



ADS-B and other means of surveillance implementation status

May 15th, 2018

Control

Approved by	Nicolas Warinsko General Manager	Date 14/05/2018	Signature Signed
Reviewed by	Mariagrazia La Piscopia Head of Strategy, Technical and Operations	Date 10/05/2018	Signature Signed
Prepared by	Cristian Pradera DP Planning Manager Heiko Teper Deputy Head of Strategy, Technical and Operations - DP Realisation Manager	Date 07/05/2018	Signature Signed

Table of contents

Executive summary	5
Introduction	6
1. Context	7
2. Surveillance systems	9
2.1. Radar	9
2.2. Multilateration	10
2.3. ADS-B.....	10
2.4. Surveillance information in ATM systems.....	12
3. Reporting Approach	13
4. Current status	14
4.1. Mode S	14
4.1.1 Ground segment – Airspace and Airport surveillance.....	14
4.2. Multilateration	16
4.2.1 Ground segment – Airspace and Airport surveillance.....	16
4.3. ADS-B.....	18
4.3.1 Ground ADS-B segment – Airspace and Airport surveillance	18
4.3.2 Airborne ADS-B segment	19
4.3.3 Space based ADS-B.....	22
4.4. Current overall implementation outlook.....	22
5. Future status	25
5.1. Mode S	25
5.1.1 Ground segment in 2020 – Airspace and Airport surveillance	25
5.1.2 Ground segment beyond 2020 – Airspace and Airport surveillance	27
5.1.3 Mode S implementation expected timeline.....	28
5.2. Multilateration	29
5.2.1 Ground segment in 2020 – Airspace and Airport surveillance	29
5.2.2 Ground segment beyond 2020 – Airspace and Airport surveillance	30
5.2.3 Multilateration implementation expected timeline	32
5.3. ADS-B.....	32
5.3.1 Ground ADS- B segment in 2020 – Airspace and Airport surveillance.....	32
5.3.2 Ground ADS-B segment beyond 2020 – Airspace and Airport surveillance	34
5.3.3 Ground based ADS-B implementation expected timeline	36
5.3.4 Airborne ADS-B segment	37

5.3.5	Space based ADS-B.....	37
5.4.	Overall implementation outlook in and beyond 2020.....	37
6.	Other considerations	41
6.1.	Spectrum congestion issues.....	41
6.2.	Common point of failure	42
6.3.	Certification of GNSS for Safety of Life provision.....	43
6.4.	Other national security aspects.....	44
7.	Main findings	47
7.1.	Ground segment	47
7.2.	Airborne segment	47
7.3.	New international requirements	47
7.4.	Way forward.....	47
	Appendix A – ADS-B Surveys.....	49
	Ground surveillance	49
	Airborne surveillance.....	53
	Appendix B – List of Respondents	54

Executive summary

Automatic Dependent Surveillance-Broadcast (ADS-B) is a surveillance technique that relies on aircraft broadcasting their identity, position, and other information derived from on board systems. This signal can be received for surveillance purposes on the ground (ADS-B Out) or on board of the aircraft (ADS-B In).

As requested by the European Commission through its letter Ref. Ares(2018)1019272 - dated 15/02/2018 and in order to provide a clear and complete picture of the current situation of ADS-B implementation in Europe that could support the development, the consultation and the execution of an ADS-B recovery plan, the SDM has carried out a survey contacting all the Operational Stakeholders (ground and airborne) affected by the **Commission Implementing Regulation (EU) No 1207/2011 and its amendments (EU) No 1028/2014 and (EU) No 2017/386**, referred as “**the Regulation**” in this report. SDM has also contacted one main European supplier to check industry’s capability to deliver timely. Finally, SDM has investigated the deployment and, where relevant, decommissioning of other means of surveillance. The results are collected within this report and show the current status and the future plans of Mode S radars, Multilateration (MLAT) / Wide Area Multilateration (WAM), and ADS-B stations.

The analysis of the data shows that most of the European airspace and main airports have ADS-B coverage, either by ADS-B stations or Mode S and WAM/MLAT systems. Furthermore, there are clear plans by the ANSPs to improve the overall coverage. It has to be noted that many ANSPs are, via WAM or ADS-B, capable to receive and process the ADS-B data and that some degree of operational use of the airborne ADS-B transmissions is already well established.

The geographical and functional extent of such use is highly variable. Nowadays, ADS-B is considered as one of the layer of Air Traffic Service (ATS) Surveillance needed to ensure current separation minima. Whilst the use of ADS-B in Non Radar Airspace is supported by ED126, acceptance of ADS-B as a potential sole means of surveillance in all airspaces may require some key challenges highlighted in this report to be solved (see chapter 1).

This report also provides the status of the aircraft equipage regarding ADS-B Out capability (transponder ED-102A (DO-260B) compliant with the Regulation).

Out of 3108 aircraft reported through the surveys, only 613 (~20%) are equipped and certified with the ED-102A (DO-260B) transponder. It can be assumed that this percentage is a good representation of the overall European fleet equipage rate. This figure is in line with some of the Airbus aircraft equipage rate (~21% for the A320 family and ~31% for the A330/A340 family). This capability is largely comprised of forward fit installations, whilst the retro-fit plans reported by the Airspace Users show very few airlines planning to install the DO-260B transponder to be compliant by 2020. However, even if beyond the scope of the survey, it should be noted that many aircrafts are able to transmit ADS-B as they are equipped with ED-102 (DO-260 and DO-260A transponders) but they are not fulfilling the quality requirements defined in the Regulation.

Other aspects like the spectrum congestion, certification of GNSS¹ or national security are also addressed in the report in order to provide a complete and holistic view of the overall ADS-B situation in Europe.

¹ Global Navigation Satellite System

Introduction

Commission Implementing Regulation (EU) No 1207/2011 lays down the requirements on the systems contributing to the provision of surveillance data, their constituents and associated procedures, in order to ensure the harmonisation of performance, the interoperability and the efficiency of these systems within the European air traffic management network (EATMN) and for the purpose of civil-military coordination. The regulation was amended twice, by (EU) No 1028/2014 and by (EU) No 2017/386 due to, among other reasons, delays in certification and availability of required equipment, as well as industrial capacity constraints for equipping aircraft and synchronisation with the ADS-B mandate in USA. This last amendment postpones the aircraft² equipment of ADS-B Out functionality by 7 June 2020.

The SESAR Deployment Manager (SDM) received the request from the European Commission through its letter Ref. Ares(2018)1019272 to collect data on the status of implementation of ADS-B on 15th February 2018. As part of the its request, the Commission requested the SDM to collect, analyse and report on ADS-B ground stations deployment in Europe, their integration in the existing surveillance chain, as well as the management of the data into the Air Traffic Management (ATM) systems.

In response to the mandate, the SDM presents in this document the implementation status of the Surveillance systems (Mode S, Multilateration, and ADS-B), in their ground, airborne and space constituent segments, as well as the future deployment plans. The inclusion of these elements pursues the goal of providing a complete and consistent view of the situation of all the surveillance systems in Europe.

Consequently, this report should be read as a robust snapshot of the current means of surveillance state of play, also including plans ahead when available. It reports factual information that do not require any stakeholders' consultation beyond the surveys which have been performed during the last 2 months. This report intends to provide the basis for the European Commission to develop, consult and execute an ADS-B Recovery Plan. It is not a Recovery Plan itself. Based on its experience drawn from the DLS Recovery Plan, SDM stands ready to continue its support to the European Commission through these further steps.

² For those aircraft with a maximum certified take-off mass exceeding 5700 Kg or having a maximum cruising true airspeed capability greater than 250 knots.

1. Context

Globally, ADS-B has been undergoing deployment since early 2000's. The technology has proven particularly attractive in locations where previously no form of surveillance was physically possible or economically feasible, such as in the Australian inland or over Hudson Bay in Canada. In such areas, ADS-B supports new, radar-like separation modes, enabling a drastic increase in airspace capacity. Many States around the World have assessed and implemented ADS-B independently for airport surface or airspace surveillance. The hitherto unexplained disappearance of MH370 over the Indian ocean in 2014 provided an additional impetus towards the introduction of ADS-B over vast oceanic areas, culminating in a global scale implementation of a satellite based variant of ADS-B.

In highly complex environments with dense traffic, such as ECAC or the continental US, ADS-B has faced challenges. The technology has been part of the long-term surveillance vision since mid-1990 on both sides of the Atlantic. Evaluations spanning many years were conducted under FAA and Eurocontrol led programmes. Since 2010, both FAA and the EU, have promulgated airborne mandates, which have gone through a series of revisions and postponements to finally converge on the currently applicable scopes (generally medium and heavy commercial traffic in the case of EU and including light General Aviation (GA) operating in controlled airspace in the case of FAA) and deadlines (2020 in both cases).

The key challenges related to the progress of ADS-B implementation in these complex and traffic heavy environments could be generalized as follows:

- **Competitive advantage.** Existing radar surveillance is already of high technical standard. In the short to medium term, Mode S radars offer enhanced performance and substantial RF capacity improvements, whilst multilateration offers a cost-effective alternative to radar with similar performance to ADS-B. In the long run, ADS-B offers potential for new applications which the conventional sensors cannot match.
- **Dependence on GNSS.** ADS-B uses GNSS as its primary positioning source. The only two operational constellations in existence today being military systems controlled by US and Russia, and the relative vulnerability of GNSS to interference and spoofing, raised hitherto unresolved questions of state liability and approval. While the advent of the EU owned and operated Galileo constellation, expected to see operational use in aviation earliest 2026, will help alleviate the concerns of national sovereignty, the vulnerability issue will remain. Other existing positioning alternatives to GNSS are either not sufficiently widespread (DME³/DME updating or eLORAN⁴) or come with a performance limitation (stand-alone inertial platform) making them unsuitable for sustained air traffic control operations. This leads to local concerns from some NSAs on the use of non-European GNSS.
- **Integrity and security.** Even discounting the dependency on GNSS, ADS-B was proven easily eavesdropped and/or spoofed when compared to conventional surveillance sensors such as the radar or the multilateration. This raises substantial concerns to actors who value operational security or privacy. Technological mitigations have been proposed and

³ Distance Measurement Equipment

⁴ Enhanced Long Range Navigation

developed, but are yet to prove their efficacy before they become part of the global ICAO⁵ standard.

- **Mixed mode challenge.** In Air Traffic Control (ATC) operations, mixed mode is a common phenomenon. In its generic instance, the term refers to an air traffic picture where different participants exhibit different performance characteristics to a degree where ATC needs to apply systematic mitigations to guarantee sustained service provision. Often the mitigation takes the form of tailoring operations to the lowest common denominator so as to encompass the maximum possible share of traffic and result in a high degree of operational uniformity. In terms of ATC surveillance, this means that ADS-B as a surveillance technology could not be able to fully replace conventional sensors (radar and multilateration) until all airspace users are equipped and capable.
- **First mover disadvantage.** Without a proper air/ground synchronization and coordination, there could be the risk of a first mover disadvantage for the implementing Stakeholders. This could happen when multiple stakeholders are investing separately in order to materialize a joint benefit.
- **Protracted standardization.** The original variant of the 1090ES ADS-B was codified in RTCA DO-260; many early adopters equipped to that standard in the early days of the rushed ADS-B implementation. In the course of the validation programmes of the first decade of the new millennium, it was concluded that the original standard was inadequate particularly with respect to the quality indicators embedded with the surveillance data, and the standard was updated twice to settle on the currently applicable edition RTCA DO-260B equal to EUROCAE ED-102A.

⁵ International Civil Aviation Organisation

2. Surveillance systems

This chapter provides a short description of the main surveillance systems characteristics as the analysis of ADS-B implementation status shall be performed in the light of other surveillance technologies' state of play in order to provide a full and reliable picture.

2.1. Radar

Two types of radar are in use for ATM surveillance: primary and secondary. The Primary Surveillance Radar (PSR) operates independently and measures target position and movement by means of a transmitted electromagnetic wave that is reflected by the target (the return). The Secondary Surveillance Radar (SSR) requires a piece of equipment installed aboard the aircraft and known as the transponder, to receive and decode the radar signal (the interrogation) and after a set delay, produce, encode and transmit a reply. The radar will measure the target position from the direction and timing of the arriving reply and decode additional information that the transponder encoded in the reply as instructed in the original interrogation signal. The SSR is the predominant type of radar used in ATM surveillance. Several generations of SSR were developed over time, each improving on its predecessor in terms of functionality, performance and spectrum efficiency. At present the legacy generation, the Monopulse Secondary Surveillance Radar Mode A/C (MSSR), is undergoing a phase-out and replacement by the modern Mode S MSSR.

Mode S is a cooperative independent surveillance sensor that detects and measures the position of aircraft and obtains additional information from the aircraft by means of a point-to-point data link (Mode S data-link) connection. The Mode S system consists of a ground based interrogator and aircraft based transponder.

The transponder contains a large memory bank comprising of registers where it regularly stores and updates data, items sourced from multiple avionic systems (mainly aircraft identity), telemetry, various systems status and capability information but also external measured data. The ground-based interrogator will, at chosen times, address to the aircraft a request for the content of specific registers. The transponder decodes the request and encodes in its reply the data found in the corresponding registers. There are a total number of 256 registers. Some of the most commonly used registers contains aircraft identity, aircraft intent and aircraft heading and speed. Altitude is included in several target status report registers. Some registers are reserved for Extended Squitter functionality, i.e. ADS-B, which is further elaborated in chapter **Error! Reference source not found.** Several specific registers were deemed particularly desirable and were subsequently encapsulated as Elementary (ELS) and Enhanced (EHS) Surveillance. This was done to promote adoption and facilitate the promulgation of the Regulation. ANSPs have been implementing ELS and EHS.

In the ground domain, the Mode S system also includes functions to cluster the ground infrastructure in order to limit the number of interrogations to individual aircraft, thus optimising utilisation of spectrum.

Physically the system is based on a rotating antenna in the centre of the area of coverage, thus the position accuracy varies and depends on the distance between antenna and aircraft as it is based on measurements of range and azimuth. A typical coverage of a singular Mode S interrogator is 200-256 NM.

The target position update rate at the system output is driven by the antenna rotation speed; typically, every sixth to tenth second.

2.2. Multilateration

Multilateration is a surveillance technique based on the time difference of arrival of a radio signal at a number of geographically remote stations at known times. The ground infrastructure consists of a number of receiving stations that listen for replies to Mode A/C or Mode S interrogations, much like a Secondary Radar would. The system can also operate passively by intercepting broadcast transmission (ADS-B) or aircraft to aircraft transmissions (ACAS⁶). Since an aircraft will be at different distances from each of the ground stations, their replies will be received by each station at fractionally different times allowing an aircraft's position to be precisely calculated provided that a sufficient number of receivers were able to detect and decode the reply simultaneously. Failing that, the system can still read aircraft position from its ADS-B transmissions.

The system consists of a central processing station and a number of peripheral receivers, some or all of which can be equipped to act as interrogator antennae. Position accuracy is affected by Dilution Of Precision (DOP) which itself depends on antenna geometry with respect to the target. Multilateration is highly scalable; it can be designed to serve a relatively compact and obstacle rich environment such as a large airport, in which case the system is simply referred to as Multilateration (MLAT); the desired coverage can be conveniently achieved by a smart placement of as many receivers as are needed. When scaled up to serve large airspace surveillance needs, the system is referred to as Wide Area Multilateration (WAM).

Multilateration requires no additional avionic equipment and no actions from pilots beyond what is required for legacy radar surveillance; in fact, the aircraft systems perceive the system no different than they would a regular MSSR.

A typical update rate at the system output is fully configurable; RF environment characteristics and operational need will determine the desired setting. An update rate between one to four seconds is a common configuration.

2.3. ADS-B

Automatic Dependent Surveillance – Broadcast (ADS-B) is a surveillance technology in which an aircraft's navigation systems determines its position using a separate positioning source, primarily satellite navigation and periodically broadcasts it together with other data such as aircraft identity and barometric altitude, enabling it to be seen by any adequately equipped agent. In terms of the mandates under consideration in this report, this setup is referred to as ADS-B Out. The next step would be ADS-B In, in which the aircraft is equipped with an ADS-B receiver and a suitable traffic information display to enable pilots to see surrounding ADS-B Out equipped traffic. ADS-B In is not in the scope of the Regulation.

ADS-B is "automatic" as it requires no pilot or external input trigger, it is "dependent" as it depends on data from the aircraft's navigation system.

An ADS-B ground infrastructure consists of any number of ADS-B receivers connected in a network to provide derived surveillance information to an ATM system. The topography of the

⁶ airborne collision avoidance system

ground station network determines the low altitude coverage characteristics and the reception probability of the ADS-B reports. Position accuracy and distribution is inherited from the position source. The ADS-B receivers will monitor the accuracy and integrity of the derived position information and append scalar flags in its reports to be used for surveillance picture generation in the ground systems.

There exist three ICAO datalink standards supporting ADS-B, out of which the predominant technology is the 1090 Extended Squitter, which is also subject to the Regulation (EU) No 1207/2011. The 1090 Extended Squitter derives its name from:

- the common operating frequency 1090 MHz which is shared with both the secondary radar and the multilateration,
- the autonomous character of its broadcast (the "Squitter" being the term for an unsolicited broadcast transmission, in contrast with the "Squawk" being a reply to an incoming interrogation),
- and the additional space in its downlink messages which allow for a 112-bits of data to be encoded on the reply, in contrast to the 56 bits in the original short squitter used by the Airborne Collision Avoidance System (ACAS).

Functionally, the 1090ES transponder is an adaptation of the Mode S transponder discussed at chapter 2.1 above. In this instance, the transponder is fitted with a device that, at predetermined intervals, will prompt the transponder to assemble a message and encode in it the content of the required extended squitter registers. Since the primary purpose of ADS-B is to inform its listener of the sender's identity and position, a suitable and approved positioning source must be connected to populate the transponder registers.

The primary positioning source for ADS-B is GNSS. The only operational GNSS systems today are the American Global Positioning System (GPS) and the Russian Global Navigation Satellite System (GLONASS), both military systems. Implementation of Galileo the European civilian equivalent, is ongoing. Alternatively, the position can be sourced from the aircraft's inertial platform (IRS or INS); the inertial platform is continuously updated from other sources such as GNSS or DME/DME. When updating is lost, the position quality will start to degrade after some time and the accuracy will be downgraded.

The use of GNSS as a positioning source is already well established in navigation. Excessive reliance on GNSS for multiple separate applications of ATM could lead to a common point of failure, which is further detailed at chapter 6.2 and needs to be considered carefully. A typical position update rate at system output is determined by the datalink used; for 1090ES, the variant required by the Regulation, it is once per second.

A new technology is currently emerging in the form of Space based ADS-B. In that concept a constellation of Low Earth orbit (LEO) satellites collects ADS-B reports (1090ES) from aircraft in lieu of ground based receivers and retransmits them to own ground stations for distribution to ground based users.

Space-based ADS-B offers the opportunity to give a radar like control environment over oceanic, remote and geographically challenging areas of the World, in areas with poor infrastructure as well as in areas, like Europe, rich of surveillance infrastructure. In combination with improved Air/Ground (A/G) communication, this would allow for reduced separation, improved safety levels and greater efficiency and capacity in the airspace.

In areas with existing surveillance infrastructure, Space-based ADS-B has the potential to complement ground-based surveillance sensors as an additional surveillance layer, thus providing an opportunity to rationalise ground surveillance infrastructure.

Space-based ADS-B data is offered by Aireon on a commercial basis. The Aireon system is based on a specific payload on the Iridium satellite constellation. When the full constellation will be in place, the latency is expected to be better than 2 seconds with an update rate of every 8th second. The full constellation will give multiple coverage over most areas of the earth, thus supporting triangulation measurements as an independent verification of position data in the ADS-B messages, fully independent from GNSS.

The Aireon ADS-B service is available today with 50 satellites already launched for test purposes, the full satellite constellation is expected to be in place and in operation Q3 2018.

ICAO has established the Global Aeronautical Safety System (GADSS) with the intention to help ensure that no planes would ever “disappear” again, especially over remote and oceanic airspace. At the heart of the GADSS recommendations is the ability for airlines to track their aircraft in one-minute intervals should the plane enter a state of distress. Additionally, under normal flight conditions, it is recommended that airlines receive location updates at a minimum of once every 15 minutes. Aireon is offering this global tracking capability for ADS-B equipped aircraft by 2018. While specific details for GADSS implementation and additional requirements are still under debate by ICAO, this is a paramount element that needs to be taken into consideration.

2.4. Surveillance information in ATM systems

Presentation of surveillance information to controllers is one of the main tasks in an ATM system. In most cases a tracking function (like ARTAS⁷) is used to merge position, velocity and other telemetry information from all available surveillance sources into one track of uniform quality and presentation, then displayed on the controller’s screen at a predetermined common update rate. This is the case of most Air Navigation Service Providers (ANSP) controlling en-route airspace.

Originally, all surveillance systems communicated using proprietary interfaces. At present however, the ASTERIX standard interface is widely used in Europe to convey surveillance information.

⁷ ATM surveillance tracker and server

3. Reporting Approach

SDM prepared and distributed a survey⁸ to the European operational stakeholders on March 14th, targeting separately the Airspace Users, Airport Operators and Air Navigation Service Providers who are members of or represented at the Stakeholders Consultation Platform (SCP) of the SDM. The feedback from the individual stakeholders was received by March 30th, and then consolidated by SDM⁹.

In total, 35 EU-headquartered Airlines replied to the questionnaire, 12 major Airport Operators, and 31 ANSPs from the 28 EU Member States, plus Norway, Switzerland, and Iceland. The list of stakeholders replying to the questionnaires can be found in Appendix B to this document.

The results shown in this report are explicitly derived from the inputs received from the operational stakeholders. Due to potential confidentiality and security issues, in some cases, data and information have been aggregated, in order to produce the corresponding graphs and/or tables.

The level of detail and comprehensiveness of answers and data received from operational stakeholders vary. Nevertheless, SDM has assessed the overall bulk of collected information and considered it as reliable. It has to be noted, however, that further consultation with stakeholders could have been beneficial to have a more robust picture.

In order to provide a visual and intuitive picture snapshot of the surveillance systems scenario across Europe, maps have been produced identifying the location of the systems, together with the estimated surveillance coverage on ground side.

For each surveillance system, different maps have been elaborated and are provided in the following chapters, in order to illustrate the current situation¹⁰, and to provide information on the expected deployments, based on the implementation plans reported and declared by local stakeholders¹¹. In addition, the charts on the future situation are complemented with graphs reporting the evolution on such surveillance systems, in terms of systems installed or decommissioned in the timeframe 2018-2025¹².

Finally, with respect to the airborne domain, given the number of commercial aircraft, number of departures/arrivals and market share of the respondents, the outcome of the Airspace Users' surveys is deemed by SDM as representative of the overall current state-of-play across the European Union.

⁸ The original questionnaires – respectively distributed to each Stakeholder category – are embedded in this report within the Appendix A.

⁹ The full list of respondents to the survey is included in this report within the Appendix B.

¹⁰ Whenever specific information for a clearly identified and located surveillance systems was missing, average values were assumed, both in terms of range of coverage (i.e. 200 Nautical Miles for Mode S radars) and expected lifetime of the stations/systems (i.e. 15 years for Mode S radars, 10 years both for ADS-B stations and WAM/MLAT systems).

¹¹ In order to ensure a higher level of reliability of presented data on the future situation, the provided maps include only surveillance systems for which a clear location has been clearly identified by respondents. Furthermore, whenever a range of years (e.g. 2022-2023) was provided as the date of installation of specific stations and systems, the earliest year (e.g. 2022) was selected.

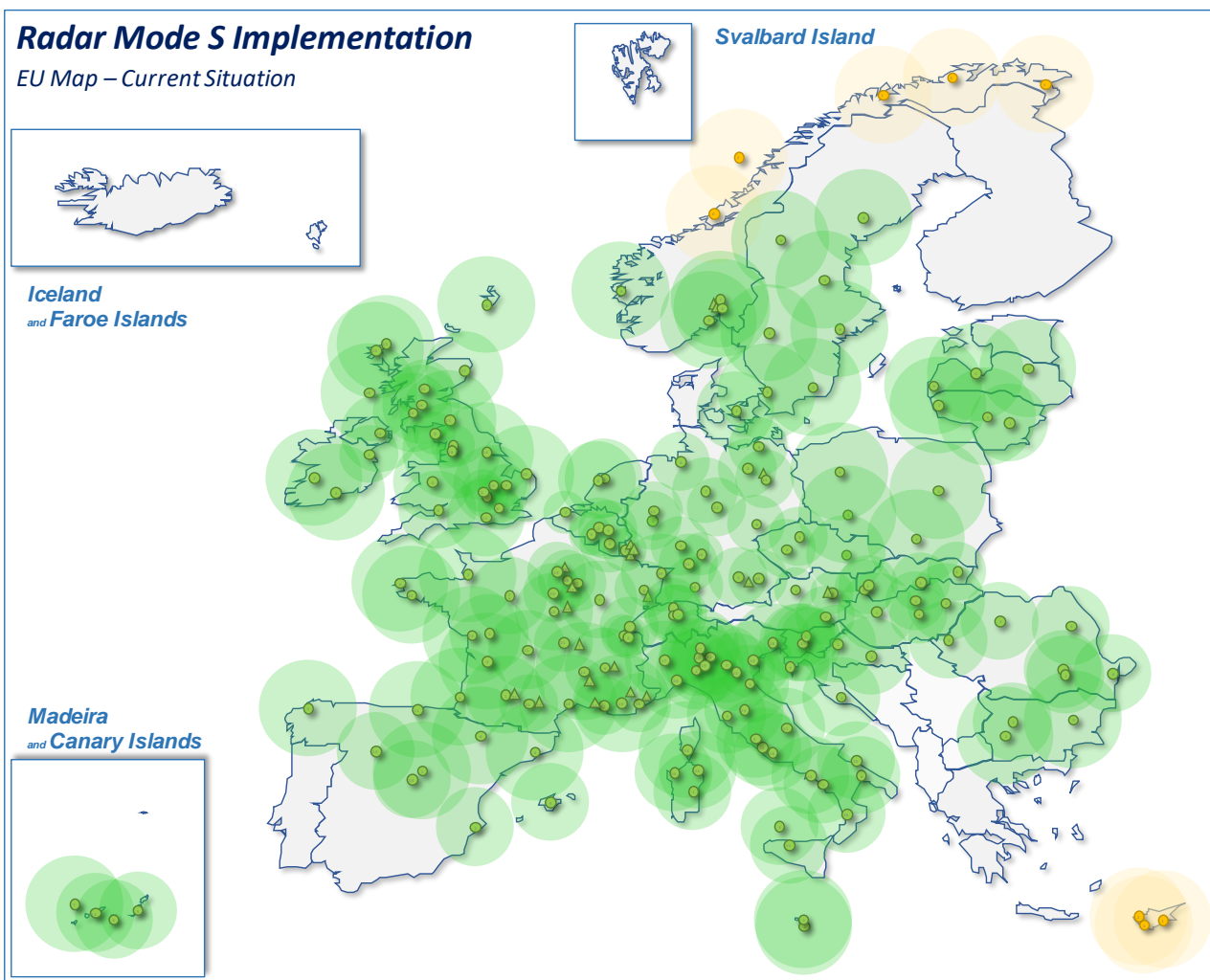
¹² If the lifetime was indicated as a range (e.g. 15-20 years), the highest number of the range was selected (e.g. 20).

4. Current status

4.1. Mode S

4.1.1 Ground segment – Airspace and Airport surveillance

The following chart shows the current status implementation of Mode S radars across Europe, their associated surveillance coverage, as well as the level of integration of the related surveillance data in the ATM systems. The paragraphs below provide a more detailed outlook, with regard both to Air and Ground Surveillance.



LEGEND

- ▲ Mode-S Radar for Airport surveillance integrated in the ATM systems
- ▲ Mode-S Radar for Airport surveillance not integrated in the ATM systems
- Mode-S Radar for EnRoute surveillance integrated in the ATM systems
- Mode-S Radar for EnRoute surveillance not integrated in the ATM systems
- Mode S Radar Area of Coverage
- Mode S Radar Area of Coverage

It needs to be noted that those areas in the map without Mode S coverage can be explained by the existence of other type of radars (Mode A/C, like in Finland or Greece) or because the surveys carried out by SDM were focused only on the EU+2 Member States (SES area).

AIRSPACE SURVEILLANCE

Mode S radar surveillance is widespread in Europe: around 200 radars are currently in operation, of which only a few do not have position data integrated within the ATM systems.

The radar separation modes applied by European ANSPs generally require multiple coverage, which is why many radars are seemingly grouped together. This aims at guaranteeing the redundancy required for the provision of radar separation 5 NM or less. It is a feature of the Mode S system to organize the grouped radars into spectrally efficient, functionally cooperating entities called Mode S clusters. The aircraft transponder perceives the cluster as a singular radar station.

Legacy Mode A/C MSSR complements the Mode S network; these aging stations, not shown on the map, are slowly being replaced by Mode S or multilateration, but those still remaining in operation cause high load on the radar channels. New Mode S radars will sometimes operate in Mode A/C when required to serve legacy transponders or whilst awaiting the upgrade of other components of the surveillance chain.

Military radars are not shown in the map, since this information was not available during the elaboration of the report. It has to be noted that there may be confidentiality and security issues to obtain this information in the future.

The designed lifetime of a new Mode S station is 18 years with an average remaining lifetime of the existing stations of 9 years.

AIRPORT SURVEILLANCE

Mode S infrastructure is widely deployed on/near airports (major and regional) in each country, and more especially on PCP airports. Three countries in Europe which have replied (Finland, Greece and Portugal) that they do not have Mode S infrastructure on their airports.

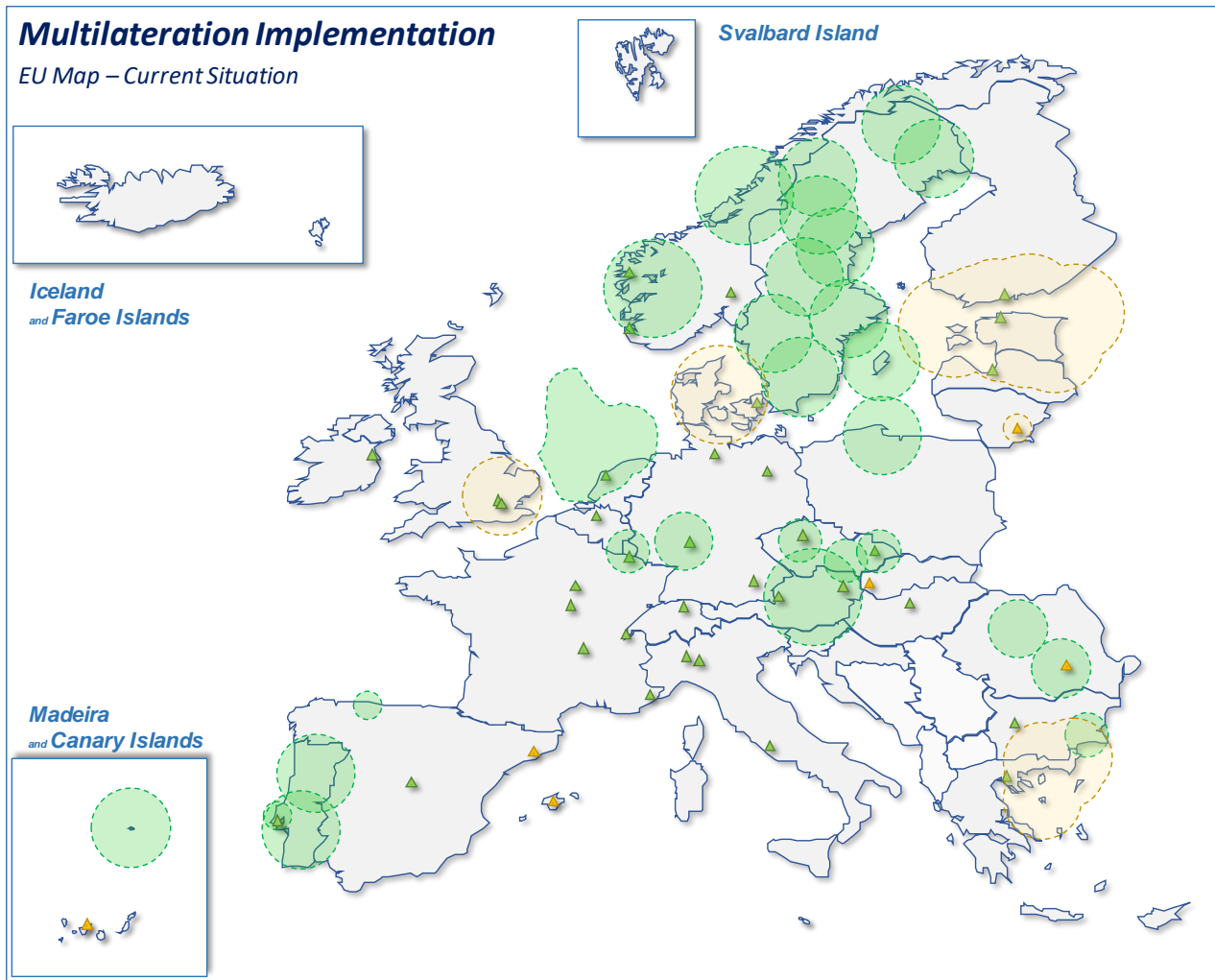
Mode S is used in Terminal and Approach Areas. The coverage can differ from airport to airport, as some use Mode S on ground (typically on manoeuvring area) and others mask out the airport area. Information such as position and other data elements are processed in trackers and/or A-SMGCS data fusion applications resulting in track data delivered to ATM systems via standard ASTERIX protocols.

In general, Airport Operators have data sharing agreements with ANSP's integrating surveillance data for airport surrounding into e.g. A-SMGCS. The remaining average lifetime of the existing Mode S infrastructure is 9 years.

4.2. Multilateration

4.2.1 Ground segment – Airspace and Airport surveillance

The following chart shows the current status of implementation of Multilateration Surveillance systems across Europe, their associated coverage, as well as the level of integration of the related surveillance data in the ATM systems. The paragraphs below provide a more detailed outlook, with regard both to Air and Ground Surveillance.



LEGEND

▲ MLAT for Airport surveillance integrated in the ATM system

▲ MLAT for Airport surveillance not integrated in the ATM system

● WAM coverage for EnRoute surveillance integrated in the ATM system

● WAM coverage for EnRoute surveillance not integrated in the ATM system

AIRSPACE SURVEILLANCE

WAM is in operation in an increasing number of places in Europe: there are roughly 80 WAM areas reported, spread across 16 countries.

WAM could be used as a potential alternative to the Mode S radar. Acquisition cost is lower but siting costs can vary significantly as a WAM system will comprise of 6 sites at a minimum. Performance is comparable.

The capabilities of the implemented systems vary from just providing position information to the ATM system to also include airborne derived data elements found in Mode S EHS (DAP) and ADS-B. Most WAM stations are configured to also function as ADS-B receivers; ADS-B is used for target acquisition in the core operational area but the system can provide ADS-B derived surveillance at the outer edge of its coverage, an area which can be as much as double that of the declared WAM coverage.

The designed lifetime of a WAM system is 15 years with an average remaining lifetime of the existing systems of 10 years.

AIRPORT SURVEILLANCE

MLAT infrastructure is less deployed than Mode S with around 40 systems installed on major European airports, in particular on PCP airports. MLAT complements Mode S infrastructure and together they cover all airports in Europe.

Almost all MLAT systems located within the airports are integrated in the ATM system except for Bratislava, Bucharest, Barcelona, Palma, Tenerife, and Vilnius.

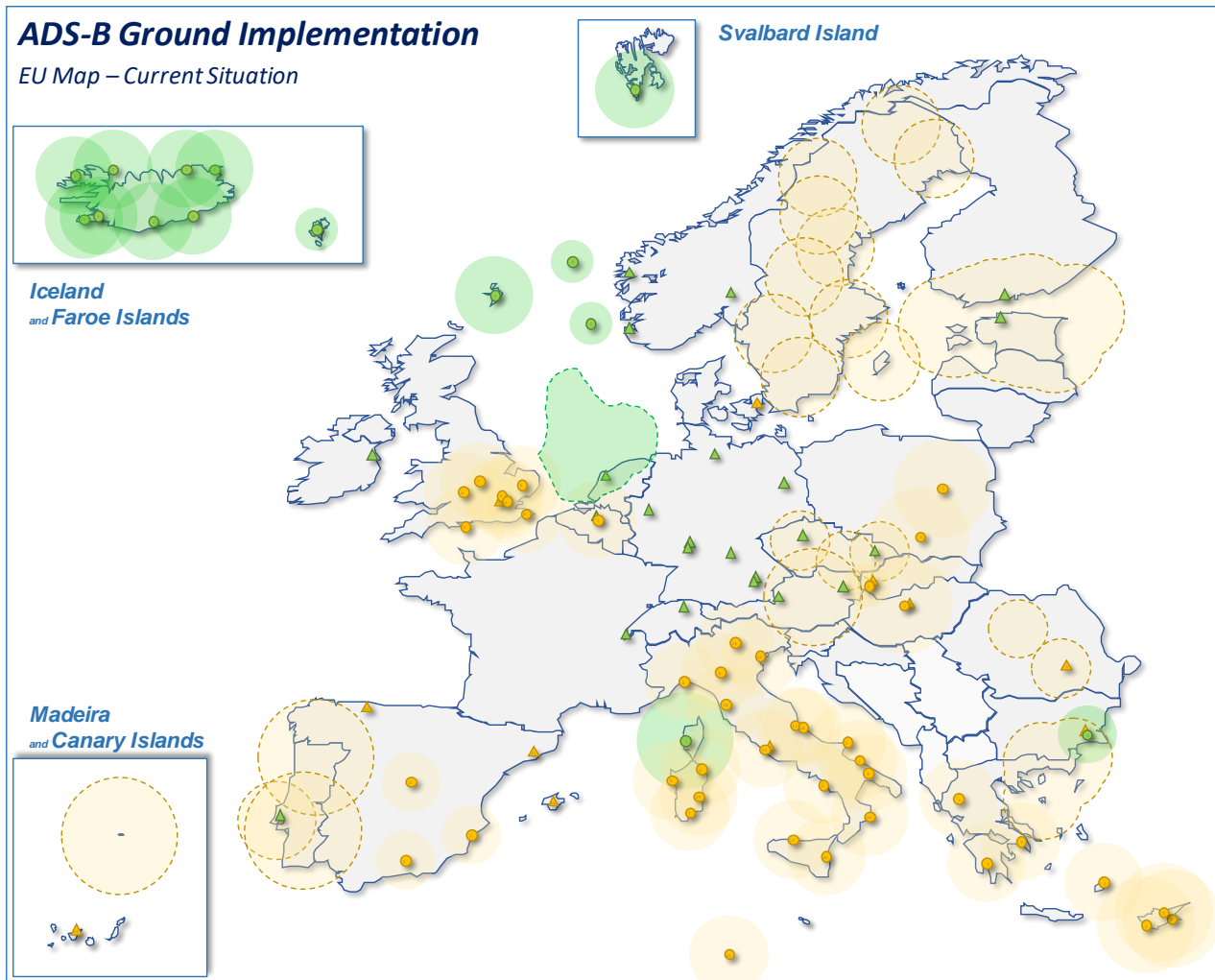
MLAT is applied for aircraft and vehicle tracking at airport surface. All respondents reported full coverage on the manoeuvring area and mainly full coverage on apron area, and report that the multilaterated position data is used for ATM purposes interfaced using standard ASTERIX protocol.

The remaining average lifetime of the existing MLAT infrastructure is 9 years.

4.3. ADS-B

4.3.1 Ground ADS-B segment – Airspace and Airport surveillance

The following chart shows the current status of implementation of ADS-B Surveillance systems across Europe, their associated coverage, as well as the level of integration of the related surveillance data in the ATM systems. The paragraphs below provide a more detailed outlook, with regard both to Air and Ground Surveillance.



LEGEND

- ▲ ADS-B Ground Station for Airport surveillance integrated in the ATM system
- ▲ ADS-B Ground Station for Airport surveillance not integrated in the ATM system
- ADS-B Ground Station for EnRoute surveillance integrated in the ATM system
- ADS-B Ground Station for EnRoute surveillance not integrated in the ATM system
- ADS-B Station Area of Coverage
- ADS-B Station Area of Coverage
- Coverage of WAM Stations able to process ADS-B position information
- Coverage of WAM Stations able to process ADS-B position information

AIRSPACE SURVEILLANCE

The current situation on ADS-B receiver installation in Europe is fragmented. In total more than 70 ADS-B capable stations are installed, of which around 90% are in operational use and the remaining 10% for tests and validation purposes.

The locations are within in the peripheral areas with a few places where ADS-B is implemented in ATM systems and in the process to be used in operations. A typical area of usage is on isolated islands (Corsica and Faroe Islands) and on oil rigs in the North Sea. Uniquely, Norway has issued a local ADS-B mandate in offshore areas on ADS-B as sole means of surveillance for aircraft with ADS-B transponders certified to ED-102A (DO-260B).

WAM systems often provide ADS-B coverage and use ADS-B information for varying purposes. For example, a passive-active WAM will listen to ADS-B Out broadcasts and use them to acquire targets instead of transmitting an all-call, to conserve bandwidth. A WAM can also read and use other data from ADS-B reports such as target identity, altitude, speed or intent. The crucial difference to a pure ADS-B system is that target position is determined by the WAM/MLAT system itself, at least inside the WAM coverage area; the aircraft derived position contained in ADS-B reports is not used.

The remaining average lifetime of the existing ADS-B stations is 12 years.

AIRPORT SURVEILLANCE

ADS-B for airport surveillance is widespread. Currently, 34 ADS-B stations have been installed in Europe:

- 23 are integrated into the ATM systems,
- 11 are not integrated into the ATM systems, but in most of cases, there are plans to integrate them with MLAT System.

Few countries (Croatia, France, Latvia, Lithuania, Luxembourg and Slovenia) do not have deployed ADS-B stations at their main airports (National or Regional)

When it is integrated into the ATM system, ADS-B, combined or not with MLAT, is only used for identification and position data for ground vehicles as the data quality requirement is less stringent than that imposed on aircraft.

Most common usage of ADS-B is on airports for ground surveillance purposes, where it forms a part of the Advanced Surface Movement Guidance and Control System (A-SMGCS), including ground vehicles that are equipped with ADS-B.

At last, some ANSPs will use ADS-B infrastructure for smaller Airport not yet covered by any surveillance means.

The remaining average lifetime of the existing ADS-B stations is 8 years.

4.3.2 Airborne ADS-B segment

The following figure shows the current status of implementation of ADS-B ED-102A (DO-260B) compliant transponders for a total number of 3108 aircraft, as included in the responses from the survey provided by 35 EU headquartered carriers.

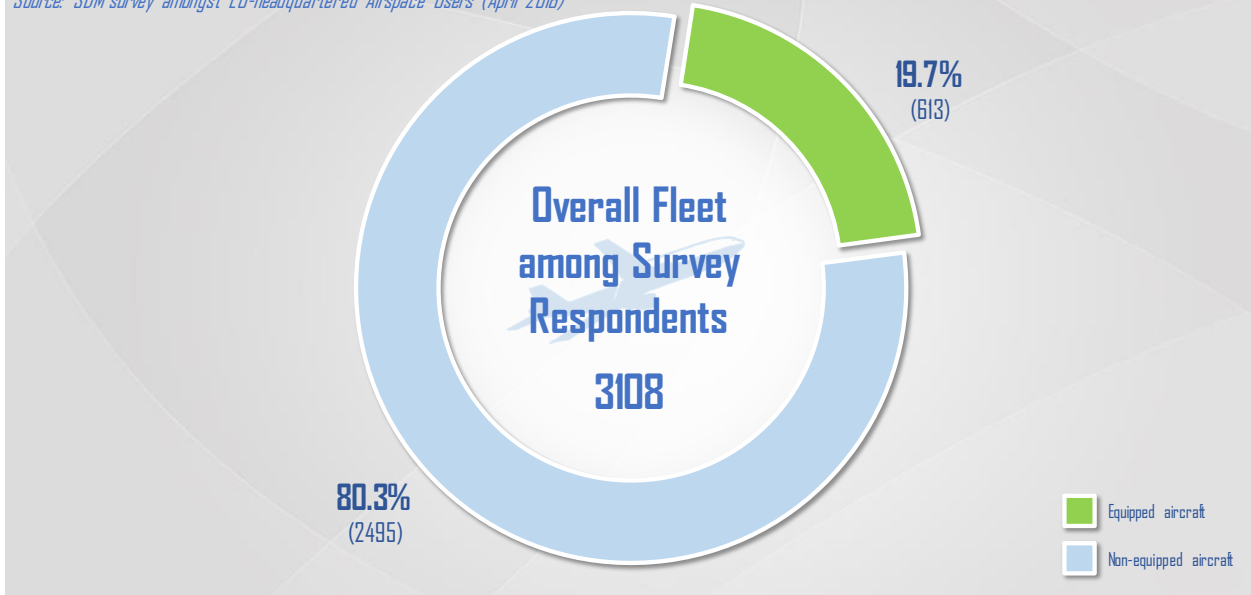
In order to facilitate the feedback from Air Operators, it has been decided to address the compliance to IR (EU) 1207/2011 through the compliance to ED-102A (DO-260B) MOPS,

because it is the standard applicable for both EU and US mandates and therefore very well known by the manufacturing as well as airline industry. It has to be noted that there are several aircrafts already equipped with the old version of the transponders (DO-260 and DO-260A).

The paragraphs below provide a more detailed outlook.

Current percentage of ADS-B ED-102A-compliant fleet

Source: SDM survey amongst EU-headquartered Airspace Users (April 2018)



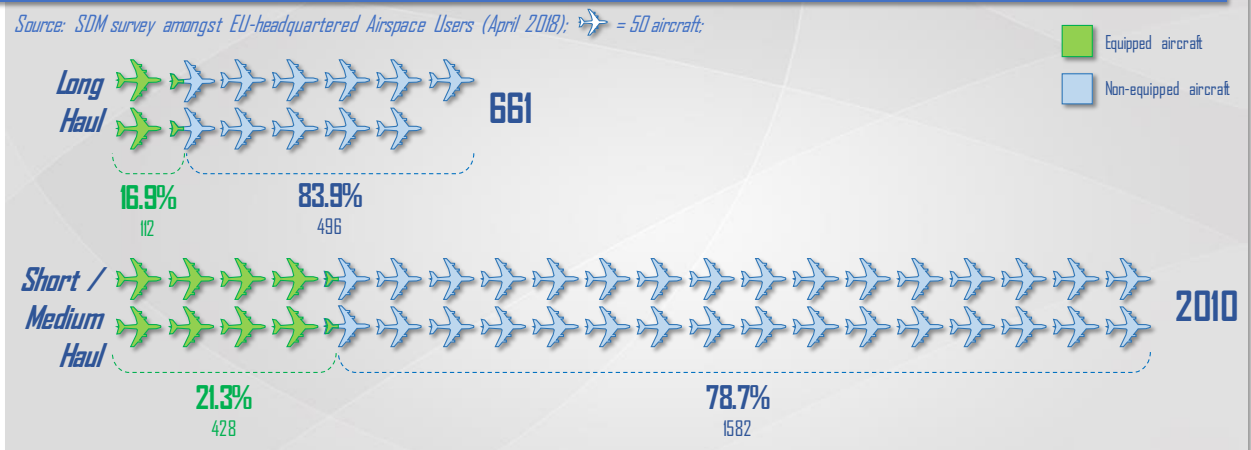
As can be seen only around 20% of the EU operator’s fleets are compliant with ED-102A (DO-260B), the majority of these are forward fit on new deliveries, as off the last few years, once it became known that this would be the required standard for the future. It can be assumed that this percentage is a good representation of the overall European fleet equipage rate.

In addition, the data gathered through the AU survey has been clustered to differentiate between the long haul and short/medium haul equipped fleets, as shown in the picture below.

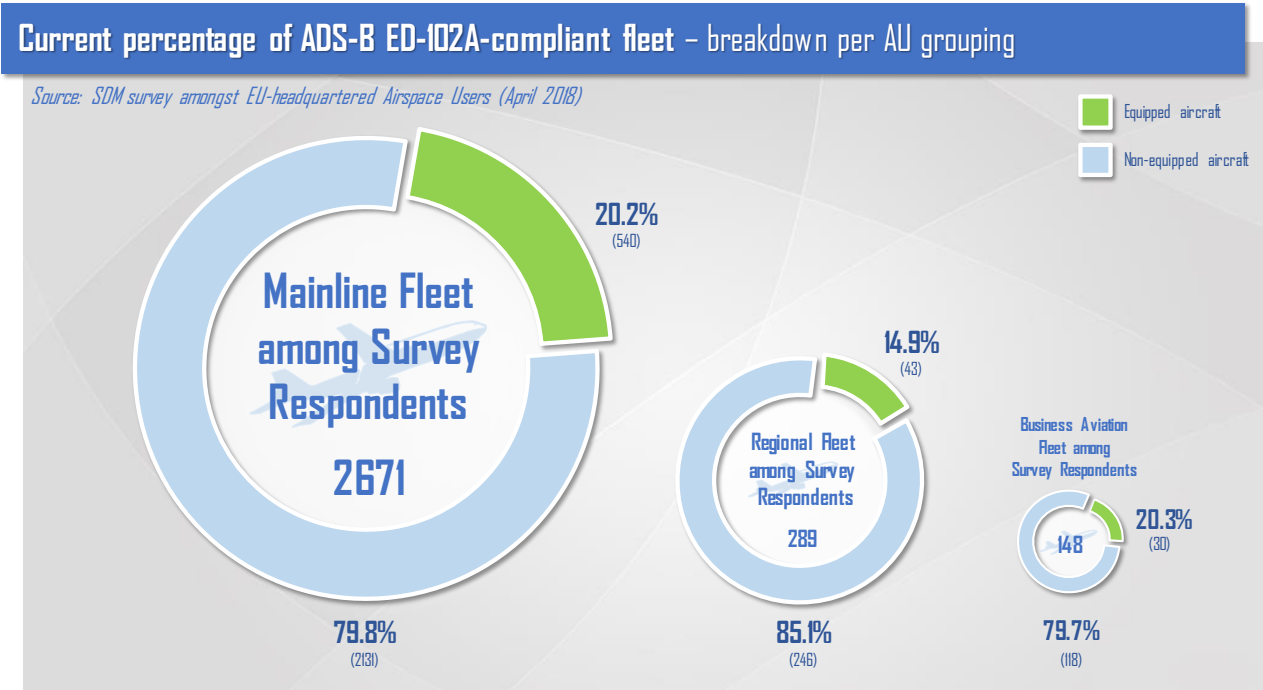
Results show that for the long-haul aircraft, almost 17% of the fleet is equipped, whilst for the short / medium haul aircraft, more than 21% is compliant with the Regulation.

Current percentage of ADS-B ED-102A-compliant Mainline fleet – breakdown per flight length

Source: SDM survey amongst EU-headquartered Airspace Users (April 2018); ✈ = 50 aircraft:



Moreover, it should be noted that the results of the survey are consistent with the figures provided by Airbus. The only disparity being with the percentage of ED-102A (DO-260B) equipage on long haul aircraft, where Airbus show the A330/340 series as being 31% equipped. It is expected that this percentage on the long-haul fleets will increase greatly before 2020 to meet the USA (FAA) ADS-B mandate.



The above graph shows a consistent equipage level of 20% between mainline carriers and business aviation, with regional carriers falling behind that at 15%.

For the regional fleet, and especially Turboprops, ATR is offering the ED-102A (DO-260B) compliance as an option on ATR's -600 fleet, which is the last certified version. Regarding ATR-500 fleet, a ED-102A (DO-260B) retro-fit solution should be certified by end of 2018.

Compared to the current European Regulation, the FAA mandate requires all aircraft operating in the USA after 1st Jan 2020 to have DO-260B transponders, additionally Selected Availability (SA) Aware MMR's are required. The use of the SAPT¹³ GPS prediction tool and also to have some form of GPS augmentation WAAS¹⁴/SBAS¹⁵ is required by 2025. This could facilitate a potential rationalisation of ground surveillance infrastructure. Some European operators are considering the implementation of WAAS as an augmentation of the GNSS position.

Finally, it is worth highlighting that ADS-B has already been successfully deployed in the Hudson Bay area of Canada, an ADS-B corridor on the N. Atlantic and the interior of Australia, offering operational benefits.

¹³ Service Availability Prediction Tool

¹⁴The Wide Area Augmentation System (WAAS) is an air navigation aid developed by the Federal Aviation Administration to augment the Global Positioning System (GPS), with the goal of improving its accuracy, integrity, and availability.

¹⁵ A Satellite-based Augmentation System (SBAS) is a civil aviation safety-critical system that supports wide-area or regional augmentation

4.3.3 Space based ADS-B

Space-based ADS-B in the near future offers the opportunity to give a radar like control environment over oceanic, remote and geographically challenging areas of the world, in areas of poor infrastructure as well as in areas well equipped with surveillance systems (like core Europe).

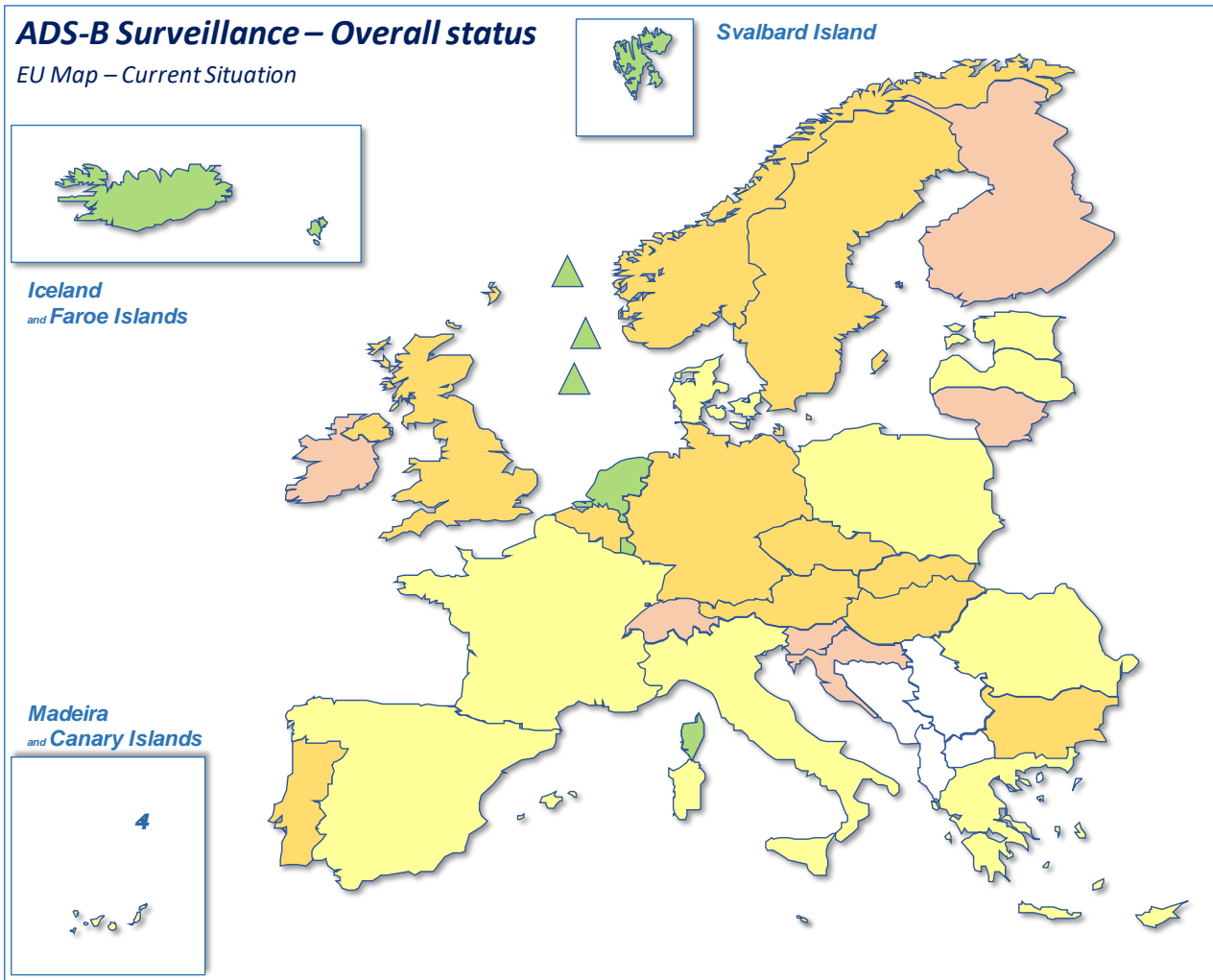
This would aid the separation management for controllers and phase-out/modernize the position reporting. In combination with improved A/G communication, this would allow for reduced separation, improved safety levels and greater efficiency and capacity in the airspace.

Regarding the ground use of the Satellite ADS-B information, among 28 ANSPs responding to the questionnaires, 15 have reported that have no plans to use the satellite ADS-B data, whilst 13 have reported that they are considering using it once the service is available.

NATS & Nav Canada plan to deploy Space based ADS-B (Aireon) on the North Atlantic and Canada in the 2019-2020 timeframe. Some European ANSPs are planning to use it as from first quarter 2019.

4.4. Current overall implementation outlook

The following map represents the aggregated view of the current ADS-B implementation in Europe, using the information displayed in the previous maps for each surveillance system able to receive and process ADS-B (ADS-B, Mode-S and WAM stations).



LEGEND

- ADS-B system in place supporting early / marginal / initial operations

■ ADS-B infrastructure in place, not used operationally, Mode S ELS/ EHS implemented

■ ADS-B infrastructure in place, not used operationally
- ADS-B infrastructure is not currently in place

▲ Oil rig – color depends on the legend above

The legend explained:

Green – ADS-B system in place supporting early/marginal/initial operations

In these environments, ADS-B position information is used in operations to support ATC. The extent of the support varies; the initial step is to provide situational awareness to the controller whilst procedural control applies for provision of ATC separation. In this configuration ADS-B can serve as sole means already today as the data quality requirements are generally limited to the information being usable. In a more advanced setup, ADS-B position would be used to provide radar-like ATC separation; first as a complementary sensor and eventually as sole means. This configuration requires ADS-B position information quality to meet a standard equivalent to radar in terms of accuracy and integrity.

Yellow – ASD-B infrastructure in place, not used operationally.

In these environments, ADS-B position is not used in ATC although the surveillance capability is installed providing at least partial coverage of the respective airspace. Thus other use cases for ADS-B may be implemented, such as the use of squitter for passive acquisition to Mode S systems or use of ADS-B for position tracking of airport surface vehicles. The ATC surveillance system is capable of receiving and forwarding ADS-B messages to other users.

Amber – ADS-B infrastructure in place, not used operationally. Mode S ELS/EHS implemented.

This status is similar to the preceding setup but with additional operational use of aircraft derived data (in the form of ELS and EHS) in ATC systems. While ELS and EHS are provided by Mode S, the mechanics behind the data acquisition, processing and presentation are similar to ADS-B and so it is assumed that experience with ELS and EHS will prove itself a facilitating factor in the eventual adoption of ADS-B.

Pink – ADS-B infrastructure not in place

In these environments the capability to receive ADS-B messages is not installed.

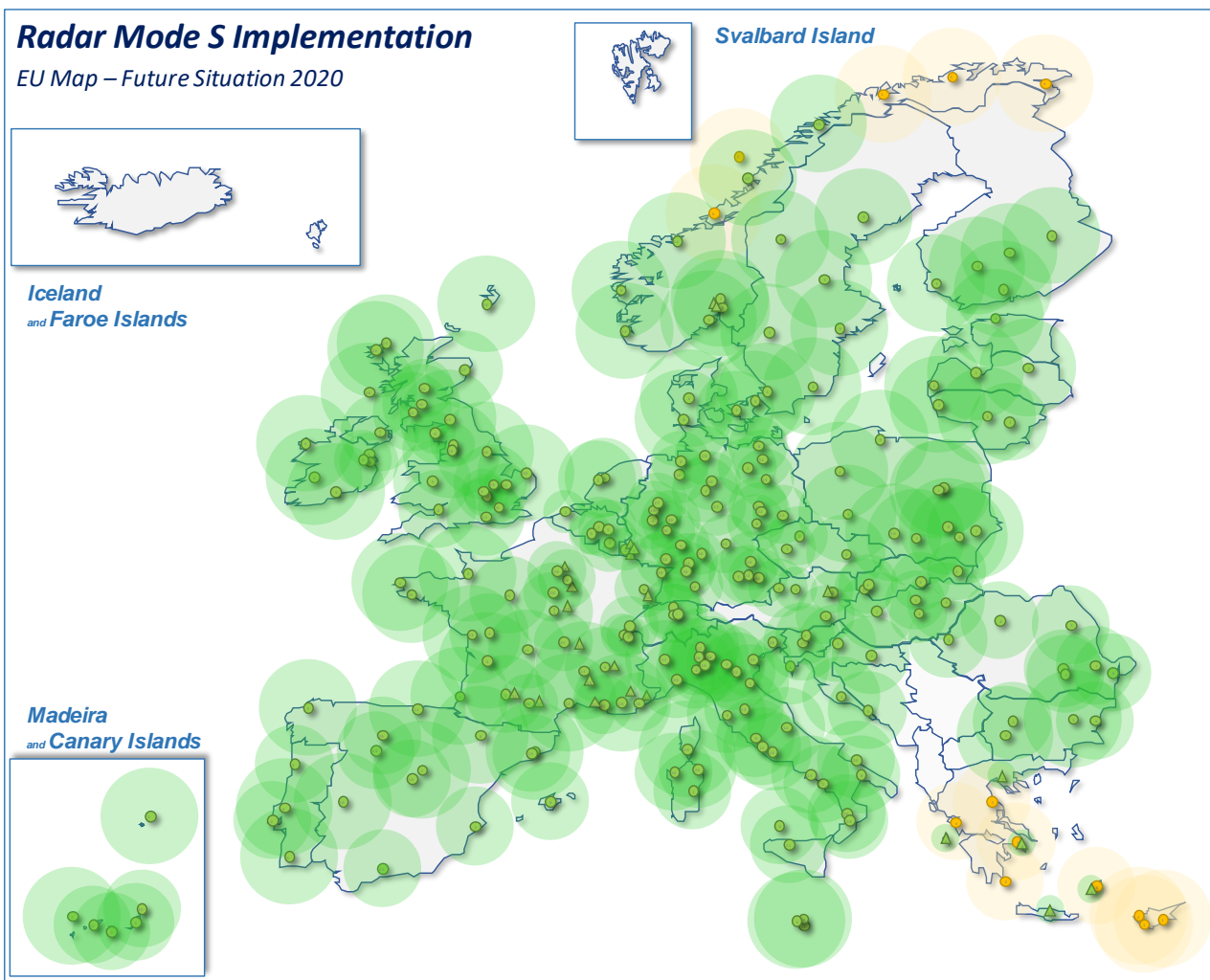
Considering what above, it can be seen that currently most countries have the infrastructure in place, but operational use is not yet widespread. Only few countries do not have the infrastructure in place, like Ireland, Switzerland, Croatia, Slovenia, Finland and Lithuania. This reflects the fragmented nature of ADS-B deployment.

5. Future status

5.1. Mode S

5.1.1 Ground segment in 2020 – Airspace and Airport surveillance

The following chart shows the expected short-term plans from operational stakeholders to implement Mode S radar systems across Europe. In particular, the chart includes all Mode S radar systems which are expected to be installed and/or operational before 2020¹⁶. The paragraphs below provide a more detailed outlook on stakeholders' plans, with regard both to Air and Ground Surveillance.



LEGEND

- ▲ Mode-S Radar for Airport surveillance integrated in the ATM systems
- ▲ Mode-S Radar for Airport surveillance not integrated in the ATM systems
- Mode-S Radar for EnRoute surveillance integrated in the ATM systems
- Mode-S Radar for EnRoute surveillance not integrated in the ATM systems
- Mode S Radar Area of Coverage
- Mode S Radar Area of Coverage

¹⁶ The chart also includes all existing Mode S radars whose operational lifetime – according to the local stakeholders – is expected to last until 2020.

AIRSPACE SURVEILLANCE

The Mode S radar infrastructure continues to evolve with new stations with multiple coverage in most parts of Europe. Around 60 new Mode S radars are planned for deployment in the near future scenario. More in detail, Finland and Portugal plan to move towards Mode S based surveillance by 2020. Other countries, such as Poland, Spain, and Germany plan to increase the coverage by implementing some additional Mode S radars. Additionally, Greece plans to cover its airspace with new Mode S radars, however ADS-B data will not be integrated within the ATM systems.

To summarise, all continental European airspace will continue to be covered by radars by 2020. Modern Mode S radars will supplant the surviving Mode A/C units within a few years which will lead to significant improvements in spectrum usage efficiency. The Mode S radar includes a function to download additional aircraft parameters to ATM systems on ground to be used for improved safety and efficiency of operations. These data elements can also be transported using ADS-B, thus supporting a smooth transition from Mode S to ADS-B when and if required.

The designed lifetime of a new Mode S station is 18 years.

AIRPORT SURVEILLANCE

Some ANSPs plan to install/renew Mode S stations between 2018 and 2020 at their airports, including those who reported no present Mode S in Chapter 4 (Finland, Greece, Portugal). These stations will complement and/or replace the current infrastructure and will enhance the Mode S airport coverage in Europe (including Norway and Switzerland).

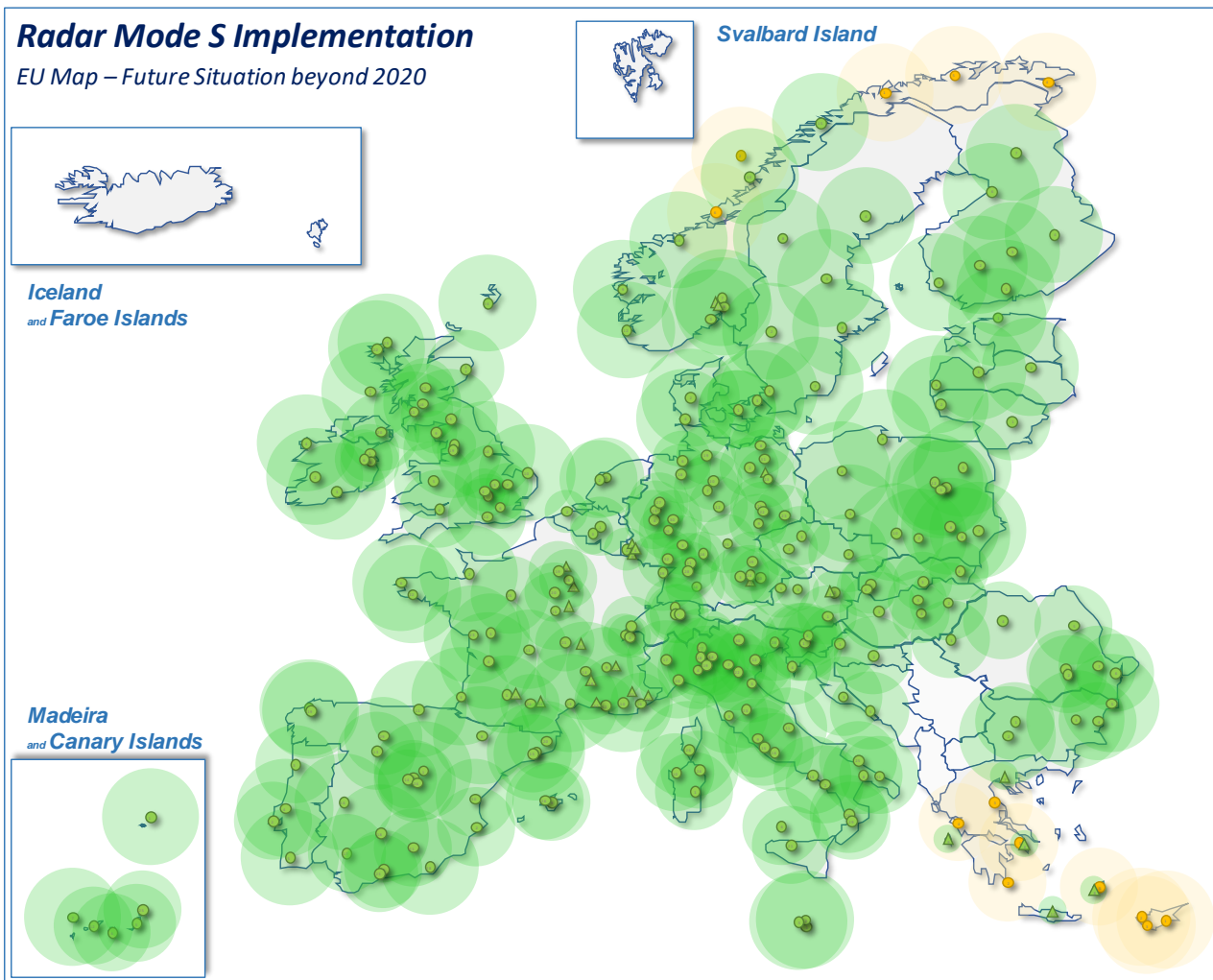
From 2018, the remaining average lifetime of the existing Mode S infrastructure is 16 years.

Like in the current situation, Mode S will be used in Terminal and Approach Areas. Information such as Positions will continue to be integrated in ATM system trackers (A-SMGCS data fusion application) via standard ASTERIX protocols.

5.1.2 Ground segment beyond 2020 – Airspace and Airport surveillance

Complementing the shorter-term picture included in the previous paragraph, the following chart includes information on the expected long-term plans from operational stakeholders to implement Mode S radars in the upcoming years. In particular, the chart includes all Mode S radars which are expected to be installed and operational from 2021 onwards¹⁷.

The paragraphs below provide a more detailed outlook on stakeholders’ plans, with regard both to Air and Ground Surveillance.



LEGEND

- ▲ Mode-S Radar for Airport surveillance integrated in the ATM systems
- ▲ Mode-S Radar for Airport surveillance not integrated in the ATM systems
- Mode-S Radar for EnRoute surveillance integrated in the ATM systems
- Mode-S Radar for EnRoute surveillance not integrated in the ATM systems
- Mode S Radar Area of Coverage
- Mode S Radar Area of Coverage

¹⁷ Accordingly, the chart also includes all existing Mode S radars whose operational lifetime – according to the local stakeholders – is expected to exceed 2020. It is also worth noting that the chart includes all Mode S radars for which stakeholders declared future plans without the exact year of installation.

AIRSPACE SURVEILLANCE

Beyond 2020, the total number of Mode S radars slightly increases, thus covering most of the European Airspace. Additional stations are planned to be installed in Southern Spain, Northern Finland, Poland, Bulgaria, and Romania.

AIRPORT SURVEILLANCE

ANSPs will continue to install/renew Mode S stations from 2021 to 2035. These stations will complement and/or replace the current infrastructure and will enhance the Mode S airport coverage in Europe.

From 2020, the remaining average lifetime of the Mode S infrastructure is 17 years.

Like the current situation, Mode S will be used in Terminal and Approach Areas. Information such as Positions will continue to be integrated in ATM system trackers (A-SMGCS data fusion application) via standard ASTERIX protocols.

5.1.3 Mode S implementation expected timeline

The following graph shows the evolution of the Mode S radars implementation in Europe according to the feedback received from the ANSPs.



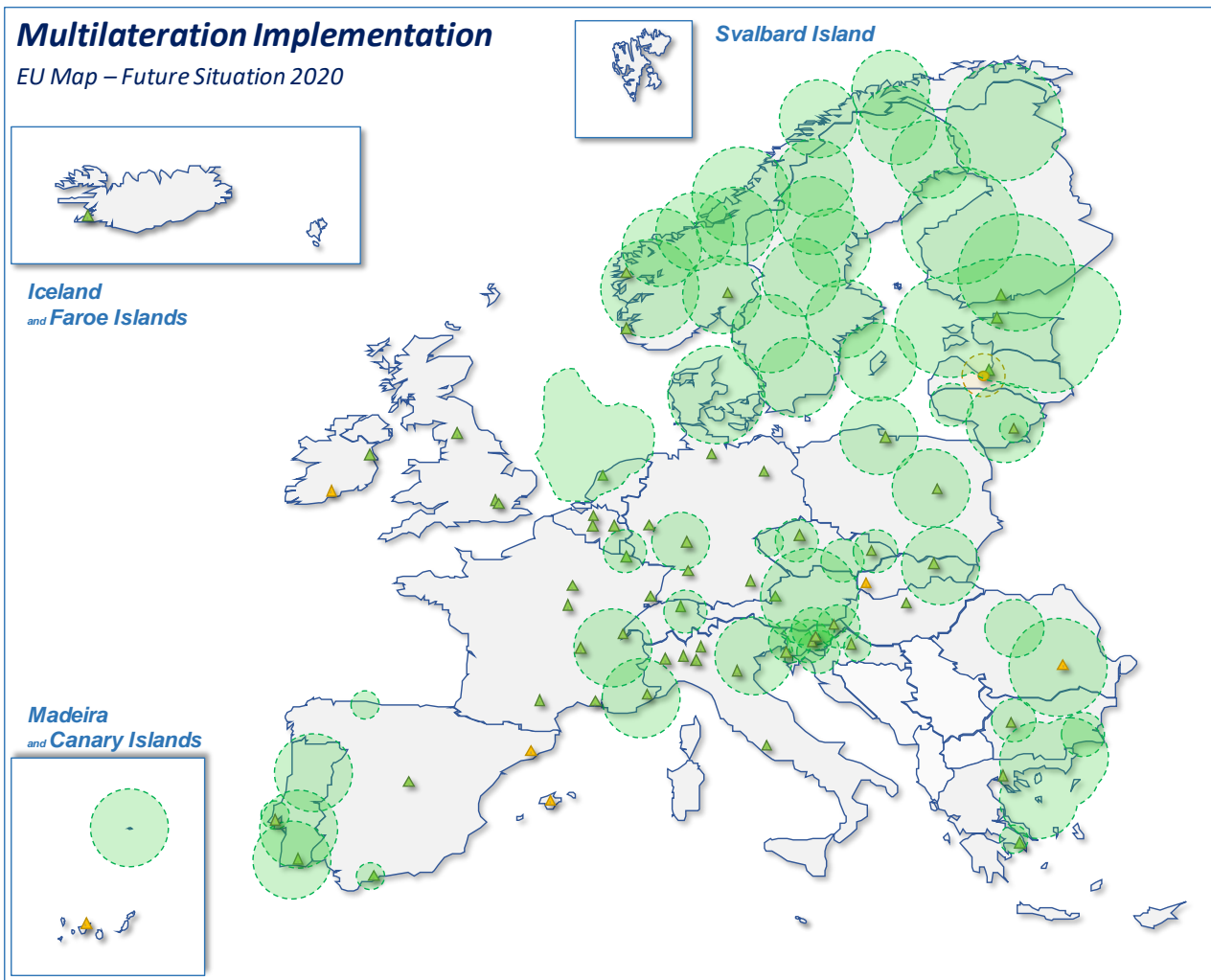
It can be seen that there is a significant increase of the Radars between 2018 and 2021 (+58 stations), whilst the number tends to fall slowly from 2022 onwards.

5.2. Multilateration

5.2.1 Ground segment in 2020 – Airspace and Airport surveillance

The following chart shows the expected short-term plans from operational stakeholders to implement Multilateration surveillance systems across Europe. In particular, the chart includes all MLAT systems which are expected to be installed and/or operational before 2020¹⁸.

The paragraphs below provide a more detailed outlook on stakeholders' plans, with regard both to Air and Ground Surveillance.



¹⁸ The chart also includes all existing MLAT surveillance systems whose operational lifetime – according to the local stakeholders – is expected to last until 2020.

AIRSPACE SURVEILLANCE

WAM will continue to see increasing adoption in the near future. There are more than 20 new WAM areas planned.

A large-scale deployment initiative is ongoing in the Alpine region while systems currently undergoing deployment or in test mode will be put in operations in Greece and Romania, the Baltics and Denmark. All new systems will in all likelihood be able to provide ADS-B data.

Use of ADS-B position is not anticipated in areas of existing radar or WAM coverage. In areas where there is no pre-existing surveillance cover, ADS-B could be used to improve situational awareness, but no explicit plans were reported by stakeholders.

The designed lifetime of a new WAM system is 18 years with an average remaining lifetime of 15 years.

AIRPORT SURVEILLANCE

MLAT use at airports is set to continue to increase in the near future. Airports (ANSPs and Airport Operators) plan to install/renew around 30 MLAT systems between 2018 and 2020. These stations will complement and/or replace the current infrastructure and will enhance the MLAT coverage in airport areas. All Airports Operators intend to keep the Multilateration systems in use and potentially extend the systems with additional receiving stations, in order to keep or improve surveillance performance.

Cyprus airports still have no plan to implement MLAT.

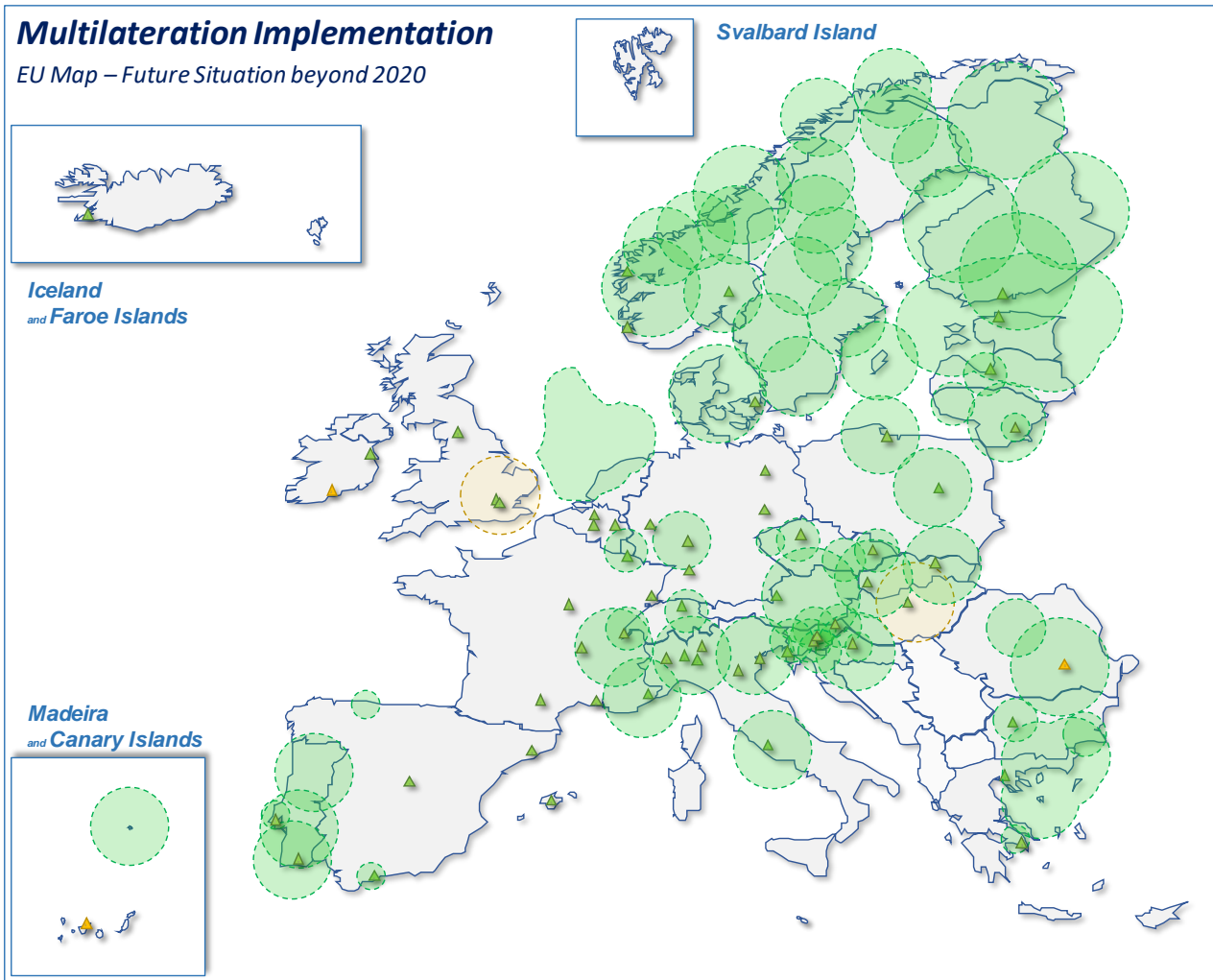
From 2018, the remaining average lifetime of the existing MLAT infrastructure will be 14 years.

5.2.2 Ground segment beyond 2020 – Airspace and Airport surveillance

Complementing the shorter-term picture included in the previous paragraph, the following chart includes information on the expected long-term plans from operational stakeholders to implement Multilateration Surveillance systems in the upcoming years. In particular, the chart includes all MLAT systems which are expected to be installed and operational from 2021 onwards¹⁹.

The paragraphs below provide a more detailed outlook on stakeholders' plans, with regard both to Air and Ground Surveillance.

¹⁹ The charts also include all existing MLAT surveillance systems whose operational lifetime – according to the local stakeholders – is expected to exceed 2020. It is also worth noting that the chart includes all MLAT systems for which stakeholders declared future plans without the exact year of installation.



AIRSPACE SURVEILLANCE

In the long run, WAM will continue to fulfil its role as the alternative to Mode S radar, as few more new systems are planned for deployment beyond 2020. Some countries, such as Italy, Finland, Croatia, and Slovak Republic will implement additional Wide Area Multilateration, whilst other Member States like UK and Hungary have plans to install new WAM stations, whose data, however, will not be integrated into the ATM systems.

AIRPORT SURVEILLANCE

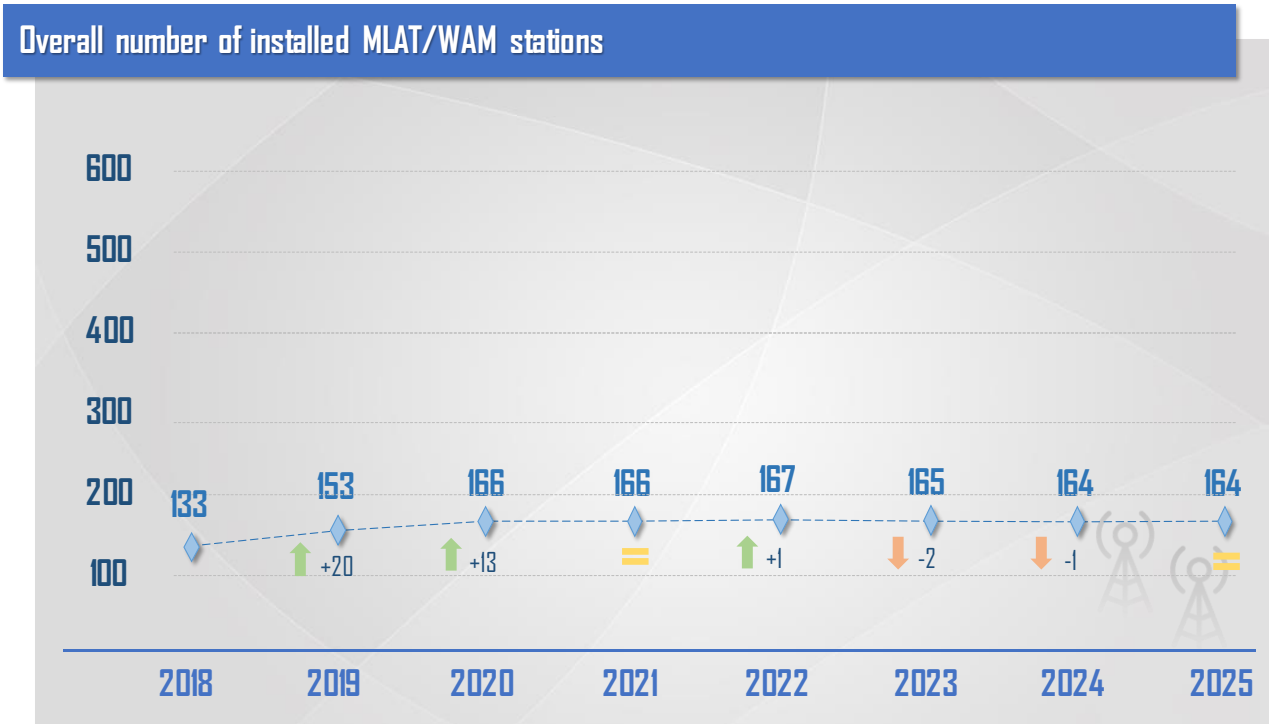
Airports (ANSPs and Airport operators) plan to install/renew 8 MLAT infrastructures between 2021 and 2028. These stations will complement and/or replace the current infrastructure and will enhance the MLAT coverage in airport areas.

From 2018, the remaining average lifetime of the existing MLAT infrastructure will be 14 years.

All Airports Operators intend to keep the multilateration systems in use and potentially extend the systems with additional receiving stations in order to keep or improve surveillance performance. No Airport Operator foresee any rationalization benefits.

5.2.3 Multilateration implementation expected timeline

The following graph shows the evolution of the Multilateration systems implementation in Europe.



It can be seen that there is a significant increase of the MLAT stations between 2018 and 2020 (+33 stations), whilst it remains more or less constant after 2020.

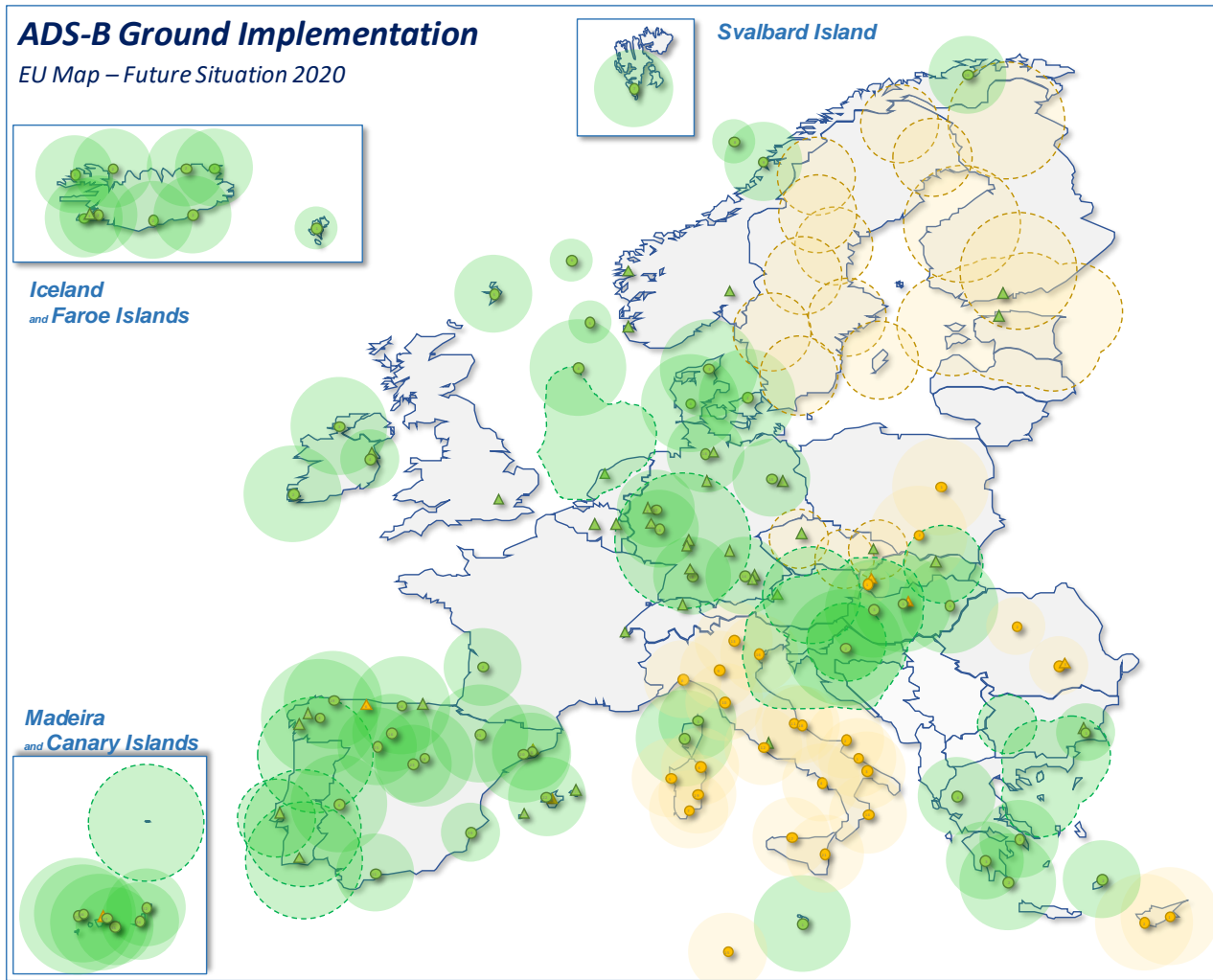
5.3. ADS-B

5.3.1 Ground ADS- B segment in 2020 – Airspace and Airport surveillance

The following chart shows the expected short-term plans from operational stakeholders to implement ADS-B based surveillance systems across Europe. In particular, the chart includes all ADS-B systems which are expected to be installed and/or operational before 2020²⁰.

The paragraphs below provide a more detailed outlook on stakeholders' plans, with regard both to Air and Ground Surveillance.

²⁰ The chart also includes all existing ADS-B based systems whose operational lifetime – according to the local stakeholders – is expected to last until 2020.



LEGEND

- ▲ ADS-B Ground Station for Airport surveillance integrated in the ATM system
- ▲ ADS-B Ground Station for Airport surveillance not integrated in the ATM system
- ADS-B Ground Station for EnRoute surveillance integrated in the ATM system
- ADS-B Ground Station for EnRoute surveillance not integrated in the ATM system
- ADS-B Station Area of Coverage
- ADS-B Station Area of Coverage
- Coverage of WAM Stations able to process ADS-B position information
- Coverage of WAM Stations able to process ADS-B position information

AIRSPACE SURVEILLANCE

The future situation on ADS-B receiver installation in Europe shows an increasing trend of adoption of ADS-B. In total, more than 60 ADS-B capable stations for EnRoute surveillance are included in the ANSPs’ investment plans. It is worth highlighting that a substantial planned ADS-B capability will be delivered by WAM or Mode S radars on top of ADS-B stations (e.g. Baltic region, Central Europe).

As for the use of ADS-B data in ATM systems, the breakdown of the ANSPs feedback is as follows:

- 15 of the 30 surveyed respondents are planning some form of operational implementation or integration in the near term. 14 are planning same in the long term, that is beyond the applicable date of the standing mandate. Note that these are independent, non-

complementary sets; a respondent may, and usually will, plan operational transition both in the near and in the far term.

- Additional 3 (short term) respectively 2 (long term) respondents are planning technical implementation for test and validation purposes but not for operational use.
- 2 respondents are already permitting ADS-B as sole means, albeit in one case that is a very specific operating environment at the North-Sea oil drilling platforms, and in the other case it is only used to aid Flight information service rather than full ATC service.
- 7 out of the 30 surveyed respondents expressed their intent to use ADS-B as a complementary surveillance layer to conventional sensors. This implies that despite ADS-B is in use, no rationalization potential will be realized.
- 11 out of 30 surveyed respondents reported that operational use of ADS-B in general is contingent upon adequate data quality and airborne equipage levels which the Regulation is broadly expected to deliver.

A typical lifetime of the ADS-B stations is 15-18 years.

AIRPORT SURVEILLANCE

Complementing the aforementioned investments, ANSPs and Airport Operators plan to install/renew around 25 ADS-B stations for airport surveillance between 2018 and 2020. These stations will complement and/or replace the current infrastructure and will enhance the ADS-B coverage in European airports.

Nine Stakeholders in Austria, Denmark, Cyprus, Latvia, Lithuania, Luxemburg, Poland, Romania, Sweden) do not currently have plans to install or integrate ADS-B position reports:

- 4 airports (Austria, Poland, Romania, Sweden) have recently installed ADS-B stations;
- 3 airports (Latvia, Lithuania, Luxemburg) have no plan to install ADS-B stations;
- For Cyprus airports, the remaining average lifetime of their infrastructures is less than 5 years;
- Copenhagen airport (Denmark) will launch an assessment project, in order to assess whatever is feasible to use ADS-B position report from aircrafts on ground.

In the near term, ADS-B infrastructure will continue to be integrated into the ATM system, by tracking vehicles' position in a first time, then by enhancing it to aircraft. Several reasons, according the country, explain this strategy: aircraft fleet not fully equipped, service certification, complement the Mode S/ MLAT coverage, accuracy/integrity of data.

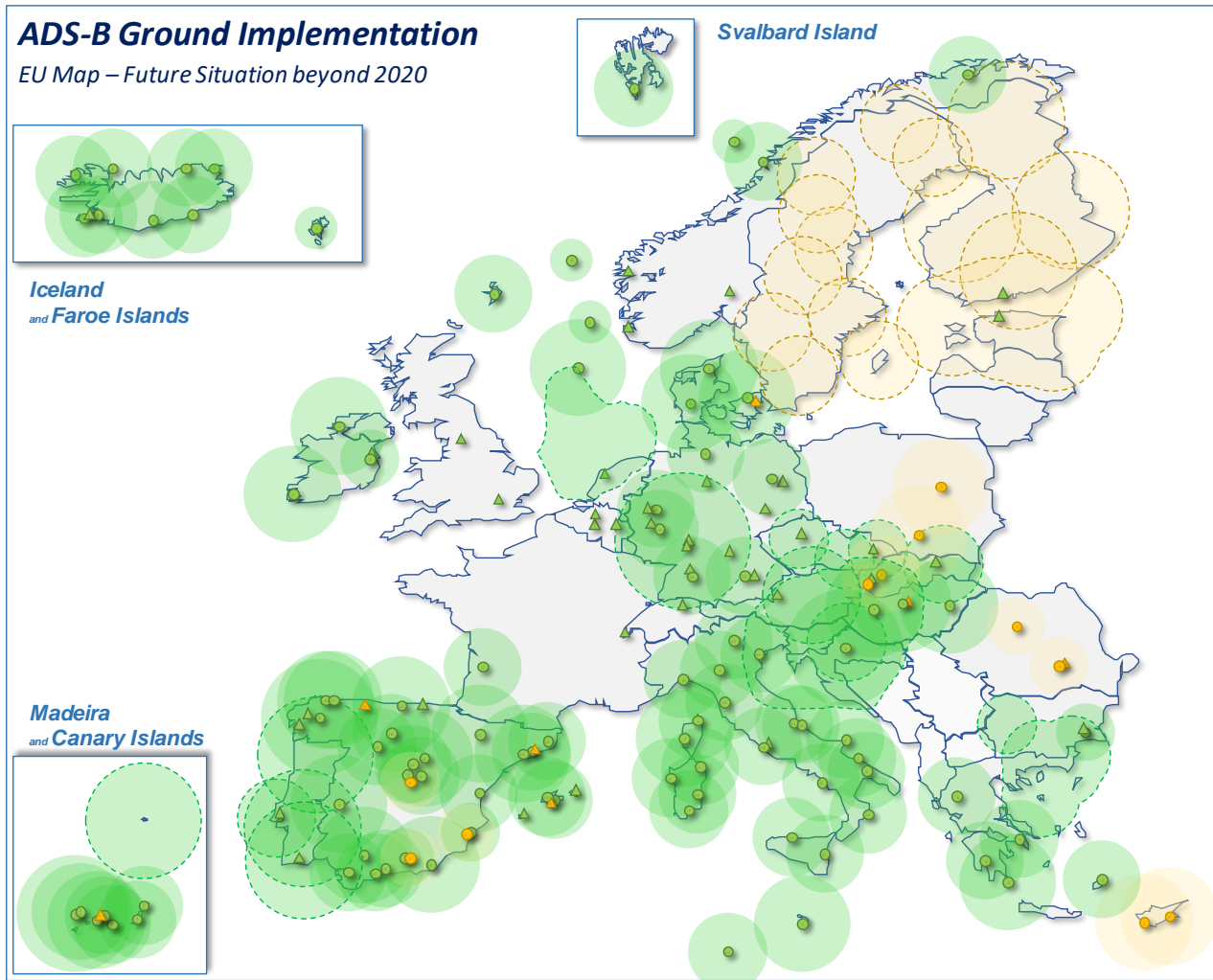
From 2018, the remaining average lifetime of the existing ADS-B Stations will be 15 years.

5.3.2 Ground ADS-B segment beyond 2020 – Airspace and Airport surveillance

Complementing the shorter-term picture included in the previous paragraph, the following chart includes information on the expected long-term plans from operational stakeholders to implement ADS-B surveillance systems in the upcoming years. In particular, the chart includes all ADS-B systems which are expected to be installed and operational from 2021 onwards²¹.

The paragraphs below provide a more detailed outlook on stakeholders' plans, with regard both to Air and Ground Surveillance.

²¹ The charts also include all existing ADS-B based systems whose operational lifetime – according to the local stakeholders – is expected to exceed 2020. It is also worth noting that the chart includes all ADS-B stations and systems for which stakeholders declared future plans without the exact year of installation.



LEGEND

- ▲ ADS-B Ground Station for Airport surveillance integrated in the ATM system
- ▲ ADS-B Ground Station for Airport surveillance not integrated in the ATM system
- ADS-B Ground Station for EnRoute surveillance integrated in the ATM system
- ADS-B Ground Station for EnRoute surveillance not integrated in the ATM system
- ADS-B Station Area of Coverage
- ADS-B Station Area of Coverage
- Coverage of WAM Stations able to process ADS-B position information
- Coverage of WAM Stations able to process ADS-B position information

AIRSPACE SURVEILLANCE

Compared to the situation in 2020, the European ADS-B outlook slightly improves with plans to install a few ADS-B capable stations for EnRoute surveillance.

There are plans for new ADS-B stations to be added by Spain, covering the Southern portion of the airspace (through ADS-B receivers integrated within newly installed Mode S radars). On the other hand, Italy and Czech Republic will make operational use of ADS-B data, thus integrating the information into the ATM systems. Finally, an additional WAM station able to receive ADS-B data will cover the Eastern airspace of Finland, however without the information being integrated in the ATM systems.

AIRPORT SURVEILLANCE

Complementing the picture above, ANSPs and airport operators plan to install/renew 6 ADS-B stations for airport surveillance between 2021 and 2030. These stations will complement and/or replace the current infrastructure and will enhance the ADS-B coverage in Europe.

9 airport operators /ANSPs in Austria, Denmark, Cyprus, Latvia, Lithuania, Luxemburg, Poland, Romania, Sweden) have not plan to install or integrate ADS-B position reports:

- 4 airports (Austria, Poland, Romania, Sweden) have recently installed ADS-B stations;
- 3 airports (Latvia, Lithuania, Luxemburg) have no plan to install ADS-B stations;
- For Cyprus airports, the remaining average lifetime of their infrastructures is less than 5 years;
- Copenhagen airport (Denmark) will launch an assessment project, in order to assess whatever is feasible to use ADS-B position report from aircrafts on ground.

At last, some ANSPs will use ADS-B infrastructure for other Airports not yet covered by any surveillance means.

ADS-B infrastructure will be more and more integrated into the ATM system, by tracking vehicles' position in a first time, then by enhancing it to aircraft. Several reasons, according the country, explain this strategy: aircraft fleet not fully equipped, service certification, complement the Mode S/ MLAT coverage, accuracy/integrity of data.

From 2018, the remaining average lifetime of the existing ADS-B Stations will be 16 years.

5.3.3 Ground based ADS-B implementation expected timeline

The following graph shows the evolution of the ADS-B stations implementation in Europe.



It can be seen that there is a significant increase of the ADS-B stations from 2018 until 2021 (+54 stations), whilst the number remains more or less constant from 2021 onwards.

5.3.4 Airborne ADS-B segment

Whilst for the forward fit plans, all major airlines are planning to cope with the Regulation for new aircraft entering into service, for the retro-fit plans the situation is different. For the long-haul fleet, some airlines are planning to retro-fit their aircraft to comply with the Regulation. However, for the medium/short haul fleet, major airlines foresee difficulties to retro-fit due to the high number of aircraft needed to be equipped in the short-term.

The situation is very similar for the Regional and Business Aviation according to the feedback received: generally, there are no plans to retro-fit their fleet, with very few exceptions.

This scenario is further amplified by expectations arising from potential decision by the EC to offer a five-year transition period 2020-2025 as well as further exemptions for aircraft retiring before 2025, leading to another amendment of the Regulation.

Besides the difficulties expressed to retro-fit their fleets by 2020, airspace users are also affected by the misalignment of ADS-B mandates, especially between EU and US as can be seen here below:

- European global airlines must equip their fleet in order to cope with US mandate which requires to modify the Multi-Mode Receiver (MMR) by including the WAAS (Wide Area Augmentation System) function.
- On the other hand, the US developed an affordable solution for General Aviation (GA), based on UAT transponders so that GA are compliant with DO-260B and then all category of AU's have the capability to comply with ADS B surveillance systems.
- European GA is out of the scope of EU mandate, in hindsight a similar system to UAT that has been deployed in the USA, would offer a low-cost alternative to GA traffic and avoid the mix mode of operation.

In addition to EU and USA, ADS-B out (DO-260B transponder) is or will be mandated in other countries like China, Australia or Japan.

5.3.5 Space based ADS-B

Several (11) ANSPs are considering space based ADS-B and investigations are on-going (based on Aireon's service availability).

The existing dense surveillance infrastructure in continental Europe, implies that this satellite based ADS-B service will be of interest if seen as contingency layer, potentially allowing a rationalization of ground sensors. However, in vast and remote areas lacking proper surveillance coverage space based ADS-B is considered an interesting alternative.

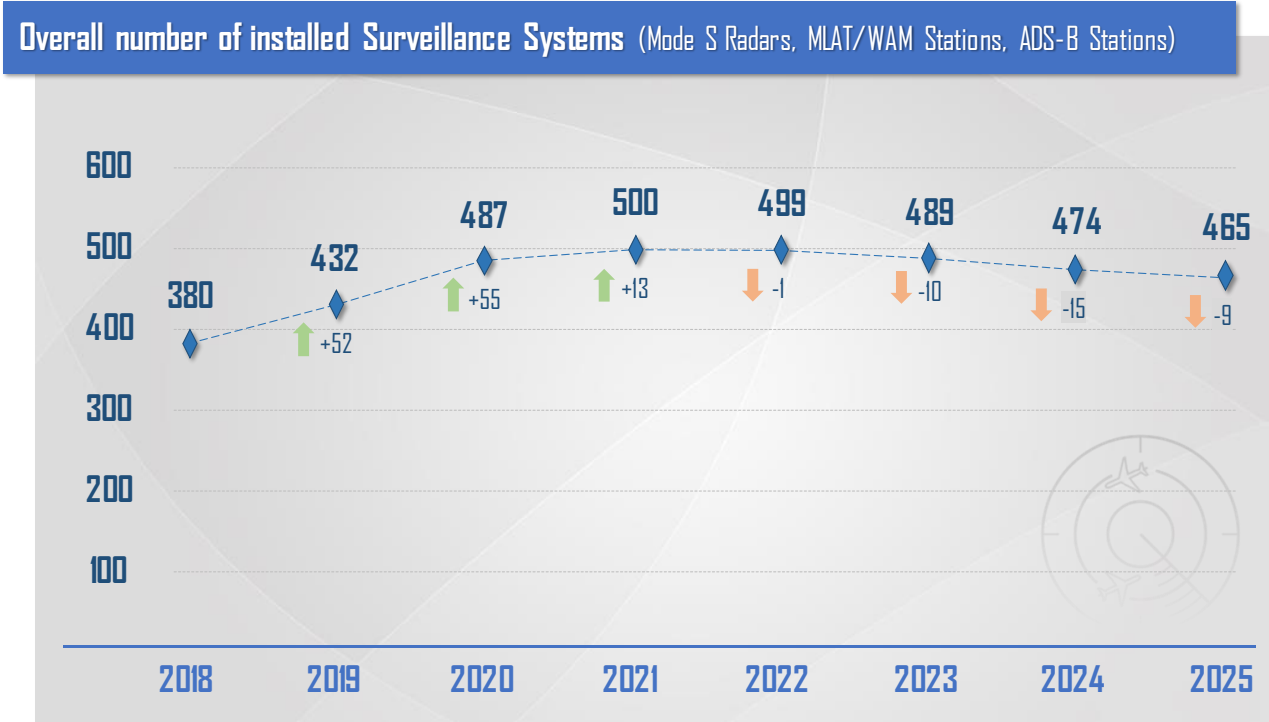
Three ANSPs are planning to use space based ADS-B. In Italy spaced based ADS-B will be integrated in a ATS test platform and beyond 2020 operational use is envisaged as a ground independent layer of ATS Surveillance, used for contingency and for surveillance augmentation. In mid-term, it could part of the global optimisation of traditional surveillance infrastructure.

5.4. Overall implementation outlook in and beyond 2020

This chapter provides an outlook of the situation of the surveillance systems in and beyond 2020. Specifically, the overall evolution of the surveillance systems (Mode S, Multilateration, and ADS-B stations) in the timeframe 2018 – 2025 is described. In addition, and along the content of

chapter 4.4, such picture is complemented by two maps representing the aggregated scenario in Europe, as reported in surveys provided by the respondents.

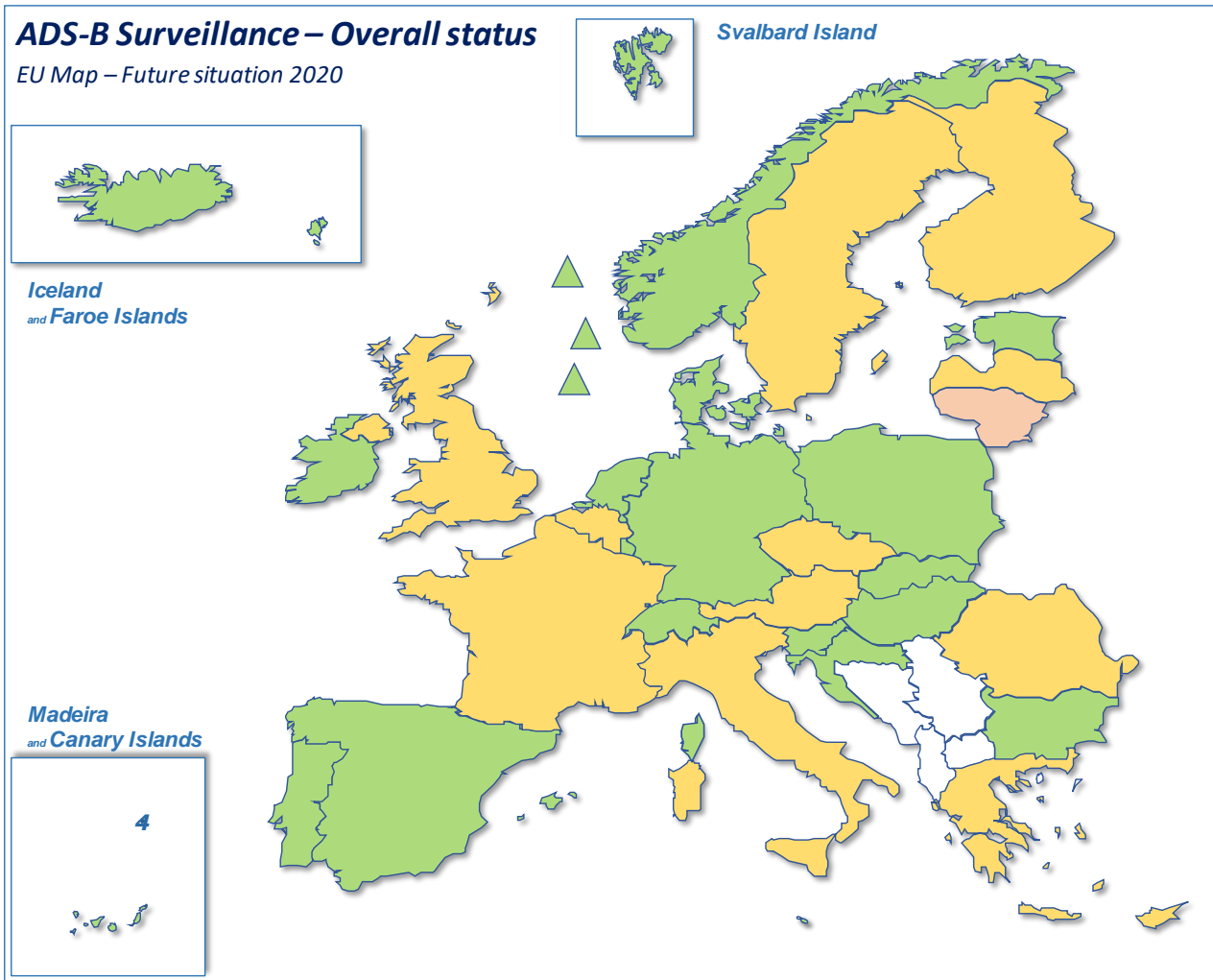
The following graph shows the evolution of the overall surveillance systems implementation in Europe, combining the Mode S radars, ADS-B stations and MLAT/WAM stations.



The figures shown in this chart represent all surveillance systems installed and to be installed in the future in Europe. The overall number increases until 2021, with 120 stations implemented thus reaching a total number of 500. Starting from 2022, the number slightly drops until 2025.

In this context, it needs to be noted that the sum of the stations reported in the charts shown in chapters 5.1.3, 5.2.3, and 5.3.3 does not add up to the total number reported above. The reason relies on the fact that some systems (e.g. WAM stations) are capable of receiving ADS-B data. For this reason, they were accounted for and displayed in both maps (Multilateration and ADS-B stations), however they should be counted as one infrastructure only.

In addition, the following two maps represent the aggregated view of the overall ADS-B implementation in Europe, using the information displayed in the previous chapters for each surveillance system. The first one represents the status by 2020, whilst the second one aims at providing an outlook beyond 2020 (until 2025).



LEGEND

- Operational ADS-B implementation planned*
- No current plans for ADS-B implementation*
- Technical ADS-B implementation planned*
- Oil rig – color depends on the legend above*

The legend explained:

Green – Operational ADS-B implementation planned

In these environments the survey respondents indicated plans to implement ADS-B for operational use by ATC. This could be either as a complementary surveillance layer to radar and multilateration or as sole means where no other sensor coverage exists.

Amber – Technical ADS-B implementation planned

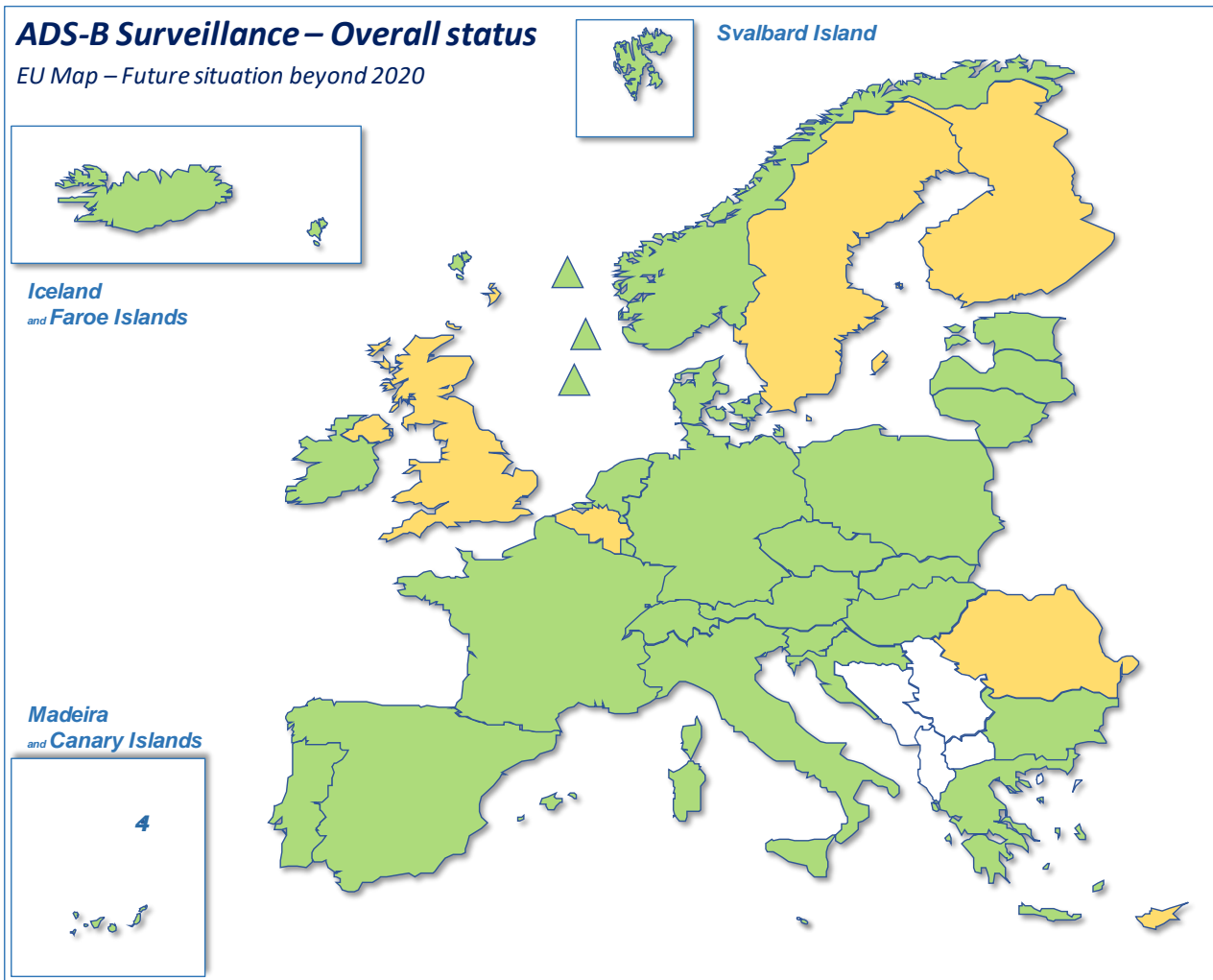
In these environments the survey respondents indicated plans to implement the infrastructure necessary to receive and forward ADS-B information but no operational implementation is planned. In this category the stakeholders may intend to implement ADS-B for validation purposes or for surveillance of airport surface vehicles but there are no immediate plans to integrate ADS-B position in ATC systems and to use it for provision of ATC services.

Pink – No current plans for ADS-B implementation.

In these environments the survey respondents indicated no plans to acquire and implement surveillance systems capable of receiving ADS-B.

Considering what above, in the near future, it can be seen that most of the EU States will be either capable to process and use the ADS-B data, or have plans to implement it.

For what concerns instead the situation beyond 2020, the map below clearly shows how the picture will improve with time.



All countries plan to implement ADS-B operationally, except UK, Belgium, Sweden, Finland, Romania and Cyprus, where it will be implemented without making actual use of the ADS-B data.

6. Other considerations

A number of well-known issues have been reported through the replies received from the stakeholders consulted. These issues are described here with the aim to reflect them in the report, so that they can be eventually considered when preparing the way forward as described in chapter 7.

6.1. Spectrum congestion issues

Radio frequency spectrum is a scarce natural resource at the disposal of each sovereign country. Management of the spectrum is handled globally by the International Telecommunications Union (ITU) where States are represented. All allocations are documented in the Radio Regulation (RR) and they can only be changed at World Radio Conferences that are typically held every fourth year. It should be noted that aviation only has a status as observer in ITU and is not part of decision making. Aviation is represented by States that often has other priorities to consider.

Considerable portion of the available spectrum is since many years allocated to aviation and protected as spectrum for "safety-of-life" services. Management of frequency assignments within the aviation spectrum is delegated to International Civil Aviation Administration (ICAO), who developed frequency assignment parameters in order to protect the services and is using the regional offices to administrate the frequency assignments accordingly.

Coordination of frequency assignments in Europe is handled by the European Air Navigation Planning Group (EANPG) with support from national aviation and telecommunications authorities and Eurocontrol. Usage of spectrum for military purposes is handled on national basis and is many cases coexisting with civilian services.

Usage of aviation spectrum is not charged by the States, but possible charging schemes are being discussed in Europe.

The aviation spectrum is very attractive to commercial telecommunication service providers driven by mobile and Internet connectivity. Traditionally, it was sufficient for aviation to claim "flight safety" to protect its spectrum, but during the last 20 years a strong pressure has emerged from satellite service providers, mobile phone industry, broadcast companies etc., demanding access to aviation spectrum. Examples are MLS-spectrum was taken over by satellite communication service providers and many other frequency bands are being shared with non-aviation services. Argument used against aviation is that the reserved spectrum is underutilised because of expected new systems not in operation and low spectrum efficiency due to old and obsolete technologies.

The aeronautical band 960-1215 MHz is coming under increasing pressure to allow channel sharing with non-aviation services that by design are not compatible with the aeronautical applications incumbent in the band. Their equipment is neither maintained nor operated to the standard that safety of life critical aviation equipment is. If the aviation community is forced to share the channel with such external users, the risk of uncontrollable service degradations or outright denial of service to aviation application, including Mode S radar, multilateration and ADS-B, is unacceptably high. The band is also used for DMEs, military data links etc. The new datalink system, LDACS²² is expected to share the spectrum as well.

²² L-band Digital Aeronautical Communication System

In the context of this report it is the original SSR frequencies 1030/1090 MHz that are the focus of spectrum congestion and competition. This pairing was consisting of two 10 MHz wide channels centred at 1030 MHz for uplink from the radar to the aircraft, and 1090 MHz for the downlink from the aircraft back to the radar. Traffic in these channels originally consisted of repeated burst of pulse encoded scans along the radar azimuth. As density of radar installations grew so did channel saturation, manifesting itself as over-interrogation²³ at aircraft antenna and garble²⁴ at the ground based radar antenna.

The oversaturation at the 1090 MHz downlink channel was alleviated by advancements in radar technology until, in the 1990s, new operational modes appeared and took place alongside the pre-existing radar; ACAS/TCAS²⁵ and ADS-B. These new modes were specific in that they were largely autonomous and broadcast – the ground based radar no longer had the necessary authority to keep the channel clean and organized, rather channel saturation largely became a function of traffic density in a given block of airspace. Both ACAS and ADS-B use random channel access. The practical effect is that when the channel becomes saturated at a certain location, the operational range of ADS-B in that location is substantially reduced.

Saturation of the 1090MHz channel is a regular occurrence in core European airspace. The progressive rollout of the significantly more spectrum efficient Mode S radars in lieu of old Mode A/C units alleviates this issue but the freed capacity is being taken up by ADS-B with its rigid band usage character. ACAS is a significant contributor to channel congestion [ref SESAR 15.04.01 D10 Final report] and can amount to 50% of radio traffic in a dense environment; a potential solution is to adapt ACAS to use ADS-B messages instead and reduce the rate of own transmissions. This concept is known as ACAS Hybrid surveillance and is included as an option in EASA ACAS II / TCAS 7.1 AMC (AMC 20-15). The standard is published (RTCA DO-300).

There exists a concrete risk of band oversaturation in the transitional period when all aircraft are expected to both broadcast ADS-B and reply to Mode S interrogations on the same channel. The selectivity of the Mode S technology is a valuable tool to moderate the channel as it allows the ground system to intelligently choose which targets to interrogate and how often.

On the topic of RF spectrum congestion, the survey participants were asked whether they conduct any form of RF monitoring and if so, whether they detect any issues.

- In airspace surveillance, 14 of the 30 responding participants indicated that some form of RF monitoring is taking, or has taken place.
- 6 participants indicated that they encountered few disturbances, most often related to unauthorized transmissions from non-compliant transponders.

6.2. Common point of failure

ADS-B uses GNSS as its primary positioning source. While other possible sources exist, they are not required in EASA CS.

²³ Over-interrogation or excessive interrogation occurs when the airborne transponder is interrogated more often than it can handle producing and transmitting replies to interrogations. The required behavior in such a case is to lock up and cease operation for a given amount of time. Many times the transponder had to be manually reset by the crew.

²⁴ Garble occurs when replies from two different transponders arrive at the antenna at the same time. No information can be decoded, the radar will continue to operate as before but no plot will be produced for that specific revolution. Subsequent behavior is subject to operational needs; in a typical configuration, if no plot is produced for 2-3 successive revolutions, the target will be flagged as coasting and the track will cease to be updated. A coasting track is dropped after 30 seconds of no updates.

²⁵ traffic collision avoidance system

The use of GNSS for positioning has, in the recent years, seen widespread adoption in navigation under the umbrella of Performance Based Navigation. PBN implementation, now subject to own implementing rules in the form of Pilot Common Project (PCP) and the anticipated Subpart PBN, has progressed largely to the point where potential for rationalization of conventional navigation infrastructure is being identified and realized. The European vision, enshrined in the ATM Masterplan, is for navigation within ECAC to become based solely on GNSS with the exception of contingency operation by 2030. When ground based navigation infrastructure is rationalized, ANSPs will usually depend on radar vectoring²⁶ to provide the primary contingency in case of a GNSS failure.

If surveillance is to follow navigation in this trend and make itself largely dependent upon GNSS by replacing ground based surveillance sensors (radar, multilateration) with ADS-B, the shared dependency will lead to a significant common point of failure, since ATC is no longer able to determine aircraft positions. In the absence of an independent positioning source, both the aircraft crew and the ground ATC have effectively become blind and can no longer sustain safe provision of navigation or other ATC services including navigation.

It needs to be noted that GNSS is a relatively fragile system; its weak received power makes it easy to interfere with, obstruct and spoof. Multiple cases of each have been demonstrated in the recent years and the number of interference events has been showing a sharply rising trend. While the advent of dual frequency multi-constellation (DFMC) GNSS operations is expected to partially alleviate this vulnerability, the general consensus in the ATM community is that a robust, fully GNSS independent positioning and timing solution of some form will be necessary to provide some level of sustained operational capacity. The concept is under development in SESAR under the acronym A-PNT and revolves around the use of DME/DME positioning in the short term and additional positioning modes in the long term. Until the solution is mature and ready for implementation, it will be difficult to construct a safety argument that allows the exclusive joint use of GNSS for both navigation and surveillance while supporting the air safety targets promulgated in the European ATM regulation.

6.3. Certification of GNSS for Safety of Life provision

Another aspect of operations dependent solely of GNSS is that of GNSS operation vs state liability. As was elaborated earlier in the document, the only two GNSS core constellations available today are two military systems, each owned, operated and fully controlled by USA and Russia. They are provided realistically on an as-is basis with an expression of commitment from the respective federal administrations. This raises a dilemma concerning the role of national authorizations or approvals of these foreign-power controlled systems for use in the provision of safety of life services such as ATC.




















This issue was identified and broadly discussed in the context of implementation of Performance Based Navigation, where GNSS acts as the primary positioning means. Since ADS-B uses GNSS in much the same role, the issue of national authorization/approval will have to be addressed here as well at least in the short to medium term and until Dual Frequency Multi-Constellation (DFMC) GNSS operations supported by Galileo are implemented in ECAC.

²⁶ Various known also as radar control or tactical control, the concept involves ATC using surveillance sensors to determine aircraft position and telemetry and subsequently issuing heading, speed and altitude instructions to the aircraft to navigate to.

6.4. Other national security aspects

In most states, civil and military air operations are intertwined to some degree. The military may operate their own ATM systems, provide their own ATC service or depend, to some degree, on the civilian infrastructure. There are cases where the entire ATM/ATC operation is joint or shared. As military generally operates outside of the ICAO framework, any infrastructure development and rationalization plans are contingent on the military coordination and an agreement at national levels.

The survey asked the respondents to provide information on their arrangements concerning mutual sharing of civil and military surveillance data. However, a deep analysis of the situation fully involving the Military authorities was not carried out due to time constraints, and further work would be needed, engaging the militaries to have a complete picture on the civil-military exchange of surveillance data.

ADS-B Civil-Military Data Sharing									
		Current		Future			Current		Future
	Austria	Airports	Yes	Yes		Latvia	Airports	No	No
		EnRoute TMA's	Yes	Yes			EnRoute TMA's	Yes	Yes
	Belgium	Airports	No	No		Lithuania	Airports	No	No
		EnRoute TMA's	Yes	Yes			EnRoute TMA's	Yes	Yes
	Bulgaria	Airports	Yes	Yes		Luxemburg	Airports	No	No
		EnRoute TMA's	No	Yes			EnRoute TMA's	No	No
	Croatia	Airports	Yes	Yes		Malta	Airports	No	No
		EnRoute TMA's	Yes	Yes			EnRoute TMA's	No	Yes
	Cyprus	Airports	No			Netherlands	Airports	No	No
		EnRoute TMA's	No				EnRoute TMA's	Yes	Yes
	Czech Republic	Airports	No	No		Norway	Airports	Yes	
		EnRoute TMA's	Yes	Yes			EnRoute TMA's	Yes	Yes
	Denmark	Airports	No	No		Poland	Airports	No	No
		EnRoute TMA's	Yes	Yes			EnRoute TMA's	Yes	Yes
	Estonia	Airports	No	No		Portugal	Airports	No	
		EnRoute TMA's	No	Yes			EnRoute TMA's	Yes	Yes
	Finland	Airports	No	No		Romania	Airports	No	
		EnRoute TMA's	Yes				EnRoute TMA's	Yes	Yes
	France	Airports	Yes	Yes		Slovak Republic	Airports	No	No
		EnRoute TMA's	Yes	Yes			EnRoute TMA's	Yes	Yes
	Germany	Airports	No	No		Slovenia	Airports	No	Yes
		EnRoute TMA's	Yes	Yes			EnRoute TMA's	Yes	Yes
	Greece	Airports	No	Yes		Spain	Airports	No	
		EnRoute TMA's	Yes	Yes			EnRoute TMA's	Yes	Yes
	Hungary	Airports	No	No		Sweden	Airports	No	No
		EnRoute TMA's	No	Yes			EnRoute TMA's	Yes	
	Ireland	Airports	Yes	Yes		Switzerland	Airports	No	
		EnRoute TMA's	Yes	Yes			EnRoute TMA's	Yes	Yes
	Italy	Airports	No	Yes		United Kingdom	Airports	No	No
		EnRoute TMA's	Yes	Yes			EnRoute TMA's	Yes	Yes

NE. Light yellow boxes correspond to missing information

Protocols for aeronautical data sharing between civil and military organizations are fairly well established. As the figure above shows, some sharing agreements exist in all but five countries surveyed; additional 3 protocols are planned in the future. It is however a matter of operational security to discuss what data is shared and how it is used by the respective military, putting this discussion beyond the scope of this report.

It should also be mentioned in this context that, in accordance with ICAO Annex 12, all countries have implemented own protocols for aeronautical Search and Rescue (SAR). The respective SAR organization (ARCC or JRCC) will, as a rule, also have access to surveillance data produced by ANSPs and airport operators, unless the SAR function is integrated in the ANSP itself.

7. Main findings

7.1. Ground segment

According to the current plans reported by the ANSPs, the ADS-B stations will increase in the near future as well as the number of Mode S radars. This is due to the fact that not all aircraft are or will be equipped with ADS-B Out capability, and therefore radar coverage will still be needed to provide surveillance services to all air traffic. Indeed, this approach would have obvious implications in terms of costs (new installations and maintenance cost) and would not be in line with a European CNS rationalisation. All in all, the surveys show that several ANSPs have plans to progress with the implementation of ADS-B capable stations.

Considering the security and safety dimension of the surveillance infrastructure, military stakeholders should be involved and duly consulted in all future developments related to ADS-B ground network.

7.2. Airborne segment

With regards to the airborne segment, technically speaking, ADS-B Out capability is available and already implemented in many aircraft as demonstrated through the surveys and confirmed by Airbus during dedicated bilateral meetings. Ground ATM systems are capable to process and integrate the data received through ADS-B ground stations receivers already deployed. ADS-B technology is widely used worldwide, also in areas with high traffic.

However, currently only around 20% of the aircraft flying in Europe are equipped with the Commission Implementing Regulation (EU) No 1207/2011 compliant transponder ED-102A (DO-260B). This means that, considering the lack of plans declared through the surveys, it is unlikely to reach the 100% equipage rate by June 2020 for the mandated aircraft (exceeding 5700 Kg or having maximum cruising true airspeed capability greater than 250 knots).

Furthermore, it would be near impossible to have all aircraft flying in European airspace equipped with the ADS-B Out capability, considering that the current Regulation does not cover General Aviation. This implies that even in the best scenario (100% of aircraft mandated by Regulation equipped by 2020) complementary surveillance sources (like Mode S radars) would be needed to ensure that surveillance service is provided to all European traffic.

7.3. New international requirements

Another important consideration is that ICAO has established the Global Aeronautical Safety System (GADSS) with the intention to help ensuring that no planes would ever “disappear” again, especially over remote and oceanic airspace. At the heart of the GADSS recommendations is the ability for airlines to track their aircraft. ADS-B space based surveillance is offering this global tracking capability for ADS-B equipped aircraft by 2018 and, as reported, several ANSPs are considering moving towards it.

7.4. Way forward

This report provides a robust picture of the surveillance implementation status in Europe by 2018 and related plans towards 2020-2025 timeframe. It confirms the ADS-B as a solution “ready to

implement”, even already significantly implemented. In other words, ADS-B is a pure deployment issue, not subject to any further development, validation, standardisation or regulatory issue.

This report is delivered by SDM to the European Commission about 2 years ahead of the current regulatory deadline for ADS-B. This timeframe offers only a very last small window in the next few months that shall be used to elaborate, consult with all impacted stakeholders, including the military, and start the execution of a recovery plan. In this plan, the ground-air coordination and synchronisation would be overarching in order to restore the required mutual trust between ground and air stakeholders as well as the legitimacy of ADS-B as an alternate form of surveillance, leading to its progressive adoption in suitable environments and thus paving the way for future ground infrastructure rationalisation.

The SDM stands ready to support the European Commission throughout these further steps towards ADS-B implementation.

Appendix A – ADS-B Surveys

Ground surveillance

ADS-B Monitoring questionnaire, Enroute / TMAs surveillance, Current situation

Current situation (surveillance system deployed)							
Type of system	Location	Operational Range	Year of installation	Remaining lifetime	Is the data integrated into the existing ATM systems? Y/N	If integrated into the ATM systems, what data elements?	Additional notes
ADS B station							
System 1	Geographical location or latitude and longitude	Nautical miles	YYYY	Number of years		Free text	Free text
System 2							
System 3							
System 4							
System 5							
WAM							
System 1	Geographical location or latitude and longitude	Nautical miles	YYYY	Number of years		Free text	Free text
System 2							
System 3							
System 4							
System 5							
Mode S radars							
System 1	Geographical location or latitude and longitude	Nautical miles	YYYY	Number of years		Free text	Free text
System 2							
System 3							
System 4							
System 5							

	Answer	Additional Notes
Question 1	Is all the controlled airspace covered? If not, please specify the areas not covered	
Question 2	Is the ADS-B information integrated in the ATM systems?	
Question 3	Is there any data-sharing between military and civil stakeholders?	
Question 4	Is the NSA in your country accepting the use of GPS for surveillance purposes?	
	If yes, it is accepted as a sole mean of surveillance?	
Question 5	Are you monitoring the 1090Mhz RF?	
	If yes, have you experienced any sort of RF saturation?	

Distributed to Air Navigation Service Providers and Airport Operators

ADS-B Monitoring questionnaire, Enroute / TMA surveillance, Future situation

Future situation (surveillance system plans)							
Type of system	Planned location	Standard operational range	Planned year of installation	Expected lifetime	Will the data be integrated into the existing ATM systems? Y/N	If integrated into the ATM systems, what data elements?	Additional notes
ADS B station							
System 1	Geographical location or latitude and longitude	Nautical miles	YYYY	Number of years		Free text	Free text
System 2							
System 3							
System 4							
System 5							
WAM							
System 1	Geographical location or latitude and longitude	Nautical miles	YYYY	Number of years		Free text	Free text
System 2							
System 3							
System 4							
System 5							
Mode S radars							
System 1	Geographical location or latitude and longitude	Nautical miles	YYYY	Number of years		Free text	Free text
System 2							
System 3							
System 4							
System 5							

	Answer	Additional Notes
Question 1	Are you planning to implement data-sharing between military and civil stakeholders?	
Question 2	Are there any infrastructure rationalisation plans thanks to the ADS-B implementation?	
Question 3	Do you have any plans to use the satellite ADS-B information?	

Distributed to Air Navigation Service Providers and Airport Operators

ADS-B Monitoring questionnaire, Airport surveillance, Current situation

Current situation (surveillance system deployed)							
Type of system	Location	What is the coverage in maneuvering, apron and other relevant area?	Year of installation	Remaining lifetime	Is the data integrated into the existing ATM systems? Y/N	If integrated into the ATM systems, what data elements?	Additional notes
ADS B station							
System 1	Name of the airport	Specify if full or partial coverage in which area	YYYY	Number of years		Free text	Free text
System 2							
System 3							
System 4							
System 5							
MLAT station							
System 1	Name of the airport	Specify if full or partial coverage in which area	YYYY	Number of years		Free text	Free text
System 2							
System 3							
System 4							
System 5							
Mode S radars							
System 1	Name of the airport	Specify if full or partial coverage in which area	YYYY	Number of years		Free text	Free text
System 2							
System 3							
System 4							
System 5							

	Answer	Additional Notes
Question 1	Have you already implemented/deployed "ADS-B out" technology in your airport?	
Question 2	Please specify the type and number of ADS-B equipment (Vehicles, Drones, others), and their performance requirements (MOPS)	
Question 3	What are the ADS-B standards in operation/used at your airport: 1090 ES, UAT, VDL Mode 4?	
Question 4	Are you monitoring the 1090Mhz RF?	
	If yes, have you experienced any sort of RF saturation?	
Question 5	Is there any data-sharing between military and civil stakeholders?	

Distributed to Airport Operators

ADS-B Monitoring questionnaire, Airport surveillance, Future situation

Future situation (surveillance system plans)							
Type of system	Planned location	What will the coverage be in maneuvering, apron and other relevant areas?	Planned year of installation	Expected lifetime	Will the data be integrated into the existing ATM systems? Y/N	If integrated into the ATM systems, what data elements?	Additional notes
ADS B station							
System 1	Name of airport	Specify if full or partial coverage in which area	YYYY	Number of years		Free text	Free text
System 2							
System 3							
System 4							
System 5							
MLAT station							
System 1	Name of airport	Specify if full or partial coverage in which area	YYYY	Number of years		Free text	Free text
System 2							
System 3							
System 4							
System 5							
Mode S radars							
System 1	Name of airport	Specify if full or partial coverage in which area	YYYY	Number of years		Free text	Free text
System 2							
System 3							
System 4							
System 5							

	Answer	Additional Notes
Question 1	Please specify the type and number of ADS-B equipment (Vehicles, Drones, others), and their performance requirements (MOPS) which will be equipped.	
Question 2	What will the ADS-B standards be in operation at your airport: 1090 ES, UAT, VDL Mode 4?	
Question 3	Are you planning to implement ADS-B in non-radar (SMR) areas?	
Question 4	Are you planning to implement data-sharing between military and civil stakeholders?	
Question 5	Are there any rationalisation plans thanks to the ADS-B implementation?	
Question 6	Do you have any plans to use the satellite ADS-B information?	

Distributed to Airport Operators

Airborne surveillance

ADS B OUT / DO260B fleet compliance and equipage policy					
Aircraft Type / Model		Total Number of Aircraft	ADS-B OUT / DO260B		
			Aircraft Equipped (number)	Operational certification (Y/N)	Flight Crew Trained (Y/N)
A319-xxx					
A320-xxx					
A321-xxx					
...					
...					

Forward fit equipage policy					
		Answer	Additional notes		
Question #1	Are all new A/C entering your fleet compliant with the SPI Regulation (as from today)?				
	If not compliant, how many aircraft will be equipped, but not operationally certified?	# Aircraft			

Retrofit equipage policy					
		Answer	Additional notes		
Question #2	Is your airline planning to cope with the ADS-B retrofit date of 7 June 2020 for your short/medium haul fleet?				
	If no, are you awaiting for possible transition period regarding the proposed EASA amendment of the SPI IR regulation?				
Question #3	When operating in the European Airspace, are your pilots reporting / experiencing any Mode S transponder failures? (Specify the locations, if possible)				
Question #4	Is your airline planning to cope with the ADS-B retrofit date of 1 Jan 2020 for your long haul fleet, if applicable?				
Question #5	Are you planning to implement any form of augmentation i.e. SBAS?				

Distributed to EU headquartered Airspace Users including Main lines, Regional and Business aviation

Appendix B – List of Respondents

Air Navigation Service Providers

ANA

ANS CR

ANS Finland

Austro Control

Avinor

Belgocontrol

BULATSA

Croatia Control

DCAC

DFS

DSNA

EANS

ENAIRE

ENAV

HCAA

HungaroControl

IAA

Isavia

LFV

LGS

LPS SR

LVNL

MATS

NATS

NAV Portugal

Naviair

Oro Navigacija

PANSA

ROMATSA

skyguide

Slovenia Control

Airport Operators

Aeroporti di Roma

Aéroports De Paris

Berlin Brandenburg Airport

Brussels Airport

Copenhagen Airport

Frankfurt International

London Gatwick

London Heathrow

Manchester Ringway

Munich Franz Josef Strauss Airport

Oslo Airport

Swedavia

Airspace Users

Aerologic GmbH

Aegean Air

Air Baltic

Air Europa

Air France

Air Service Liege

Albatar SA

ASL Airlines

ASL Group

Aurigny Air Services

Austrian Airlines

Bmi regional

British Airways

Croatia Airlines

easyJet

Eurofly Service

Eurowings Group

HOP!

Jet2

KLM

Lufthansa

Lufthansa Cargo

Lufthansa CityLine

NetJets

Novair

Portugalia

PrimeraAir

Ryanair

SAS

Swiss

TAP Portugal

Thomas Cook Airlines

TUI fly

Tyrolean Jet Services

Wamos Air

Zimex