TT21 / TT22 Minor Change for CS-23 Aircraft

18 February 2014

Document Control	
Title:	TT21 / TT22 Minor Change for CS-23 Aircraft
Identifier:	SUP/TT2X/009
Issue:	Issue 1.0
Issue Date:	18 February 2014
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CCB Category:	2
File Name:	SUP TT2X 009 Issue 1 0
Printed on:	28/02/2014 13:58:00

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1. Preface

1.1 Purpose

This document contains the Minor Change instructions to replace an existing transponder with a Trig Avionics TT21 or TT22 Mode S transponder.

1.2 Scope

This Minor Change applies to unpressurised single engine piston aeroplanes with fixed landing gear and 14 Volt or 28 Volt DC electrical systems, having an existing certified transponder installation.

The applicable aircraft are:

PIPER PA-28-236	TCDS USA 2A13
PIPER PA-28-201T	TCDS USA 2A13
PIPER PA-28R-201T	TCDS USA 2A13
PIPER PA-28R-180	TCDS USA 2A13
PIPER PA-28-150	TCDS USA 2A13
PIPER PA-28RT-201	TCDS USA 2A13
PIPER PA-28-180	TCDS USA 2A13
PIPER PA-28-151	TCDS USA 2A13
PIPER PA-28-235	TCDS USA 2A13
PIPER PA-28-181	TCDS USA 2A13
PIPER PA-28RT-201T	TCDS USA 2A13
PIPER PA-28R-200	TCDS USA 2A13
PIPER PA-28R-201	TCDS USA 2A13
PIPER PA-28S-160	TCDS USA 2A13
PIPER PA-28S-180	TCDS USA 2A13
PIPER PA-28-160	TCDS USA 2A13
PIPER PA-28-140	TCDS USA 2A13
PIPER PA-28-161	TCDS USA 2A13

1.3 Changes from Previous Issue

None, this is the first issue

1.4 Changes Forecast

None.

1.5 Document Cross-References

1.5.1 Internal Documents

00560-00	TT21/TT22 Installation Manual	Issue AL

DEV/TT21/007	TT21 Declaration of Design Performance	Issue 1.0
DEV/TT22/007	TT22 Declaration of Design Performance	Issue 1.0
DEV/TC20/005	TC20 Declaration of Design Performance	Issue 4.0
DEV/TT21/005	TT21 System Failure Analysis	Issue 2.1
00559-00	TT21 and TT22 Mode S Transponder Operating Manual	Issue AE
SUP/TT2X/010	TT21 / TT22 Minor Change for CS-23 AircraftFlight Manual Supplement	Issue 1

1.5.2 External Documents

CS-23 (Amdt 3)	Certification Specifications for Normal, Utility, Aerobatic, and Commuter Category Aeroplanes	EASA
CAP747	Mandatory Requirements for Airworthiness	CAA
ED-73C	MOPS for SSR Mode S Transponders	Eurocae
CS.ACNS	Certification Specifications and Acceptable Means of Compliance for Airborne Communications, Navigation and Surveillance	EASA
Commission Regulation (EU) No 1207/2011	Laying down requirements for the performance and the interoperability of surveillance for the single European sky	European Commission

1.5.3 Approval Traceability

Document	Additional Aircraft	Document Changes	EASA Minor Change Approval
SUP/TT2x/003 Issue 1.0	Piper PA-28	Original Document	N/A

1.6 Abbreviation and Acronyms

The following abbreviations and acronyms are used in this document:

AFM	Aircraft Flight Manual
DC	Direct Current
DDP	Declaration of Design Performance
EASA	European Aviation Safety Agency
ETSO	European Technical Standards Order
MOPS	Minimum Operational Performance Standard
POH	Pilots Operating Handbook

2. Introduction

The TT21/TT22 Mode S transponder system is an ED-73C compliant Mode S level 2els datalink transponder, with support for ADS-B extended squitter, elementary surveillance and SI codes, which also meets the relevant environmental requirements of ED-14F. The TT21 has a nominal power output of 125 Watts, and meets the power output requirements for Class 2. The TT22 has a nominal power output of 250 watts, and meets the power output requirements for Class 1. The ADS-B function meets DO-260B class B0 for the TT21 and class B1S for the TT22. The TT21/TT22 is certified to ETSO C112c and ETSO C166a, and to FAA TSO C112c and C166b.

The TT21/TT22 transponder is controlled using a separate front panel controller, called the TC20. This allows the transponder to be mounted separately from the instrument panel, and reduces the amount of panel space taken by the transponder. The TC20 includes an altitude encoder. The TC20 is certified to ETSO 2C112b and ETSO C88a, and to FAA TSO C112c and TSO C88b.

This minor change describes the process of upgrading an existing transponder to a TT21 or TT22.

Although the TT21/TT22 Mode S transponder system adds support for ADS-B extended squitter, this is beyond the scope of these Minor Change instructions and further compliance to CS.ACNS is required to enable the ADS-B functionality.

3. Change Details

3.1 Description of Change

This change involves removing an existing transponder, and replacing it with a Trig Avionics TT21 or TT22 Mode S transponder.

The processes involved in the change includes pre-testing of the installation; verification of the suitability of the existing power supply wiring; installing the TC20 and the TT21/TT22 transponder; transponder commissioning; and post-installation testing. These processes are described in detail in the accomplishment instructions in this document.

The existing transponder mounting tray will need to be removed and a new panel installed to mount the controller or install a blanking panel if a conventional 57mm instrument cut-out will be used. The connectors will need to be replaced. If there is an existing altitude encoder fitted it should be removed as it is not required for correct operation of the TT21/TT21. The existing antenna and circuit breaker will be re-used.

3.2 Mechanical Details

The TT21/TT22 uses a TC20 head unit to control the transponder, it has a combination of knobs and press buttons to set transponder codes and control the functions of the unit. The operating mode, squawk code and altitude are displayed on an LCD. The panel location should allow the screen to be visible to the pilot and have reasonable access to the knobs and buttons.

The TT21/TT22 is compatible with any transponder antenna approved to (E)TSO C74 or C112.

The TT21/TT22 combined with the TC20 has a total weight of 440 grams. The effect on weight and balance of the aircraft will be small due to the low weight of the transponder equipment. After the installation a weight and balance check should be calculated or performed in accordance with the manufactures instructions.

3.3 Continued Airworthiness Instructions

An approved aircraft maintenance program will normally include periodic functional checks of the transponder installation using a test set including frequency tolerance, side lobe suppression, and Mode C and Mode S performance. The Mode S checks should confirm that the aircraft assigned Mode S address is correct. Please refer to Appendix 1 for an example of Continued Airworthiness Instructions based on compliance with CS-23.

Other than for periodic functional checks required by the regulations, the TT21/TT22 Mode S transponder has been designed and manufactured to allow “on condition maintenance”. This means that there are no periodic service requirements necessary to maintain continued airworthiness, and no maintenance is required until the equipment does not properly perform its intended function. When service is required, a complete performance test as detailed in section 4.5 of these instructions should be accomplished following any maintenance action.

3.4 Installed Equipment Suitability

3.4.1 ETSO

The TT21 is certified to ETSO C112c and ETSO C166a under ETSOA EASA.21O.10034900.

The TT22 is certified to ETSO C112c and ETSO C166a under ETSOA EASA.21O.10034899

The TC20 is certified to ETSO 2C112b and ETSO C88a under ETSOA EASA.21O.1112, REV.B.

3.4.2 Deviations

The environmental standard tested against was RTCA DO-160F rather than DO-160E which is referenced by ETSO C166a and ETSO 88a.

3.4.3 Environmental

The environmental testing conducted for the TT21/TT22 and TC20 is appropriate for this installation.

Key aspects of the TT21 and TT22 environmental qualification are summarised here:

DO-160F reference	Qualification	Applicability
Temperature & Altitude	Category A2 and C1	Equipment intended for installation in a partially controlled temperature but pressurised location and installed is a non-pressurised but controlled temperature location.
Loss of Cooling	+70C without cooling air	Forced air cooling not required.
Temperature Variation	Category C	Temperature controlled internal section of the aircraft.
Humidity	Category A	Standard humidity environment.
Operational Shock & Crash Safety	Category B type 5	Equipment generally installed in fixed-wing aircraft or helicopters, VLA's and sailplanes tested for standard operational shock and crash safety.
Vibration	Aircraft zone 2; type 3, 4, 5 to category S level M, type 1	Single engine fixed wing reciprocating or turboprop. Multi engine less than 5700Kg. Helicopters, reciprocating and turbojet engines. Equipment fitted to instrument panel, console or equipment rack.
Magnetic Effect	Category Z	Equipment and or its connecting cable harness may be mounted within 0.3m of magnetic compass. All verified during ETSO environmental qualification testing.
Power Input	Category BX	DC equipment intended for use on aircraft electrical system supplied by engine driven alternator or generator, where a battery of significant capacity is on the DC bus at all times.
Voltage Spike	Category B	Installation where a lower standard of protection is acceptable.
Audio Susceptibility	Category B	DC equipment intended for use on aircraft electrical system supplied by engine drive alternator or generator, where a battery of significant capacity is on the DC bus at all times.
Induced Signal Susceptibility	Category AC	Equipment intended for operation where interference-free operation is desirable and installed on aircraft whose primary power is constant frequency or DC.
RF Susceptibility	Category TT	Specified in the HIRF rules; representative of the internal EMI environment from aircraft equipment.
RF Emission	Category B	Basic emission control.

Key aspects of the TC20 environmental qualification are summarised here:

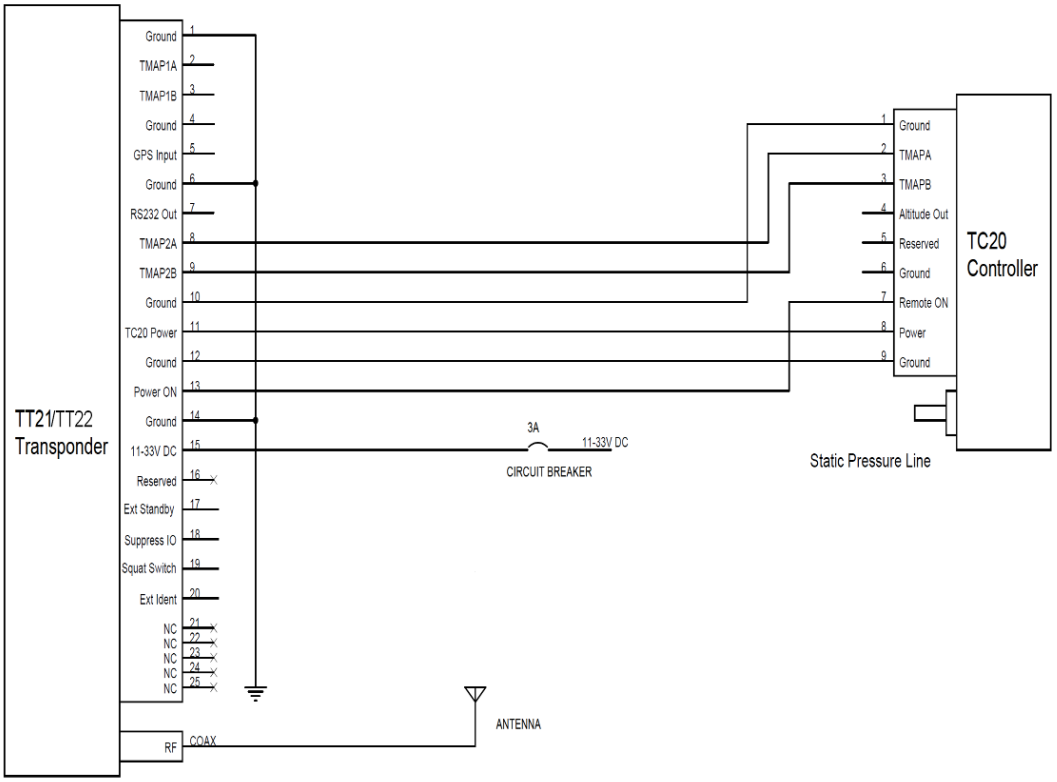
DO-160F reference	Qualification	Applicability
Temperature & Altitude	Category A4 and C2	Equipment intended for installation in a controlled temperature and pressurized location. Equipment intended for installation in non-pressurised and non- controlled temperature location.
Loss of Cooling	+70C without cooling air	Forced air cooling not required.
Temperature Variation	Category A	Equipment external to the aircraft or internal to the aircraft.
Humidity	Category A	Standard humidity environment.
Operational Shock & Crash Safety	Category B type 5	Equipment generally installed in fixed-wing aircraft or helicopters, tested for standard operational shock and crash safety.
Vibration	Aircraft zone 2; type 3, 4, 5 to category S level M, type 1 (Helicopters) to category U level G	Single engine fixed wing reciprocating or turboprop. Multi engine less than 5700Kg. Helicopters, reciprocating and turbojet engines. Equipment fitted to instrument panel, console or equipment rack.
Magnetic Effect	Category Z	Equipment and or its connecting cable harness may be mounted within 0.3m of magnetic compass. All verified during ETSO environmental qualification testing.
Power Input	Category X	Equipment identified as Category X – no test required
Voltage Spike	Category X	Equipment identified as Category X – no test required
Audio Susceptibility	Category X	Equipment identified as Category X – no test required
Induced Signal Susceptibility	Category BC	Equipment intended for operation in systems where interference would be controlled to a tolerable level and is installed on aircraft whose primary power is constant frequency or DC.
RF Susceptibility	Category TT	Specified in the HIRF rules; representative of the internal EMI environment from aircraft equipment.
RF Emission	Category B	Equipment and interconnected wiring located in areas where apertures are electro-magnetically significant and not directly in view of radio receivers antenna.

In each case the environmental qualification is appropriate to the installation in the instrument panel of a light piston engine aircraft with a DC electrical system.

3.5 Wiring Diagram

3.5.1 General Wiring Arrangement

The wiring diagram is the same in 14V and 28V aircraft.



Note 1: Suppress I/O is only required in aircraft with DME.

Note 2: External Ident feature is optional and not present on most aircraft.

Note 3: The squat switch is not connected.

Note 4: The GPS Input is not required as part of this minor change, and is shown here not connected.

Note 5: The Altitude Out from the TC20 Controller is not required as part of this minor change, and is shown here not connected.

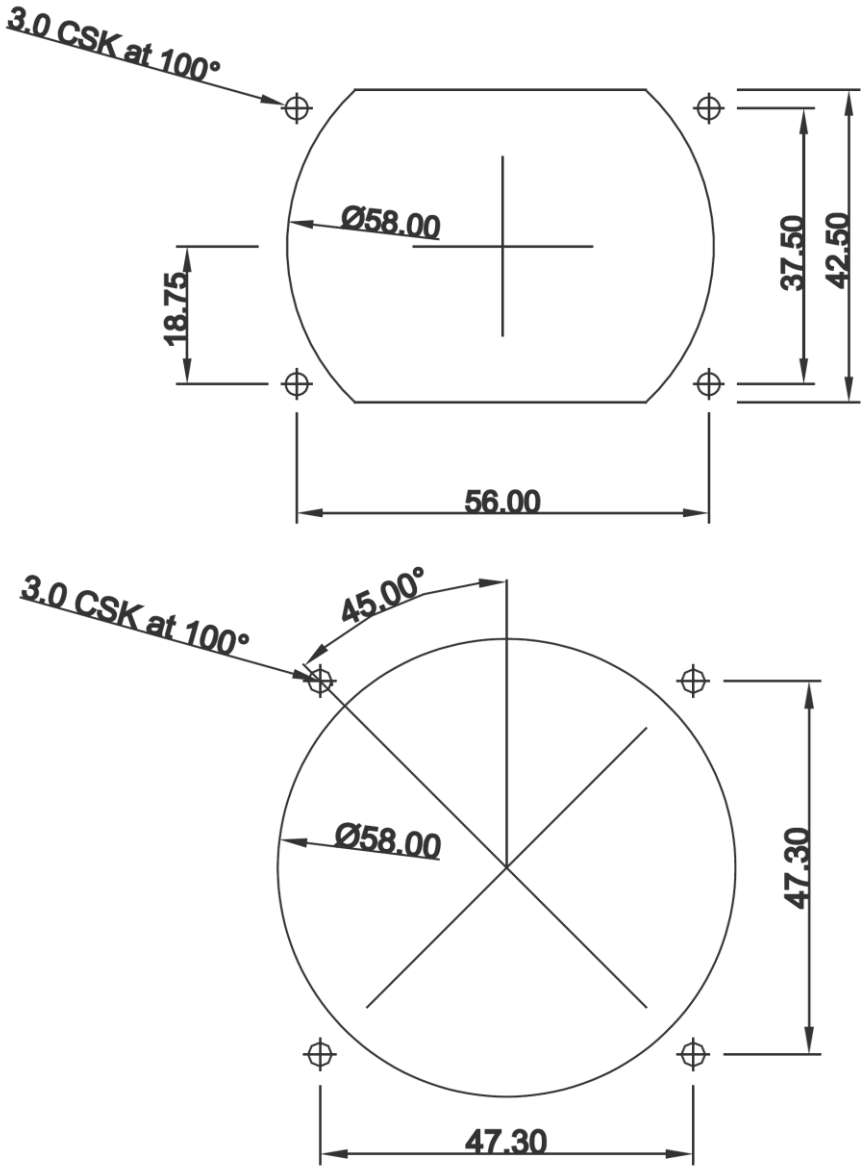
3.5.2 Voltage Conversion in 28 Volt Aircraft

Some existing Mode A/C transponders are 14 Volt only devices. When installed in a 28 Volt aircraft, these transponders will be fitted with a voltage converter. This is typically a passive resistive dropper, but may be an active voltage regulator such as the KA39. The TT21/TT22 will NOT meet the certification low voltage requirements when installed with the dropper resistor in place and the resistor should therefore be removed or bypassed. Active voltage regulators need not be removed.

3.6 Drawings

3.6.1 Front Panel Cut-out

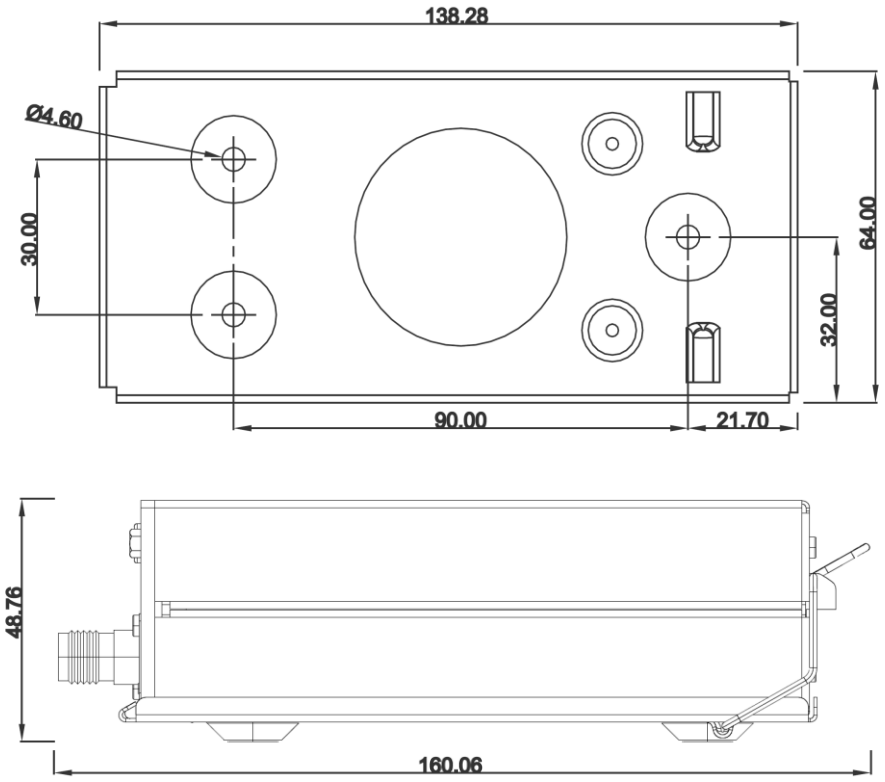
The front panel controller can be fitted to either the compact mounting hole or a conventional 57mm (2¼ inch) instrument cut-out. The compact mounting is a truncated 58 mm opening; please note that the mounting screws are NOT in the same location for the two options.



All dimensions in millimetres. The drawing is not to scale.

(Drawing A)

3.6.2 Mounting tray fixing and overall dimensions



All dimensions in millimetres. The drawing is not to scale

(Drawing B)

3.7 Electrical Load Analysis

Existing Mode A/C transponders draw typically 1.1 Amp from the DC power supply, with currents of up to 1.9 Amp during high activity.

The TT21 draws typically 0.15 Amp from a 14V DC power supply on standby, with currents of around 0.28 Amp during high activity. On 28V supplies the currents are lower.

The TT22 draws typically 0.15 Amp from a 14V DC power supply on standby, with currents of around 0.45 Amp during high activity. On 28V supplies the currents are lower.

If the current taken by the TT21/TT22 is less than that of the transponder it is replacing, any systems that were properly sized to support the previous transponder will be adequate to support the TT21/TT22.

Conversely, if the TT21/22 has higher power requirements than the unit being replaced, the power supply circuitry must be inspected and meet the requirements as per Section 4.

On the same basis, it can be concluded that the 30 minute battery requirement of CAP747 compliance with GR6 will not be adversely affected.

3.8 Testing Details

The test procedure is based on the installation test guidelines in ED-73C, the MOPS for SSR Mode S Transponders.

3.9 Flight manual/POH Amendments

No AFM amendments are required as part of this Minor Change. A pilot operating booklet is provided (reference 00559-00) with the TT21/TT22 and this should be made available to the flight crew.

3.10 Radio Station Licence

Installation of this transponder may require a new or updated aircraft radio licence. For UK registered aircraft the change needs to be reported to the Directorate of Airspace Policy on a Form DAP1902. For other European registered aircraft the relevant national authority should be contacted.

3.11 Mode S Address

Installation of the TT21/TT22 transponder requires allocation of an Airframe Address from the national authority of aircraft registration for the aircraft.

In the case of UK aircraft, Mode S addresses have been allocated to all aircraft, and can be obtained directly from the CAA web site G-INFO database.

4. Accomplishment Instructions

4.1 Equipment and tools required

You will need a Mode S transponder ramp test set, a pitot/static system test set, aircraft aluminium, the TT21/TT22 install kit and standard avionics workshop tooling.

4.2 Preparation

During the installation you will need to program the unique Mode S airframe address into the transponder. Allocation of Mode S addresses comes from the appropriate national authority of aircraft registration; ensure that you have applied for and been issued with a Mode S address before you start.

4.3 Pre-test Existing Installation

This step is optional, but may assist in fault finding if a problem is found later in the process. Pre-testing will not be possible if the reason you are replacing the Mode A/C transponder is because the transponder itself is faulty.

The pre-test activities involve testing the existing installation and noting in particular:

- Transponder receiver sensitivity – Minimum Triggering Level or MTL. The existing transponder MTL should have an MTL between -71 dBm and -77 dBm. Sensitivity below this range may indicate a problem with the antenna or antenna cable, although could also be an indication of a fault in the existing transponder.
- Transponder transmitted power. The existing transponder should provide not less than 125 Watts (Class 1) or 70 Watts (Class 2) at the antenna. Power levels below this may also indicate a problem with the antenna or antenna cable, although could also be an indication of a fault in the existing transponder.
- Altitude indication. Test the altitude indication system, ideally over the service ceiling of the aircraft. A problem with the altitude reporting may indicate a fault icablen the static system of the aircraft or the aircraft altimeter.

If a fault is identified in the pre-testing, you will need to trace the fault cause. If the fault is in the transponder to be replaced, then the upgrade process described here would clear the fault. If the fault is in the existing installation however, upgrading the transponder will not fix it.

4.4 Process

4.4.1 Verify Circuit Breaker Status

Trace and identify the existing transponder circuit breaker. Verify that the circuit breaker is in satisfactory condition and is rated adequately for the wire gauge in use. The recommended minimum value circuit breaker is 3 Amps, to avoid nuisance tripping.

4.4.2 Verify Antenna Status

Trace and identify the existing transponder antenna. The transponder antenna will be a small stub or blade antenna on the bottom of the aircraft. Note that on an aircraft with DME the antenna for the DME will look similar to the transponder antenna; ensure you are looking at the right one. Check the condition of the antenna, including the attachment to the airframe. It is important that the ground plane of the antenna is correctly bonded to the aircraft skin. The antenna should be in a vertical orientation, as clear as possible from other antennae and from airframe obstacles and protrusions, such as landing gear.

4.4.3 Remove Existing Transponder

Remove the existing transponder and mounting tray. If fitted remove the existing altitude encoder, inspect the static line plumbing and retain for reuse.

4.4.4 Inspect Wiring

Inspect the wiring to the interface connector, check general condition and gauge. The power wires should be AWG 22 or heavier; the other signal wires carry only light currents and may be any gauge appropriate to the mechanical environment.

4.4.5 Remove Voltage Converter (28V Only)

If this is a 28 Volt aircraft with a 14 Volt transponder, such as the KT76A, trace the power wire from the transponder connector to determine the method used for voltage conversion. The voltage reduction typically uses a resistive dropper attached to the firewall or other metal aircraft structure. Remove or bypass the resistive dropper; the power supply to the TT21/TT22 must come directly from the 28V aircraft supply.

4.4.6 Replacement of Unit

4.4.6.1 Replace Interface Connector

Before replacing the connector, establish what wires provide power and ground – all other wires should be removed. Manufacture the connectors and wiring looms in accordance with the wiring diagram in section 3.5.1.cable

Aircraft standard wire should be used for the installation. For example, wire that meets MIL-W-22759/1 to 23, 32 to 35 specifications would be acceptable for this installation. Common wire types include MIL-W-22759/34 or Raychem 55 wire.

Care must be taken to ensure surface damage does not occur to the wires during installation and that all wire looms are appropriately secured to prevent damage during its installed life. Ensure the loom does not chafe on any parts of the aircraft or interfere with any moving parts especially if you are using thin walled insulated wire to save on weight, such as MIL-22759/16, 17, 18 or 19.

The power wires should be AWG 22 or heavier; the other signal wires carry only light currents and may be any gauge appropriate to the mechanical environment.

4.4.6.2 Inspect/Replace Antenna Connector

Inspect the antenna connector removed from the previous transponder tray. As most transponders use a blind-mate BNC connector it will be necessary to replace the existing antenna connector with the supplied TNC connector.

4.4.6.3 Manufacture a Panel Plate

Manufacture a suitable panel from aircraft aluminum to blank the existing transponder hole. If the TC20 is going to be installed in the same location as the original transponder manufacture the panel using the compact mounting hole or conventional round instrument cut out. Refer to drawing A in section 3.6.

4.4.6.4 Installing the TC20 controller

Mount the TC20 in a position that the pilot is able to see the screen and operate the unit. The TC20 can be mounted in the ultra compact mounting hole or in a conventional 57mm (2 ¼ inch) instrument cut out; refer to drawing A, in section 3.6. Before completing the installation of the controller, connect the 9 way, D type connector to the rear of the TC20. If the aircraft had an existing altitude encoder, connect the existing static pressure line to the static port on the rear of the TC20. If necessary extend

the static pressure line by using a length of 5mm EPDM rubber tubing. If the aircraft did not have an existing altitude encoder choose a point in the existing static pressure line that is as close as practical to the TC20 mounting location. Cut the static pressure line and use the supplied T fitting with a length of 5mm EPDM rubber tubing supplied in the installation kit to connect to the static pressure port on the rear of the TC20. Install the TC20 IAW the installation manual.

4.4.6.5 TT21/TT22 Transponder Main Unit

Mount the TT21/TT22 to the underside of the flight manual storage box, located on the right of the instrument panel. Secure the mounting tray using the 3 mounting holes in the tray and ensure the tray is supported by the three dimples as well as the three mounting points. Install the transponder in accordance with the installation manual.

4.4.7 Commission Transponder

4.4.7.1 Installation Setup Process

Apply power. The TC20 should light up and – assuming this is the first installation – will automatically start the installation setup process.

Continue with the setup process by entering the Mode S address and other parameters in accordance with the TT21/TT22 Installation Manual.

4.4.7.2 Altitude Encoder Calibration

Using a pitot-static system test set, check and if necessary calibrate the TC20 built in altitude encoder to correspond to the primary altimeter in accordance with the Installation Manual.

4.5 Post-installation Test

4.5.1 Testing Precautions

Before carrying out transponder testing the following measures and precautions should be considered in order to minimise the possibility of causing nuisance warnings to ACAS equipped aircraft.

(1) When not required, ensure all transponders are selected to ‘OFF‘ or ‘Standby‘.

(2) Before starting any test, contact the local Air Traffic Control Unit and advise them of your intention to conduct transponder testing. Advise the Air Traffic Unit of your start time and test duration. Also inform them of the altitude(s) at which you will be testing, your intended Aircraft Identification (Flight Id) and your intended Mode A code.

Note: Certain altitudes may not be possible due to over flying aircraft.

(3) Set the Mode A code to 7776 (or other Mode A code agreed with Air Traffic Control Unit).

Note: The Mode A code 7776 is reserved for SSR ground transponder monitoring. This code may be used for transponder testing after having received agreement from the Air Traffic Control Unit.

(4) Set the Aircraft Identification (Flight Id) with the first 8 characters of the company name. This is the name of the company conducting the tests.

(5) Set the on-the-ground status for all Mode S replies, except when an airborne reply is required (e.g. for altitude testing).

(6) Where possible, perform the testing inside a hangar to take advantage of any shielding properties it may provide.

(7) As a precaution, use antenna transmission covers whether or not testing is performed inside or outside.

(8) When testing the altitude (Mode C or S) parameter, radiate directly into the ramp test set via the prescribed attenuator.

(9) In between testing, i.e., to transition from one altitude to another, select the transponder to 'standby' mode.

(10) If testing transponder parameters other than 'altitude', set altitude to minus 300 m (minus 1 000 feet) or over 18 250 m (60 000 feet). This will minimise the possibility of ACAS warning to airfield and overflying aircraft.

(11) When testing is complete, select the transponder(s) to 'OFF' or 'Standby'.

4.5.2 Equipment Function

Verify that the proper mechanical and electrical connections have been made. Operate each of the controls and verify that each performs the intended function.

4.5.3 Interference Effects

With the transponder powered on, operate each of the other electrically operated aircraft systems to determine that no significant interference effects are present.

4.5.4 Leak Test

To ensure the installation of the TC20 Controller has not had an adverse effect on the primary altimeter or existing static system, an aircraft pitot/static system sense and leak test must be carried out.

4.5.5 Ramp Test

Using the transponder ramp test set, verify the following parameters. Note that actual procedures may vary according to the test set specific operating instructions; many test sets will execute the tests listed here in a semi-automated sequence, and will report the answers directly or as a Pass/Fail indication.

The following parameters are required to be tested to comply with EU Reg 1207/2011 Annex 2 Part A.

4.5.5.1 Mode A code

Ensure the Mode A squawk code reported on the test set matches the code displayed on the TC20 controller.

4.5.5.2 Pressure Altitude Transmission

Verify using the pitot/static system test set that altitudes are correctly reported by the transponder. Use at least 10 test points and verify that the altitude reported is within ± 25 feet of the supplied altitude.

NOTE: Precautions must be taken during altitude reporting tests to prevent nuisance ACAS Traffic Advisories and ACAS Resolution Advisories to aircraft flying in the area.

4.5.5.3 On-the-ground status

If squat switch input on the transponder has been connected ensure the reported air ground status on the test set indicates the correct air or ground status.

If there is no squat switch input, ensure the test set always reports airborne.

NOTE: Physically turning the TC20 controller mode knob to the GND position will not

change the air/ground status in a Mode S transmission. The GND mode on the TC20 is only used to inhibit replies to Mode A/C interrogations.

4.5.5.4 Aircraft Identification

Interrogate the transponder with UF=4 or 5, and correct address, with RR=18. Verify that the equipment correctly reports the aircraft call sign in the MB field of the reply.

4.5.5.5 Special Position Identification (SPI)

Ensure the test set indicates the SPI or IDENT is active when the ID button is pressed on the TC20, the SPI pulse should be active for 18 seconds.

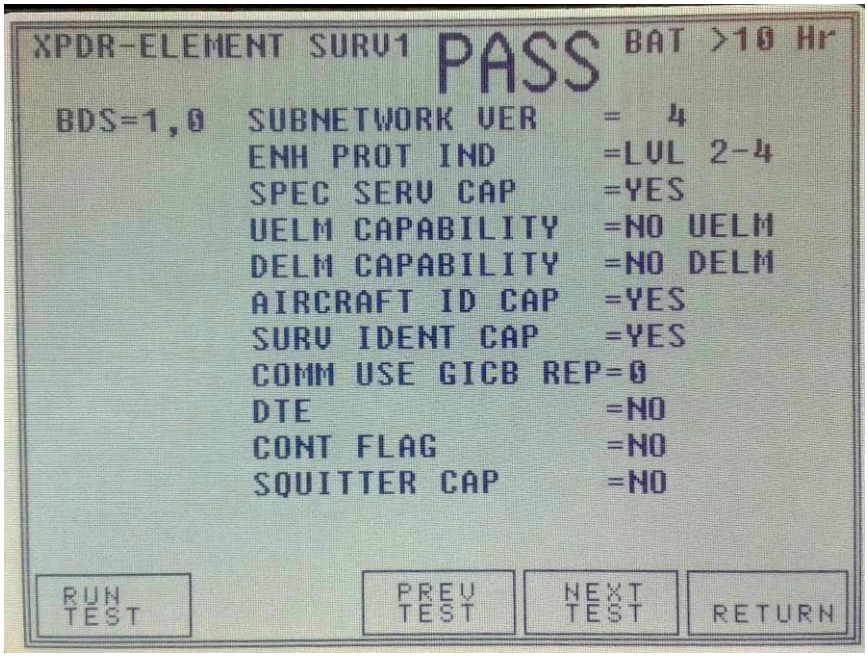
If an external ident switch has been installed then this should also be tested.

4.5.5.6 Data link Capability report

Check the capability report indicates the following:

- Airborne collision avoidance system (ACAS) capability = Not Capable
- Mode S specific services capability = Capable
- Squitter capability = Not Capable
- Surveillance identifier capability = Capable
- Common usage Ground initiated Comms –B = Capable
- Mode S sub network version number = Capable

An example of an IFR6000 test set displaying datalink capability is shown below:



4.5.5.7 Common Usage GICB Capability Report

Ensure the transponder can transmit a Common Usage GICB Report.

This will normally = 0 as the TT21/22 is strictly an ELS transponder but it can change if the ADS-B functionality is enabled. This test is just to ensure the transponder is capable of populating this field.

4.5.5.8 ICAO 24-bit Address

Ensure the test set display the correct 24-bit ICAO address (Mode S address)

4.5.5.9 Receiver Sensitivity

Verify that for Mode A/C interrogations the receiver sensitivity of the transponder at the antenna is -73 dBm ± 4 dB.

Verify that for Mode S interrogations the sensitivity of the transponder at the antenna is -74 dBm, ±3dB.

4.5.5.10 Transmitter Power Output

Verify that the TT22 transponder has a peak pulse power at the antenna of at least +21 dBW (125 Watts). Verify that the TT21 transponder has a peak pulse power at the antenna of at least +18.5 dBW (71 Watts).

4.5.5.11 Airspeed Fixed Field

Interrogate the transponder to confirm the maximum airspeed reported is correctly set.

4.5.5.12 Reply Frequency

Verify that the reply frequency is 1090 ± 1 MHz.

4.5.5.13 Emergency Status

Verify the Mode S test indicates the correct emergency status according to the Mode A code selected:

- Code 7700 = Emergency Code
- Code 7500 = Hijack Code
- Code 7600 = Loss of Communication

5. CS-23 Compliance table

This table refers only to the applicable specifications of CS-23 that are affected by this Minor Change.

CS 23 Amdt 3 Para	Requirement	Compliance	References
23.1301 (a)	Installed equipment to be of a design appropriate to its intended function.	TT21/TT22 is approved under ETSO C112c. Review of certification basis in DDP completed.	TT21 DDP. TT22 DDP. TC20 DDP.
23.1301 (b)	Be labeled as to its identification, function or operating limitations.	All controls are adequately labeled. No limitations are recorded. ETSO compliance is shown on the product identification label.	TT21/TT22 Installation Manual.
23.1301 (c)	Be installed according to specified limitations	Review of environmental testing, deviations and limitations in DDP completed.	TT21 DDP. TT22 DDP. TC20 DDP.
23.1301 (d)	Function properly when installed.	System tested by ground tests on completion	Section 4.5 of accomplishment instructions
23.1309 (a. 1,2)	System must not adversely affect existing systems	The TT21/22 does not interface with and is physically separate from other aircraft systems. TT21/TT22 system integrity is commensurate with a minor failure condition and unit failure does not affect the correct function of other existing systems. EMI tests carried out post-installation.	Section 3.5, Wiring Diagram. Section 4.5.2 of accomplishment instructions.
CS 23.1325 (a,b)	Static Pressure System	This minor change uses the existing static pressure system. The TC20 connects directly to the static pressure system using rubber tubing, which will not compromise the integrity of the static pressure system.	Section 4.4.6.4 Installing the TC20 Controller DEV/TT21/005
23.1351(a)	Electrical system capacity	In accordance with Section 4, existing circuit breaker may be used, supplying nominal 0.45A load. Wire gauge 22 appropriate. Battery endurance is not adversely affected.	TT21/TT22 Installation Manual.

23.1357	Circuit Protective Devices	Existing circuit breaker used - inspected as part of this Minor Change.	Section 4.4.1 of accomplishment instructions.
23.1365	Electric Cables and Equipment	Wire which meets MIL-W-22759/1 to 23, 32 to 35 specifications is used. The power wires should be AWG 22 or heavier.	Section 4.4.6.1 Replace Interface Connector
23.1431(a)	Environmental conditions must be considered.	Section 3.4.3, review of environmental testing.	TT21 DDP. TT22 DDP.
23.1431(b)	Not adversely affect simultaneous operation of other radio or electronic systems or units.	EMI tests carried out post-installation.	Section 4.5.2 of accomplishment instructions.
23.1529	Instructions for Continued Airworthiness	Other than for periodic functional checks required by the maintenance program, the TT21/TT22 Mode S transponder has been designed and manufactured to allow "on condition maintenance". This means that Trig do not enforce any periodic service or maintenance requirements necessary to maintain continued airworthiness; no maintenance is required until the equipment does not properly perform its intended function. However, this does not take precedence over certain EU regulations which are applicable to some operators such as Commission Regulation (EU) No 1207/2011.	Section 3.3 Continued Airworthiness Instructions. Appendix 1, section 4.
23.1581	General	The TT21/22 Operating Manual will be used to supplement the existing flight manual, in conjunction with the Flight Manual Supplement SUP/TT2X/010.	TT21/22 Operating Manual. Flight Manual Supplement SUP/TT2X/010
23.1585 (j)	Operating Procedures	Safe operation of the TT21/22 is explained in the Operating Manual, including how to set an emergency code.	TT21/22 Operating Manual. Flight Manual Supplement SUP/TT2X/010
CAP747, GR6	Battery duration not less than 30 minutes	In accordance with Section 3.7, it is insured that new equipment does not adversely affect battery endurance.	TT21/TT22 Installation Manual.

6. CS-ACNS Compliance Table

The TT21/22 is a Mode S ELS transponder and therefore does not need to comply with CS.ACNS.S.AC (Mode A/C only Surveillance) or CS.ACNS.D.EHS (Mode S Enhanced Surveillance). ADS-B Extended Squitter is also beyond the scope of the Minor Change and does not show compliance against CS.ACNS.D.ADSB (1090 MHz Extended Squitter ADS-B Out).

A transponder installation carried out in accordance with this Minor Change will meet the requirements of CS.ACNS.D.ELS – Mode S Elementary Surveillance. The following table demonstrates compliance against CS.ACNS.D.ELS.

CS-ACNS Section 2 Ref	Part	Compliant	Means of Compliance	Reference
GENERAL				
CS ACNS.D.ELS.001 **Applicability**		YES	The TT21 and TT22 are Mode S Elementary Surveillance transponders.	TT2X Install Manual
SYSTEM FUNCTIONAL REQUIREMENTS				
CS ACNS.D.ELS.010 **Transponder characteristics**	(a)	YES	1. The TT21/22 hold ETSO-C112c 2. The TT21/22 is a Level 2 transponder 3. The TT21/22 has the SI code capability and indicates ‘s’ in the transponder capability. 4. The TT21/22has Elementary Surveillance functionality and indicates ‘l’ in the transponder capability. 5. The TT21/22does not have ACAS compatibility	TT21 DDP TT22 DDP
	(b)	N/A	This installation does not have ACAS II installed	N/A
	(c), (d)	YES	The TT21 has a nominal power output of 125 Watts, and meets the power output requirements for Class 2. The TT22 has a nominal power output of 250 watts, and meets the power output requirements for Class 1 Both the TT21 and TT22 will be suitable for aircraft operating below 15000 feet or a have max cruise speed of less than 175 knots.	TT21 DDP TT22 DDP
CS ACNS.D.ELS.015 **Data transmission**	(a)	YES	The TT21/22 is certified to ETSO-C112c and by virtue of this ETSO they meet all the requirements of an ELS transponder. These will be verified during ground tests specified in section 4.5 of this document. The relevant section of this document is identified below each requirement statement.	TT2X Install Manual

	(a) 1	YES	The Mode A Code ranges from 0000 to 7777 (octal). The Mode A code can be changed using the TC20 controller. Tested in section 4.5.4.1	TT21/22 Operating Manual
	(a) 2	YES	The TC20 controller will be used which has an integrated altitude encoder. This transmits the pressure altitude data in 25ft increments. The consistency of the altitude reported in Mode C and Mode S is checked during ground tests. Tested in section 4.5.4.2	TT21 DDP TT22 DDP
	(a) 3	YES	On the ground status information is populated in FS field DF20/21. Tested in section 4.5.4.3	Section 4.5
	(a) 4	YES	The aircraft identification is populated into the Mode S transmission. The aircraft ID is programmed on initial installation and can be changed during normal operation using the TC20 controller. Tested in section 4.5.4.4	Section 4.5
	(a) 5	YES	The SPI will be reported by the TT21/22 system if the IDENT button is pressed on the TC20 controller. This will last for 18 seconds. Tested in section 4.5.4.5	Section 4.5
	(a) 6	YES	The Emergency status will be reported when the appropriate emergency squawk code is dialled into the TC20 controller Tested in section 4.5.4.13	Section 4.5
	(a) 7	YES	The capability report will be transmitted in the CA field of the transponder transmission. Tested in section 4.5.4.6	Section 4.5

	(a) 8	YES	This Minor Change uses the TT21/22 strictly as an ELS transponder and will therefore set the BDS $17_{16} = 0$. This Minor Change does not cover the extended squitter (ADS-B) functionality of the transponder. Tested in section 4.5.4.7	Section 4.5
	(a) 9	YES	The ICAO 24 bit address is reported and is programmed in to the TC20 controller during the initial setup. This cannot be altered during normal operation. Tested in section 4.5.4.8	Section 4.5
	(a) 10	N/A	No ACAS II installed.	N/A
CS ACNS.D.ELS.015 **Data transmission**	(b) 1	N/A	The TT21/22 system is not an EHS transponder	N/A
	(b) 2	N/A	This Minor Change does not include the TT21/22 does not have the ADS-B functionality	N/A
CS ACNS.D.ELS.020 **On-the-ground status determination**	(a)	YES	The on-the-ground status can only be set using the squat switch input of the transponder. The transponder will not have access to additional parameters and therefore will always believe any squat switch input. Selecting GND mode on the TC20 controller does not set the Mode S on-the-ground status.	TT2X Install Manual
	(b)	YES	If the squat switch input is not connected then the on-the-ground status always defaults to airborne.	TT2X Install Manual
CS ACNS.D.ELS.025 **Altitude source**	(a)	YES	The pressure altitude source is from the TC20 integrated altitude encoder which is certified to ETSO-C88a	TT2X Install Manual
	(b)	YES	The altitude resolution is reported in 25ft increments	TT21 DDP TT22 DDP

	(c)	YES	The TC20 altitude encoder is connected to the same static tubing as the aircraft altimeter. There is an altitude repeater output from the TC20 to feed the pressure altitude to other aircraft systems if required.	TT2X Install Manual
CS ACNS.D.ELS.030 **Flight deck interface**			The TT21/22 system will be installed in accordance with section 4.4.6 of this document to ensure it meets the Flight Deck Interface requirements.	Section 4.4.6
	(a) 1	YES	The TC20 controller has a code selector knob which allows the operator to select the Mode A code	TT2X Install Manual
	(a) 2	YES	The TC20 controller has an ID button which initiates the IDENT feature for 18 seconds	TT2X Install Manual
	(a) 3	YES	The TC20 allows the pilot to change the aircraft identification during normal operation	TT2X Install Manual
	(a) 4	YES	The TC20 display will show dashed lines "---" adjacent to the flight level readout if pressure altitude is inhibited. Pressure altitude reporting can be suppressed by turning the mode switch to ON	TT2X Install Manual
	(a) 5	YES	The TC20 mode switch will allow the transponder to be switched into OFF or Standby modes. In standby the transponder will power up but not reply to any interrogations or transmit any Mode S squitters.	TT2X Install Manual
	(a) 6	YES	The TC20 will automatically display a warning or fault on the TC20 display if the TT21/22 system detects a failure.	TT2X Install Manual
	(a) 7	YES	The TC20 will display the Mode A code	TT2X Install Manual
	(a) 8	YES	The TC20 will display the aircraft identification	TT2X Install Manual
	(b)	YES	Data which is not intended to be altered in flight cannot be changed by the operator during normal operation of the transponder. This data such as ICAO address, aircraft category, max airspeed, etc is input during the initial installation.	TT2X Install Manual

SYSTEM PERFORMANCE REQUIREMENTS				
CS ACNS.D.ELS.040 **Integrity**		YES	A system safety analysis of the TT21 and TT22 has been carried out and the TT21/TT22 system integrity is commensurate with a minor failure condition.	DEV/TT21/005
CS ACNS.D.ELS.045 **Continuity**		YES	The TT21/TT22 system installation continuity is designed to an allowable qualitative probability of 'remote' The TT21/22 transponder, altitude source (TC20) and antenna being utilised are (E)TSO certified and the whole system is powered from the main aircraft power supply bus. Any additional wiring which may be required has been specified in section 4 and uses simple/direct wiring interfaces consistent with the existing aircraft wiring.	Section 4
INSTALLATION REQUIREMENTS				
CS ACNS.D.ELS.050 **Dual/multiple transponder installation**		N/A	Only one transponder is installed	N/A
CS ACNS.D.ELS.055 **ICAO 24-bit Aircraft address**		YES	The 24 bit ICAO address will be programmed into the TC20 during setup. The Mode S address will be verified during ground testing.	TT2X Install Manual
CS ACNS.D.ELS.060 **Antenna installation**	(a)	YES	This installation will utilise the existing antenna and antenna location.	TT2X Install Manual
CS ACNS.D.ELS.065 **Antenna diversity**		N/A	This aircraft does not require antenna diversity	N/A

7. Appendix 1

TT21/TT22 Instructions for Continued Airworthiness

1. Description

This document describes the necessary maintenance requirements and instructions necessary to ensure the continued airworthiness of the aircraft following the embodiment of the Minor Change to add the TT21/TT22 Transponder system.

2. Operation

Operating instructions for the Trig Avionics TT21/TT22 Mode S Transponder are detailed in the following documents;

- 00559-00 Operating Manual
- 00560-00 Installation Manual section Normal Operation

3. Servicing

There are no periodic service requirements necessary to maintain continued airworthiness of the TT21/TT22 Transponder.

4. Maintenance Instructions

Trig do not enforce any periodic maintenance requirements in order to maintain continued airworthiness of the TT21/TT22 Transponder.

For operators who must comply with the Commission Regulation (EU) No 1207/2011, of 22 November 2011, article 7, point 2 the transponder should be checked at least every two years.

Transponder tests are detailed in Minor Change Instructions SUP/TT2X/009 Section 4.5. When carrying out tests, ensure the precautions also listed in SUP/TT2X/009 Section 4.5 are taken into consideration to avoid nuisance transmissions to ACAS equipped aircraft.

5. Install and Removal Instructions

Please refer to Trig Avionics TT21/TT22 Installation Manual;

- 00560-00 Installation Manual section Installation

6. Required Tools and Test Equipment

- Mode S Transponder Test Set
- Pitot-Static Test Set

7. Airworthiness Limitations

There are no Airworthiness Limitations applicable to the Trig Avionics Minor Change to install a TT21/TT22 Mode S Transponder.