AIRCRAFT AVIONICS INSTALLATIONS

1. INTRODUCTION

For all aircraft on the British register, whether on a Permit to Fly or Certificate of Airworthiness, and including aeroplanes, microlights and gyroplanes, there are certain requirements that need to be met in relation to aircraft avionics that transmit radio signals. This Technical Leaflet applies to VHF radios (transceivers), transponders and other electronic conspicuity devices. Although radio navigation devices (DME, etc) aren't directly covered by this leaflet, the maintenance advice in section 7 is still relevant.

Further advice on related topics can be found in the following Technical Leaflets:

- TL 3.14 – radio interference
- TL 3.18 – ELT installations
- TL 3.20 – EFIS installations
- TL 3.26 – electrical systems

2. FLIGHT RADIO-TELEPHONY OPERATOR'S LICENCE

All operators of radios in aircraft, whether of permanently installed equipment or portable 'hand-held', are required to possess a Flight Radio-Telephony Operator's Licence. Such licences are issued by the CAA on successful completion of an appropriate course. Courses are usually conducted as part of the PPL training syllabus and include some airtime as well as ground school instruction and exam.

The fundamental purpose of the licence is to allow the CAA to ensure that radio transmissions in the aviation environment are made only by competent 'qualified' individuals. For further information we suggest you contact a local flying training organisation directly, or the CAA Flight Crew Licensing Department, Tel. 01293 567171.

3. RADIO LICENCE

All owners of aircraft fitted with radio equipment must obtain a radio licence from Ofcom, which must be renewed every three years for as long as the aircraft remains in service. There is a fee, which varies depending on the extent of the equipment fitted. The application form and details of the fees can be downloaded from the Ofcom website at https://www.ofcom.org.uk/manage-your-licence/radiocommunication-licences. This also applies to hand-held radios that are installed in aircraft.

4. EQUIPMENT APPROVAL

All transmitting radio equipment including portable equipment and transponders installed in UK aircraft must be of a type that has undergone an appropriate approval process by either EASA, the CAA or the FAA. In the case of equipment approved by the FAA, it must also be checked that the equipment meets European requirements that may not apply in the USA, e.g. 8.33Khz spacing for radios. For the purposes of LAA aircraft, this equipment must have either a CAA approval number, an EASA ETSO approval number or an FAA TSO. Usually the equipment manufacturer or importer will have dealt with this matter. Details of avionics types that have been approved are provided on the CAA, EASA and FAA websites – a list of popular equipment and their approval numbers can be found in Appendix 4 of this leaflet. If in doubt about the status of new equipment, check with the supplier or contact the CAA. Note that equipment obtained abroad, and even the latest products from well-established manufacturers, are sometimes found to be of a type that is not approved by CAA, EASA or FAA. Aircraft imported or found fitted with non-approved equipment will need to have that equipment removed.

Note that the CAA equipment approval numbering system for radio equipment has two sub-categories. 'LA1' equipment has no operational restrictions, but 'LA3' equipment may only be used

where the carriage of the equipment is not mandatory. Under the current version of the Air Navigation Order, LAA understands this to be when flying in notified airspace or when flying at night when needing to remain in communication with ATC when a flight plan is filed. Notified airspace is listed in AIP GEN 1.5 paragraph 5, and includes flight in Controlled Airspace below FL195, Class A, B & C airspace, flight in a Radio Mandatory Zone (unless alternative procedures are being followed), and all aircraft flying IFR.

'Passive' equipment that just receives signals, such as GPS units, do not normally need to have an equipment approval. Where a GPS unit is connected to a transponder to provide 'ADS-B out' some configurations require a certified GPS unit, please see section 9 below. Where units transmit on non-aviation frequencies (e.g. FLARM and PilotAware), these do not need to have been approved by CAA, EASA or FAA.

5. AVIONICS INSTALLATION APPROVAL

The permanent installation of transmitting avionics into LAA aircraft must be approved by the LAA. However, note that avionics equipment designed to be portable (hand-held radio, hand-held GPS, carry on Electronic Conspicuity devices, etc) or transmit on non-aviation frequencies (e.g. FLARM and PilotAware) do not need installation approval but must be fitted in accordance with standard aviation practice (see section 6 below). These installations must nonetheless be checked and a logbook entry made with a Permit Maintenance Release (PMR) statement by an LAA inspector prior to flight.

The investigation of an avionics equipment installation involves checking that the avionics equipment is of an approved type, an inspection and ground test of the installation followed by a flight test. Applications for avionics installation approval must be made using a form LAA/MOD7 which must be completed and signed up by a suitably approved LAA inspector or suitably licensed CAA/EASA avionics engineer (see also section 9 for variations to this procedure for ADS-B Out).

Provided that the inspector is satisfied that the avionics installation meets the criteria listed on form LAA/MOD7, has signed the declaration on that form and the aircraft has a valid Permit to Fly, PFRC (Permit Flight Release Certificate) or Certificate of Clearance, a flight test is to be carried out according to schedule LAA/FT-AVIONICS.

Approval of the installation is given by LAA Engineering once the installation is shown to be of an acceptable standard and a satisfactory flight test report is received. Since May 2008 this has been signified by LAA Engineering issuing an avionics installation approval certificate AD917/LAA for the aircraft which is sent to the aircraft owner. Provided that the inspection recorded on form LAA/MOD7 and the flight test recorded on form LAA/FT-AVIONICS have been satisfactorily carried out, the aircraft may be flown whilst waiting for the AD917/LAA to be issued.

Subsequent changes and upgrades to avionics equipment will require the same attention as above, including application on form LAA/MOD7 followed by a flight test according to flight test schedule LAA/FT-AVIONICS – checking that both new and existing equipment continue to operate satisfactorily after the change.

Where a Mode S transponder installation has already been approved on a form AD917/LAA for that individual aircraft and an owner subsequently wishes to connect an uncertified or TABS (Traffic Awareness Beacon System) GPS to the transponder to provide ADS-B Out, an application may be made on form LAA/MOD14. Approval of the connection following a satisfactory test is signified by the issue of a certificate AD917/LAA/ADS-B for that aircraft.

When submitting form LAA/MOD7, please bear in mind the following:

- Check that all parts of the form are filled in correctly and the inspector has signed in the right places, including the right-hand column and at the end of the form.
- Include all currently installed bits of kit including items that have previously been approved by the LAA on this aircraft, and not just the new bit of kit (don't include items that have been removed, though).
- Include all the fuse/circuit breaker ratings for each of these items and check they're still appropriate. The equipment manufacturer's recommended rating should be used. Note that using one circuit protection device to protect multiple bits of equipment is not recommended practice.
- State the type and location of each antenna, including those previously fitted. Stating 'as previously fitted' isn't acceptable, as we can't readily check this. The 'type' can be a generic type, e.g. whip or blade, rather than a specific make/model.

When submitting the LAA/FT-AVIONICS test schedule:

- Test all of the currently installed equipment and not just the new item (where the transponder is being swapped, the radio also needs to be checked as there might be interference issues, for example).
- When testing a transponder, don't forget to include the check on the altitude encoder, which may be integral to the transponder unit. The 'indicated altitude' is the altitude reading on the aircraft's altimeter. The 'reported altitude' is the altitude seen by the controller on his/her display and reported by radio to you. A report from the controller of the altitude being 'within limits' is not acceptable as the controller's 'limits' are wider than required of the transponder/altitude encoder – always ask for a specific height. The altitude reported from encoder must be within 125 feet of the altitude shown on the aircraft's altimeter when the altimeter is set to the same pressure setting as being used by the ground controller.
- When testing the radio, ensure that it's tested from a minimum distance of 20nm from the ground station and no more than 2000' above it. If testing from further away, the height can be proportionally greater: e.g. at 30nm not higher than 3000', at 40nm not higher than 4000', etc.

6. AVIONICS INSTALLATION PRACTICES

The following points are those that will need to be satisfied during installation and maintenance.

- Electrical installation must be in accordance with the equipment manufacturer's instructions.
- The aircraft's electrical circuit and/or wiring diagrams must be updated.
- Equipment must be securely installed leaving no possibility that equipment can fall free, perhaps causing injury or jamming controls, especially in aerobatic aircraft.
- The existing structural integrity of the aircraft must not be compromised by the avionics installation: holes must not be drilled in structural components.
- The pilot must be able to operate associated switches and controls from the 'strapped-in' position and switches and controls must be suitably marked and placarded.
- Installation must not interfere with the satisfactory operation of the aircraft's controls or systems. For example, movement of control column must not be restricted and the pilot's line of sight of cockpit instruments must not be impeded.
- The quality of the pilot's external view must not be significantly degraded.
- Proper circuit protection must be incorporated and the correct gauge of wires used to ensure that wiring doesn't overheat in the event of a short circuit.
- Installation must not present a hazard to the aircraft in the event of failure of the equipment; proper electrical circuit installation should avoid this possibility.

- Possible hazard to the occupants in the event of a crash should be minimised by ensuring that protruding knobs and brackets are not in line with occupant's head, knees, etc, and that adequate soft furnishing protection is provided.
- Equipment must not unduly restrict occupant emergency egress from the cockpit.
- Associated wiring and cables must be properly 'bundled' and secured. Unsupported and 'spaghetti' wiring is not acceptable.
- Only aviation quality wiring and terminals should be used. PVC-insulated wiring should not be used due to the hazard of toxic fumes when it overheats.
- The aircraft weight schedule and any associated weight-related placards must be amended if there is any significant change in weight.
- The aircraft compass should be checked and swung – noting that changes to fasteners or brackets or different bits of equipment can significantly affect the compass.
- Aerials must be soundly installed with aerial cables properly routed and secured.
- Checks must be made that the equipment is not affected by other electrical systems (e.g. strobe lights) and also that the transmitting equipment does not adversely affect other systems.
- GR 18 (CAA CAP747) recommends that multiple radio systems are not fed by a system whereby a single failure (of fuse, switch, relay, etc) does not render all the radios unavailable. An excellent article by Bob Nuckolls describes a very sensible approach (www.aeroelectric.com/articles/avmaster.pdf).
- Where an aircraft is approved for night and/or IFR operations, the effect of equipment changes on the battery and alternator capacity requirements need to be re-assessed.
- Where an uncertified GPS is connected to a Mode S transponder to provide ADS-B Out, the transponder must be set to SIL=0 and SDA=0.
- Where a certified TABS (Traffic Awareness Beacon System) GPS unit is connected to a transponder that is capable of receiving a TABS input, the transponder may alternatively be set to SIL=1 and SDA=1.
- Certified GPS units may be connected to appropriate Mode S transponders to provide ADS-B Out with SIL and SDA greater than one – see section 9.

While there is no legally mandatory requirement to fit a back-up press-to-transmit button in Permit aircraft, it makes good sense to do so in case of failure of the primary PTT switch. In radio-equipped aircraft which are fitted with dual controls, separate PTT buttons should be available for the pilots in the P1 and P2 position and the intercom wiring should be arranged so that radio transmissions can be made from either headset depending on which PTT button is depressed. Radio transmissions ('sidetone') and reception should be clearly audible in flight from both pilot positions. This is now more important than in the past because 2-seat Permit aircraft are increasingly being used for carrying out coaching flying and biennial review flights, which include a requirement to demonstrate and monitor radio calls. It is impossible to provide effective coaching unless clear communication is available between the P1 and P2 positions, as well as to and from the ground. Circumstances have also arisen in the past where the check pilot could not transmit from the P2 position and was unable to transmit a warning call when an emergency arose. Consult your intercom or radio manufacturer for the necessary wiring and switching circuits required to achieve the above.

Avionics installations may be carried out by anyone, including the owner, but the system will need to be signed off by an appropriate signatory (as given in the appropriate application form) before flight, so the installation work should be carried out under your inspector's supervision from the start to be sure that there will be no showstoppers on completion.

7. CONTINUED AIRWORTHINESS - MAINTENANCE

LAA aircraft avionics installations must be inspected during the annual inspection for the Permit to Fly renewal to check that they are in good working order and remain securely installed. In

particular, during the annual check flight the quality of transmission and reception of radios must be checked. The CAA's Light Aircraft Maintenance Schedule (LAMS) requires CofA aircraft to have a radio transmission frequency tolerance check every 3 years and LAA recommend that LAA aircraft owners contact a suitably equipped avionics engineer for this check on a similar basis, although modern digital systems are not generally susceptible to frequency drift.

It is advisable to check the altitude encoding information transmitted by Mode C and S transponders, as received by the air traffic unit, corresponds with the aircraft's altimeter at the corresponding pressure setting, at least annually. The programmed aircraft identifier code should also be checked regularly. LAA recommends that avionics equipment, such as transponders and navigation equipment, should also be presented to a suitably-equipped avionics engineer for checking and testing from time to time.

One method of checking the performance of Mode S transponders is to use a flight tracking website such as FlightRadar24 to check that the record displayed matches your actual flight path.

8. RADIOS

All radio installations must now include 8.33 kHz frequency spacing. The only exceptions are where radio fit is non-mandatory and communications are only with ground stations still operating on 25 kHz spacing and the emergency frequency. It is permissible to retain a 25 kHz radio alongside an 8.33 kHz radio (e.g. as an emergency unit or where it incorporates navigation functionality) as long as it is only used for 25 kHz frequency communications. The current advice from the CAA on this subject can be found on their website: https://www.caa.co.uk/General-aviation/Aircraft-ownership-and-maintenance/8-33-kHz-radios/

UK CAA has issued a generic approval for 8.33 kHz hand-held radios that meet minimum requirements. Owners buying a radio purporting to be approved to this standard should obtain written confirmation from the manufacturer that the conditions of CAA Aircraft Equipment Approval certificate LA301075 have been met. Note that these radios have an 'LA3' approval – see note in section 4.

9. TRANSPONDERS AND ADS-B OUT

The installation of a transponder is not mandatory on LAA aircraft but it is a useful tool in helping other airspace users be aware of your position. Although Mode S units are mandatory in certain areas (e.g. above FL100, the London TMA, transponder mandatory zones, etc – full details in UK AIP-GEN 1.5), it is still permissible to install Mode A or C units on aircraft where transponder carriage is voluntary. Note, however, that the long-term ambition of the CAA is to phase out Mode A and C units and so they may have a limited useful life. Also, the requirements might be different when flying in other countries.

With Mode C and Mode S transponders, the aircraft height is transmitted as part of the signal. This uses an altitude encoder that is either integrated in the transponder or an external unit. This encoder must be connected to the same static source as the aircraft's altimeter. The requirement is for the aircraft altimeter to be within 125 feet of the encoder. It is the height transmitted by the altitude encoder that the air traffic controller will see on his or her screen, so it's important that this is reasonably accurate – note also that on LAA aircraft there may be errors in the static system due to the positioning of the static port that may give 'position' errors, even if the altimeter itself is known to be accurate. It is advisable to leave plenty of margin for error when navigating.

At a basic level, Mode S transponders transmit the aircraft's identity and height, enabling suitably equipped ground radar stations to provide identity, position and height information to the ground controller. More advanced Mode S transponders transmit an 'extended squitter' which includes

additional information such as GPS position and speed: this is known as ADS-B (automatic dependent surveillance broadcast). Any aircraft or ground station equipped with an ADS-B receiver ('ADS-B In') will have more information about the transmitting aircraft which can be displayed on a screen and/or generate collision avoidance advice.

Along with the position and speed information, ADS-B Out systems also transmit various information about the equipment generating the data. For instance, when an uncertified GPS source is used for the position/speed transmission, the system must tell the wider world that it's SIL (Source Integrity Level) and SDA (System Design Assurance level) are 'zero': this enables the receiving stations to understand that the information being transmitted isn't necessarily reliable. Certain receivers are programmed to filter out such transmissions.

In order to transmit higher SIL and SDA levels, the GPS source and the system as a whole need to meet certain requirements so that the accuracy of the data is guaranteed to a minimum level.

Where uncertified GPS units are used to provide ADS-B Out on a suitable transponder, the SIL and SDA must be set to 'zero'. Where an approved TABS (Traffic Awareness Beacon System) GPS is used with an appropriate transponder, the SIL and SDA may be set to 'one'. Form LAA/MOD7 is used to apply for these installations if the LAA has not yet approved the installation of the transponder unit in the individual aircraft, or LAA/MOD14 is used if the LAA has already approved the transponder installation. The results of one of the methods given in Appendix 1 must also be submitted as evidence of the transmission settings. Note that systems with certified GPS units that don't fit the configurations listed in Appendix 2 may also be used, but the SIL and SDA must be set to zero. There is no fee for applications made using forms MOD7 or MOD14.

Where certified GPS units are used to provide ADS-B Out with SIL and/or SDA greater than one, the configuration must be one of the combinations given in Appendix 2. The manufacturer's installation instructions must be followed exactly and a form LAA/MOD17 must be completed. After installation, the equipment must be inspected by an LAA inspector for satisfactory mechanical installation and then ground-tested by a licensed avionics engineer using appropriate test equipment. There is no specific flight test required of the ADS-B Out signal, as the proper functioning is established by the results found with the test equipment during the ground test.

For convenience, provided it has a valid Permit to Fly or flight test authorisation and the mechanical aspects of the avionics installation has been signed off by an LAA inspector, the aircraft may be flown for the purposes of meeting up with a licensed avionic engineer for ground testing provided that the transponder is switched off during the positioning flight. The normal prohibition on flying with a serviceable transponder switched off does not apply while the installation is as yet unapproved due to not having been tested.

Due to the additional work of checking these installations, when making an application on form MOD17 a fee of £30 is chargeable for the assessment of the application: please make payment via the LAA webshop quoting your aircraft's registration.

Should a member wish to install a combination of equipment that is not listed in Appendix 2, it is up to him or her to demonstrate to LAA Engineering that the installation will comply with the requirements given in Appendix 3. The transponder manufacturer or agent should be able to provide help with this. Once it has been established that the combination meets the requirements, the applicant should contact LAA Engineering with details before purchase or installation of the equipment.

Note that the compatibility of equipment is a complex subject and just because two or more pieces of kit meet the minimum approval/TSO requirements does not mean that they will work well together. It is strongly recommended that you consult with an avionics professional prior to

spending money. You will need to engage with a licensed aircraft engineer with avionics approvals in order for him/her to inspect the installation – it's also possible that the necessary installation manuals are only available to professionals, so early contact is advisable.

ADS-B In devices (receivers) do not need any particular approval and can be treated as general instrumentation, subject to the usual LAA inspector oversight.

10. ELECTRONIC CONSPICUITY DEVICES

Transponders can be expensive and some aircraft are not able to accommodate the additional weight or drain on the electrical system that approved transponder systems can incur.

The CAA is encouraging pilots to adopt lightweight, low power electronic conspicuity devices where traditional transponders are not possible or practical. CAP 1391 (2nd edition) discusses the subject and describes the requirements and benefits of such devices, which are generally lightweight and portable. These use the transponder frequency to transmit positional and identification information to other airspace users and are interoperable with standard transponder transmissions. A list of equipment for which manufacturers have declared compliance with CAP 1391 is given on the CAA's Electronic Conspicuity website: https://www.caa.co.uk/General-aviation/Aircraft-ownership-and-maintenance/Electronic-Conspicuity-devices/

CAP 1391 also gives advice on the licensing requirements for operating such devices. AIC Y 141/2019 gives further guidance on using an electronic conspicuity device at the same time as a traditional transponder on the same aircraft.

In addition to the above, other systems are available that use proprietary communication formats and unlicensed frequencies to transmit positional information. Examples are FLARM and PilotAware.

At the current time, all electronic conspicuity devices described in this section (but not transponder devices) may be fitted to LAA aircraft without further reference to LAA Engineering provided that the devices are installed (where appropriate) in accordance with the manufacturer's instructions and any interfaces with the aircraft (power, antenna, etc) follow the guidance given in section 6 of this TL. Prior to flight, any installations must be signed for in the aircraft logbook by an LAA inspector. Devices that are 'carry on equipment' do not need any particular approval.

APPENDIX 1 – GROUND TESTING OF ADS-B OUT USING UN-CERTIFIED OR TABS GPS

In order to verify the ADS-B output, the transmitted data must be checked. Two methods are described below to receive the ADS-B data and display it in a useable format. If an alternative method is used, this must be agreed with LAA Engineering prior to submitting test reports (e.g. output from a calibrated set of ground test equipment).

METHOD 1: PILOTAWARE

TEST EQUIPMENT SETUP

In order to receive the ADS-B data, a PilotAware system is required, running software version 20160307 or later. This need not be fitted to the subject aircraft. A tablet or smartphone ('computer') equipped with a GPS receiver is also required to generate receiver position data and display the received ADS-B data (the GPS data may alternatively be generated by a GPS receiver attached to the PilotAware unit). The PilotAware and computer need to be setup in accordance with the instructions provided by PilotAware (www.pilotaware.com).

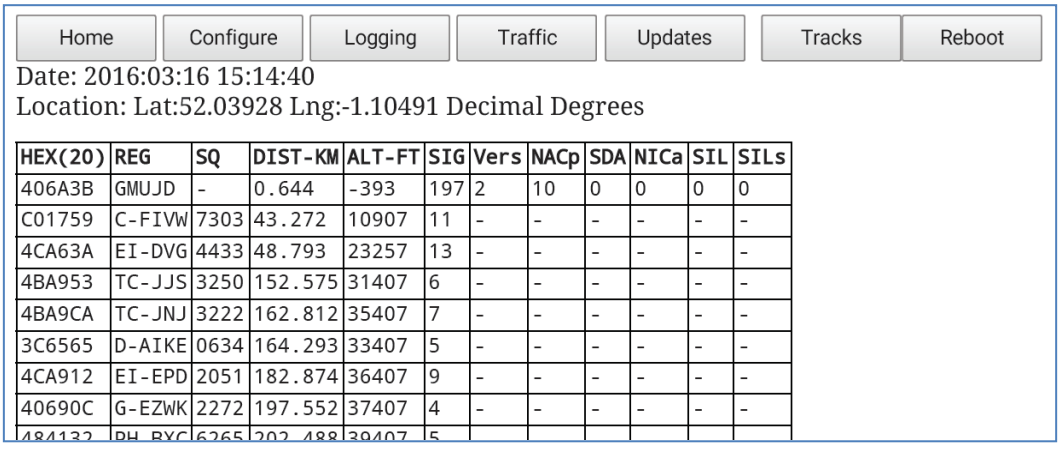
Position the PilotAware and associated computer at a safe distance from the aircraft – a nearby clubhouse is ideal!

TEST PROCEDURE

Ensure that the aircraft is chocked and in a safe area with an appropriate person at the controls.

With the engine running and all electrical services switched on (e.g. strobes, lights, avionics, etc), ensure that the source GPS and transponder are on and transmitting.

Using the computer linked to the PilotAware unit, use a web browser to navigate to the PilotAware data screen (URL: 192.168.1.1). Select the 'traffic' screen, which should show a screen similar to this:



HEX(20)	REG	SQ	DIST-KM	ALT-FT	SIG	Vers	NACp	SDA	NICa	SIL	SILs
406A3B	GMUJD	-	0.644	-393	197	2	10	0	0	0	0
C01759	C-FIVW	7303	43.272	10907	11	-	-	-	-	-	-
4CA63A	EI-DVG	4433	48.793	23257	13	-	-	-	-	-	-
4BA953	TC-JJS	3250	152.575	31407	6	-	-	-	-	-	-
4BA9CA	TC-JNJ	3222	162.812	35407	7	-	-	-	-	-	-
3C6565	D-AIKE	0634	164.293	33407	5	-	-	-	-	-	-
4CA912	EI-EPD	2051	182.874	36407	9	-	-	-	-	-	-
40690C	G-EZWK	2272	197.552	37407	4	-	-	-	-	-	-
484132	PH-BXC	6265	202.488	39407	5						

- Check that the date, time and position are correct.
- Check that the aircraft being checked is listed (probably at the top) and that it shows the correct Mode S 'hex' code (which can be checked on the CAA's G-INFO database), registration and squawk code. The 'SDA' and 'SIL' fields must show '0' unless an approved TABS GPS unit is connected to a transponder capable of receiving TABS data, in which case 'SDA' and 'SIL' fields may be '1'. Note that on later versions of PilotAware, this data is shown under the 'ADSB data' column as a series of numbers separated by commas. The 3rd and 5th numbers must both be zero (or one if using TABS).

If possible, take a screen print. On Google Chrome for tablets, this can be done by selecting 'print' from the drop-down menu and then saving as a PDF. Otherwise, a photo of the screen can be taken. Send the screen print/photo to LAA Engineering along with the completed form LAA/MOD7.

METHOD 2: GETYOURWINGS.CO.UK SOFTWARE

TEST EQUIPMENT SETUP

In order to receive the ADS-B data, you will need a Windows computer equipped with an appropriate antenna (costing around £10) and software provided by getyourwings.co.uk. The website describes the equipment needed and how to install and set it up.

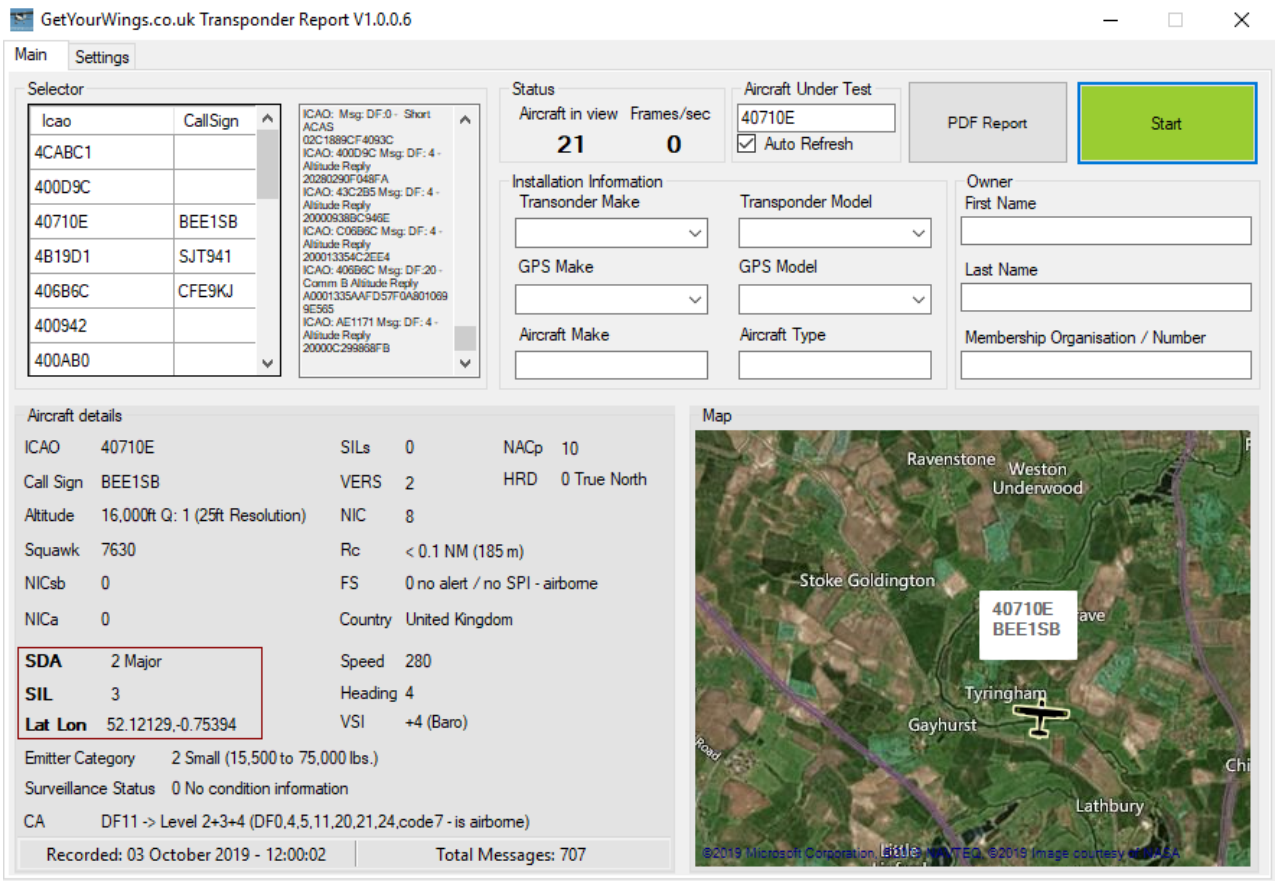
Position the computer at a safe distance from the aircraft – a nearby clubhouse is ideal!

TEST PROCEDURE

Ensure that the aircraft is chocked and in a safe area with an appropriate person at the controls.

With the engine running and all electrical services switched on (e.g. strobes, lights, avionics, etc), ensure that the source GPS and transponder are on and transmitting.

The software on the computer should show a screen similar to below.



- Check that the date, time and position are correct.
- Select the aircraft being checked and check that it shows the correct Mode S 'hex' code (labelled 'ICAO' - this can be checked on the CAA's G-INFO database), registration and squawk code. The 'SDA' and 'SIL' fields must show '0' unless an approved TABS GPS unit

is connected to a transponder capable of receiving TABS data, in which case 'SDA' and 'SIL' fields may be '1'.

Complete the 'Installation Information' fields in the top right of the screen and then click on 'PDF Report'. Save the resulting report and send a copy to LAA Engineering along with the completed form LAA/MOD7.

APPENDIX 2 – ACCEPTED EQUIPMENT COMBINATIONS FOR ADS-B OUT WITH SIL/SDA GREATER THAN ONE

The following combinations of equipment are acceptable to LAA for installation in conjunction with form LAA/MOD17 for the provision of ADS-B Out transmissions that use SIL/SDA greater than one. If a combination is not listed here, in the first instance you should contact the manufacturer or UK agent for the transponder in question to find out if the equipment meets the requirements given in Appendix 3. If the combination is considered to meet the requirements, please write to or email LAA Engineering with details for potential addition to this Appendix.

Garmin

#	Transponder model	Min transponder software version	Transponder antenna	GPS make/model	Min main software version	Min GPS software version	GPS antenna	Altitude encoder
G1.1	GTX 33, 33D, 330 or 330D	7.01	Garmin 010-01060-00 or alternative approved to TSO C112, C66 or C74	Garmin GTN 625	3.00	5.0	As listed in GPS installation manual	Garmin GAE 43 or alternative approved to TSO C88a or C88b
G1.2				Garmin GTN 635				
G1.3				Garmin GTN 725				
G1.4				Garmin GTN 750				
G1.5				Garmin GDL 88 or 88H or 88D or 88DH (all with internal GPS)	2.00	5.0		
G1.6				Garmin GTX 335 or 335R (both with internal GPS)	N/A	N/A		
G1.7				Garmin GTX 345 or 345R (both with internal GPS)	N/A	N/A		
G1.8				Garmin GPS 175	2.00	N/A		
G1.9				Garmin GNC 355A	3.00	N/A		
G1.10				Garmin GNX 375	2.00	N/A		
G1.11				Garmin GTN 650	3.00	5.0		

#	Transponder model	Min transponder software version	Transponder antenna	GPS make/model	Min main software version	Min GPS software version	GPS antenna	Altitude encoder
G2.1	GTX 335, 335R, 335D, 335DR, 345, 345R, 345D or 345DR	N/A	As listed in installation manual	Garmin GTN 625	3.00	5.0	As listed in GPS installation manual	Garmin GAE 12 or alternative approved to TSO C88a or C88b
G2.2				Garmin GTN 635	3.00	5.0		
G2.3				Garmin GTN 725	3.00	5.0		
G2.4				Garmin GTN 750	3.00	5.0		
G2.5				Garmin GDL 88, 88H, 88D or 88DH (all with internal GPS)	2.00	5.0		
G2.6				Garmin GTX 335 or 335R (both with internal GPS)	N/A	N/A		
G2.7				Garmin GTX 345 or 345R (both with internal GPS)	N/A	N/A		
G2.8				Garmin GPS 175	2.00	N/A		
G2.9				Garmin GNC 355A	3.00	N/A		
G2.10				Garmin GNX 375	2.00	N/A		
G2.11				Garmin GTN 650	3.00	5.0		
G3.1	GTX 35R or 45R	N/A	As listed in installation manual	Garmin GTN 625	3.00	5.0	As listed in GPS installation manual	Garmin GAE 12 or alternative approved to TSO C88a or C88b
G3.2				Garmin GTN 635	3.00	5.0		
G3.3				Garmin GTN 725	3.00	5.0		
G3.4				Garmin GTN 750	3.00	5.0		
G3.5				Garmin GPS 175	2.00	N/A		
G3.6				Garmin GNC 355A	3.00	N/A		
G3.7				Garmin GNX 375	2.00	N/A		
G3.8				Garmin GTN 650	3.00	5.0		

#	Transponder model	Min transponder software version	Transponder antenna	GPS make/model	Min main software version	Min GPS software version	GPS antenna	Altitude encoder
G4.1	GNX 375	2.00	As listed in installation manual section 3.1.2	Garmin GNX 375	2.00	N/A	As listed in GPS installation manual section 3.1.1	Garmin GAE 12 or alternative approved to TSO C88a or C88b

Trig

#	Transponder model	Min transponder software version	Transponder antenna	GPS make/model	Min main software version	Min GPS software version	GPS antenna	Altitude encoder
T1.1	TT21 or TT22	2.7	Approved to TSO C74 or C112	Trig TN70	N/A	N/A	Approved to TSO C190 or C144	Trig TC20
T1.2				Accord NexNav Mini	N/A	N/A		
T1.3				Avidyne IFD 4xx or 5xx	N/A	N/A	Avidyne p/n 200-00282-000	
T1.4				Garmin GTN 625	3.00	5.0	As listed in GPS installation manual section 1.11	
T1.5				Garmin GTN 635	3.00	5.0		
T1.6				Garmin GTN 725	3.00	5.0		
T1.7				Garmin GTN 750	3.00	5.0		
T2.1	TT31	3.13	Approved to TSO C74 or C112	Trig TN70	N/A	N/A	Approved to TSO C190 or C144	Any encoder approved to TSO C88a or C88b
T2.2				Accord NexNav Mini	N/A	N/A		
T2.3				Avidyne IFD 4xx or 5xx	N/A	N/A	Avidyne p/n 200-00282-000	
T2.4				Garmin GTN 625	3.00	5.0	As listed in GPS installation manual section 1.11	
T2.5				Garmin GTN 635	3.00	5.0		
T2.6				Garmin GTN 725	3.00	5.0		
T2.7				Garmin GTN 750	3.00	5.0		

Transponder antennae known to hold TSO C74 or C112 approvals:

Manufacturer	Model
Comant	CI 100, -2, -3, -4, -5, -6
Comant	CI 101
Comant	CI 105, -3, -3-2, -4, -6, -7, -9, -10, -11, -11-4, -14, -16, -20, -22, -24, -25, -25-1, -25-1L, -35, -35-0, -35-1
Comant	CI 110-40-30, -41-30, -60-30, -61-30
Comant	CI 305, -2, -3
Comant	CI 310-22-4
Comant	CI 5000-1, -1L, -2L
Rami	AV-22
Rami	AV-61
Rami	AV-74

GPS antennae known to hold TSO C190 or C144 approvals:

Manufacturer	Model
Comant	CI 401-220, -221, -230, -460
Comant	CI 419-200
Comant	CI 420-220, -221, -230, -420
Comant	CI 428-200, -410
Comant	CI 429-200, -410
Rami	AV-801
Trig	TA70

Altitude encoders known to hold TSO C88a or C88b approvals:

Manufacturer	Model
ACK Technologies Inc	AE Model A-30
Trans-Cal Industries	SSD-120-(xx)
Sandia Aerospace	SAE 5-35

APPENDIX 3 – REQUIREMENTS FOR ADS-B OUT SYSTEMS WITH SIL/SDA GREATER THAN ONE

For equipment combinations to be accepted in Appendix 2, the following requirements must be met.

- The transponder and its installation must meet CS ACNS.D.ELS.010 (which requires a Mode S transponder level 2 (or greater), transponder class 1 or 2, peak power output 70 to 500 W, elementary surveillance and SI capability).
- The transponder must be approved to ETSO-C166b or later.
- The altitude encoder must be approved to ETSO-C88a or later and be connected to the aircraft's static system.
- The GPS source must be approved to ETSO-C145c, ETSO-146c or ETSO-C196a.
- The GPS source must interface directly with the transponder or be integral to the transponder (i.e. there must be no intermediate devices).
- The transponder manufacturer must state that the whole system meets the requirements of AMC 20-24.

Note that where ETSO numbers are given, the equivalent FAA TSO number should also be acceptable. Subsequent issues of (E)TSOs are indicated by higher letters: therefore, for example, if a unit is approved to ETSO-166c, then this fulfils the requirement to be approved to 'ETSO-166b or later'.

The above criteria are based on CS-STAN CS-SC002c and CS-SC005a. These requirements are expected to be reviewed and developed as experience is gained and certification rules are developed.

APPENDIX 4 – LIST OF POPULAR AVIONICS EQUIPMENT APPROVAL NUMBERS

The list below is not a comprehensive list of approved avionics equipment and their approval numbers. It is a list of 'popular' equipment installed by LAA members in LAA aircraft. The purpose of this list is to assist members who are experiencing difficulty in locating approval numbers on the CAA, EASA or FAA websites in order to complete their LAA/MOD 7 forms or CAA radio licence application forms.

TYPE	MAKE	MODEL	APPROVAL NO	8.33 kHz
AUDIO PANEL	GARMIN INTERNATIONAL	GMA 35	EASA.IM.21O.10037276	N/A
AUDIO PANEL	GARMIN INTERNATIONAL	GMA 347	EASA.IM.21O.479	N/A
CONTROLLER	TRIG AVIONICS LTD	TC20	EASA.210.1112, REV.B	N/A
CONTROLLER	TRIG AVIONICS LTD	TC90	EASA.21O.10042343	N/A
DME	HONEYWELL INTERNATIONAL INC	KN-64	LA100279	N/A
ELT	ACK TECHNOLOGIES INC.	E-04	EASA.IM.21O.10028407	N/A
ELT	AMERI-KING CORPORATION	AK-451-(AF)(AP)(S)	EASA.IM.21O.1102	N/A
ELT	AMERI-KING CORPORATION	AK 451.017-1B	EASA.IM.21O.10033545	N/A
ELT	ARTEX AIRCRAFT SUPPLIES INC	ME406	EASA.I.M.21O.416	N/A
ELT	KANNAD	406 AF COMPACT	EASA.21O.818, REV. A	N/A
GPS	ACCORD TECHNOLOGY	NEXNAV MINI	TSO-C145c	N/A
GPS	GARMIN INTERNATIONAL	GPS 100	LA301005	N/A
GPS	GARMIN INTERNATIONAL	GPS 175	TSO-C146e	N/A
GPS	GARMIN INTERNATIONAL	GPS 155XL	VC01134	N/A
GPS	GARMIN INTERNATIONAL	GTN 625	TSO-C146c	N/A
GPS	GARMIN INTERNATIONAL	GTN 725	TSO-C146c	N/A
GPS	HONEYWELL INTERNATIONAL INC	KLN-89B	VC01071	N/A
GPS	HONEYWELL INTERNATIONAL INC	KMD 250	EASA.210.036.REV. A	N/A
GPS	II MORROW	GX 50	VC01160	N/A
GPS	SKYFORCE AVIONICS LTD	KMD 150	LA301065	N/A
GPS	SKYFORCE AVIONICS LTD	SM2000	LA301047	N/A
GPS	SKYFORCE AVIONICS LTD	SKYMAP IIIC (SM4000)	EASA.21O.203 Rev. A	N/A
GPS	TRIG AVIONICS LTD	TN70	TSO-C145c	N/A
GPS	TRIG AVIONICS LTD	TN72	EASA.21O.10062747	N/A
GPS	TRIMBLE NAVIGATION LTD	TNL-1000	LA301023	N/A
GPS	TRIMBLE NAVIGATION LTD	TNL2000	LA301004	N/A
NAV	BECKER FLUGFUNKWERK GMBH	NAV3300	EASA.21O.738	N/A
NAV	HONEYWELL INTERNATIONAL INC	KNS-81	VC00346	N/A
TCAS	RYAN STORMSCOPE	9900BX	LA101077	N/A
TRANSPONDER	AIRPLUS MAINTENANCE GMBH	KTX-2	EASA.21O.10058477	N/A
TRANSPONDER	AIRPLUS MAINTENANCE GMBH	KTX-2 Software V0.2.10	EASA.21O.10055186, Rev A	N/A
TRANSPONDER	BECKER FLUGFUNKWERK GMBH	BXP6400	EASA.21O.322	N/A
TRANSPONDER	BECKER FLUGFUNKWERK GMBH	BXP6401	EASA.21O.322	N/A
TRANSPONDER	BECKER FLUGFUNKWERK GMBH	BXP6402	EASA.21O.322	N/A
TRANSPONDER	BECKER FLUGFUNKWERK GMBH	BXP6403	EASA.21O.717	N/A
TRANSPONDER	DYNON	SV-XPNDR-261	USE DETAILS FOR TRIG TT22	N/A
TRANSPONDER	DYNON	SV-XPNDR-262	USE DETAILS FOR TRIG TT21	N/A
TRANSPONDER	FILSER ELECTRONIC GMBH	TRT600	VC01211	N/A
TRANSPONDER	FUNKWERK AVIONICS GMBH	TRT800H	EASA.21O.269	N/A
TRANSPONDER	FUNKWERK AVIONICS GMBH	TRT800	EASA.21O.045	N/A
TRANSPONDER	FUNKWERK AVIONICS GMBH	TRT800A	EASA.21O.268	N/A
TRANSPONDER	GARMIN INTERNATIONAL	GTX 328	EASA.IM.21O.809	N/A
TRANSPONDER	GARMIN INTERNATIONAL	GTX 327	LBA.N.0.10.930-57 JTSO	N/A

TYPE	MAKE	MODEL	APPROVAL NO	8.33 kHz
TRANSPONDER	GARMIN INTERNATIONAL	GTX 330	LBA.N-O.10.930/064 JTSO	N/A
TRANSPONDER	GARMIN INTERNATIONAL	GTX 320	VC01108	N/A
TRANSPONDER	GARMIN INTERNATIONAL	GTX 320A	LBA.N-O.10.930/61 JTSO	N/A
TRANSPONDER	GARMIN INTERNATIONAL	GTX 23	EASA.IM.21O.1255, REV. B	N/A
TRANSPONDER	GARMIN INTERNATIONAL	GTX 33/GTX 33D	EASA.IM.21O.1255, REV.B	N/A
TRANSPONDER	GARMIN INTERNATIONAL	GTX 330/GTX 330D	LBA.N-O.10.930/064 JTSO	N/A
TRANSPONDER	GARMIN INTERNATIONAL	GTX 335/GTX 335R	TSO-C112E	N/A
TRANSPONDER	GARMIN INTERNATIONAL	GTX 345/GTX 345R	TSO-C112E	N/A
TRANSPONDER	GARMIN INTERNATIONAL	GTX 35R	TSO-C112E	N/A
TRANSPONDER	GARMIN INTERNATIONAL	GTX 45R	TSO-C112E	N/A
TRANSPONDER	GARMIN INTERNATIONAL	GNX 375	TSO-C122E/-C166B	N/A
TRANSPONDER	GARRECHT AVIONIK GMBH	VT-01	EASA 21O.384 Rev.A	N/A
TRANSPONDER	GARRECHT AVIONIK GMBH	VT-02	EASA 21O.705	N/A
TRANSPONDER	HONEYWELL INTERNATIONAL INC	KT76A	LA100208	N/A
TRANSPONDER	HONEYWELL INTERNATIONAL INC	KT-76	LA100208	N/A
TRANSPONDER	HONEYWELL INTERNATIONAL INC	KT76C	LA101050	N/A
TRANSPONDER	HONEYWELL INTERNATIONAL INC	KT-73	EASA.21O.063	N/A
TRANSPONDER	MICROAIR AVIONICS PTY LTD	T2000SFL	LA101080	N/A
TRANSPONDER	NARCO AVIONICS INC	AT-150TSO	VC00245	N/A
TRANSPONDER	NARCO AVIONICS LTD	AT-50	LA100198	N/A
TRANSPONDER	TERRA CORPORATION	TRT250	LA100346	N/A
TRANSPONDER	TQ-SYSTEMS GMBH	KTX2-F.0100	EASA.21O.10070633	N/A
TRANSPONDER	TQ-SYSTEMS GMBH	KTX2.0200	EASA.21O.10062647, REV A	N/A
TRANSPONDER	TQ-SYSTEMS GMBH	KTX2.0300	EASA.21O.10069784	N/A
TRANSPONDER	TRIG AVIONICS LTD	TT31	EASA.21O.906 REV. A	N/A
TRANSPONDER	TRIG AVIONICS LTD	TT21 Software V1.xx	EASA.21O.1056, REV.A	N/A
TRANSPONDER	TRIG AVIONICS LTD	TT22	EASA.21O.1277	N/A
TRANSPONDER	TRIG AVIONICS LTD	TT21 Software V2.xx	EASA.21O.10034900	N/A
TRANSPONDER	TRIG AVIONICS LTD	KT74	EASA.21O.10046583	N/A
VHF COMM	**AIRPLUS MAINTENANCE GMBH**	**KRT-2**	**EASA.21O.10038036**	**Yes**
VHF COMM	BECKER FLUGFUNKWERK GMBH	AR 4201	EASA.21O.10038538	No
VHF COMM	BECKER FLUGFUNKWERK GMBH	AR-3201	VC00457	No
VHF COMM	**BECKER FLUGFUNKWERK GMBH**	**AR6201**	**EASA.21O.1249, REV A**	**Yes**
VHF COMM	**BECKER FLUGFUNKWERK GMBH**	**RT6201**	**EASA.21O.1249, REV A**	**Yes**
VHF COMM	**BECKER FLUGFUNKWERK GMBH**	**AR6203**	**EASA.21O.10054849**	**Yes**
VHF COMM	DITTEL GMBH	FSG 50	VC00358	No
VHF COMM	DITTEL gmbh, WALTER	FSG-70 SERIES	LA100331	No
VHF COMM	DITTEL,Gmbh WALTER	FSG-71M	LA100331	No
VHF COMM	**DYNON**	**SV-COM-X83**	**USE DETAILS FOR TRIG TY91**	**Yes**
VHF COMM	FUNKWERK AVIONICS GMBH	ATR-500	LBA.O.10.911/113 JTSO	No
VHF COMM	FUNKWERK AVIONICS GMBH	ATR 600	LBA.O.10.911/106 JTSO	No
VHF COMM	**FUNKWERK AVIONICS GMBH**	**ATR833**	**EASA.21O.193**	**Yes**
VHF COMM	**FUNKWERK AVIONICS GMBH**	**ATR833-II**	**EASA.21O.100621008, REV A**	**Yes**
VHF COMM	**FUNKWERK AVIONICS GMBH**	**ATR833A**	**EASA.21O.270**	**Yes**
VHF COMM	**FUNKWERK AVIONICS GMBH**	**ATR833S**	**EASA.21O.10060316**	**Yes**
VHF COMM	GARMIN INTERNATIONAL	SL40	EASA.21O.119	No
VHF COMM	**GARMIN INTERNATIONAL**	**GTR 225A**	**EASA.IM.21O.10043491**	**Yes**
VHF COMM	**GARMIN INTERNATIONAL**	**GTR 225B**	**EASA.IM.21O.10043488**	**Yes**
VHF COMM	HONEYWELL INTERNATIONAL INC	KY-97A	VC00439	No
VHF COMM	HONEYWELL INTERNATIONAL INC	KY-96A	VC00439	No
VHF COMM	HONEYWELL INTERNATIONAL INC	KY-92	LA100272	No

TYPE	MAKE	MODEL	APPROVAL NO	8.33 kHz
VHF COMM	HONEYWELL INTERNATIONAL INC	RT 241 SERIES	LA100211	No
VHF COMM	HONEYWELL INTERNATIONAL INC.	KY-197	VC00324	No
VHF COMM	ICOM (UK) LTD	IC-A200	LA301011	No
VHF COMM	ICOM (UK) Ltd	IC-A20	LA300341	No
VHF COMM	**ICOM AMERICA INC**	**IC-A220T**	**TSO-C128a/-C169a**	**Yes**
VHF COMM	MICROAIR AVIONICS PTY LTD	MICROAIR 760	LA301068	No
VHF COMM	NARCO AVIONICS INC	COM 120	VC00300	No
VHF COMM	NARCO AVIONICS INC	COM 800	VC00355	No
VHF COMM	NARCO AVIONICS INC	COM 810	VC00355	No
VHF COMM	TERRA CORPORATION	TX760D	LA301009	No
VHF COMM	TKM INC	MX 11	VC01085	No
VHF COMM	**TQ-SYSTEMS GMBH**	**TQ-KRT2**	**EASA.21O.10063547**	**Yes**
VHF COMM	**TRIG AVIONICS LTD**	**TY91**	**EASA.21O.10042695, REV. B**	**Yes**
VHF COMM	**TRIG AVIONICS LTD**	**TY92**	**EASA.21O.10042695, REV. B**	**Yes**
VHF COMM	**TRIG AVIONICS LTD**	**TY96**	**EASA.21O.10058724, REV. B**	**Yes**
VHF COMM	**TRIG AVIONICS LTD**	**TY97**	**EASA.21O.10058724, REV. B**	**Yes**
VHF COMM/GPS	GARMIN INTERNATIONAL	GNC 250 XL	LA101043	No
VHF COMM/GPS	**GARMIN INTERNATIONAL**	**GNC 355A**	**TSO-C146e/-C169a**	**Yes**
VHF COMM/GPS	**GARMIN INTERNATIONAL**	**GTN 635**	**TSO-C146c/-C169a**	**Yes**
VHF COMM/NAV	GARMIN INTERNATIONAL	SL30	LBA.N-O.10.985/005 JTSO	No
VHF COMM/NAV	**GARMIN INTERNATIONAL**	**GNC 255A**	**EASA.IM.21O.10043506**	**Yes**
VHF COMM/NAV	**GARMIN INTERNATIONAL**	**GNC 255B**	**EASA.IM.21O.10043490**	**Yes**
VHF COMM/NAV	HONEYWELL INTERNATIONAL INC	KX-125	LA301029	No
VHF COMM/NAV	NARCO AVIONICS INC	MARK 12D	LA300305	No
VHF COMM/NAV	NARCO AVIONICS INC	MARK 12E	LA300345	No
VHF COMM/NAV	TERRA CORPORATION	TN-200 D	LA301013	No
VHF COMM/NAV	TERRA CORPORATION	TMA 230 D	LA301010	No
VHF COMM/NAV/GPS	**AVIDYNE**	**IFD440**	**TSO-C112E/-C128A/-C169A**	**Yes**
VHF COMM/NAV/GPS	**GARMIN INTERNATIONAL**	**GNS 530W**	**EASA.IM.21O.919**	**Yes**
VHF COMM/NAV/GPS	**GARMIN INTERNATIONAL**	**GTN 750**	**EASA.IM.21O.10048536.REV.A**	**Yes**
VHF COMM/NAV/GPS	**GARMIN INTERNATIONAL**	**GNS 430W**	**EASA.IM.21O.920**	**Yes**
VHF COMM/NAV/GPS	**GARMIN INTERNATIONAL**	**GTN 650**	**EASA.IM.21O.10037627**	**Yes**
VHF COMM/NAV/GPS	**GARMIN INTERNATIONAL**	**GNS 430**	**LA101059**	**Yes**
VHF COMM/NAV/GPS	HONEYWELL INTERNATIONAL INC	KX-155	LA101079	No
VHF COMM/NAV/GPS	HONEYWELL INTERNATIONAL INC	KX 155A	LA101052	No
VHF COMM/NAV/GPS	NARCO AVIONICS LTD	MARK 12E/NCS-812	LA300345	No
VHF COMM/NAV/GPS	NARCO AVIONICS LTD	ESCORT II	LA300328	No
VOR-VHF	NARCO AVIONICS INC	NAV-121 TSO	LA100260	No