TEST REPORT

Intermap Technologies Radar System
(Synthetic Aperture Radar for Airborne Mapping)
For Operation under Part 90, Subpart F, Radiolocation Service

Measurement of Operating Characteristics as Required per 47 CFR 2.1033(c)(14)

Testing and compilation of this test report was performed by:

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Intermap Technologies

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1 Company Information

Company Name:	Intermap Technologies Inc.
Address:	8310 South Valley Highway, Suite 400 Englewood Colorado, USA 80112-5812
Contact Name:	Mark Frank, VP, Acquisitions Operations & Engineering

2 Equipment Under Test (EUT)

2.1 Identification of Equipment Under Test (EUT)

2.1.1 Active components

Description:	Power Distribution Unit (PWRDIST)
Manufacturer:	Intermap Technologies
Model :	PWRDIST01
Serial Number:	03
Country of Manufacture:	Germany

Description:	Receiver / Exciter Module (RCVEX)
Manufacturer:	Intermap Technologies
Model :	RCVEX01
Serial Number:	01
Country of Manufacture:	Germany

Description:	X-Band High Power Transmitter (XTRANS)
Manufacturer:	dB Control
Model :	dB-3710 C
Serial Number:	102
Country of Manufacture:	USA

Description:	Wave Guide Assembly Module (WGASS)
Manufacturer:	Intermap Technologies
Model :	WGASS01
Serial Number:	01
Country of Manufacture:	Germany

Note: Intermap seeks equipment certification for this transmitter, which is used in Intermap's radar systems STAR-3, STAR-4, STAR-5 and STAR-6. The only difference in these systems is the antenna. As this is a Part 90 device, antenna-connected measurements are not required.

2.1.2 Interconnecting Cables

Description:	RCVEX 28V Power Cable
Manufacturer:	Intermap Technologies
Model :	Not Available
Serial Number:	1125
Cable Identifier	1
Country of Manufacture:	Germany

Description:	WGASS 28V Power Cable
Manufacturer:	Intermap Technologies
Model :	Not Available
Serial Number:	1123
Cable Identifier	2
Country of Manufacture:	Germany

Description:	Transmitter 28V Power Cable
Manufacturer:	Intermap Technologies
Model :	Not Available
Serial Number:	1129
Cable Identifier	3
Country of Manufacture:	Germany

Description:	WGASS-RCVEX Link Cable
Manufacturer:	Intermap Technologies
Model :	Not Available
Serial Number:	1122
Cable Identifier	4
Country of Manufacture:	Germany

Description:	X Transmit Cable
Manufacturer:	Spectrum
Model :	18-S001-55-55
Serial Number:	1064
Cable Identifier	5
Country of Manufacture:	Germany

Description:	X Receive Cable
Manufacturer:	Spectrum
Model :	18-S001-55-55
Serial Number:	1060
Cable Identifier	6
Country of Manufacture:	Germany

Description:	STAR-Bus Cable
Manufacturer:	Intermap Technologies
Model :	Not Available
Serial Number:	1111
Cable Identifier	7
Country of Manufacture:	Germany

Description:	TX-Gate Cable
Manufacturer:	Intermap Technologies
Model :	Not Available
Serial Number:	1136
Cable Identifier	8
Country of Manufacture:	Germany

Description:	X Transmit Cable
Manufacturer:	Spectrum
Model :	18-S001-51-55
Serial Number:	1054
Cable Identifier	9
Country of Manufacture:	Germany

Description:	X Sample Cable
Manufacturer:	Spectrum
Model :	18-S001-51-55
Serial Number:	1069
Cable Identifier	10
Country of Manufacture:	Germany

Description:	RS-232 Serial Interface Cable for Transmitter
Manufacturer:	PCCW
Model :	MC-302
Serial Number:	Not Available
Cable Identifier	11
Country of Manufacture:	China

Description:	3 Ethernet LAN Cables, Cat 5
Manufacturer:	Industry Standard
Model :	Not Available
Serial Number:	Not Available
Cable Identifier	12, 13, 14
Country of Manufacture:	Not Available

Description:	Wave Guide from Transmitter to WGASS, WR90
Manufacturer:	Intermap Technologies
Model :	Not Available
Serial Number:	Not Available
Cable Identifier	16
Country of Manufacture:	Canada

Description:	Aircraft 28V Power Cable Bus 1
Manufacturer:	Intermap Technologies
Model :	Not Available
Serial Number:	1132
Cable Identifier	17
Country of Manufacture:	Germany

Description:	Aircraft 28V Power Cable Bus 2+3
Manufacturer:	Intermap Technologies
Model :	Not Available
Serial Number:	1133
Cable Identifier	18
Country of Manufacture:	Germany

2.2 Description of EUT

The equipment under test is the transmitter section of an airborne synthetic aperture radar for mapping. It is subdivided into four physical modules for rack mounting:

- **Power distribution module (PWRDIST)**
  - Distribution and monitoring of the 28 V DC power supply
  - Circuit breakers
  - Ethernet LAN switch
- **Receiver / Exciter module (RCVEX)**
  - 10 MHz master reference oscillator
  - Chirp signal generator
  - Generation of all RF signals at a low power level
  - Radar receiver and signal digitizer
- **X-Band high power transmitter (XTRANS)**
  - Traveling wave tube amplifier (TWTA)
- **Wave guide assembly module (WGASS)**
  - Monitoring of the high power transmit signal
  - Switchable high power dummy load for self testing
  - Transmit / receive circulator and receiver low noise amplifier (LNA)

Antennas for airborne mapping are not included in the EUT and the transmitter antenna waveguide port is terminated with a load. The EUT is software controlled and set to transmit mode with a diagnostic software, running on a laptop.

2.3 Additional Information Related to Testing

Power Supply Requirement:	28 V DC nominal (24 – 32 V), three buses, 60 A each
Equipment Category:	Radar
Type of System:	Installed in aircraft, DC supplied
Interface Ports:	Ethernet LAN, antenna waveguide port
Transmit Frequency Range:	9537.5 to 9672.5 MHz
Highest Fundamental Frequency:	9672.5 MHz
Occupied Bandwidth:	135 MHz

2.4 Test Support Equipment

Description:	Laptop
Manufacturer:	Lenovo
Model:	T61 Type: 7663-2EU
Serial Number:	L3-P7113

Description:	115V AC Power Supply Cable for Laptop
Manufacturer:	Lenovo
Model:	Not Available
Serial Number:	Not Available
Cable Identifier:	15

Description:	DC Power Supply In: 3-phase 115 VAC, Out: 28 V DC, three buses, 60 A each
Manufacturer:	Intermap Technologies
Model:	Not Available
Serial Number:	Not Available

Description:	Cross Guide Coupler, WR 90, at antenna port
Manufacturer:	ATM
Model:	90-303A-40-6-6
Serial Number:	J248604-01
Coupling:	40 dB

Description:	X-Band High Power Dummy Load, WR 90, at antenna port
Manufacturer:	Ferrite Co
Model:	XL3-14
Serial Number:	C6210
VSWR specified:	≤ 1.10

3 Configuration and Operation of the EUT During Testing

Programs required: RCAS Diagnostic Tools Version 1.5.3.0
WGASS/XPTrans Diagnostic Utils v 2.2.0.2
PWRDIST Diagnostic Utils Version 2.1.0.0

Antenna port: Connect WR 90, 40 dB cross guide coupler and high power dummy load

Waveform file: T135_226.WAV
135 MHz bandwidth, 22.6 µs pulse width

PRF: Set pulse repetition frequency (PRF) to 1800 Hz
(1800 pulses per second will generate a transmit duty cycle of 4.07 %)

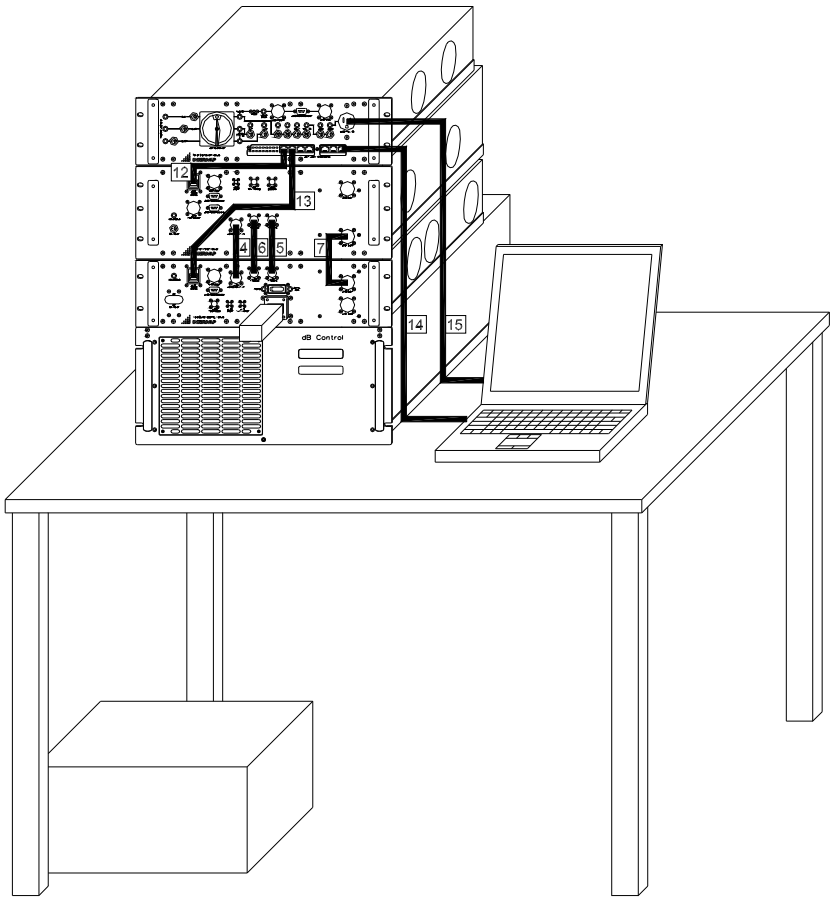
Warm up time: 5 minutes for:
- 10 MHz reference oscillator to stabilize
- RF oscillators to lock
- TWTA tube to heat up

TWTA: Set in WGASS/XPTrans Diagnostic Utils to “Operate”,
after warm up time

Wave guide switch: Set switch on WGASS module front panel to “Antenna”
For measurement of the output power via the cross guide coupler,
set in WGASS/XPTrans Diagnostic Utils to “Antenna”.
In case the external dummy load exceeds temperatures around 100 degC,
it is recommended to switch to the module internal dummy load with
forced air cooling (switch in WGASS/XPTrans Diagnostic Utils to “Dummy Load”).

Laboratory test setup: Shown is the stack of modules, interconnected with cables, labeled with the cable identifier.

Power distribution module	(PWRDIST, top)
Receiver / Exciter module	(RCVEX)
Wave guide assembly module	(WGASS)
X-Band high power transmitter	(XTRANS, bottom)
28 VDC, 3 x 60 A power supply	(floor)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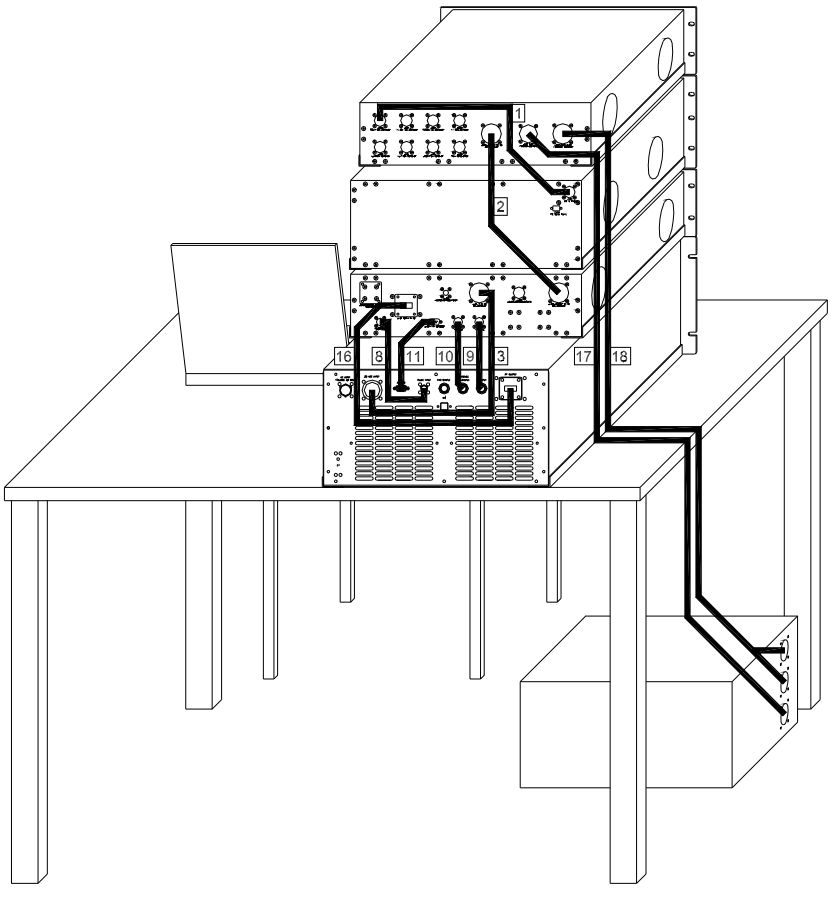
dB Control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Summary of Test Results

Range of Measurements:	Specification Reference	Port Type	Compliancy Status
Transmitter Carrier Output Power	FCC 47 CFR Part 2.1046	Antenna port	Not Applicable *
Transmitter Modulation Characteristics	FCC 47 CFR Part 2.1047	Antenna port	Not Applicable *
Transmitter Occupied Bandwidth	FCC 47 CFR Part 2.1049	Antenna port	Not Applicable *
Spurious Emissions at Antenna Terminals	FCC 47 CFR Part 2.1051	Antenna port	Complied
Field Strength of Spurious Radiation	FCC 47 CFR Part 2.1053	Open field measurement	Complied
Transmitter Frequency Stability (Temperature Variation)	FCC 47 CFR Part 2.1055	Antenna port	Complied
Transmitter Frequency Stability (Voltage Variation)	FCC 47 CFR Part 2.1055	Antenna port	Complied

Notes:

** As no limits are stated in the standard, compliancy cannot be stated at this stage.*

3.1 Transmitter Carrier Output Power: Section 2.1046(a)

The EUT was configured to nominal operation and the average transmit power was measured at the wave guide antenna port (output port Ⓒ, see block diagram next page)

Test conditions:	Pulse width:	22.6 µs
	Pulse repetition frequency:	1800 Hz
	Wave form:	Linear FM chirp pulse
	Chirp bandwidth:	135 MHz
	Transmission into:	High power dummy load (VSWR ≤ 1.10)
Power meter:	Manufacturer:	Rohde & Schwarz
	Model:	NRP-Z22
	S/N:	100121
	Calibrated:	2007-09-19 (recalibration due: 2009-09-19)
Test date:	2008-07-09	

Results

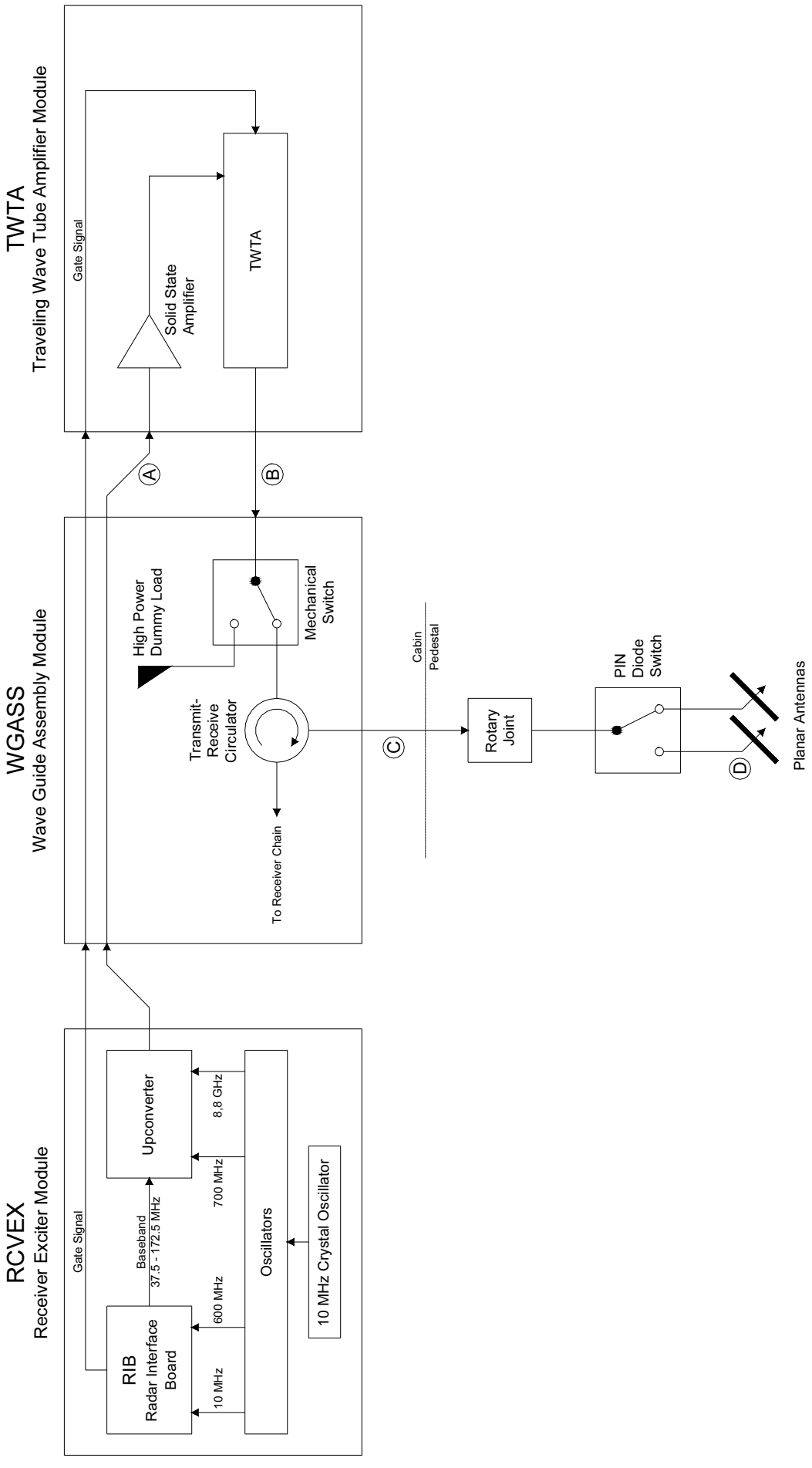
Frequency	Average output power at output port Ⓒ	Loss between output port Ⓒ and antenna port Ⓓ	Transmitted average power at antenna port Ⓓ
9537.5 to 9672.5 MHz	54.6 dBm	2.2 dB	52.4 dBm

Notes:

Average output power of TWTA at test conditions according to the manufacturer test data: 55.15 dBm
(nominal insertion loss of the WGASS module: 0.5 dB)

Variation of average output power of different TWTA modules (model dB-3710 C from dB Control):

S/N	Stated average output power at test condition
101	55.74 dBm
102 (EUT)	55.15 dBm
103	54.59 dBm
104	55.32 dBm
105	55.59 dBm
106	55.39 dBm


TWTA
Traveling Wave Tube Amplifier Module
Gate Signal
Solid State Amplifier
TWTA
A
B
WGASS
Wave Guide Assembly Module
High Power Dummy Load
Mechanical Switch
Transmit-Receive Circulator
To Receiver Chain
C
Cabin
Pedestal
Rotary Joint
PIN Diode Switch
D
Planar Antennas
RCVEX
Receiver Exciter Module
Gate Signal
Baseband
37.5 - 172.5 MHz
Upconverter
8.8 GHz
700 MHz
600 MHz
10 MHz
RIB
Radar Interface Board
Oscillators
10 MHz Crystal Oscillator

3.2 Transmitter Modulation Characteristics: Section 2.1047(d)

Modulation:	Linear FM chirp pulse
Pulse width:	22.6 µs
Pulse repetition frequency:	1800 Hz
Chirp bandwidth:	135 MHz

Signal generation:

A baseband chirp is generated by a digital waveform generator (proprietary design by Intermap). The digital waveform generator comprises a lookup table and a D/A converter. The lookup table is software configurable and loaded from a waveform file.

Quantisation:	8 bit
Sampling rate:	600 M samples / sec 600 MHz clock rate locked to 10 MHz reference oscillator
Lookup table:	32 k samples samples beyond the chip pulse are zero padded
Baseband chirp:	37.5 - 172.5 MHz 135 MHz bandwidth 105 MHz center frequency

Upconversion frequency plan:

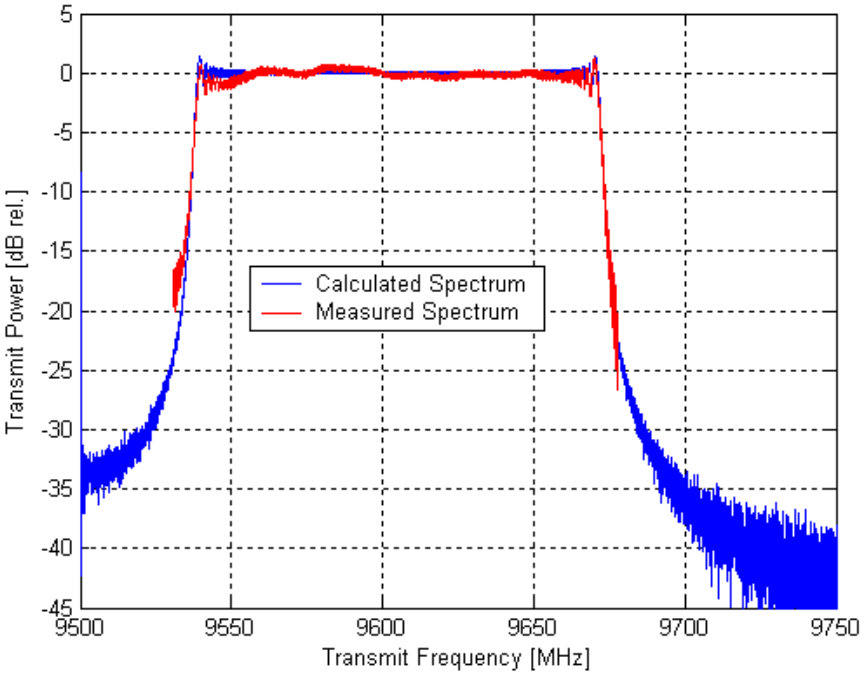
Baseband chirp:	37.5 - 172.5 MHz
1st LO:	700 MHz locked to 10 MHz reference oscillator
IF:	737.5 MHz – 872.5 MHz upper sideband
2nd LO:	8800 MHz locked to 10 MHz reference oscillator
Transmit signal:	9537.5 – 9672.5 MHz upper sideband

Test date: 2006-07-06

Spectrum measured:

The transmit signal has been down converted with the radar receiver into baseband and sampled with 300 Msamples / sec and 8 bit resolution.

Calculated and measured chirp spectrum



3.3 Transmitter Occupied Bandwidth: Section 2.1049

Method: Numerical integration of the nominal transmit power spectrum (given in the section above) over frequency and calculation of the bandwidth which covers 99 percent of the total transmitted power.

Occupied bandwidth: 184.9 MHz

Note: This method overestimates the transmitted power outside the nominal band edges, as it does not take into account the steeper roll off of the spectrum, caused by the transmit signal band pass filtering in the transmit signal chain. Consequently, the given occupied bandwidth is a worst case number.

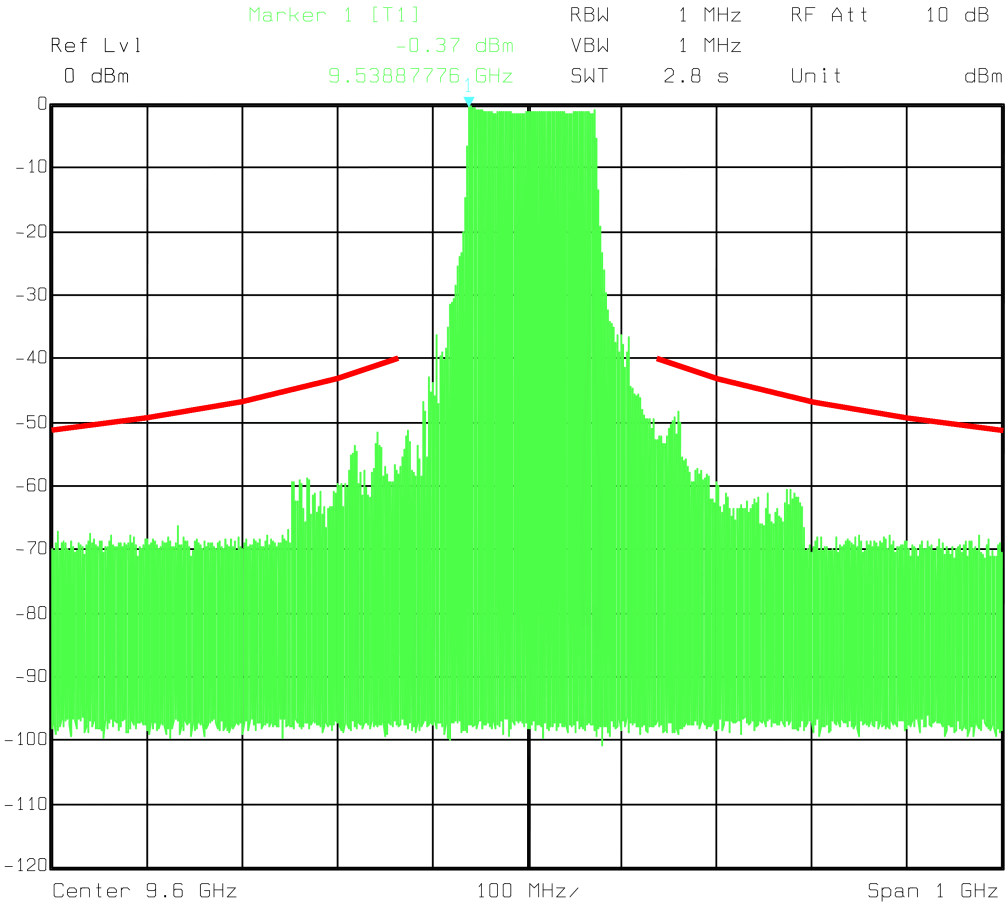
3.4 Transmitter Spurious Emissions at Antenna Terminals: Section 2.1051

System parameters:	F_o	9605 MHz	operating frequency
	B_c	135 MHz	bandwidth of frequency deviation
	t	22.6 µs	emitted pulse duration
	t_r	> 0.1 µs	emitted pulse rise time
	t_f	> 0.1 µs	emitted pulse fall time
	P_t	+15.2 dBm / kHz	spectral density
	B(-40 dB)	±138 MHz	emission mask width at –40 dBc
	B(-60 dB)	±1382 MHz	emission mask width at –60 dBc

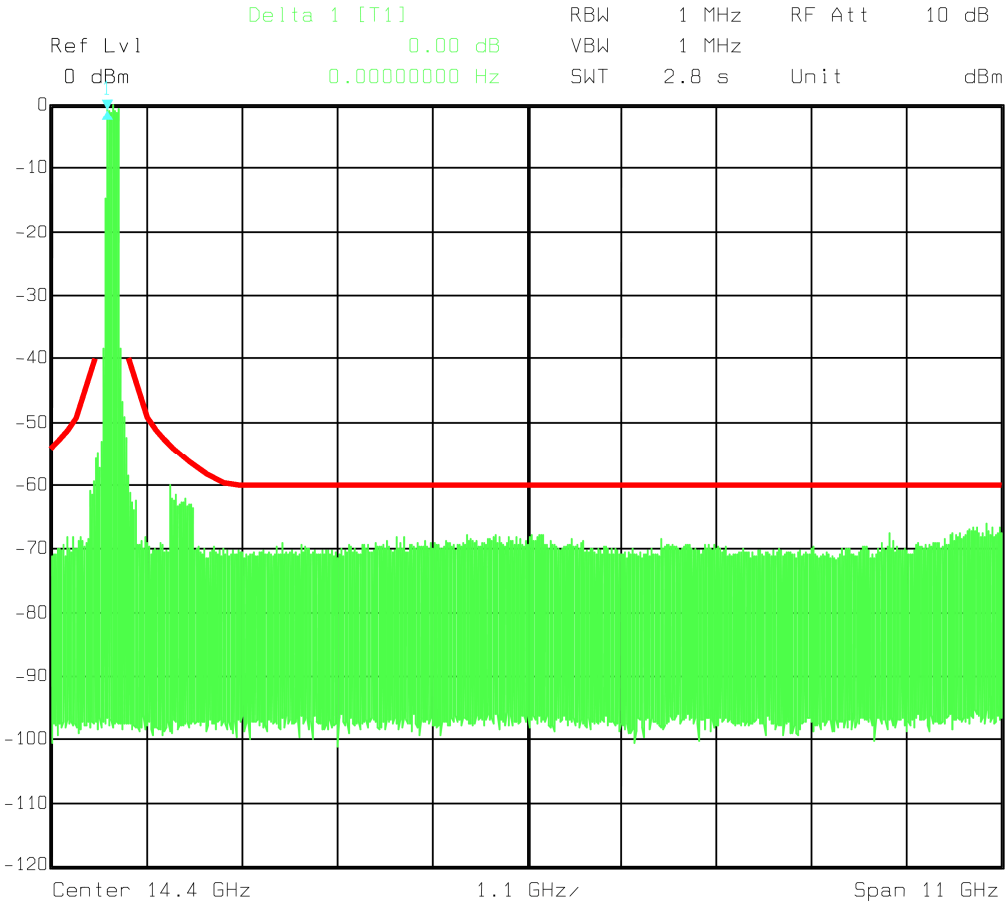
Test date: 2006-03-06

Spectrum analyzer: Manufacturer: Rohde & Schwarz
Model: RS-FSEK30

Measured spectra



Spectrum of wanted emission, compliant with the emission mask



Spurious and harmonic signals, compliant with the emission mask

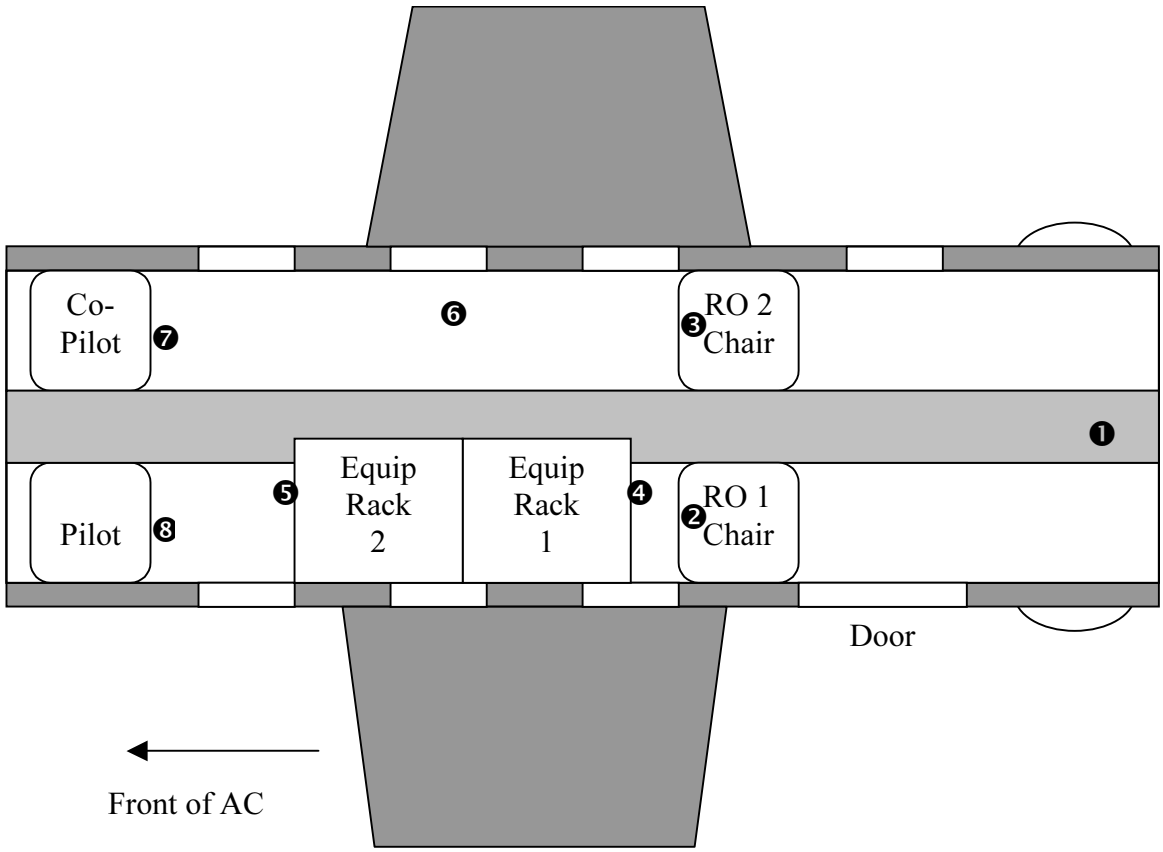
Note: The equipment meets the applicable Federal Government Technical Standards.

3.5 Field Strength of Spurious Radiation: Section 2.1053

Method: In regular operation, the EUT is installed in the cabin of an aircraft. One suitable method to measure the spurious radiation, was to use a calibrated, isotropic radiation field probe, and measure the radiation levels at defined locations inside the cabin, while the EUT was operating at nominal power levels. This test was also intended to ensure that radiation levels for operators and pilots inside the cabin are well within the regulatory limits.

RF meter:	Model:	Narda EMR-300
	Probe:	Type 26.1
	Frequency range:	300 kHz – 40 GHz
	Calibrated:	2006-07-21 (recalibration due: 2008-07-20)
	Intensity range:	100 % regulatory limit (ICNIRP, 1998, occupational)
		equivalent to 50 W / m^2
		equivalent to 5 mW / cm^2
		equivalent to +7 dBm / cm^2
Radar data:	Average power:	52.5 dBm
	Antenna gain:	30.8 dB
	ERP:	83.3 dBm
Test date:	2006-12-16	
Limit:	+23.3 dBm	Spurious emissions are required to be 60 dB below ERP

Measurements: Measurements were taken with the RF probe at eight locations within the cabin. As an alternative method, measurements were taken at the same locations with an open WR 90 wave guide probe, connected to a power meter, capturing predominantly the RF leakage at X-band frequencies (8.2 – 12.4 GHz)



Results:

Location	Narda probe		Alternate test (open WR 90 wave guide)	Limit according to Section 2.1053
	% of regulatory limit	Absolute power		
❶ Rear section of air craft	0.01 %	-33 dBm	-34 dBm	+23 dBm
❷ Radar operator 1 seat	0.01 %	-33 dBm	-31 dBm	
❸ Radar operator 2 seat	0.01 %	-33 dBm	-30 dBm	
❹ In front of aft rack	0.02 %	-30 dBm	-32 dBm	
❺ In front of forward rack	0.02 %	-30 dBm	-32 dBm	
❻ Aisle	0.01 %	-33 dBm	-31 dBm	
❼ Copilot seat	0.02 %	-30 dBm	-35 dBm	
❽ Pilot seat	0.02 %	-30 dBm	-34 dBm	

3.6 Transmitter Frequency Stability (Temperature Variation): Sections 2.1055

General: All oscillators and clocks for digital circuits are locked to a high performance oven controlled 10 MHz master reference oscillator. As frequency stability is critical for this type of imaging radar, the stability of the reference oscillator is tracked against the extremely accurate 1 pulse per second signal from the integrated GPS receiver (accuracy: better than 0.05 Hz).
The radar system is installed inside an aircraft cabin and automatically shuts down if the equipment temperature exceeds temperature limits below +10 degC or above +45 degC.

Manufacturer: Wenzel Associates, Inc.

Model: 501-04609 Rev A

Frequency: 10 MHz

Specifications:

Warm up time:	5 min
Temperature stability:	±5 x 10-9 (±0.05 Hz) with a temperature range of 0 to +50 degC

Test results:

S/N:	2313-9817
0 degC:	+2.0 x 10-9 (+0.020 Hz)
+50 degC:	-3.4 x 10-9 (-0.034 Hz)
Tested by:	Manufacturer (Test data sheet, CofC)

3.7 Transmitter Frequency Stability (Voltage Variation): Sections 2.1055

General:	All module internal power supply voltages are generated by DC/DC converters. Input voltage: aircraft DC power, nominal +28 V. Output voltage: for the 10 MHz reference oscillator: +15 V Given below is a calculation of the maximum nominal frequency variation vs. power supply variation.	
Input voltage range:	18 – 36 VDC, nominal 28 VDC	
DC/DC converter:	Model : Power: Line regulation:	Vicor V24C15C100A 100 W max. ±0.2 % max (0.02 % typ.) +15 V ±0.03 V
Reference oscillator:	Model: Power supply range: Frequency variation:	501-04609 Rev A, 10 MHz, Wenzel Associates, Inc. +15V ±5 %, (14.25 V to 15.75 V) < ±5 x 10-9 (±0.05 Hz) over power supply range
Frequency variation: (worst case)	Aircraft power supply: Oscillator power supply: Frequency variation:	18 – 36 VDC +15 V ±0.03 V < ±2 x 10-10 (±0.002 Hz)