TIS-B Transceiver

System Requirements Document

V0.2D

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Approval

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V0.2D	_____

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1 Introduction

This document defines the System Requirements for the development of a TIS-B (Traffic Information Service – Broadcast) surveillance system. These System Requirements build on the ADS-B (Automatic Dependant Surveillance – Broadcast) requirements contained in Reference 6. The TIS-B capability is incorporated into the already existing ADS-B Quadrant System.

The goal of the project is to develop a surveillance concept based around a low cost to manufacture, 1090MHz receiver/transmitter.

This initiative recognises the move towards universal equipage of Mode S on aircraft across all aviation communities, including General Aviation and the military, as an institutional change that offers an opportunity for new surveillance techniques.

Given the evolution of aircraft equipage, the requirement is also based on the evidence of the emergence of the global use of ADS-B and future capability of multilateration, rather than in response to an individual user requirement.

Single Statement of User Need

Provision of timely, reliable and accurate positional and supplementary information with regards to targets of interest.

1.1 Users Background

Possible Users of the system shall include Air Navigation Service Providers, Military Organisations (Air Force & Navy), Airports and Fleet operators.

- ANSP shall need Air Situation and Positional Information of cooperative aircraft. This information may be used for safety related purposes.
- Military organisations shall need Air Situation and Positional Information of cooperative aircraft. This information may be used for safety related purposes.
- Airports shall need positional information of ground targets which shall be fed into A-SMGCS. This information may be used for safety related purposes.
- Airports shall require positional information for logistics and business efficiency purposes.
- Fleet operators (including oil rigs) shall require positional information for logistics and business efficiency purposes.

Users may obtain the service through self-managed infrastructure or through network service providers.

All users will require sufficient System Monitoring providing information on the health of the system, and control of the ability to configure the system.

ADS-B Overview

The increasing air traffic volume in most areas of the world has lead to a strong development push for advanced Air Traffic Control technology. As part of this, new types of sensors have been introduced, in particular the Mode S radar sensors and the ADS-B (Automatic Dependent Surveillance-Broadcast) surveillance technology.

ADS-B is based on the aircraft on-board capability to derive a geographical position from positioning systems such as GPS. This positional information together with other flight attributes like speed or heading is broadcast by means of ADS-B messages to other aircraft (air-to-air) and to ADS-B ground stations (air-to-ground).

On the ground the ADS-B data together with conventional data are consolidated by means of a SDPS (surveillance data processing system) and presented to air traffic controllers.

As part of an effort to produce a better situational awareness for airline pilots, the TIS-B approach aims at upgrading aircraft with equipment that permit to have an on-board view of the aircraft's neighbourhood. For this purpose it is proposed to equip every ADS-B capable airplane with a so-called CDTI (cockpit display of travel information) displaying an accurate picture of the direct surrounding of an in-flight aircraft.

While some of the aircraft surrounding can be viewed taking into account the ADS-B air-to-air messages, the CDTI is blind for any type of non-ADS-B aircraft. For this reason, it is proposed to establish a TIS-B (Traffic Information System – Broadcast) uplink that completes the air situation picture for the cockpit display ("gap filler scenario").

While the TIS-B server is the central coordinating instance of this gap filling protocol, the TIS-B Transmitter handles the input from the TIS-B Server and generates the ADS-B signal.

The TIS-B Transmitter will eventually be integrated in the Quadrant Transceiver.

1.2 Timing Diagram

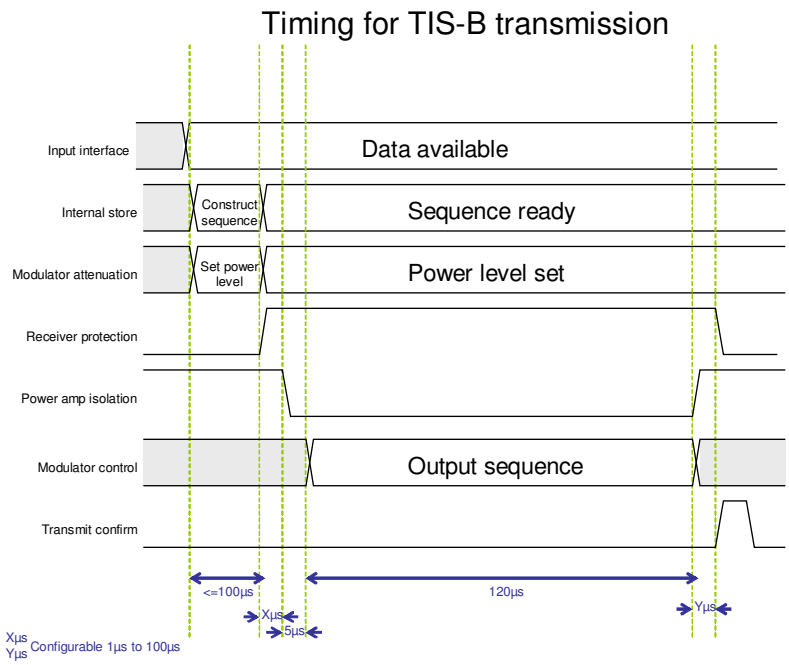

Figure 1: Timing for TIS-B Transmission

1.3 Scope of System Requirement

The scope of the system for the purposes of this document is the transceiver

Requirements for an extended system which would permit multiple sensors to perform a multilateration function through a central processing function are outside the scope of this document.

2 Layout of System Requirements

The System Requirements are set out in the following table. The column headings are explained below:

- URD Link Associated User Requirement.
- SRD ID Uniquely identifies each System Requirement, regardless of its position in the hierarchy. The ID cannot change through the life of the SRD.
- System Requirement The definition of the System Requirement.
- Validation Method to verify Requirement (e.g. Certification, Inspection, Demonstration, Analysis and Test).
- Notes. Any points of interest affecting the requirement.
- Status. To record System Requirement status: Compliant / Non-Compliant.
- Priority. Requirement Priority as defined below.

Table 1: Priority of requirements

KSR	Key System Requirement - assessed as key to the achievement of the mission need, or for some other reason assessed as of particular interest to management (e.g. ISD). A KSR cannot be traded without approval from the CCB.
M	Mandatory Requirement – dictated by law, regulation, convention, international treaty etc. Cannot be traded.
P1	High priority Requirement assessed as very important to the User's need. Will only trade if technically unachievable or to avoid unacceptable time/cost impacts. A P1 System Requirement cannot be traded without approval from the CCB.
P2	Medium priority Requirement (an important, but not fundamental, item). Will trade if too technically challenging (risky); may trade for significant time/cost advantage. A P2 System Requirement cannot be traded without approval from the CCB.
P3	Low priority Requirement (a 'nice to have' item). May be willing to trade for any performance/time/cost advantage. A P3 System Requirement cannot be traded without approval from the CCB.

3 Key/Mandatory System Requirements

URD Link	SRD ID	System Requirement	Validation	Notes	Status	Priority
	SR239	The system shall provide a 1090MHz output compliant with ICAO Annex 10 Volume IV Section 3.1.2.2. and EUROCAE MOPS for Secondary Surveillance Radar Mode S Transponders, ED-73B		This requirement will cascade to the Power Amplifier which may also introduce out-of-band interference.		KSR
	SR245	The system shall accept TIS-B payload messages from an external TIS-B server via Ethernet connection.		Preference for UDP for better timing. Multiple messages (sequences) can be included in a single UDP packet.		KSR
	SR253	The systems shall ensure that, when not transmitting, its own receiver is isolated from any internal 1090MHz signals to –90dBm				M
	SR268	The system shall comply with EMC standards EN301-489-1 30 and EN301-489-22 31		Standards to be confirmed		M
	SR269	The user requires that the capability comply with all EU regulations current at time of deployment		The standards will be identified in the certificate of conformity		M
	SR270	The system shall be provided with a safety argument sufficient to be integrated into a safety case				M

4 System Requirements

URD Link	SRD ID	System Requirement	Validation	Notes	Status	Priority
		4.1 Effective Deployment				
		Intended Life				
		The system shall have an In-Service life of no less than 10 years				P1
		Environment (Non-Operating)				
		Identical to Quadrant System (see 6)				P3
		Environment (Operating)				
		Identical to Quadrant System Indoor unit (see 6)				P1
		Interfaces / Interoperability				
	SR239	The system shall provide a 1090MHz output compliant with ICAO Annex 10 Volume IV Section 3.1.2.2. and EUROCAE MOPS for Secondary Surveillance Radar Mode S Transponders, ED-73B		This requirement will cascade to the Power Amplifier which may also introduce out-of-band interference.		KSR
	SR240	The output power shall be configurable for each output message when provided with an “Output Power” parameter associated with the message payload.				P1
	SR241	The system shall provide a 5V pull-up 120mA signal as an output to act as a		Assumes that the Power Amplifier is able to isolate its output stage to		P1

URD Link	SRD ID	System Requirement	Validation	Notes	Status	Priority
		transmit suppression for control of an external power amplifier.		-90dBm in response to the suppression signal.		
	SR242	The system shall provide a 5V pull-up 120mA signal as an output to act as driver for receiver protection of multiple external receiver units.		Capability to operate multiple suppression devices to provide receiver protection for remote receivers on a local site.		P1
	SR243	The system shall provide a minimum of three 5V pull-up 120mA signals as output to act as drivers for antenna switching.		Used where sectorised TIS-B deployment is required.		P1
	SR244	The antenna switching lines shall be driven in accordance with TBD when provided with an “Antenna Identifier” parameter associated with the message payload.		Used where sectorised TIS-B deployment is required. Line selection matrix and timing are TBD.		P1
	SR245	The system shall accept TIS-B payload messages from an external TIS-B server via Ethernet connection.		Preference for UDP for better timing. Multiple messages (sequences) can be included in a single UDP packet.		KSR
	SR246	In an overload condition the system shall drop arbitrary messages from the transmission sequence.				P1
	SR247	The system shall inform the external TIS-B server of an overload condition.				P1
	SR248	The system shall provide information on operational status of the TIS-B transmission to the TIS-B server.		*Overload conditions etc.*		P1
		System Security				
	SR87	The system shall be configurable to allow access to surveillance functions by allowing				P2

URD Link	SRD ID	System Requirement	Validation	Notes	Status	Priority
		connections from specific IP addresses only				
	SR88	The system shall support configuration of allowed IP addresses through the maintenance function				P2
	SR89	The system shall support enabling and disabling access control for surveillance functions through the maintenance function		With reference to access control requirement outlined in SR87		P3
	SR90	The system shall provide authorised access only to maintenance functions by the use of Username and Password		The maintenance function and SNMP interface are different ways to interact with the system		P1
	SR91	The system shall support configuration of usernames and passwords via the maintenance function				P2
		Functions				
	SR249	The output power shall be configurable in 12 steps of 1dB over a range of dB.				P1
	SR250	The transmit suppression signal shall be removed 5µs ahead of commencing a TIS-B transmission.		*See Figure 1: Timing for TIS-B Transmission*		P1
	SR251	The transmit suppression signal shall be applied immediately at completion of a TIS-B transmission.		*See Figure 1: Timing for TIS-B Transmission*		P1
	SR252	The system shall ensure that its own receiver is protected from damage during transmission.				P1
	SR253	The systems shall ensure that, when not transmitting, its own receiver is isolated from any internal 1090MHz signals to –90dBm				M

URD Link	SRD ID	System Requirement	Validation	Notes	Status	Priority
	SR254	The system shall support the scheduled transmission of payload when provided with a ”Time of Applicability” parameter associated with the payload message.		*This is an enhancement of the “TIS-B primitive mode” that will allow a greater control over the precision of TIS-B scheduling.*		P1
		Capabilities				
	SR255	The maximum power of the 1090MHz output shall be not less than +7dBm at the output connection.		This will provide a transmit capability of +53dBm (200W) with the minimum requirement power amplifier.		P1
	SR256	The maximum power of the 1090MHz output shall be not less than +12dBm at the output connection.		This will provide a transmit capability of +60dBm (1000W) with the minimum requirement power amplifier.		P2
	SR257	The system shall initiate a 1090MHz TIS-B transmission within 100ms of accepting a TIS-B payload from the TIS-B server.		This is “TIS-B primitive mode” and is comparable to the ADS-B mode whereby basic ADS-B payload from the decoder is forwarded to the external comms interface.		P1
	SR258	When provided with a “Time of Applicability” the system shall schedule message transmission with a precision of 10 microseconds.		*The accuracy of delivery time is governed by the accuracy of the clock, whether this be NTP or GPS synchronised.*		P2
	SR259	When provided with a message requiring immediate transmission, the delay between accepting TIS-B payload and commencement of TIS-B transmission shall not exceed 50ms (95%)		*Limit on latency.*		P2
	SR260	When provided with a message requiring immediate transmission, the variability of delay between accepting TIS-B payload and		*Limit on variability. Uncertain what is feasible here but the lower the variability the more accurate the*		P2

URD Link	SRD ID	System Requirement	Validation	Notes	Status	Priority
		commencement of TIS-B transmission shall not exceed 10ms (95%)		*control of the server over TIS-B scheduling. <=1ms would be adequate, >10ms would probably be a problem.*		
	SR261	The system design shall foresee the performance of a full TIS-B scheduling function using data provided in ASTERIX from the external communication interface.		*This is "TIS-B server mode". Implementation of this mode is not foreseen in the initial development but should not be precluded by the design.*		P3
	SR262	The system shall be capable of handling up to 1000 TIS-B messages per second in the absence of any other activity.		*If the system is required to run at maximum TIS-B rate it is probable that it will operate as a dedicated TIS-B device and not be required to perform the ADS-B receiver function also.*		P1
	SR263	A minimum interval between consecutive transmissions (start-to-start) shall be assured at a value between 120µs and 2000µs, configurable in steps of 10 µs through the control and monitoring interface.		*This is because an external TIS-B server cannot guarantee delivery rates.*		P2
	SR264	When performing a contiguous TIS-B sequence, the PA suppression and rx-protection signals shall not be removed between messages.		*With reference to the timing diagram, contiguous means new "Data available" before "Output sequence" has completed.* *This requirement allows sequencing with minimum delay between messages (burst mode).*		P3
		Statutory Regulations				

URD Link	SRD ID	System Requirement	Validation	Notes	Status	Priority
	SR268	The system shall comply with EMC standards EN301-489-1 30 and EN301-489-22 31		Standards to be confirmed		M
	SR269	The user requires that the capability comply with all EU regulations current at time of deployment		The standards will be identified in the certificate of conformity		M
	SR270	The system shall be provided with a safety argument sufficient to be integrated into a safety case				M
		4.2 Deployment and Mobility				
		Power Requirements				
		Setup Requirements				
	SR265	The output power shall be configurable via the control and monitoring interface.		This is an installation parameter that is unlikely to change frequently during normal operating life.		P2
	SR266	The receiver protection signal shall operate ahead of commencing a TIS-B transmission by a period between 5µs and 100µs in steps of 1µs, configurable through the control and monitoring interface.		*This is an installation parameter that is unlikely to change frequently during normal operating life (see Figure 1: Timing for TIS-B Transmission).*		P3
	SR267	The receiver protection signal shall be removed after completion of a TIS-B transmission by a period between 1µs and 100µs in steps of 1µs, configurable through		*This is an installation parameter that is unlikely to change frequently during normal operating life (see Figure 1: Timing for TIS-B*		P3

URD Link	SRD ID	System Requirement	Validation	Notes	Status	Priority
		the control and monitoring interface.		*Transmission).*		
		Transportability				
UR49	SR172	The system shall be packaged in two boxes when shipped from the factory, excluding cables				P3
UR50	SR173	The packaging of the sensor and GPS shall not exceed 500wx500hx500d mm		Per box		P3
UR50	SR174	The weight of the sensor and GPS as packaged shall not exceed 15Kg		Both boxes combined		P3
UR50	SR175	The packaging of the reference antenna shall not exceed 1600x100x100mm		The specification of different sized antenna by the user is not precluded.		P3
UR50	SR176	The weight of the reference antenna as packaged shall not exceed 5Kg		The specification of different sized antenna by the user is not precluded.		P3
UR51, UR52, UR53	SR177	Suitable packaging is to be provided to enable the system to be transported by a commercial parcel service. This includes transportation worldwide.		Packaging as defined “suitable” by carrier		P1
		4.3 Sustainability and Logistics				
		Availability, Reliability, Maintainability and Testability				
UR55	SR180	The sensor component should provide an availability of at least 99.999%		Benign environment		P2
UR56	SR181	The sensor component should provide a hardware MTBF of 50,000 hours				P2
UR57	SR182	The system shall not require any preventative maintenance for proper				P2

URD Link	SRD ID	System Requirement	Validation	Notes	Status	Priority
		operation				
		The system shall comprise of the following LRUs:				
UR58	SR183	- Sensor component				P3
UR58	SR184	- 1090Mhz Antenna				P3
UR58	SR185	- Optional Antenna Mast Head Amplifier		Question: What about the optional weather protection shield?		P3
UR58	SR186	- Optional GPS Receiver				P3
UR59	SR187	The system shall provide an MTTR of 30 minutes for an LRU				P3
UR60	SR188	The system shall provide the capability to perform firmware updates via the Maintenance Function		Note, The system may disable normal operations when firmware updates are being performed		P2
UR61	SR189	The system shall be supported by a Logistics support solution.				P1

5 Glossary

A-SMGCS	Advanced Surface Movement Guidance and Control System
ADS-B	Automatic Dependent Surveillance – Broadcast
CBIT	Continuous Built-In Test
CPU	Central Processing Unit
CRC	Cyclical Redundancy Check(ing)
DSP	Digital Signal Processor
EMC	Electro Magnetic Compatibility
EMI	Electro Magnetic Interference
EU	European Union
FPGA	Field Programmable Gate-Array
GPS	Global Positioning System
ICAO	International Civil Aviation Organization
ICMP	Internet Control Message Protocol
MIB	Management Information Base
NTP	Network Time Protocol
POST	Power-On Self Test
RTCA	Radio Technical Commission for Aeronautics
SNMP	Simple Network Management Protocol
TIS-B	Traffic Information Service - Broadcast
UDP	User Datagram Protocol
TCP/IP	Transmission Control Protocol/Internet Protocol

6 References / Bibliography

[1] Quadrant Sensor User Requirements Document (URD)
[2] Quadrant Sensor System Requirements Document (SRD)

