# Automatic Dependent Surveillance – Broadcast System

## An Overview of the System and Retrofitting to Older Aircraft

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Mechanical and Production Engineering
Aircraft Engineering

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**ABSTRACT**

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The main objective of this thesis was to write a clear overview of the Automatic Dependent Surveillance – Broadcast system and to investigate the rules and options regarding retrofitting the system to older aircraft. The ADS-B system is a new solution for the surveillance of air traffic, a task that is currently accomplished with radars. This study was conducted per a request from the Finnish Aviation Academy. Retrofit options were studied for the aircraft in the fleet of the Aviation Academy, which also gave a good overview of various aircraft types in relation to the ADS-B system.

Information was gathered by studying the regulations given by officials mandating the system. These included European Union Commission regulations and rulings of the Federal Aviation Administration. Also materials from aircraft and equipment manufacturers and operators were studied such as service bulletins and modification plans.

It was concluded that it would be possible to perform the retrofit for all the aircraft in the Aviation Academy fleet. It was found that for the oldest aircraft type the installation was the most complicated, but there were also more options to choose from than with other aircraft. In the case of the newer aircraft the options became more limited and the installation process got easier. It was also found out that according to the European Union regulations, only the largest aircraft type in the Aviation Academy fleet would have to be retrofitted with the system.

The implementation of the ADS-B system was found to provide multiple benefits for the operators and for the air traffic management. It was also established that the amount of these benefits depend on the scale in which the system is implemented.

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Key words: Air traffic management, Single European Sky

**TIIVISTELMÄ**

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Opinnäytetyön päämääränä oli kirjoittaa selkeä kuvaus Automatic Dependent Surveillance -Broadcast-järjestelmästä ja tutkia järjestelmän jälkiasennukseen liittyviä sääntöjä ja mahdollisuuksia. ADS-B -järjestelmä on uusi ratkaisumalli lennonvalvontaan, joka nykyisellään toteutetaan tutkajärjestelmillä. Tutkimus tehtiin Suomen Ilmailuopiston pyynnöstä. Jälkiasennusvaihtoehtoja tutkittiin ilmailuopiston lentokalustoa varten ja tämä myös antoi hyvän yleiskuvan erilaisista konetyypeistä järjestelmän kannalta.

Tietoa haettiin tutkimalla järjestelmän käyttöönottoa vaativien viranomaisten määräyksiä. Näihin lukeutuivat Euroopan komission ja Yhdysvaltojen ilmailuviranomaisen FAA:n säädökset. Lähteinä käytettiin myös lentokone- ja laitevalmistajien materiaaleja, kuten huolto-ohjeita ja modifikaatiosuunnitelmia.

Tutkimus vahvisti, että järjestelmän asennus on mahdollista kaikkiin ilmailuopiston lentokoneisiin. Tutkiessa huomattiin, että järjestelmän asennus oli haastavinta vanhimpaan koneeseen, mutta siihen asennettavissa laitteistoissa oli myös eniten valinnanvaraa. Uudempiin koneisiin siirryttäessä järjestelmän asennuksesta tuli yksinkertaisempaa ja vaihtoehdot vähenivät. Tutkimuksessa selvisi myös, että Euroopan komission säädöksien mukaan Suomen Ilmailuopiston lentokalustosta järjestelmän asennus on pakollista vain suurimpaan konetyyppiin.

ADS-B -järjestelmän käyttöönoton huomattiin tuovan useita hyötyjä lentokoneiden käyttäjille ja ilmatilan valvontaan. Tutkimuksessa selvisi myös, että järjestelmän tuomien hyötyjen määrä oli riippuvainen siitä, missä mittakaavassa järjestelmä otetaan käyttöön.

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Avainsanat: Lennonjohto, air traffic management, Single European Sky

**CONTENTS**

**GLOSSARY**

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|---|---|
| ADS-B | Automatic Dependent Surveillance – Broadcast |
| ATC | Air Traffic Control |
| ATM | Air Traffic Management |
| CDA | Continuous Descent Approach |
| CDTI | Cockpit Display of Traffic Information |
| EGNOS | European Geostationary Navigation Overlay Service |
| FINAA | Finnish Aviation Academy |
| GPS | Global Positioning System |
| GS | Glide Slope |
| ICAO | International Civil Aviation Organization |
| LOC | Localizer |
| TIS-B | Traffic Information Service – Broadcast |
| UAT | Universal Access Transceiver |
| VHF | Very High Frequency |
| VOR | VHF Omni-directional Range |
| WAAS | Wide Area Augmentation System |

# 1 INTRODUCTION

Traditionally the situational awareness of air traffic controllers has relied on radar pictures, provided by large on ground radar systems, that indicated the current location of the aircraft in the airspace.  Pilots of smaller aircraft have relied on this information passed to them whereas larger aircraft may have had their own radar systems. The problem with radar systems is that they are expensive and even after the initial installation they are also very expensive to maintain. One of the core ideas of Automatic Dependent Surveillance – Broadcast system is to transfer this task to the aircraft themselves. The idea is for GPS and internal avionics based systems in the aircraft to broadcast the surveillance data, the location and more, periodically to the ground stations and to other aircraft. This also means that the perks of this data being available are not limited to the airspaces that have the expensive ground radar systems installed and operated.

Goal of the introduction of this system is to make the air traffic more efficient by helping to minimize separation and helping to take more optimal flightpaths. This is achieved simply by having more and more accurate info about the current situation of the aircraft in the airspace. This leads to optimal take off and landing times, which decrease the waiting time in the ground and especially waiting time for a landing slot, while on the air. Also the flight paths can be more easily optimized, considering the route and the ascent and descent paths, leading to faster flight times and less environmental affect and less cost. The old systems are also becoming more crowded which increases delays and prevents optimal times and routes. This in turn decreases the cost effectiveness and increases the environmental impact.

As this is a new system that's being introduced the goal of the thesis was to study the essence of the ADS-B system and why its being implemented to the air traffic management. After studying the system, the goal was to write a clear overview that describes and explains the system and its benefits. Another goal was to investigate the regulations and solutions for retrofitting the aircraft fleet of Finnish Aviation Academy with the system.

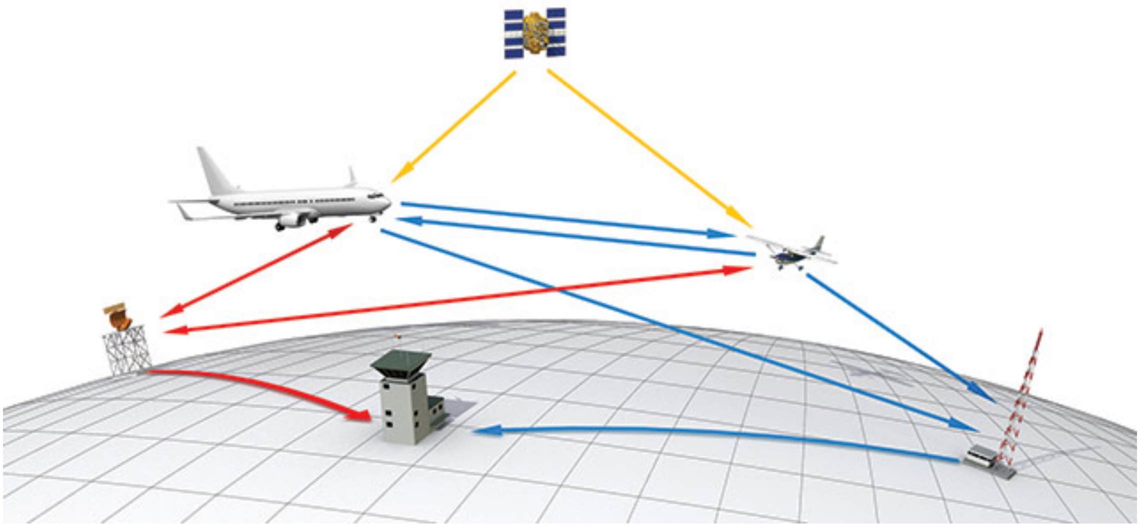
# 2 AUTOMATIC DEPENDENT SURVEILLANCE - BROADCAST

The acronym ADS-B comes from the words Automatic Dependent Surveillance – Broadcast. In depth this means: The system is automatic and sends out the speed and the location of the aircraft at least once a second with no input from the flight crew. The whole system and function is dependent on the information from the GPS and the aircraft's avionic system that is sent by the aircraft to the receivers on the ground and other aircraft. This shows the main difference to the old system where the aircraft was noticed with a primary radar or a secondary surveillance radar sent an inquiry and got a response from the aircraft. Surveillance refers to the surveillance data that is broadcasted by the system and broadcast refers to that aforementioned broadcasting itself. (Air Services Australia 2015)

The main components of the system are a high integrity GPS system, which is the source of majority of the needed data, the aircraft's avionic system and the ADS-B datalink/transponder. The transponder is the main part of the system that is used to broadcast the data from the aircraft to the ground stations and the other aircraft equipped to receive these broadcasts. This broadcast can go straight to these destinations or it can also be transmitted through terrestrial or satellite communication link. (Boeing 2010)

## 2.1 Theory of operation

The theory of the operation of the ADS-B system is very effectively illustrated on PICTURE 1. The accurate GPS data broadcasted by the GPS satellites to the aircraft to utilize in the internal systems, such as the ADS-B system, is represented with the yellow arrows. The ADS-B signals broadcasted out by the on-board systems in the aircraft that are received by the other aircraft and the ground station, from which the data is forwarded to the controllers managing the airspace, is represented by the blue arrows. The red arrows represent the signals from the secondary surveillance radar which will still operate alongside the ADS-B system. Ultimately the ADS-B is designed to replace the radar.



PICTURE 1. ADS-B Illustration by John Macneil (AOPA.org)

It is crucial to notice that the arrows representing the GPS and the ADS-B systems in the illustration are one way as opposed to the arrows representing the radar which are two-way. This illustrates the crucial difference between the systems. The GPS and the ADS-B arrows are one way since their information is constantly broadcasted, without external request, from the moment the system becomes operational. The way the secondary surveillance radar operates is vastly different as in its operation the radar sends out a request and the transponder aboard the aircraft sends out the information only per this request.

## 2.2 In and Out functionalities

The ADS-B system is divided into two different functionalities ADS-B In and ADS-B Out. Only ADS-B Out is mandated as it is the part of the system that will broadcast the mandatory data from the aircraft and is the essential part for the system to operate from the air traffic management viewpoint. ADS-B In functionality will provide a lot of useful information to the flight crew, but it is not necessary for the operation of the system, so its left for the owner of the aircraft to decide weather to include that side of the system or not. For commercial operators the In functionality will most likely be considered as a worthy investment when compared to the benefits. However, many general aviators will most likely settle with only the mandated Out functionality simply to make the financial load from the implementation of the system less significant.

The system will operate at 1090Mhz frequency. In the United States the general aviators can also choose to operate on Universal Access Transceiver (UAT) system frequency of 978Mhz. This will provide some additional benefit, like free weather service, but the aircraft with UAT based ADS-B system will need to retain their old transponders in addition to the UAT. FAA also rules that aircraft operating ADS-B systems on 1090Mhz frequency can operate in all parts of the airspace but the aircraft operating systems on the UAT frequency are not permitted to fly in Class A airspaces. (FAA 2015)

### 2.2.1 ADS-B Out functionality

The ADS-B Out functionality broadcasts the needed surveillance data from the aircraft to the receivers in the ground and in the air. This data includes (but is not limited to): speed, magnetic heading, position, altitude, vertical rate and aircraft identification data such as 24-bit ICAO Aircraft Address. The ADS-B Out functionality is the crucial part of the ADS-B system and its therefore the system that the aircraft are mandated to have functional. (COMMISSION IMPLEMENTING REGULATION (EU) No 1207/2011)

### 2.2.2 ADS-B In functionality

The ADS-B In functionality provides the ability to receive the ADS-B data, broadcast by the ADS-B transponders on the surrounding aircraft, aboard the ADS-B In equipped aircraft. This functionality is not mandatory to be implemented as it is not crucial for the function of the ADS-B system in whole.

The In functionality will, however, benefit the pilot as they will be able to see the surrounding air traffic on a Cockpit Display of Traffic Information (CDTI) (PICTURE 2). In a cockpit equipped with this system the pilot will get more immediate information about the surrounding traffic and can adjust routes accordingly. For example, the pilots can assume responsibility of separation in a passing situation which is a task that would normally be handled by the air traffic control. This applies to maximum of two of the surrounding aircraft. The additional aircraft will still be handled by the ATC. (Boeing 2010)


PICTURE 2. View on a CDTI. (Eurocontrol.fr)

## 2.3 ATC modernisation plans and the mandate

The ADS-B system is part of the modernisation plans of many air traffic authorities around the world. In the larger scale projects ADS-B is a part of the Single European Sky ATM Research (SESAR) in Europe and a part of the US Next Generation Air Transport System (NextGen) in the United States.

ADS-B systems are already in use on voluntary bases around the world in selected areas and airports. Also, more notably, the ADS-B system has been mandated for flights over Hudson Bay in Canada since late 2010 and in the Australian airspace since late 2013. (Boeing 2010) In the United States the system will be mandated for virtually all air traffic from January 2020. Some aircraft that were originally certified with no electrical systems are exempt from this ruling. This ruling doesn't apply if they have subsequently had electrical systems installed and they have been re-certified with these systems. This group includes balloons and gliders for example. (Federal Aviation Administration 2015)

In Europe the system will be mandated for new aircraft with the certificate for airworthiness issued on or after June 8th 2016 with take off weight exceeding 5700kg or the maximum cruising true airspeed exceeding 250 knots. Retrofitting the aircraft with the aforementioned characteristics and the certificate of airworthiness issued before June 8th 2016, the system will be mandated from June 7th 2020. (COMMISSION IMPLEMENTING REGULATION (EU) No 1028/2014. Appendix 1.)

### 2.4 Benefits

The implementation of the system will undoubtedly provide multiple benefits for both the users and the air traffic controllers. The scale of these benefits will greatly wary depending on to which degree the system mandated in the airspace and which systems the individual aircraft has installed.

#### 2.4.1 For Air Traffic Control

One of the key benefits of the ADS-B system is that the responsibility for obtaining the flight data is transferred from radars, that survey the information, to aircraft that broadcast the info themselves. This means that the benefits are available where-ever the aircraft operate not only in locations where the expensive radar systems are built and operated. Because of this in the future more areas will benefit from the precise air traffic management previously available only in areas served by radar systems. For example, the separation between aircraft can be reduced considerably in remote areas with no radar systems, such as Hudson Bay in Canada, where the in trail separation between aircraft was reduced from 80 nautical miles to 5 nautical miles. This also applies to aerodromes without radar systems where the ADS-B system can be similarly utilised to create the possibility of modern advanced ATC operations. For example, these less equipped aerodromes can benefit from improved approach and separation control.

One notable weakness with radar systems has been that per design they do not work well at low altitudes or on the ground. Contrarily, the ADS-B systems works well in these locations. This will provide great benefit not only because it helps with low flying aircraft, but because it will also be utilized with the traffic on the ground. As the precise location information is now available on the apron, taxiways and runways too, the advanced planning capabilities are available also while on ground. This will help the ATC to conduct smoother operations for the aircraft moving in the ground. On top of the aircraft, other airport vehicles can also be equipped with ADS-B Out. These benefits in combination will, on top of the smoother operation, provide extra safety factor by reducing the possibility of collision on ground.  (Boeing 2010)

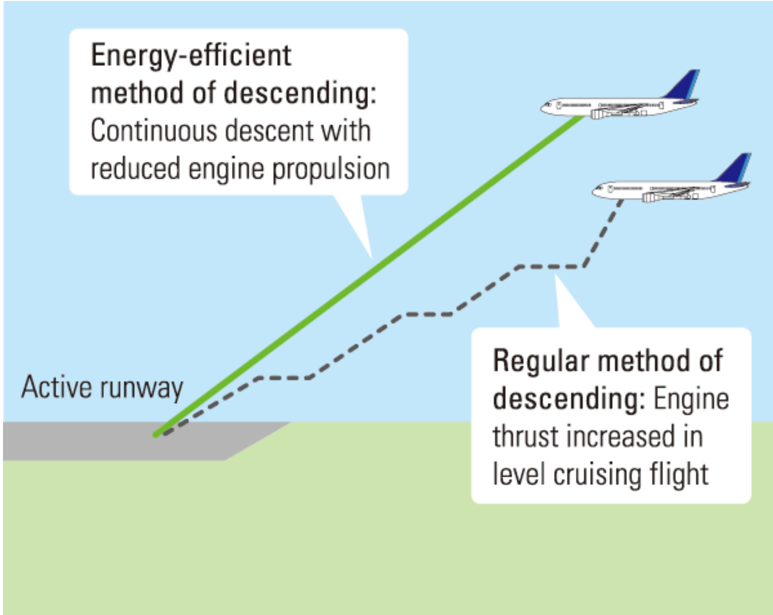
The datalink provided by the ADS-B In system can also be utilized to send other important information to the aircraft. These include weather information and messages of Traffic Information Service – Broadcast (TIS-B), which can be used to inform about temporarily restricted airspaces, for example. In the United States all the aircraft equipped with UAT (978 MHz) ADS-B In functionality will receive subscription free weather information. (FAA 2015)

This can be viewed as an enticement to invest into the better system as the cost of the no-longer-needed subscription based weather service can be factored into the cost of purchasing the more expensive ABS-B option.

### 2.4.2 For users

Benefit for aircraft operators is that, because of the raised situational awareness, flight routes and descent paths can be planned more optimal. This is made possible since the separation between aircraft can be reduced without reducing the safety. This, in turn, is possible because the location, speed and the direction of the flight are known in more precise level than with the old systems. This means more optimal takeoff and landing times, less waiting time in the taxiways and more importantly in the air. It also leads to shorter routes, optimal flight levels and, possibly even more importantly, more optimal or even direct ascent and decent to these levels. This means for example, that in the optimal situation the landings can more frequently be conducted as Continuous Descent Approaches (CDA). Continuous Descent Approaches are possible with the current air traffic control equipment, but with current systems they are not possible as frequently as they should. In low traffic airspaces they can be conducted as there is a lot of space for separation. In busy international airports they are not possible as frequently due to high amount of traffic in the airspaces.

All these improvements will greatly reduce the operating cost of an aircraft by reducing the amount of burned fuel and decreasing the flight hours accumulated for the airframe, engines and aircraft systems. The system can be also beneficial to the environment in the ground as the time spent by aircraft flying in low altitudes can be minimized. This will have affect on the noise pollution in the areas surrounding airports.




PICTURE 3. Comparison between a conventional approach and a CDA. (ANA.co.jp)

The amount of received benefit on the user side is largely dependent on whether the aircraft in question has a system with only ADS-B Out or a system equipped with both ADS-B In and Out functionalities. If the aircraft is equipped only with the Out functionality the benefit is limited on the information passed on by the ATC and the ground stations. However, if the aircraft is also equipped with the In functionality the information broadcasted by the surrounding aircraft is received by the onboard systems and shown on a Cockpit Display of Traffic Information giving the flight crew a possibility to utilize this information instantaneously. This data can be received from surrounding aircraft from distanced even greater than 100 nautical miles. The data can be utilized by the flight crew in situations such as passing and changing flight levels in the vicinity of other aircraft. The ADS-B In functionality allows the flight crew to assume the responsibility of separation from up to two surrounding aircraft while the additional aircraft are still handled by an air traffic controller. (Boeing 2010)

# 3 RETROFITTING OF ADS-B SYSTEM

Implementing the system on the aircraft by aircraft manufacturers does not differ from the normal product development since new systems are always introduced and the designs and configurations are changed accordingly. The addition of the ADS-B system will not be different in the sense of aircraft manufacturing compared to the addition of any other new system. The problem with implementing the system comes from retrofitting the system to existing aircraft as the deadline to have the aircraft equipped with the system comes closer.

With some aircraft the process is straightforward with parts and service bulletins provided by the manufacturer. With older and smaller aircraft, like many of the general aviation aircraft, the process isn’t as simple. This will not create as large of a problem in Europe as the smaller general aviation aircraft will not be mandated to start using the system so many private general aviation pilots and hobbyist will most likely opt out of installing the system. However, in the United States where the system will be mandated for all aircraft the situation will become more complicated.

All the modifications have to be based on tested data and approved systems. It is an option to do a previously unapproved install as a prototype install, for example a new type of a transponder or new combination of systems, but these need to be conducted by an approved organisation and tested after. For example, in Europe the organization needs to have a Part-21 approval for a design organization.

## 3.1 Finnish Aviation Academy

In this thesis the aircraft from Finnish Aviation Academy are used as examples. The Finnish Aviation Academy Ltd is a special purpose vocational school located in Pori, Finland. The academy trains pilots for the needs of professional aviation in Finland. The academy was founded in 2001 and it replaced the pilot training school of the Finnish national airline Finnair. The academy is owned jointly by the Government of Finland and Finnair with a minority share owned by the city of Pori. FINAA also has a Part-145 and Part-M -approved maintenance organisation for maintaining the aircraft fleet on site. (Finnish Aviation Academy 2015)

For the purpose of this thesis the FINAA fleet is an excellent example. The fleet consists of a mix of new advanced business jets and piston engine powered general aviation aircraft of different sizes and purposes. This provides an excellent overview of different types of installations of the ADS-B system.

The fleet consists of a pair of Embraer EMB-500 Phenom 100 jets, three Diamond DA42 Twin Stars twin engine piston powered aircraft and seven Cessna 152 single engine piston powered aircraft. The academy also has an Extra 300L aircraft, but it was left out from the thesis as its comparable to the Cessna for the purposes of the thesis.

### 3.2 Cessna 152

Out of the FINAA fleet the Cessna will require the most work to implement the ADS-B systems to work on it as it features the oldest avionics systems. Under the European regulations it is not, however, required to be upgraded to utilize the system. However, since under the regulations in the United States the ADS-B system is mandated for all the flying aircraft, there is multiple solutions in the market to implement the system into the C152 and similar cockpits.

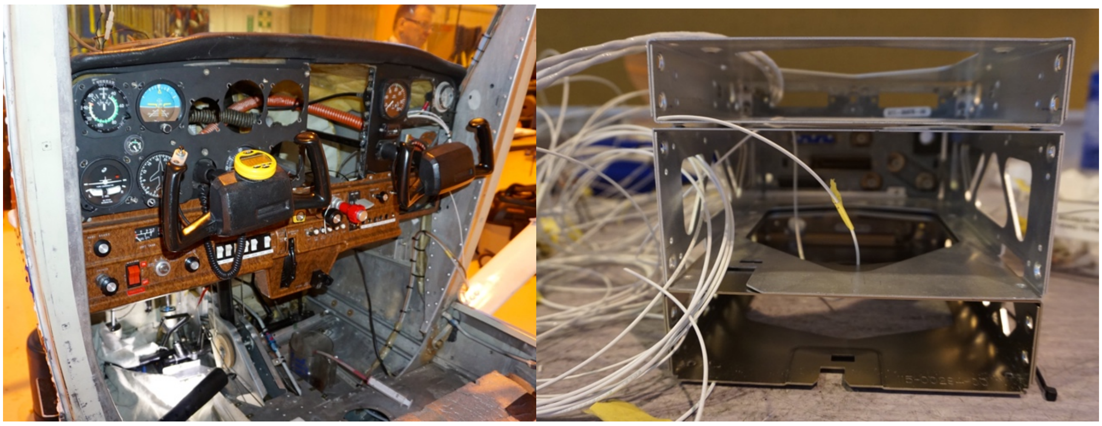
There are multiple third party solutions for retrofitting a general aviation aircraft like Cessna 152 with an ADS-B system from multiple manufacturers. The price for these solution range from base prices from below $2000 before installation to around $10 000 for a more capable unit, optional additions and/or installation. The overall cost of the installation depends on the existing hardware the aircraft in question has installed already. For example, if the aircraft is already equipped with an accuracy improved GPS system that get additional accuracy from ground stations such as WAAS in the North America or EGNOS in Europe. (Cessna Flyer Association 2015)

### 3.2.1 OH-COG

The Finnish Aviation Academy has recently acquired an additional used Cessna 152 to their fleet with the registration OH-COG. The aircraft was equipped with older avionic system compared to the rest of the fleet and the system needed to be updated. As the avionic systems needed to be updated anyway, the aircraft is now being equipped with a system that also includes ADS-B Out capability. The retrofitting is done with a German PART 21 approved design organization Avionik Straubing. The project is done with a design organization abroad as there are no public design organizations like this operating in Finland.


PICTURE 4. Finnish Aviation Academy Cessna 152 OH-COG undergoing heavy maintenance and modifications.

The old Communication/Navigation system, some of the indicators, distance metering equipment, VHF transceiver, old unsuitable antennas and the old non-ADS-B capable transponder is removed and replaced by modern avionics.



PICTURES 5 and 6. Left: OH-COG cockpit with old equipment removed. Right: Rack for the new avionics. The rack will be installed on the larger rectangular hole in the instrument panel.

The new additions to the avionic system will include Garmin GNS430W GPS/Navigation/Communication system, Garmin GMA340 audio panel and Garmin GTX330ES transponder that is ADS-B enabled. The system will also include Bendix/King KEA-130 encoding altimeter, that feeds data to the GNS430W and GTX330ES, and Bendix/King KI206 VOR/LOC/GS indicator. (Tuominen 2015)


PICTURE 7. Garmin GTX330 transponder equipped with ADS-B capabilities

The GPS system is WAAS/EGNOS capable. Also a new antenna is needed for the system to operate. The modification works will be completed in house at Finnish Aviation Academy and after a test program will be conducted and the results are sent to Avionik Straubing for assessment.

### 3.3 Diamond DA42-VI Twin Star

The installation of the ADS-B system to the Twin Star will not be mandatory in Europe as the weight of the aircraft does not exceed 5700kg and the airspeed does not exceed 250 knots. For that reason the aircraft does not have an ADS-B capable transponder in the basic configuration. It is, however, possible to order the aircraft from the manufacturer with an ABS-B capable transponder installed as an option. (Appendix 2.)

If the ADS-B capable transponder is chosen as an option it will replace the non-ADS-B capable transponder in the avionics configuration. The Twin Star is equipped with Garmin G1000 avionics and is currently equipped with the Garmin GTX33 transponder. If the ADS-B option is chosen, the transponder will be substituted with Garmin GTX330ES which is the same transponder that is being installed to the OH-COG. (Diamond 2016)

There is no public information available of the retrofitting, but judging from the information above, it should be possible and very straightforward.


PICTURE 8. Finnish Aviation Academy DA42-VI OH-DAD (finaa.fi)

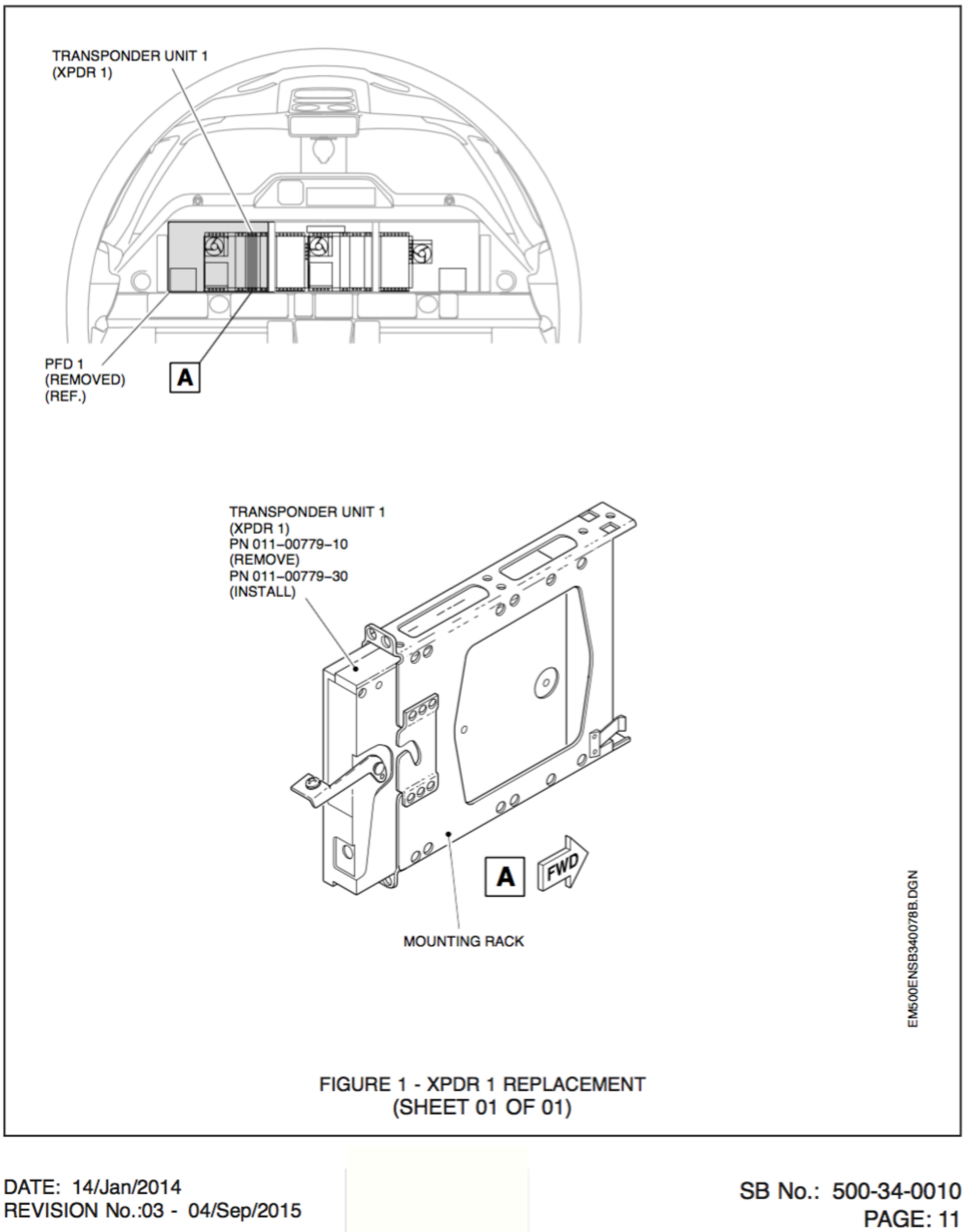
### 3.4 Embraer EMB-500 Phenom 100

Out of the FINAA fleet the Phenom 100 is by far the easiest to upgrade to the regulations. The reason for this is that the Phenom is a modern business jet and its still heavily supported by the manufacturer through a maintenance support program. This is the case with many modern aircraft. Additional reason for why the instructions and plans are more clear is also the fact that out of FINAA fleet the Phenom is the only aircraft that is mandated to be upgraded to use the system under the regulations in Europe. As the installation of the system for an aircraft like this is mandatory, clear instructions from the supplier exist and they are distributed to all users of the aircraft model.

The actual installation of the system to the Phenom 100 jet is a simple procedure. The current non-ADS-B capable transponder is removed from the aircraft and it is replaced by a new ADS-B capable transponder. The new transponder will work with the existing systems and antennas and the installation does not require any new installations or additional replacement parts. (Appendix 3.)

Embraer has issued a service bulleting about the upgrade on January 14$^{th}$ 2014 and it has been revised three times since, most decently on September 4$^{th}$ 2015. The service bulletin includes the instructions for the required operation including the information of needed parts, estimation of the needed manpower and information on the effects on weight and balance caused by the modification. In this case, however, the balance and weight do not change. These instructions are given for aircraft in two different configurations of the avionics systems. This service bulletin describes the installation of a unit enabling the ADS-B Out function.

The instructions on the service bulletin describe the outline of the operation and refer to different task of which instructions are explained in the maintenance manuals.  The task instructions also include the basic preparation and finishing tasks, that are included in the instructions for every maintenance task. (Appendix 4.)




PICTURE 9. Page from the Phenom 100 service bulletin (Embraer 2015)

The required maintenance task itself is really straightforward as it only includes removing a display to access the work area, removing a transponder unit, replacing it with another externally similar unit and re-attaching the removed parts in reverse order. (Appendix 4.)

# 4 DISCUSSION

The implementation of the system will clearly provide multiple benefits for air traffic management. The mandate varies greatly between regions so it is not a straightforward subject in the world scale to compare. This includes both the rules and the amount of benefit the system will provide.

## 4.1 The overall effects

In Europe the system will not provide as large amount of benefits as less aircraft are required to be equipped with the system whereas the benefits in the United States will be larger as all flying aircraft will have the system functional. In my opinion this makes the push to adapt the system in Europe questionable as it will have serious drawbacks compared to the complete adaptation done in the United States. As a large part of the aircraft in the airspace wont the equipped with the system the aircraft equipped with the system wont get the full benefit. Also the older systems, like the radars, are required to be kept functioning and no saving are made on this front. The system will still deliver parts on the benefit especially in airspaces mostly used by large aircraft such as international airports.

However, while the system will provide more benefits in the United States it doesn’t come without a price. As the system is mandated to be operational in every flying aircraft from early 2020, the implementation of the system will put considerable amount of financial pressure on the small aircraft owners. The effect will be especially significant on the owners of older and less valuable aircraft. This is because the price of the ADS-B solutions compared to the value of the aircraft is higher, but also because the simpler aircraft will require additional systems. For example, a more advanced GPS system might have to be installed to facilitate the ADS-B equipment. In the more modernly equipped aircraft the installation of ADS-B system will be comparatively cheaper as the additional systems will already be in use for other applications.

### 4.2 Implementation of the system at FINAA

As the mandate in Europe will, in its current form, only affect the aircraft above the maximum take off weight of over 5700kg or the maximum cruising true airspeed of over 250 knots the mandatory upgrades at the Finnish Aviation Academy are not enormous. From the fleet, only the two Phenom 100 -business jets require the system to be retrofitted under the mandate.

For the interest of flight training a fleet wide installation of the system could be considered. This, however, raises the question of how useful that would be as majority of the aircraft in the surrounding airspace will not be equipped with the system. For this reason, the benefit from installing an ADS-B In system is questionable. ADS-B Out falls partly in the same category. Since the ADS-B Out system is automatic and doesn't require any input from the pilot, equipping the aircraft with this system wont provide any addition to the flight training. However, there would be an additional benefit since the whole fleet could be tracked by the aviation academy. This is possible as, on top of the air traffic management tasks, the ADS-B receivers can be operated by businesses and individuals without any special licenses. The receivers can be bought by anyone and they can even be built by hobbyist.

**REFERENCES**


The Academy. Finnish Aviation Academy. Read 20.4.2016 http://www.finaa.fi/en/the-academy/presentation.html

ADS-B Frequently Asked Questions. Federal Aviation Administration, 2015. Read 18.4.2016 https://www.faa.gov/nextgen/programs/adsb/faq/

Air Traffic Services Brief -- Automatic Dependent Surveillance-Broadcast (ADS-B). AOPA.org, 2015. Read 28.4.2016 http://www.aopa.org/Advocacy/Air-Traffic-Services-,-a-,-Technology/Air-Traffic-Services-Brief-Automatic-Dependent-Surveillance-Broadcast-ADS-B

Are You Ready for 2020? Current Options for ADS-B Compliance. Cessna Flyer Association. Read 29.2.2016. http://www.cessnaflyer.org/articles-news/item/726-are-you-ready-for-2020-current-options-for-ads-b-compliance.html

COMMISSION IMPLEMENTING REGULATION (EU) No 1207/2011. Official Journal of the European Union. Available online: http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32011R1207

COMMISSION IMPLEMENTING REGULATION (EU) No 1028/2014. Official Journal of the European Union. Available online: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R1028&from=EN

DA42-VI information page. Diamond Aircraft. Read 17.4.2016. http://www.diamondaircraft.com/aircraft/da42/

Embraer Phenom 100 Service Bulletin 500-34-0010 Revision 03. Embraer S.A., 2015.

Global Warming Countermeasures. All Nippon Airways. Read 28.4.2016 http://www.ana.co.jp/eng/aboutana/corporate/csr/reading/warming/fr_index.html

How ADS-B works. Air Services Australia. Read 16.4.2016. http://www.airservicesaustralia.com/projects/ads-b/how-ads-b-works/

New Air Traffic Surveillance Technology. Boeing.com. Read 8.3.2016. http://www.boeing.com/commercial/aeromagazine/articles/qtr_02_10/pdfs/AERO_Q2-10_article02.pdf

OH-COG Avionics Modification Plan. Tuomo Tuominen, 2015. Suomen Ilmailuopisto.

On display at the Maastricht ATC exhibition. Eurocontrol.fr, 2003. Read 28.4.2016 http://www.eurocontrol.fr/Newsletter/2003/March/Maastricht/Maastricht_Overview.htm

# APPENDICES

## Appendix 1. COMMISSION IMPLEMENTING REGULATION (EU) No 1028/2014

Available online: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R1028&from=EN

30.9.2014 EN Official Journal of the European Union L 284/7

**COMMISSION IMPLEMENTING REGULATION (EU) No 1028/2014**

**of 26 September 2014**

**amending Implementing Regulation (EU) No 1207/2011 laying down requirements for the performance and the interoperability of surveillance for the single European sky**

**(Text with EEA relevance)**

THE EUROPEAN COMMISSION,

Having regard to the Treaty on the Functioning of the European Union,

Having regard to Regulation (EC) No 552/2004 of the European Parliament and of the Council of 10 March 2004 on the interoperability of the European Air Traffic Management network (the interoperability Regulation) [1], and in particular Article 3(5) thereof,

Whereas:

(1) Commission Implementing Regulation (EU) No 1207/2011 [2] lays down requirements on the systems contributing to the provision of surveillance data in order to ensure the harmonisation of performance, the interoperability and the efficiency of those systems within the European air traffic management network and for the purpose of civil-military coordination.

(2) In order to be able to equip new aircraft with new capabilities operators must have the necessary equipment specifications at least 24 months before the foreseen application date. The relevant Certification Specifications were however adopted by the European Aviation Safety Agency (EASA) only in December 2013. As a consequence, it will not be possible for operators to equip new aircraft with the new functionalities ADS-B 'Out' and Mode S Enhanced by 8 January 2015. Implementing Regulation (EU) No 1207/2011 should therefore be amended, so as to provide the operators concerned with sufficient additional time for this purpose.

(3) Delays in certification and in availability of required equipment, as well as industrial capacity constraints for equipping aircraft, affect the smooth retrofitting of existing fleet. A number of aircraft, mainly for trans-Atlantic operations, are also to be equipped with ADS-B 'Out' functionality by 1 January 2020 as mandated by the United States Federal Aviation Administration (FAA). The retrofit date for ADS-B 'Out' and Mode S Enhanced should therefore be postponed and brought more closely into line with the deadline for the FAA ADS-B requirements.

(4) State aircraft operators should benefit from similar postponements in implementation dates as other operators of aircraft. The deadline for retrofitting for state aircraft with the new ADS-B 'Out' and Mode S Enhanced functionalities should therefore also be postponed.

(5) Implementing Regulation (EU) No 1207/2011 should be amended accordingly.

(6) The measures provided for in this Regulation are in accordance with the opinion of the Single Sky Committee, established by Article 5 of Regulation (EC) No 549/2004,

HAS ADOPTED THIS REGULATION:

*Article 1*

Implementing Regulation (EU) No 1207/2011 is amended as follows:

(1) Article 5 is amended as follows:

(a) Paragraph 4 is replaced by the following:

'4. Operators shall ensure that:

(a) aircraft operating flights referred to in Article 2(2) with an individual certificate of airworthiness first issued on or after 8 January 2015 are equipped with secondary surveillance radar transponders having the capabilities set out in Part A of Annex II;

[1] OJ L 96, 31.3.2004, p. 26.
[2] Commission Implementing Regulation (EU) No 1207/2011 of 22 November 2011 laying down requirements for the performance and the interoperability of surveillance for the single European sky (OJ L 305, 23.11.2011, p. 35).

(b) aircraft with a maximum certified take-off mass exceeding 5 700 kg or having a maximum cruising true airspeed capability greater than 250 knots, operating flights referred to in Article 2(2), with an individual certificate of airworthiness first issued on or after 8 June 2016 are equipped with secondary surveillance radar transponders having, in addition to the capabilities set out in Part A of Annex II, the capabilities set out in Part B of that Annex;

(c) fixed wing aircraft with a maximum certified take-off mass exceeding 5 700 kg or having a maximum cruising true airspeed capability greater than 250 knots, operating flights referred to in Article 2(2), with an individual certificate of airworthiness first issued on or after 8 June 2016 are equipped with secondary surveillance radar transponders having, in addition to the capabilities set out in Part A of Annex II, the capabilities set out in Part C of that Annex.'

(b) Paragraph 5 is replaced by the following:

'5. Operators shall ensure that:

(a) by 7 December 2017 at the latest, aircraft operating flights referred to in Article 2(2), with an individual certificate of airworthiness first issued before 8 January 2015, are equipped with secondary surveillance radar transponders having the capabilities set out in Part A of Annex II;

(b) by 7 June 2020 at the latest, aircraft with a maximum certified take-off mass exceeding 5 700 kg or having a maximum cruising true airspeed capability greater than 250 knots, operating flights referred to in Article 2(2), with an individual certificate of airworthiness first issued before 8 June 2016 are equipped with secondary surveillance radar transponders having, in addition to the capabilities set out in Part A of Annex II, the capabilities set out in Part B of that Annex;

(c) by 7 June 2020 at the latest, fixed wing aircraft with a maximum certified take-off mass exceeding 5 700 kg or having a maximum cruising true airspeed capability greater than 250 knots, operating flights referred to in Article 2(2), with an individual certificate of airworthiness first issued before 8 June 2016 are equipped with secondary surveillance radar transponders having, in addition to the capabilities set out in Part A of Annex II, the capabilities set out in Part C of that Annex.'

(2) In Article 8, paragraph 2 is replaced by the following:

'2. Member States shall ensure that, by 7 June 2020 at the latest, transport-type State aircraft with a maximum certified take-off mass exceeding 5 700 kg or having a maximum cruising true airspeed capability greater than 250 knots, operating in accordance with Article 2(2) are equipped with secondary surveillance radar transponders having in addition to the capability set out in Part A of Annex II, the capability set out in Part B and Part C of that Annex.'

(3) In Article 14, paragraph 1 is replaced by the following:

'1. Aircraft of specific types with a first certificate of airworthiness issued before 8 June 2016 that have a maximum take-off mass exceeding 5 700 kg or a maximum cruising true airspeed greater than 250 knots that do not have the complete set of parameters detailed in Part C of Annex II available on a digital bus on-board the aircraft may be exempted from complying with the requirements of point (c) of Article 5(5).'

*Article 2*

This Regulation shall enter into force on the twentieth day following that of its publication in the *Official Journal of the European Union*.

This Regulation shall be binding in its entirety and directly applicable in all Member States.

Done at Brussels, 26 September 2014.

*For the Commission*

*The President*

José Manuel BARROSO

Appendix 2. COMMISSION IMPLEMENTING REGULATION (EU) No 1207/2011 Article 5.

Available online: http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32011R1207

L 305/38 EN Official Journal of the European Union 23.11.2011

*Article 5*

**Interoperability requirements**

1. Air navigation service providers shall ensure that all surveillance data transferred from their systems identified in points (b) and (c) of Article 2(1) to other navigation service providers complies with the requirements set out in Annex III.

2. Air navigation service providers when transferring surveillance data from their systems identified in points (b) and (c) of Article 2(1) to other air navigation service providers, shall establish formal arrangements with them for the exchange of the data in accordance with the requirements set out in Annex IV.

3. Air navigation service providers shall ensure that, by 2 January 2020 at the latest, the cooperative surveillance chain has the necessary capability to allow them to establish individual aircraft identification using downlinked aircraft identification made available by aircraft equipped in accordance with Annex II.

4. Operators shall ensure that:

(a) aircraft operating flights referred to in Article 2(2) with an individual certificate of airworthiness first issued on or after 8 January 2015 are equipped with secondary surveillance radar transponders having the capabilities set out in Part A of Annex II;

(b) aircraft with a maximum certified take-off mass exceeding 5 700 kg or having a maximum cruising true airspeed capability greater than 250 knots, operating flights referred to in Article 2(2), with an individual certificate of airworthiness first issued on or after 8 January 2015 are equipped with secondary surveillance radar transponders having, in addition to the capabilities set out in Part A of Annex II, the capabilities set out in Part B of that Annex;

(c) fixed wing aircraft with a maximum certified take-off mass exceeding 5 700 kg or having a maximum cruising true airspeed capability greater than 250 knots, operating flights referred to in Article 2(2), with an individual certificate of airworthiness first issued on or after 8 January 2015 are equipped with secondary surveillance radar transponders having, in addition to the capabilities set out in Part A of Annex II, the capabilities set out in Part C of that Annex.

5. Operators shall ensure that by 7 December 2017 at the latest:

(a) aircraft operating flights referred to in Article 2(2), with an individual certificate of airworthiness first issued before 8 January 2015, are equipped with secondary surveillance radar transponders having the capabilities set out in Part A of Annex II;

(b) aircraft with a maximum certified take-off mass exceeding 5 700 kg or having a maximum cruising true airspeed capability greater than 250 knots, operating flights referred to in Article 2(2), with an individual certificate of airworthiness first issued before 8 January 2015 are equipped with secondary surveillance radar transponders having, in addition to the capabilities set out in Part A of Annex II, the capabilities set out in Part B of that Annex;

(c) fixed wing aircraft with a maximum certified take-off mass exceeding 5 700 kg or having a maximum cruising true airspeed capability greater than 250 knots, operating flights referred to in Article 2(2), with an individual certificate of airworthiness first issued before 8 January 2015 are equipped with secondary surveillance radar transponders having, in addition to the capabilities set out in Part A of Annex II, the capabilities set out in Part C of that Annex.

6. Operators shall ensure that aircraft equipped in accordance with paragraphs 4 and 5 and having a maximum certified take-off mass exceeding 5 700 kg or having a maximum cruising true airspeed capability greater than 250 knots operate with antenna diversity as prescribed in paragraph 3.1.2.10.4 of Annex 10 to the Chicago Convention, Volume IV, Fourth Edition including all amendments up to No 85.

7. Member States may impose carriage requirements in accordance with point (b) of paragraph 4 and point (b) of paragraph 5 to all aircraft operating flights referred to in Article 2(2) in areas where surveillance services using the surveillance data identified in Part B of Annex II are provided by air navigation service providers.

8. Air navigation service providers shall ensure that, before putting into service the systems referred to in points (b), (c) and (d) of Article 2(1), they are implementing the most efficient deployment solutions taking into account the local operating environments, constraints and needs as well as airspace users capabilities.

*Article 6*

**Spectrum protection**

1. By 5 February 2015 at the latest Member States shall ensure that a secondary surveillance radar transponder on board any aircraft flying over a Member State is not subject to excessive interrogations that are transmitted by ground-based surveillance interrogators and which either elicit replies or whilst not eliciting a reply are of sufficient power to exceed the minimum threshold level of the receiver of the secondary surveillance radar transponder.

Appendix 3. Embraer Phenom 100 Service Bulletin 500-34-0010 Revision 03. Embraer S.A., 2015. Section 1.C.

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# SERVICE BULLETIN

**C. REASON**

(1) HISTORY

The ADS-B Out (Automatic Dependent Surveillance–Broadcast) is an optional functionality which is required by the Australian Civil Aviation Safety Authority since December 2013, will be required by the Europe Aviation Safety Authority in January 2015 for new aircraft, in December 2017 for the retrofit one, and by the Federal Aviation Administration of U.S. in January 2020.

(2) OBJECTIVE

This bulletin provides instructions for the replacement of the XPDR1, and if applicable the XPDR2, and to activate the ADS-B Out (Automatic Dependent Surveillance - Broadcast) Functionality.

(3) EXPECTED BENEFITS

To allow the aircraft operation in airspaces where this functionality is required.

The general function of ADS–B Out is to provide air traffic controllers with a real-time position information, that is, in most cases, more accurate than the information available with current radar-based systems. With more accurate information, ATC will be able to position and separate aircraft with improved precision and timing.

(4) REVISION HISTORY

Revision 01

– This revision is issued to add the aircraft SN 50000016 to the service bulletin effectivity.

Revison 02

– This revision is issued to add the aircraft SN 50000141 to the service bulletin effectivity and the aircraft SN 50000282, 50000331, 50000334, 50000334 and 50000343 to the in production effectivity.

Revison 03

Appendix 4. Embraer Phenom 100 Service Bulletin 500-34-0010 Revision 03. Embraer S.A., 2015. Section 3.



## 3. ACCOMPLISHMENT INSTRUCTIONS

The steps below outline the general accomplishment instructions.

The detailed sequence is included in the respective figure, when necessary.

A. Make sure that the aircraft is safe for maintenance. Refer to AMM TASK 20-00-00-910-801-A/200 - Aircraft Maintenance Safety Procedures.

B. PART I

(1) Remove the XPDR1 (transponder 1) PN 011-00779-10 according to AMM TASK 34-52-01-000-801-A/400 - Transponder Unit - Removal. Refer to Figure 1.

**NOTE:** Send the removed transponders to Embraer, at one of the addresses given in Item 2.C.(1).

(2) Install the XPDR1 (transponder 1) PN 011-00779-30 according to AMM TASK 34-52-01-400-801-A/400 - Transponder Unit - Installation. Refer to Figure 1.

(3) Perform the functional test according to AMM TASK 34-52-00-720-801-A/500 - Transponder System - Functional Test.

C. PART II

(1) Remove the XPDR1 (transponder 1) PN 011-00779-10 and XPDR2 (transponder 2) PN 011-00779-01 according to AMM TASK 34-52-01-000-801-A/400 - Transponder Unit - Removal. Refer to Figure 2.

**NOTE:** Send the removed transponders to Embraer, at one of the addresses given in Item 2.C.(1).

(2) Install the XPDR1 (transponder 1) PN 011-00779-30 and XPDR2 (transponder 2) PN 011-00779-21 according to AMM TASK 34-52-01-400-801-A/400 - Transponder Unit - Installation. Refer to Figure 2.

(3) Perform the functional test according to AMM TASK 34-52-00-720-801-A/500 - Transponder System - Functional Test.

D. Restore the aircraft to normal. Refer to AMM TASK 20-00-00-910-801-A/200 - Aircraft Maintenance Safety Procedures.

E. Enter the accomplishment of this bulletin in the applicable documents.

F. Fill out the "Service Bulletin Implementation and Evaluation" form and click on "Submit by Email" button. To find the form, log in to the FlyEmbraer portal (http://www.flyembraer.com) and go to: "Technical Publication > Technical Data > Service Bulletin > Front Matter > SB500 - SERVICE BULLETIN IMPLEMENTATION AND EVALUATION FORM".

You can also fill out the attached form and send it by mail or e-mail to the addresses given in this form.