-route surveillance.

The undisputable advantage of PSR is that it detects all aircraft in range regardless of equipment on-board the aircraft. This means that no aircraft can remain invisible to air traffic controllers, and it is the only type of technology today to offer this level of safety and security.

“...we are investing in what we believe is the most advanced technology available on the market today. The new radar systems are fully compliant with International Standards and will further strengthen the safety of the Belarusian airspace.”

Leonid Churo, DG Belaeronavigatsia, 9 February 2011

A GLANCE AT STAR NG AND TRAC2000N

Thales’s primary Approach surveillance radar, STAR-NG, and primary en-route radar, TRAC2000N, provide independent surveillance for approach, extended approach and en-route areas.

Designed for the densest of air traffic situations, Thales’s primary radars guarantee an extremely high availability. Detection range capabilities reach up to 100NM and 230NM for the STAR-NG and TRAC2000N respectively.

The STAR NG is an evolution of the STAR2000, with better mitigation of windfarm effects, improved life cycle cost and optional dual use capabilities (altimetry, frequency agility and ECCM).

Proven technology operational in over 100 countries worldwide, the STAR2000 and its successors the STAR-NG and TRAC2000N can be deployed as a stand-alone system or co-mounted with a secondary surveillance radar.
A GLANCE AT RSM 970S

With more than 250 operational references in over 50 countries, the RSM 970 S secondary surveillance radar is at the cutting-edge of radar technology, giving controllers total support in dense air traffic situations.

Having 30 years of experience in the field of MSSR/Mode S, Thales has the unique capability to offer RSM 970 S, the higher performance sensor that gives controllers total support in severe air traffic situations. The Mode S functions cover selective interrogation, elementary/enhanced surveillance and full data-link.

The RSM 970 S has full Mode S functionalities, validated by ICAO and Eurocontrol, making Thales’ radar solution a secure investment for ANSPs.

Mode A/C/S

The information sent by an aircraft depends on the transponder on-board. If an aircraft has a Mode A/C transponder, the coded reply will contain the aircraft’s identification and altitude. However, in areas of increased air traffic, radars can mix up (called garbling) information due to overlapping signals. With Mode A/C, when a radar sends out a request for information, all aircraft in range reply. Mode S was introduced to prevent the garbling and by also providing a data link capability allowing to download aircraft information. Another feature of the Mode S was to assign to each aircraft a unique worldwide address (24-bit aircraft address) to allow selective addressing and cope with the limited number of identifier with Mode A. There are two types of datalink available, the Elementary Surveillance Mode-S (ELS) and the enhance Mode-S (EHS). Mode-S radars can also be synchronized to reduce the mode-S FRUIT (Unsynchronized False Replies) and compensate for miss detection.

2.2 Secondary Surveillance Radar (SSR)

SSR is used for approach and en-route surveillance. It detects and localises aircraft and receives additional information such as their identity and altitude.

Contrary to the PSR, the SSR requires aircraft to be fitted with a transponder on-board. With its continually rotating antenna, the SSR sends out an energy beam to interrogate aircraft. When the energy beam hits an aircraft, a coded reply will be sent back to the radar. This reply contains the aircraft’s identification, its altitude and, depending on the type of transponder on board, additional information. However, the SSR does not rely on the transponder for the position of the aircraft. It determines this itself by measuring the time it takes for the beam to be reflected back to the radar and the direction the reflection comes back from. The SSR then transmits all this information to the ATC system where it is displayed as an aircraft label. Secondary radars transmit pulses on 1030 MHz to trigger transponders installed in aircraft to respond on 1090 MHz.

PROS

- Identity and altitude of targets are detected as well as the range and azimuth
- Less sensitive to interferences than primary radar
- Covers a larger range than primary radar
- Mode S introduces the air-to-ground data-link
- Medium data integrity level

CONS

- Does not work for ground surveillance
- Confusion related to the use of Mode A/C
- High latency and low update rate

"...Nigeria’s airspace is now totally covered by radar as a result of the Total Radar Coverage of the Nigerian Airspace Project (TRACON). What this means is that we now have the technology to reduce air disasters to the barest minimum and to police and protect Nigeria’s airspace from unauthorized entry."

Goodluck Jonathon, President of the Federal Republic of Nigeria, 22 October 2010
Multilateration can be used for ground (airport surveillance generally in combination with the SMR and feeding the A-SMGCS system), terminal approach and en-route surveillance. It detects an aircraft’s position, 

A multilateration system is composed of several time synchronized beacons (mainly by using Global Navigation Satellite System (GNSS)) that receive signals emitted by aircraft transponders. These signals are either unsolicited (using “squitters”) or responses (using conventional Mode A/C and Mode S) to the interrogations of a multilateration station. Initial multilateration system were based upon the Time Difference of Arrival (TDOA) principle called hyperbolic processing. Due to the spatial distribution of each pair of beacons, the signal from the aircraft reaches them at different times, enabling localisation to be determined. New advanced multilateration systems combine now the hyperbolic processing with the elliptic (also called range aided measurement) processing. Elliptical or range aided processing do not use the time differences between times of arrival but the signal propagation time from the transponder to the ground stations. The instant of transmission time is derived from the interrogation time of a transmitter co-located with some ground stations and the delays within the transponder. These ground transmitters are also used for synchronising receivers ground stations so as to provide a redundancy in time synchronisation in case of GNSS unavailability.

Multilateration is used for ground movement surveillance, airport approaches (WAM for TMA), gap filler (a radar used to supplement the coverage of the principal radar in areas where coverage is inadequate) and en-route surveillance (Wide Area Multilateration [WAM]).

Transponder Reply or Mode S quitter

Transponder: Replied may be replied to interrogation from multilateration system or replied to SSR interrogation (Mode A, C or S)

PROS

- No additional aircraft equipment required (basic transponder is sufficient)
- System flexibility and scalability to easily expand coverage
- Suitable for difficult environments as ground stations can be mounted in all locations
- Quick, undistruptive installation thanks to small system size
- Fit for complex airspace and congested airports with high accuracy and update rates (up to 1 sec)
- Capability to achieve different performance according to each service volume
- Built-in ADS-B capability
- No rotating part, low lifecycle costs
- Highly reliable: redundancy and N-1 system design

CONS

- Cost effectiveness may not be so effective as a secondary radar, especially for large areas, if communication links are not optimized.
- Numerous sites required which may result in high infrastructure cost
- Complex system to manage: numerous sites, synchronization across system, multiple and omnidirectional interrogations

This new surveillance sensor technology supplies enhanced surveillance data to controllers to ease their daily operational work ... It provides more flexibility to feed aircraft into the approach area around Frankfurt Airport, which helps to fulfil the demand to reduce noise over densely populated areas.

DFS chairman and CEO Dieter Kaden, 17 September 2012

A GLANCE AT MAGS/MLAT

Thales MABS (Multilateration & ADS-B Ground System), designed and built by Thales Air Systems is a single, and versatile system that fulfils surface, precision approach monitoring and en-route cooperative surveillance needs. The system has a great flexibility and scalability, enabling tailored performance according to customer needs and it can operate in the harshest environments. Highly efficient and safe, the main purpose of the WAM system is to provide highly precise and current cooperative surveillance to air traffic controllers (high accuracy, refresh rate, combined elliptic and range aided processing, virtual WAM concept, degraded modes, dual synchronisation, SWAL3 software qualification). It has been tested and approved by DFS (Germany), NATS (UK) and DGAC (France).

After rigorous testing, DFS awarded Site Acceptance to the Thales WAM system for Frankfurt TMA for Precision Runway Monitoring (PRM), one of the most complex and busy airspaces in the world combined with one of the highest Radio Frequency (RF) pollution in the world.
Aircraft broadcast to anyone listening who they are, where they are, where they are going and at what speed.

An aircraft uses Global Navigation Satellite System (GNSS) to determine its position, which it broadcasts together with other information to ground stations. The ground stations (or low orbiting satellites in the case of space-based ADS-B) receive, process and send this information to the ATC system which then displays the aircraft on controllers’ screens.

ADS-B equipped aircraft broadcast their position and other information once per second, without any intervention from ground systems. As well as their position, aircraft broadcast their altitude, speed, identity and other information from on-board systems.

ADS-B broadcasts can be received and processed by any receiving unit, which means ADS-B can be used for both ground and airborne air traffic control surveillance applications.

**PROS**
- For a single ADS-B site, acquisition and installation cost is lower than any other surveillance system
- Minimal infrastructure requirements; ground station can be installed on existing infrastructure, e.g. navigation aid, radar or very high frequency (VHF) radios sites
- Used for both ground-based and airborne surveillance applications
- Air/ground data-link available
- Low latency
- Updates every second
- High accuracy (GPS)
- Very low lifecycle cost
- Intent available (level-off altitude, next waypoint etc.)
- Users can determine which applications the data can support
- Immune to multi-path

**CONS**
- Requires all aircraft to be equipped with dedicated ADS-B avionics
- Relies exclusively on Global Navigation Satellite System (GNSS) for position and speed
- Aircraft position is determined on-board without independent system validation

The ADS-B solution, part of the Thales MAGS (Multilateration & ADS-B Ground System) family, has been selected by service providers in Australia (ASA), Asia Pacific, Europe (Eurocontrol, French DGAC, German DFS,…) and North and Central America (FAA, SENEAM) to enhance surveillance in both radar and non-radar airspace. Thales has also developed and delivered TIS-B, FIS-B and CDP (ADS-B Central Data Processor).

Thales has also participated in several trials to demonstrate how ADS-B data can be used to improve situational awareness and enhance safety. In the largest ADS-B contract to date, Thales has delivered up to 1,200 systems (both in 1090ES and 978 MHz) to the FAA, through HARRIS (previously ITT Corporation) to provide a nationwide network across the US.

Thales is drawing on the knowledge of its expert teams in the US, France, Germany and Italy to meet FAA requirements, which include dual link ground equipment, containing both 1090 MHz and UAT (Universal Access Transceiver) data-link capabilities.

**ADS-B datalink technologies**

Although three ADS-B data-link technologies have been developed and standardized by ICAO (the 1090 MHz Mode S Extended Squitter (1090ES), Universal Access Transceiver (UAT) and VHF Digital Link Mode 4 (VDL Mode 4)), 1090ES has been selected as the preferred one by ICAO and IATA while UAT is favoured by the FAA for the general aviation.

**ADS-B In or OUT?**

“ADS-B Out” periodically broadcasts information about each aircraft, such as identification, current position, altitude, and velocity, through an on-board transmitter.

“ADS-B In” is the reception by aircraft of FIS-B and TIS-B data and other ADS-B data such as direct communication from nearby aircraft.

Aircraft broadcast to anyone listening who they are, where they are, where they are going and at what speed.

An aircraft uses Global Navigation Satellite System (GNSS) to determine its position, which it broadcasts together with other information to ground stations. The ground stations (or low orbiting satellites in the case of space-based ADS-B) receive, process and send this information to the ATC system which then displays the aircraft on controllers’ screens.

ADS-B equipped aircraft broadcast their position and other information once per second, without any intervention from ground systems. As well as their position, aircraft broadcast their altitude, speed, identity and other information from on-board systems.

ADS-B broadcasts can be received and processed by any receiving unit, which means ADS-B can be used for both ground and airborne air traffic control surveillance applications.

**PROS**
- For a single ADS-B site, acquisition and installation cost is lower than any other surveillance system
- Minimal infrastructure requirements; ground station can be installed on existing infrastructure, e.g. navigation aid, radar or very high frequency (VHF) radios sites
- Used for both ground-based and airborne surveillance applications
- Air/ground data-link available
- Low latency
- Updates every second
- High accuracy (GPS)
- Very low lifecycle cost
- Intent available (level-off altitude, next waypoint etc.)
- Users can determine which applications the data can support
- Immune to multi-path

**CONS**
- Requires all aircraft to be equipped with dedicated ADS-B avionics
- Relies exclusively on Global Navigation Satellite System (GNSS) for position and speed
- Aircraft position is determined on-board without independent system validation

The ADS-B solution, part of the Thales MAGS (Multilateration & ADS-B Ground System) family, has been selected by service providers in Australia (ASA), Asia Pacific, Europe (Eurocontrol, French DGAC, German DFS,…) and North and Central America (FAA, SENEAM) to enhance surveillance in both radar and non-radar airspace. Thales has also developed and delivered TIS-B, FIS-B and CDP (ADS-B Central Data Processor).

Thales has also participated in several trials to demonstrate how ADS-B data can be used to improve situational awareness and enhance safety. In the largest ADS-B contract to date, Thales has delivered up to 1,200 systems (both in 1090ES and 978 MHz) to the FAA, through HARRIS (previously ITT Corporation) to provide a nationwide network across the US.

Thales is drawing on the knowledge of its expert teams in the US, France, Germany and Italy to meet FAA requirements, which include dual link ground equipment, containing both 1090 MHz and UAT (Universal Access Transceiver) data-link capabilities.

**ADS-B datalink technologies**

Although three ADS-B data-link technologies have been developed and standardized by ICAO (the 1090 MHz Mode S Extended Squitter (1090ES), Universal Access Transceiver (UAT) and VHF Digital Link Mode 4 (VDL Mode 4)), 1090ES has been selected as the preferred one by ICAO and IATA while UAT is favoured by the FAA for the general aviation.

**ADS-B In or OUT?**

“ADS-B Out” periodically broadcasts information about each aircraft, such as identification, current position, altitude, and velocity, through an on-board transmitter.

“ADS-B In” is the reception by aircraft of FIS-B and TIS-B data and other ADS-B data such as direct communication from nearby aircraft.
Aircraft report to the ATC Centre when requested.

Most of the aircraft use Global Navigation Satellite System (GNSS) or on-board systems to determine its position and other information. Through a dedicated datalink capability (ACARS), the aircraft logs to the ADS-C equipped ATC system and establishes a contract between the aircraft and the ATC system. The contract determines the information to be exchanged between the aircraft and the ATC system. With the ADS-C function, the aircraft sends periodically surveillance data (position, aircraft intent,...). To the ATC system through available ACARS subnetwork (Inmarsat satellites, VDL or HFDL). These information are then processed by the ATC system as any surveillance sensors. It has to be noted that the datalink is only between the aircraft and the ATC centre. It is not a broadcast mode such as the ADS-B, meaning that all the aircraft around does not receive the particular ADS-C aircraft position.

ADS-C is currently the main means of getting surveillance information in areas where other means of surveillance are impractical or impossible, such as oceanic and desert areas. It is expected that the space based ADS-B will provide an alternative to the ADS-C.

**PROS**
- Surveillance coverage in areas that are impractical or impossible for other surveillance systems to operate in, such as oceanic or desert areas
- Expected flight-path information available
- Data-link between aircraft and the ground

**CONS**
- Requires all aircraft to be equipped with additional equipment
- Information is delivered by a service provider that bears the cost
- Relies partly on GNSS to determine aircraft position and speed, which may experience outages
- Aircraft surveillance applications are not supported as information is not directly available to other aircraft
- Aircraft position updated less frequently than other surveillance systems
- GNSS errors: Clock errors, ionospheric effects
- ADS-C does not support 3 NM or 5 NM separation standards and is limited to 30 X 30 Nm separation capability (note: the separation limitation is also linked to the communication availability).

**A GLANCE AT TopSky - Datalink**

TopSky - Datalink solution, implemented by Thales, enables clients to fully provide air surveillance in oceanic or desert areas. Thales is able to deliver ADS-C through FANS1/A+ and the Aeronautical Telecommunication Network. Deployed worldwide across Europe, Australia, US, China, Chile, South Africa, ASECNA, Namibia, Singapore, Vietnam, Thailand, Indonesia and Taiwan, TopSky - Datalink is field-proven and is a key data-link solution for oceanic and continental operations. TopSky - Datalink integrates the major technological and functional evolutions resulting from the Single European Sky ATM Research (SESAR) and Next Generation Air Transportation System (NextGen) programmes, which will bring visible improvements to automation products.
## Summary of Surveillance Technologies

| Aircraft position is measured from the ground (Independent) or determined on-board (Dependent) | PSR | SSR |  |  |  |  
|---|---|---|---|---|---|---|
| Independent | Independent |  |  |  |  |  |

| Technology depends on on-board aircraft equipment being present (Cooperative) or not (Non-Cooperative) | Non-Cooperative | Cooperative |  |  |  |  
|---|---|---|---|---|---|---|
| Independent | Independent | Dependent | Dependent | Independent |  |  |

| No Aircraft Transponder | Detection | – |  |  |  |  
|---|---|---|---|---|---|---|
| Mode A | Detection | Detection & Identification | – | – | Detection & Identification |  
| Mode C | Detection | Detection & Identification | – | – | Detection & Identification |  
| Mode S | Detection | Detection & Identification | – | – | Detection & Identification |  

### Major Pro

- Non-cooperative targets can be detected as no on-board equipment is required. High data integrity level.
- Determines identity and altitude of aircraft as well as range and azimuth. Less sensitive to windfarm effects. Mode S enables air-to-ground data-link.
- Can be used for ATC, vehicle tracking and on-board surveillance applications. High refresh rate (1s). Air/ground data-link available. Low latency. High update rate. Accurate localisation.
- Provides surveillance in areas with no radar coverage. Expected flight path information available. Air/ground data-link available. Space-based ADS-B may bring a better alternative to ADS-C.
- SSR technology can be used (no need for evolution of on-board equipment). Suitable for ground surveillance. Low latency. High update rate. Position accuracy. High reliability.

### Major Con

- Targets cannot be identified, nor can altitude be determined.
- High powered emissions are required, limiting its range. Cannot be used for ground surveillance (not enough accurate and refresh rate not sufficient).
- Cannot be used for ground surveillance (not enough accurate and refresh rate not sufficient).
- Use depends on ADS-B avionics equipage. Performance (especially position) may depend on implementation. Standards are still in evolution. Rely mainly on GPS.
- Depends on ADS-C avionics equipage and datalink capabilities. Accuracy is less than ADS-B. High latency time limits low separation capability.
- Highly reliant on data communication infrastructure which may bring high operating costs.
2.7 Applications of Surveillance Technologies

**PSR**
- Surface movement radar application
- Terminal area surveillance
- En-route surveillance

**SSR**
- Terminal area surveillance
- En-route surveillance
- Precision Runway Monitor (PRM): Special SSR ground stations are used by a number of states to boost precision in runway approach monitoring at parallel runways

**ADS-B**
- Surface movement
- Terminal Manoeuvring Area (TMA) surveillance
- En-route surveillance
- PRM: ADS-B shows promise for use in PRM applications when aircraft are equipped because ADS-B meets the accuracy, velocity vector performance and update requirements of PRM. However, no safety case, nor ICAO approval, has been obtained to use ADS-B for this application at this time

**Multilateration**
- Advanced Surface Movement Guidance and Control System (ASMGCS): Multilateration has been deployed at numerous locations for surface surveillance to detect and provide position/identity to these systems. Typically 10-20 ground stations are used to provide multilateration coverage across the whole airport surface (depending upon the airport size and layout).
- Terminal Manoeuvring Area (TMA) or gap-filler surveillance: TMA WAM is a cost effective solution for airport with limited traffic where MSSR is not cost effective or difficult to implement, or for airport needing accurate and high refresh rate for Precision Runway Monitoring
- En-route surveillance: Multilateration can be used in “very wide area” applications. Numerous ANSPs are implementing WAM systems to ensure a secondary (replacing one of the MSSR layer) cooperative surveillance layer both for en-route and TMA.

**ADS-C**
- En-route surveillance in remote or oceanic areas

2.8 Data provided by each Surveillance Technology

The following table provides a brief overview of the information that can be received using different types of transponders by the aforementioned surveillance technology.

<table>
<thead>
<tr>
<th>Surveillance Technology</th>
<th>Mode A/C transponder</th>
<th>Mode S transponder with Downlink Aircraft Parameters (DAPs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSR</td>
<td>Position / Calculated velocity vector</td>
<td>No data</td>
</tr>
<tr>
<td>SSR Mode A/C</td>
<td>Position / Flight level (barometric), 4 digit octal identity / Calculated velocity vector</td>
<td>Position, Flight level (barometric), 4 digit octal identity / 24 bit unique code / Selected altitude / Flight ID / Roll Angle / Track angle rate / Ground Speed / Magnetic Heading / Indicated Airspeed / Mach No / Vertical Rate</td>
</tr>
<tr>
<td>SSR Mode S</td>
<td>Position / Flight level (barometric), 4 digit octal identity / Calculated velocity vector</td>
<td>Position, Flight level (barometric), 4 digit octal identity / 24 bit unique code / Selected altitude / Flight ID, Selected Altitude / Roll Angle / Track Angle Rate / Track Angle / Ground Speed / Magnetic Heading / Indicated Airspeed / Mach No / Vertical Rate / Calculated velocity vector</td>
</tr>
<tr>
<td>Multilateration</td>
<td>No data</td>
<td>Position / Flight level (barometric) / Position integrity / Geometric altitude (GPS altitude) / 24 bit unique code / Flight ID / Velocity vector / Vertical rate / Emergency flags / Aircraft type category / Fully compliant DO260A will add a number of data fields</td>
</tr>
<tr>
<td>ADS-B</td>
<td>Position / Altitude / Flight ID / Emergency flags / Waypoint events / Waypoint estimates / Limited “intent data”</td>
<td></td>
</tr>
<tr>
<td>ADS-C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

No transponder
Tracking system

The ATC automation centre integrates data sent by all the implemented surveillance sensors. It is a vital part of any Global Surveillance Solution.

The aim of a tracking system is to process and unify all types of surveillance data, in order to provide clear, fused information for visualisation and safety nets systems.

The creation of a new set of surveillance standards has allowed the emergence of a post-radar infrastructure based on data-link technology.

A multi-sensor tracking system combines multiple received data pertaining to a single aircraft into a single surveillance track, utilising the best contribution from each surveillance source and eliminating the influence of their respective drawbacks.

The integration of this new technology in gate-to-gate architectures has above all the following purposes:

- Fluxing continuously growing air traffic,
- Increasing safety related to aircraft operations,
- Reducing global costs (e.g. fuel costs are increasing quickly and this seems to be a long-term trend),
- Reducing radio-radiation and improving the ecological situation.

A GLANCE AT TopSky-Tracking

With more than 20 years of experience, Thales’ TopSky - Tracking system is field-proven, with the highest number of operational systems in the world than any other tracking system.

The system receives and processes all types of surveillance data, including PSR, SSR, Mode S, Mode A/C, ADS-B, Wide Area Multilateration (WAM) and surface sensors (SMR, Airport Multilateration, SMGCS tracks).

For cooperative aircraft, significant information is supplied as Downlink Aircraft Parameters (DAPs) from the aircraft avionics. DAPs data is processed by the TopSky - Tracking function and is also stored in output messages for use by downstream data-processing functions.

The data fusion technique used within the TopSky - Tracking function is based on the use of Extended Kalman Filter (EKF) algorithms that make up an Interacting Multiple Model filter. The EKF features are particularly adapted for an aircraft trajectory assessment and integrate the capability to predict the aircraft motion.
3.1 Why Global Surveillance?

ANSPs are currently faced with a dilemma: choosing between mature, proven and conventional surveillance technologies and new, updated and more comprehensive surveillance solutions when optimising or renewing their global surveillance solution.

On the one hand, conventional technologies, such as primary and secondary radars, are highly mature, widely deployed and continuously being improved. In the recent past, surveillance infrastructure was composed of only Primary Surveillance Radars (PSR) and Secondary Surveillance Radar (SSR). The requirements placed upon the infrastructure were based on the use of radars achieving radar-specific performance requirements.

On the other hand, recently, new technological developments such as Automatic Dependent Surveillance - Broadcast (ADS-B), Automatic Dependent Surveillance – Contract (ADS-C) and Multilateration (MLAT) have reached maturity for operational deployment for surveillance applications and relevant standards have been defined. Due to the advanced nature of these new technologies, the technical requirements cannot continue to be expressed in terms of radar-specific performance requirements.

New performance targets and associated operational requirements involving these new technologies are emerging from Single European Sky initiatives. The environment in which ANSPs provide a surveillance service is therefore under continual pressure to evolve and keep up.

Methodology and tools have been developed to support ANSPs in decision making to optimize surveillance infrastructure regarding the attributes of various surveillance technologies. This is the concept of Global Surveillance Solutions.

A surveillance infrastructure is to provide the required functionality and performance to support a safe, efficient and cost-effective Air Traffic Control service.

3.2 Global Surveillance Solutions

New technologies, complex environments, regulations... ATC Surveillance is evolving. Methodology and tools have been developed to support ANSPs in decision making to optimize surveillance infrastructure regarding the attributes of various surveillance technologies. This is the concept of Global Surveillance Solutions. Building on strong expertise in surveillance sensors, tracking and automation systems, modelling and validation tools, a global surveillance solutions provider, such as Thales, will combine advanced technologies to find the best composite surveillance solution matching each ANSP’s needs.

Whatever the geographical constraints, environments, traffic level and budget, ANSPs must have the most adapted surveillance capabilities:

- Focus on needs, not on products;
- Complete airspace security and safety proposal, everything from ground to en-route must be considered;
- Performance excellence and cost efficiency through solution optimisation is guaranteed;
- Multiple outputs to optimise ease in using the interface of any ATM system as standard;
- Specially designed and tested multi-sensor simulation and validation tools help to optimise system design. Global surveillance solutions providers must assist customers in defining the best solution for their requirements.

Definition of the desired surveillance coverage;
- Identification of site-related constraints: complicated coverage, terrain restrictions, gapfiller;
- Identification of operational restraints: accessibility of sites, existing systems, limited communication;
- Modelling of surveillance infrastructure to cover new routes
- Several criteria have to be considered in order to provide a truly optimal solution, such as operational requirements, average and peak traffic density, budget (current and future), environment (terrain, propagation, etc.) as well as safety and security objectives. Furthermore, global surveillance system optimization is also based on several assessments:
  - Performance indexes (probability of detection/correct identification, localisation accuracy);
  - Cost evaluations (equipment acquisition, operations, maintenance);
  - External footprint (spectral occupancy, environmental impact).

Global surveillance systems are an efficient way to combine various technologies and share a part of the burden of “ancillaries” between several surveillance layers, for example:

- Infrastructure (tower, masts, etc.);
- Energy sources (power supply etc.);
- Communication links.
PSR and SSR are often installed in a “co-mounted” installation. Alternative technologies can be deployed in an integrated infrastructure too.

One can typically consider the integration of:
- An ADS-B receiver with a SSR
- ADS-B capabilities with a WAM station
- A PSR station with ADS-B and WAM into a common system

**ADS-B + WAM**

Integration of ADS-B and a Wide Area Multilateration station can be very easily achieved as both systems often use the same and single antenna, radio frequency (RF) reception and digitisation hardware. The dual functionality of an ADS-B and a multilateration ground station is a big advantage; such a capability is recognised in Eurocae standardization documents such as ED-142, and it is also noted that a WAM system may provide ADS-B data reception and handling capabilities.

ADS-B capabilities can hence be offered as a simple software addition to WAM equipment. The major benefit of this integration is the ability to provide ADS-B service and application at a marginal additional cost, when a WAM surveillance system has already been or is being deployed.

Conversely, when ADS-B ground configuration has been deployed first, a seamless service extension from ADS-B to WAM can be put in place. Such an extension will include:

- Deployment of additional WAM stations (if needed, depending on terrain and required coverage) to ensure the proper level of performance, e.g. accuracy.
- A software upgrade of existing ADS-B stations to ensure WAM capabilities.

**ADS-B + WAM + PSR**

The integration of PSR and “WAM-ADS-B” capabilities into a common system is an attractive concept that would provide a truly global surveillance service (non-cooperative, cooperative-independent, and cooperative-dependent).

The deployment of such a Global Surveillance System could be envisioned either:

- As an upgrade of surveillance systems based on WAM-ADS-B technologies, providing them with the additional capability of non-cooperative surveillance.
- Or as a direct deployment, for new airspace/airport equipment.

**A GLANCE AT UK TRIALS: A WORLD FIRST**

Thales implemented 3 new types of surveillance technology using the interface from TopSky – ATC: ADS-B, Multilateration and MSPSR prototype.

Thales has also worked closely with the UK Civil Aviation Authority to create optimal combinations of sensors that could solve both the problem of the possible sale of radio frequencies used by primary approach radars which is forecasted to occur in 2020, and the impact of wind farms and 4G / LTE. In October 2013, Thales demonstrated its ability to implement a solution combining all the new technologies such as Wide Area Multilateration (WAM), Multi-Static Primary Surveillance Radar (MSPSR) and cooperative surveillance (ADS-B) connected to a TopSky - ATC system and covering part of London’s TMA (Terminal Maneuvering Area), demonstrating the individual capabilities of each sensor but also the surveillance data fusion and display thanks to the TopSky system.
3.3 Rationalisation

Measuring or quantifying how much rationalisation is needed or, if assessed after the event, how much rationalisation was achieved is a necessary step for an ANSP.

Rationalisation activities may focus upon improving a whole range of Key Performance Areas (KPA).

There are currently no published standardised metric definitions or commonly agreed ATM performance figures for a surveillance infrastructure’s rationalisation. ANSPs can assess their surveillance infrastructure against the generic KPA below to define development targets that contribute to the overall targeted ATM improvement.

The Key Performance Areas cover:

- **CAPACITY**: An optimal ATM system should provide the capacity to meet demand at the times, when and where it is needed.
- **COST EFFECTIVENESS**: The price of air traffic services provided by an optimal ATM system should be cost-effective while meeting ANSP’s individual needs.
- **EFFICIENCY**: Optimal efficiency ensures that flight operations use only what is necessary in both operational and economic respects and is central to achieving environmental performance targets and requirements.
- **ENVIRONMENTAL SUSTAINABILITY**: Optimal environmental system performance is a requirement and ATM systems must meet their obligations in this respect.
- **FLEXIBILITY**: Flexibility addresses the ability of an ATM system to meet all modification of surveillance requirements in an efficient and cost-effective manner.
- **INTEROPERABILITY**: The functionality and design of an optimal ATM system must be based upon global standards and uniform principles to ensure technical and operational interoperability.
- **PREDICTABILITY**: Predictability refers to the ability an optimal ATM system has in enabling the delivery of consistent and dependable air transport services to airspace users.
- **SAFETY**: Safety requires the highest priority in aviation and the provisions of air traffic services. It is generally expected that no accidents occur in the aviation industry and meeting this expectation gains end customers’ confidence in air transport.
- **SECURITY**: Security refers to the protection against both direct and indirect threats, attacks and acts of unlawful interference to the ATM System, such as cyber threats.
- **HUMAN PERFORMANCE**: An efficient and capable surveillance system leads to improved Air Traffic Controller efficiency.
<table>
<thead>
<tr>
<th>KPA</th>
<th>PSR</th>
<th>SSR</th>
<th>ADS-B</th>
<th>WAM</th>
<th>Hybrid solution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CAPACITY</strong></td>
<td>• Meets all current and expected future capacity needs</td>
<td>• Mode S improves vertical capacity</td>
<td>• Supports reduced separation</td>
<td>• Supports reduced separation</td>
<td>• Support reduced separation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Increased capacity in low altitude / dense airspace</td>
<td>• Increased capacity in low altitude / dense airspace</td>
<td>• Increased capacity in any part of the covered airspace</td>
</tr>
<tr>
<td><strong>COST</strong></td>
<td>• Proven technology</td>
<td>• Proven technology</td>
<td>• Highly cost effective</td>
<td>• Generally improved cost due to improved flexibility</td>
<td>• Highly improved cost effectiveness</td>
</tr>
<tr>
<td><strong>EFFECTIVENESS</strong></td>
<td>• Limited non-recurring costs</td>
<td>• Limited non-recurring costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>EFFICIENCY</strong></td>
<td>• Solid-state amplifier improves radio frequency footprint</td>
<td>• No loss of information.</td>
<td>• Average surveillance and spectrum efficiency</td>
<td>• Improved surveillance efficiency</td>
<td>• Improved surveillance and spectrum efficiency</td>
</tr>
<tr>
<td></td>
<td>• Digital processing continuously improves performance</td>
<td>• Mode S (EHS, ELS) improve efficiency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Overlapping coverage at high altitudes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• High power transmission still impacts radio frequency footprint</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Deployment constraints</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ENVIRONMENTAL</strong></td>
<td>• Significant required infrastructure</td>
<td>• Significant required infrastructure</td>
<td>• Reduced fuel consumption and noise impact for trajectories</td>
<td>• Reduced fuel consumption and noise impact for trajectories</td>
<td>• Reduced fuel consumption and noise impact for trajectories</td>
</tr>
<tr>
<td></td>
<td>• Potentially impacted by wind turbines</td>
<td>• Potentially impacted by wind turbines</td>
<td>• Much lower visual footprint than radars</td>
<td>• Much lower visual footprint than radars</td>
<td>• Lower visual footprint than radars</td>
</tr>
<tr>
<td><strong>FLEXIBILITY</strong></td>
<td>• Best suited for long range and high altitude surveillance</td>
<td>• Best suited for long range and high altitude Surveillance</td>
<td>• Well-distributed system allows flexible deployment</td>
<td>• Well-distributed system allows flexible deployment</td>
<td>• Well-distributed system allows flexible deployment</td>
</tr>
<tr>
<td></td>
<td>• Limited adaptability to changing air routes due to its significant infrastructure</td>
<td>• Limited adaptability to changing air routes due to its significant infrastructure</td>
<td>• High update rate allows flexible trajectory management</td>
<td>• High update rate allows flexible trajectory management</td>
<td></td>
</tr>
<tr>
<td><strong>INTEROPERABILITY</strong></td>
<td>• Use of ASTERIX* format</td>
<td>• Use of ASTERIX* format</td>
<td>• Limited interoperability due to limited aircraft equipage and dual standards in certain regions</td>
<td>• Able to track any transponder-equipped target</td>
<td>• Able to track any air target</td>
</tr>
<tr>
<td></td>
<td>• Required frequency/distance separation between two PSRs</td>
<td>• Clustering of SSR Mode S</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PREDICTABILITY</strong></td>
<td>• Proven technology through experience</td>
<td>• No false tracks</td>
<td>• Not optimal in transition period due to persistence of “non-certified” transponders with poor performance</td>
<td>• Improved predictability due to steady degradation, spatial diversity, etc.</td>
<td>• Improved predictability due to steady degradation, spatial diversity, etc.</td>
</tr>
<tr>
<td></td>
<td>• Not dependent on on-board transponders</td>
<td>• Performance depends on propagation effects</td>
<td>• Performance depends on propagation effects</td>
<td>• Performance depends on propagation effects</td>
<td>• Performance depends on propagation effects</td>
</tr>
<tr>
<td></td>
<td>• Performance depends on propagation effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SAFETY</strong></td>
<td>• Not dependent on on-board transponders</td>
<td>• High added value system (Use of Mode S EHS ans DAPs)</td>
<td>• Vulnerable to GPS outages or jamming and avionics failure</td>
<td>• Improved safety due to steady degradation, spatial diversity, etc.</td>
<td>• High improved safety</td>
</tr>
<tr>
<td></td>
<td>• Redundant system in its design</td>
<td>• Redundant system in its design</td>
<td></td>
<td>• Still some limitations against transponder failures</td>
<td>• No weaknesses</td>
</tr>
<tr>
<td></td>
<td>• Poor coverage at low altitude for some configurations</td>
<td>• Performance depends on propagation effects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SECURITY</strong></td>
<td>• Non cooperative surveillance technology</td>
<td>• Non cooperative surveillance technology</td>
<td>• Subject to multiple threats e.g. GPS jamming, spoofing, deliberate switch off of transponders,...</td>
<td>• Equivalent to SSR. However still major issues remaining against various kind of threats, as relying on aircraft cooperation</td>
<td>• Highly improved security</td>
</tr>
<tr>
<td></td>
<td>• Poor coverage at low altitude for some configurations</td>
<td>• Poor coverage at low altitude for some configurations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>HUMAN PERFORMANCE</strong></td>
<td>• Proven efficient HMI</td>
<td>• High added-value information</td>
<td>• Better anticipation of conflicts or loss of adherence in contract trajectories</td>
<td>• Better anticipation of conflicts or loss of adherence in contract trajectories</td>
<td>• Better anticipation of conflicts or loss of adherence in contract trajectories</td>
</tr>
<tr>
<td></td>
<td>• Require skilled ATC controllers</td>
<td></td>
<td>• Better anticipation</td>
<td>• Better anticipation</td>
<td>• Better anticipation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Reduces ATM workload</td>
<td>• Reduces ATM workload</td>
<td></td>
</tr>
</tbody>
</table>

*All-purpose Structured Eurocontrol Radar Information Exchange*
Simulation and Validation tools

The use of validated technical and economic modelling and evaluation tools is necessary in order to offer safe and optimal surveillance solutions.

To support any ANSP wanting to develop or replace its surveillance architecture, a comprehensive suite of simulation tools has been developed with the following functions:

- Implementation of an ANSP’s surveillance needs and its environment
- Definition of scenario and performance indexes
- Development of potential solution, independent of manufacturers
- Cost evaluation of system acquisition and operation

Performance Modelling Tools

A performance modelling tool computes the performance indexes of multi-sensor systems such as WAM, or MSPSR and mono-sensor systems such as PSR, SSR or ADS-B for different surveillance architecture scenarios. The tool is able to compute non-cooperative coverage by merging data from different PSR and MSPSR systems, and can compute cooperative coverage by merging data from different SSR, ADS-B and WAM systems. Then, the system simulates the multi-sensor tracking process and data fusion. The user can also view and display selected configurations.

Economical Modelling Tools: Cost & Solution Global Valuation

The tool is able to compute both the acquisition and the operating costs (including communication, installation...), so as to determine the complete Life Cycle Cost (LCC) for each scenario. According to the metrics determined with the ANSP, an optimal solution can be determined.

Display Analysis and Replay Tools

These tools validate and monitor the designed global surveillance solution through an analysis of recorded air traffic situations based on three major factors:

- **Display**: Features tracking/plotting from different sources, ASTERIX (surveillance standard format) and specific radar formats, air situation and tabular display, data filtering
- **Complete replay capabilities and speed selection**
- **Analysis**: Features bias and noise estimation, track characteristics and bias value chart display, sensor statistics and tracking performance assessment results

Display analysis and replay tool functionalities (developed by Thales)

Air and Ground Surveillance Analysis Tools Suite

1/ **Trajectory Generation based on:**
- Mobile scenario: 3D mobile template simulation
- Sensor scenario (standard and specific characteristics per kind of sensor)
- Environment scenario (airport layout management, shadowing areas, multipath, etc.)
- Trajectory scenario

2/ **Trajectory Reconstruction**
- Sensor reports and/or track updates chaining
- Gap filler processing
- Trajectory smoother

3/ **Sensor and Tracker Performance Assessment**
- Sensor performance computation for approach and en-route radars (PSR, SSR, CMR, Mode S), surface movement radar (SMR), MLAT/WAM system, ADS-B ground station
- Tracker performance assessment: accuracy, latency, continuity and integrity metrics according to ESSAP’s (European Strategic Safety Action Plan) rules.
- Verification of International Standards from entities such as EUROCONTROL, MIT, EUROCAE, FAA, ANSP
4.1 Frankfurt am Main TMA, WAM system .................... 46
4.2 USA, Nationwide ADS-B coverage ......................... 47
4.3 Australia ................................................... 48
4.4 Hong-Kong ................................................. 48
4.5 United Kingdom ........................................... 49
Approximately 87,000 flights crisscross America’s skies each day. According to the Federal Aviation Administration (FAA), that number is projected to rise to over 128,000 flights per day by 2025. Unfortunately, the current ground-based radar air traffic control system that has served America well for the last 60 years has hit the ceiling of its growth capacity; it simply cannot keep pace with expected demand. NextGen is transforming the US National Airspace System (NAS) to meet future needs and avoid gridlock in the sky and at airports. The FAA has embarked on a continuous roll-out of new capabilities and technologies that will reduce delays, make air traffic more efficient and minimize aviation’s impact on the environment. Travel will become more predictable, quieter, cleaner, more fuel-efficient, and even more importantly, safer.

As a key member of the ITT Corporation team, Thales is providing some 1,600 ADS-B stations for nationwide coverage across the US, as well as Top-Sky - Tracking, the multi-sensor tracker for reliable fusion of radar and ADS-B targets. This satellite-based surveillance system will bring improved precision and reliability to US skies. Pilots will benefit from improved situational awareness. Controllers will be able to reduce aircraft separation and increase airspace capacity. Aircraft will fly more direct routes, reducing fuel burn. ADS-B is already supporting the 9,000 daily helicopter operations in the Gulf of Mexico allowing flights to continue even in poor visibility conditions. UPS (courier solutions) is using ADS-B at its hub in Kentucky and expects to achieve an annual fuel reduction of 800,000 gallons, a 30% decrease in noise and 34% reduction in emissions when ADS-B is fully implemented.

As one of the busiest airports in the world, Frankfurt Airport’s Terminal Manoeuvring Area (TMA) has implemented the first operational WAM system in Germany, the Precision Approach Monitoring (PAM) system, designed specifically for highly congested environments. It delivers almost five times higher update rates than conventional radar and provides controllers with enhanced situational awareness and more flexibility to feed aircraft into the approach area around Frankfurt Airport. The “WAM-PAM” system is comprised of 37 ground stations, 15 transmitters, and 37 receivers, set up around 34 individual sites. High precision surveillance data is provided throughout a 128 by 80 NM coverage area starting as low as Frankfurt Airport ground and reaching beyond cruising altitude. Around the airports of Frankfurt and Hahn, the lowest detection limit is 500 feet above ground, increasing to 1,000 feet above ground within the terminal approach area. The remaining area is covered from 3,000 feet above ground.

As one of the busiest airports in the world, Frankfurt Airport’s Terminal Manoeuvring Area (TMA) has implemented the first operational WAM system in Germany, the Precision Approach Monitoring (PAM) system, designed specifically for highly congested environments. It delivers almost five times higher update rates than conventional radar and provides controllers with enhanced situational awareness and more flexibility to feed aircraft into the approach area around Frankfurt Airport. The “WAM-PAM” system is comprised of 37 ground stations, 15 transmitters, and 37 receivers, set up around 34 individual sites. High precision surveillance data is provided throughout a 128 by 80 NM coverage area starting as low as Frankfurt Airport ground and reaching beyond cruising altitude. Around the airports of Frankfurt and Hahn, the lowest detection limit is 500 feet above ground, increasing to 1,000 feet above ground within the terminal approach area. The remaining area is covered from 3,000 feet above ground.
**Australia**

The airspace controlled by The Australian Advanced Air Traffic System (TAAATS) covers 56 million square kilometres and controls more than three million air traffic movements per year. While almost full radar coverage exists along the east coast of Australia and the majority of commercial air traffic in Australia is currently radar controlled, over 90% of Australian airspace is outside radar coverage. To combat this, the Automatic Dependant Surveillance - Broadcast (ADS-B) system is providing extensive coverage in non-radar airspace and complements the existing en-route and terminal radar Radar Sensor Procurement Programme (RASPP) network.

The ADS-B system is fully integrated with the Australian Advanced Air Traffic System (TAAATS) flight plan, radar data and Automatic Dependant Surveillance - Contract (ADS-C) data display and allows Airservices Australia to provide radar-like separation services in the current non-radar airspace. TAAATS has been upgraded to process up to 1,000 ADS-B flights simultaneously from up to 200 ground stations. The ADS-B Upper Airspace Project (UAP) programme is one of the first operational large scale ADS-B system in the world.

**Hong-Kong**

Due to the mountainous terrains of Hong-Kong’s territories and location of radar with uptilt antennas, some areas where General Aviation/helicopters are flying at low altitudes were not covered by existing secondary radar (SSR) network. After a cost and technical study comparing potential coverage of SSR mode S and ADS-B, the Civil Aviation Department (CAD) of Hong-Kong has decided to set up the best value-for-money infrastructure consisting of ADS-B ground stations installed at 8 strategic sites with signals integrated by the central data processing units to provide surveillance on both en-route aircraft and low-flying General Aviation and helicopters. Low level flight trials were especially carried out with an on-board ADS-B and SSR Mode S equipped helicopter.

When the helicopter was flying at low altitude, target drops were observed in SSR data whereas the ADS-B ground station system maintained an almost uninterrupted surveillance coverage (no target drops).

ADS-B system can thus provide very good surveillance coverage which in return enhances surveillance capabilities and situational awareness for both Air Traffic Control (ATC) and pilots. Equally important, ADS-B facilitates Search and Rescue (SAR) operations and subsequent investigation of accident/incident for low flying General Aviation.

**United Kingdom**

The first successful application of the Global Surveillance Solution was the design of the VFM (Value For Money) Surveillance architecture within the Marshall UK MoD program. AQUILA, a joint venture between NATS and Thales, has signed a contract to deliver Marshall, the UK Ministry of Defense (MOD) program to transform terminal air traffic management at military airfields. The contract is valued at around £1.5bn over the course of its 22 year life-span. Marshall seeks to ensure a safe, efficient and sustainable Air Traffic Management (ATM) service for the UK Armed Forces. It will modernize ATM at over 100 MOD locations, in the UK and overseas, including more than 60 airfields and ranges. AQUILA will deliver a system-wide modernization and rationalization of the current fragmented system, and establish a flexible ATM service – one that complies with known regulatory requirements and which is future-proofed to meet any potential change in the regulatory and technological landscape.

Taking into account the UK MoD performance based requirements, the environment (legacy surveillance systems, communication networks,...) and the operational constraints, NATS and Thales proposed an optimal solution combining conventional sensors (new primary radars –STAR NG- and RSM 970 S Mode-S secondary radars), new sensors technologies such as WAM (Thales MAGS), and upgrades of legacy radars associated to multi sensor surveillance trackers embedded in the TopSky ATC systems.
Whatever the needs, ANSP have to choose the most adapted Service level responding to their budget and selection criteria, from a traditional approach case by case basis up to a comprehensive Managed Services through the externalization of their support activities.

Between these two totally opposite approaches, different customized solutions may be considered:

- A tailored services contract streamlines the In-Service support by creating a contractual framework for the delivery of services. Within the framework, individual services can be selected by the customer and agreements made on the level of each service supplied. The benefits linked to such services contracts are a significant reduction in cost of ownership and shorter delivery times for items covered by the agreed framework.

- The Extended Support Services model is based on an agreed performance level for a fixed cost. This is generally more efficient and effective than an on-demand support service or a services contract. The benefits of this ‘care free’ approach are: clear financial planning, key performance indicators, risks relating to system availability handled by the services provider.

Whatever the Global Surveillance Support Services package chosen, the different support services usually proposed by the Services providers fall in the 4 following categories:

- **Customer contact services**
  - Customer On Line service
  - Help Desk
  - Local Support Centres
  - Customer Support Manager

- **Maintenance services**
  - Spare parts
  - Test benches
  - Repair services
  - Technical assistance
  - Technical expertise
  - Software support
  - Remote Control Monitoring Service
  - Prime Contractorship

- **Optimisation services**
  - Skills optimisation through training services and documentation
  - Maintenance organisation optimisation through Spares inventory management
  - System availability optimisation through Field Data Analysis and Obsolescence management services

- **Upgrade services**
  - Capability improvement for implementing new functionalities (life extension, regulatory requirements)
  - Capacity improvement for adapting your system to increasing operational needs

To successfully accomplish Global Surveillance operations, availability and reliability of the systems are crucial. This means In-Service support such as accurate management, adequate maintenance, and fast logistic services must be totally integrated into daily operations.
The Air Traffic Management system is currently facing a drastic need for change in order to increase capacity and safety and to reduce cost and environmental impact. There are major R&D programmes such as the Single European Sky ATM Research (SESAR) and the NextGen in the United States, that have been initiated with the aim to develop new operational concepts and enabling surveillance technologies that will be able to support the implementation of a new ATM system.

**NextGen ADS-B Program**
The Automatic Dependent Surveillance (ADS-B) system is the cornerstone of the FAA’s NextGen initiative to modernise and change ground-based air traffic control systems to satellite-based systems. This programme, led by Harris (former ITT Exelis), will have a huge impact on the entire aviation industry, affecting, to a certain degree, every aircraft in US airspace. As a key member of the HARRIS (ITT Exelis) team, Thales is providing some 1,200 ADS-B radios for nationwide coverage across the US.

**NextGen Surveillance and Weather Radar Capability**
The FAA currently operates four distinct radar systems for terminal aircraft surveillance and hazardous weather detection in US terminal airspaces. These radar systems (the Airport Surveillance Radar Models 8, 9 and 11, and the Terminal Doppler Weather Radar) are nearing the end of their lifecycles and will require Service Life Extension Programs (SLEPs) to continue operational service. Sustainment and upgrade programs can keep these radars operating in the near- to mid-term. For the long term, the FAA states that replacement of these radars is the best option. One potential alternative is the Multifunction Phased-Array Radar (MPAR), an alternative that uses active electronically scanned phased array technology. In being innovative with new technology, it is possible to reduce the total number of radars required by approximately one third.

**SESAR [WP 15.04.01]: Changes to Surveillance Infrastructure**
The objectives of the SESAR WP 15.04.01 project were twofold:
- Promoting rationalisation and adaptation of the surveillance infrastructure
- Supporting the introduction of changes to the surveillance infrastructure that are identified in the ATM master plan (ATM Master Plan is the roadmap driving the modernisation of Air Traffic Management and governing the transition from European Single Sky ATM Research (SESAR) to deployment).

**SESAR [WP 15.04.05 A & B]: System Enhancements for ADS-B**
- Enhancing ground surveillance systems to support ADS-B applications
- Developing an update for ADS-B ground stations’ specification in Surveillance Data Processing and Distribution (SDPD) and use of an ASTERIX interface
- Developing a ground-based prototype to support Airborne Separation Assurance Systems (ASAS) applications (en-route and TMA)

Thales is a major partner in these initiatives, including specific projects concerning surveillance such as:

**SESAR [WP 15.06.08.01]: Runway Wake Vortex Support Tools**
- Aiming to safely reduce wake vortex separations for arrival and departures
- Aiming to define, analyse, develop and verify a Wake Vortex Decision Support System (W VDSS) in order to:
  - Satisfy SESAR [WP 06.08.01]’s operational concept
  - Deliver position and strength of wake vortices
  - Predict wake vortices behaviour and impact on safety and capacity
  - Advise stakeholders (Air Traffic Controllers, Supervisors, etc.)
- Finding solutions for wake vortex concerns, taking into account airport infrastructure, layout and weather conditions
7.1  Windfarm Compliant Radars .............................. 56
7.2  Foreign Object Debris Detection .......................... 58
7.3  Wake Vortex Detection .................................... 59
7.4  Weather Hazards Detection ............................... 60
7.5  MultiStatic Primary Surveillance Radar .................... 61
Wind farm Compliant Radars

The development of renewable energy is now a priority all over the world, and among emerging technologies, wind energy is one of the most promising solutions.

For example, in Europe, the European Wind Energy Association forecasts that electricity production from wind turbines will be multiplied by six within the next 20 years.

However, wind turbines can disturb Air Traffic Services, and in particular Primary Surveillance Radars (PSR). Practical disturbances are the generation of false plots and tracks by the wind turbines, the loss of detection of real targets (i.e. aircraft) flying over wind farms and the masking of low level aircraft behind wind farms.

Mitigation solutions are being developed in order to prevent blocking wind energy development, making radars “Wind farm Compliant”.

As an illustration, Thales has installed a S-Band PSR at Inverness, Scotland, an airport surrounded by a number of wind farms. This was a good opportunity to take recordings on real situations and to analyse the capacity of a wind farm filter to cancel a large amount of wind turbine echoes. Such a solution is an attractive alternative to the more conventional Non Automatic Initiation (NAI) process, which prevents radars from initiating new tracks in wind farm areas.

Thales has identified several development axes, depending on the type of situation:

- **upgrading existing radars**: software processing can be improved by adding wind farm filters that filter out the wind turbines’ spurious signals
- **installation of gap-filler radar solutions**: in the case of existing radars for which such an upgrade is not yet envisaged or for solving specific issues such as masking, then gap-filler radar solutions (installed on the wind turbine itself) can be proposed.

**next generation radars**: wind farm “clutter” will be considered a requirement. Innovative radar with improved wind farms filters, such as STAR NG, the new PSR from THALES answers to this issue and shall avoid the need of wind farm Gap-fillers. New architectures are already being studied in order to propose other solutions. Among these architectures, MSPSR (Multi-static PSR)\(^1\) shows promise in its built-in wind farm mitigation features.

Thales also contributes to dedicated groups and shares its knowledge with expert ATM communities (such as the Eurocontrol Wind Turbine Task Force), therefore participating in a common effort towards a greener planet.

\(^1\) Refer to Chapter 7.5
The chance of wake vortices occurring is higher during taking off and landing phases, as aircraft are less easily able to manoeuvre.

Wake turbulence is turbulence that forms behind an aircraft as it passes through the air and can be thought of as two horizontal tornados trailing after the aircraft.

Enquiries have shown that highest occurrence of wake vortex encounters are:
- On touchdown (lower than 100ft in altitude)
- When turning onto the glideslope (between 3,500-4,500ft in altitude)

An aircraft exposed to the wake vortex turbulence of an aircraft ahead of it can experience an induced roll movement (bank angle) that is not easily corrected by the pilot or the autopilot.

However these distances can be safely reduced with the aid of smart planning techniques from future Wake Vortex Decision Support Systems based on the detection, monitoring and prediction of wake vortices (e.g. transport estimation by cross-wind), significantly increasing airport capacity.

Radar and lidar Sensors are low cost technologies with high performance, complementary wake vortex detection capabilities in all weather conditions compared to others sensors.
Multi-Static Primary Surveillance Radar (MSPSR) is an innovative independent non-cooperative civil and military surveillance solution for Terminal Approach Control and en-route purposes. It is based on a sparse network of stations able to transmit and receive omnidirectional and continuous waveforms.

Two system types are derived from this concept:
- “Active” MSPSR with dedicated (“controlled”) transmissions
- “Passive” MSPSR, relying on transmitters of opportunity, identified as Passive Coherent Location (PCL)

The strength of this technology is such that localisation of aircraft is now available in 3D and with a faster refresh rate compared to current PSR. Existing transmitters (transmitters of opportunity, using signals such as those of radio or TV broadcasts) can be used by PCL. Dedicated transmitters of active MSPSR will use current PSR frequency bands.

MSPSR offers several improvements compared to a conventional Primary Surveillance Radar:
- 3D detection
- Higher renewal rate (1.5 s instead of 4-5 s)
- Resistance to wind farms effects
- Lower energy consumption

The configuration of MSPSR is adaptable to the environment and can be easily reconfigured. It reuses existing infrastructures such as communication masts. Coverage can be extended by adding transmitters (Tx) and receivers (Rx) as necessary.

Main weather hazards that have an impact on safety are:
- storms (cumulonimbus clouds),
- heavy rain (gust fronts),
- wake vortices,
- severe weather turbulence (CAT),
- wind shears and microbursts.

Development of ATM weather systems for terminal approach and airport controls is necessary to improve safety in adverse conditions and to reduce flight delays, optimising airport capacity.

Existing surveillance equipment is not optimised for airport weather services: weather radars from National Met Offices are located far from airports, the weather channel of Primary ATC Radar is of poor quality, Terminal Weather Radars have not been deployed in Europe and are based on old technology in the US...

Some R&D programmes (US FAA/NEXGEN Multimission Phased-Array Radar (MPAR)) are working on innovative evolutions that are based on electronic multi-function approach that enables rapid and adaptive scanning, increase lead time for weather hazard warning, better data quality for national digital weather prediction, high resolution/high refresh rate for hazard monitoring (wake vortices, wind shears, etc.). Several solutions are being explored: networked short range sensors, rotating Phased Array Radar (PAR), fixed face PAR, etc.
<table>
<thead>
<tr>
<th>TERM</th>
<th>DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-SMGCS</td>
<td>Advanced Surface Movement Guidance &amp; Control System</td>
</tr>
<tr>
<td>ACAS/TCAS</td>
<td>Airborne Collision Avoidance System / Traffic Collision Avoidance System</td>
</tr>
<tr>
<td>ADS-B</td>
<td>Automatic Dependent Surveillance – Broadcast</td>
</tr>
<tr>
<td>ADS-C</td>
<td>Automatic Dependent Surveillance – Contract</td>
</tr>
<tr>
<td>ANSP</td>
<td>Air Navigation Service Provider</td>
</tr>
<tr>
<td>ASTERIX</td>
<td>All-purpose Structured Eurocontrol Radar Information Exchange</td>
</tr>
<tr>
<td>ATC</td>
<td>Air Traffic Control</td>
</tr>
<tr>
<td>ATM</td>
<td>Air Traffic Management</td>
</tr>
<tr>
<td>ATN</td>
<td>Aeronautical Telecommunication Network</td>
</tr>
<tr>
<td>EHS</td>
<td>Enhance Mode-S surveillance</td>
</tr>
<tr>
<td>ELS</td>
<td>Elementary Mode-S Surveillance</td>
</tr>
<tr>
<td>ES</td>
<td>Extended Squitter</td>
</tr>
<tr>
<td>ESARR</td>
<td>Eurocontrol Safety Regulatory Requirement</td>
</tr>
<tr>
<td>FAA</td>
<td>Federal Aviation Administration</td>
</tr>
<tr>
<td>FOD</td>
<td>Foreign Object Debris</td>
</tr>
<tr>
<td>GNSS</td>
<td>Global Navigation Satellite System</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>ICAO</td>
<td>International Civil Aviation Organization</td>
</tr>
<tr>
<td>ID</td>
<td>IDentification</td>
</tr>
<tr>
<td>KPA</td>
<td>Key Performance Areas</td>
</tr>
<tr>
<td>KPI</td>
<td>Key Performance Indicator</td>
</tr>
<tr>
<td>MLAT</td>
<td>MultiLATeration</td>
</tr>
<tr>
<td>MPAR</td>
<td>Multifunction Phased-Array Radar</td>
</tr>
<tr>
<td>MSPSR</td>
<td>Multi-Static Primary Surveillance Radar</td>
</tr>
<tr>
<td>MSSR</td>
<td>Monopulse Secondary Surveillance Radar</td>
</tr>
<tr>
<td>NextGen</td>
<td>Next Generation Air Transportation System</td>
</tr>
<tr>
<td>NM</td>
<td>Nautical Mile</td>
</tr>
<tr>
<td>PCL</td>
<td>Passive Coherent Location</td>
</tr>
<tr>
<td>PRM</td>
<td>Precision Runway Monitor</td>
</tr>
<tr>
<td>PSR</td>
<td>Primary Surveillance Radar</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
</tr>
<tr>
<td>RF</td>
<td>Radio Frequency</td>
</tr>
<tr>
<td>Rx</td>
<td>Receiver</td>
</tr>
<tr>
<td>SESAR</td>
<td>Single European Sky ATM Research Programme</td>
</tr>
<tr>
<td>SMR</td>
<td>Surface Movement Radar</td>
</tr>
<tr>
<td>SSR</td>
<td>Secondary Surveillance Radar</td>
</tr>
<tr>
<td>TDOA</td>
<td>Time Difference Of Arrival</td>
</tr>
<tr>
<td>TMA</td>
<td>Terminal Manoeuvre Area</td>
</tr>
<tr>
<td>Tx</td>
<td>Transmitter</td>
</tr>
<tr>
<td>VHF</td>
<td>Very High Frequency</td>
</tr>
<tr>
<td>WAM</td>
<td>Wide Area Multilateration</td>
</tr>
<tr>
<td>SESAR</td>
<td>Single European Sky ATM Research Programme</td>
</tr>
<tr>
<td>SMR</td>
<td>Surface Movement Radar</td>
</tr>
<tr>
<td>SSR</td>
<td>Secondary Surveillance Radar</td>
</tr>
<tr>
<td>STCA</td>
<td>Short Term Conflict Alert</td>
</tr>
<tr>
<td>TDOA</td>
<td>Time Difference Of Arrival</td>
</tr>
<tr>
<td>TIS-B</td>
<td>Traffic information services-broadcast</td>
</tr>
<tr>
<td>TMA</td>
<td>Terminal Manoeuvre Area</td>
</tr>
<tr>
<td>TOA</td>
<td>Time Of Arrival</td>
</tr>
<tr>
<td>TWT</td>
<td>Travelling Wave Tube</td>
</tr>
<tr>
<td>Tx</td>
<td>Transmitter</td>
</tr>
<tr>
<td>UAT</td>
<td>Universal Access Transceiver</td>
</tr>
<tr>
<td>VDL</td>
<td>VHF Data Link</td>
</tr>
<tr>
<td>VHF</td>
<td>Very High Frequency</td>
</tr>
<tr>
<td>WAM</td>
<td>Wide Area Multilateration</td>
</tr>
</tbody>
</table>
Although widely deployed Primary and Secondary Surveillance Radars are considered to be mature, highly proven equipment, new technologies such as Automatic Dependent Surveillance - Broadcast (ADS-B) and Wide Area Multilateration (WAM) are proving to be advanced and effective alternatives.

Choosing a surveillance solution adapted to your current and future operational needs, your ATM environment and your budget is therefore not easy.

The objective of this booklet is to concisely present the different surveillance sensors currently available on the market, their interfaces with automation systems and real case studies to help you develop a truly Global Surveillance Solution, conceptualised by Thales. This booklet will show you how the Global Surveillance concept can help you meet tomorrow’s traffic demands and your objectives for even higher safety, enhanced efficiency and lower costs while meeting all future requirements too.