

A vertical collage on the left side of the slide features a blue and white globe as a background. Overlaid on the globe are several images: a fighter jet in flight at the top, a laptop computer, a circuit board, a satellite in orbit, and a mobile phone at the bottom.

# **THE FUNDAMENTALS OF TESTING MODE S TRANSPONDERS, DME AND TCAS**

**Presented by Lee Foster  
Sales application Specialist  
Aeroflex International Ltd**

## TESTING - THE PURPOSES

Routine system verification

Investigation after reported problem

Fault-finding confirmed problem

Return to Service



Thorough testing on the aircraft:

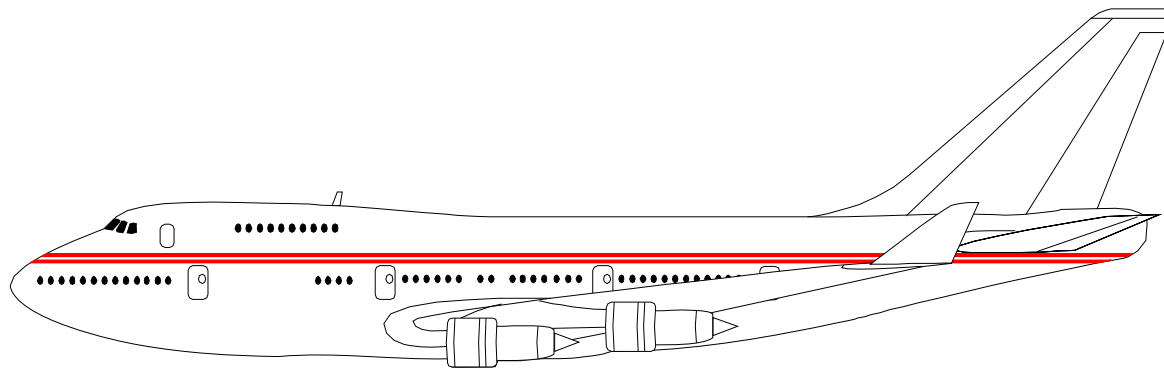
Reduces removal and return of LRUs

Thereby saving time and money

Increases confidence

By testing the whole system at once





SPECIFICALLY.....

# TRANSPONDER

Test requirements defined in FAR part 43 appendix f.

Additional tests may be required regionally e.g. Eurocontrol.



# F.A.R. - THE DETAILS

## REPLY FREQUENCY

For all classes of ATCRBS transponders, interrogate the transponder and verify that the reply frequency is  $1090 \pm 3$  Megahertz (MHz).

## BUT

For classes 1B, 2B, and 3B Mode S transponders that incorporate the optional  $1090 \pm 1$  MHz reply frequency, interrogate the transponder and verify that the reply frequency is correct.

## AND

For classes 1A, 2A, 3A, and 4 Mode S transponders, interrogate the transponder and verify that the reply frequency is  $1090 \pm 1$  MHz.



## SUPPRESSION

Verify that the transponder does not respond to more than 1 percent of ATCRBS interrogations when the amplitude of P2 pulse is equal to the P1 pulse.

Verify that the transponder replies to at least 90 percent of ATCRBS interrogations when the amplitude of the P2 pulse is 9 dB less than the P1 pulse.

## RECEIVER SENSITIVITY

For ATCRBS, the receiver minimum triggering level (MTL) is  $-73 \pm 4$  dbm,  
For Mode S, the receiver MTL is  $-74 \pm 3$  dbm.

Verify that the difference in Mode 3/A and Mode C receiver sensitivity does not exceed 1 db for either any class of ATCRBS transponder or any class of Mode S transponder.



## RF OUTPUT POWER

For Class 1A and 2A ATCRBS transponders, verify that the minimum RF peak output power is at least 21.0 dBw (125 watts).

For Class 1B and 2B ATCRBS Transponders, verify that the minimum RF peak output power is at least 18.5 dBw (70 watts).

For Class 1A, 2A, 3A, and 4 and those Class 1B, 2B, and 3B Mode S transponders that include the optional high RF peak output power, verify that the minimum RF peak output power is at least 21.0 dBw (125 watts).

For Classes 1B, 2B, and 3B Mode S transponders, verify that the minimum RF peak output power is at least 18.5 dBw (70 watts).

For any class of ATCRBS or any class of Mode S transponders, verify that the maximum RF peak output power does not exceed 27.0 dBw (500 watts).



## DIVERSITY ISOLATION

For any class of Mode S transponder that incorporates diversity operation, verify that the RF peak output power transmitted from the selected antenna exceeds the power transmitted from the non-selected antenna by at least 20 db.

## MODE S ADDRESS

Interrogate the Mode S transponder and verify that it replies only to its assigned address. Use the correct address and at least two incorrect addresses. The interrogations should be made at a nominal rate of 50 interrogations per second.



## MODE S FORMATS

Interrogate the Mode S transponder with uplink formats (UF) for which it is equipped and verify that the replies are made in the correct format.

Verify that the altitude reported in the replies to UF=4 are the same as that reported in a valid ATCRBS Mode C reply.

Verify that the identity reported in the replies to UF=5 are the same as that reported in a valid ATCRBS Mode 3/A reply.

If the transponder is so equipped, use the communication formats UF=20, 21, and 24.



## MODE S ALL-CALL

Interrogate the Mode S transponder with the Mode S-only all-call format UF=11, AND the ATCRBS/Mode S all-call formats (1.6 microsecond P4 pulse) and verify that the correct address and capability are reported in the replies (downlink format DF=11).

## ATCRBS ALL-CALL

Interrogate the Mode S transponder with the ATCRBS-only all-call interrogation (0.8 microsecond P4 pulse) and verify that no reply is generated.

## SQUITTER

Verify that the Mode S transponder generates a correct squitter approximately once per second.



## **OTHER CONSIDERATIONS**

European Elementary Surveillance

European Enhanced Surveillance

Aircraft Diagnostics



## PROPOSED EUROCONTROL EXTRA TESTS

### Transmitter Pulse Amplitude Variation

All pulses within a Mode S reply shall be within +/-1dB of each other

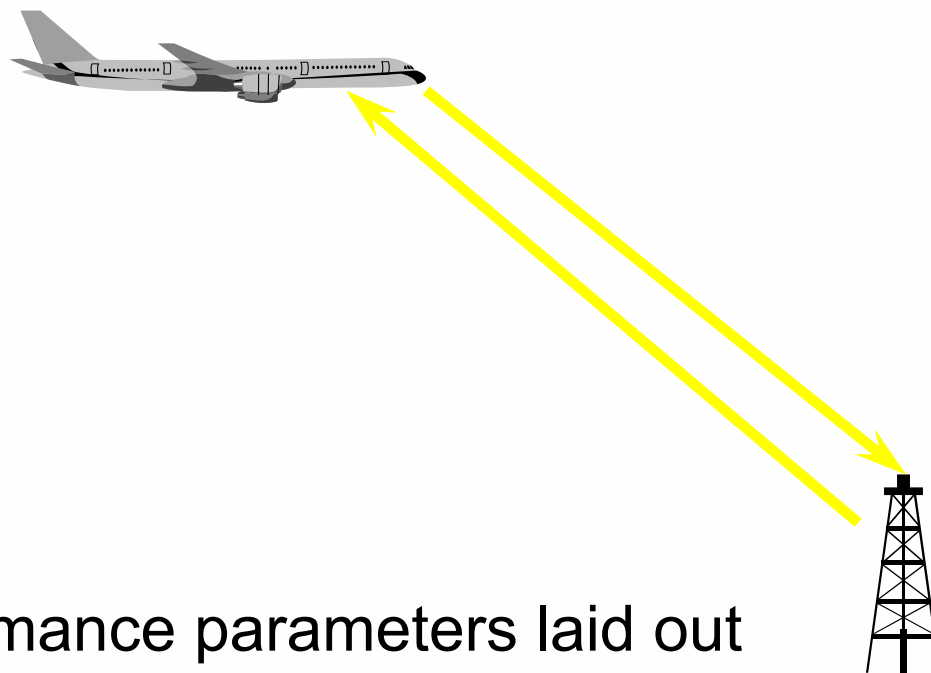
### Reply pulse characteristics

Width and Spacing

### Reply ratio, ATCRBS and Mode S



# DME



Basic performance parameters laid out  
in ICAO Annex 10 volume 1



## **Main parameters**

Radio Frequency

RF Power

Pulse Repetition Frequency

Pulse Spacing and Width

Sensitivity



## Main parameters

### Radio Frequency

Uses 352 channels, which can be identified by frequency, by reference to a VOR paired channel or by TACAN channel identifier.

### RF Power

### Pulse Repetition Frequency

### Pulse Spacing and Width

### Sensitivity



## Other Parameters

### Range and Velocity

System should work to the limit of it's coverage

### Echo

System should have immunity to false interrogations

### Ident

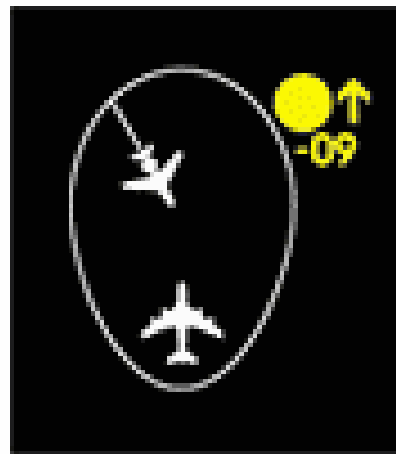
Morse Identification of ground station

### Search and Acquisition

To check parameters in search mode and acquisition time



# TCAS



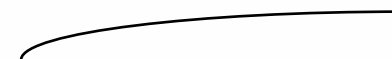
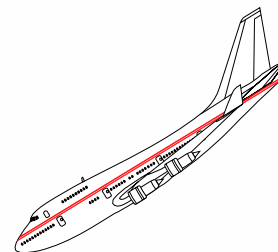
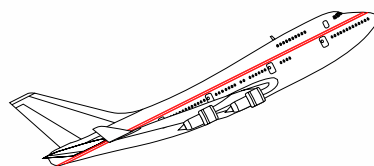
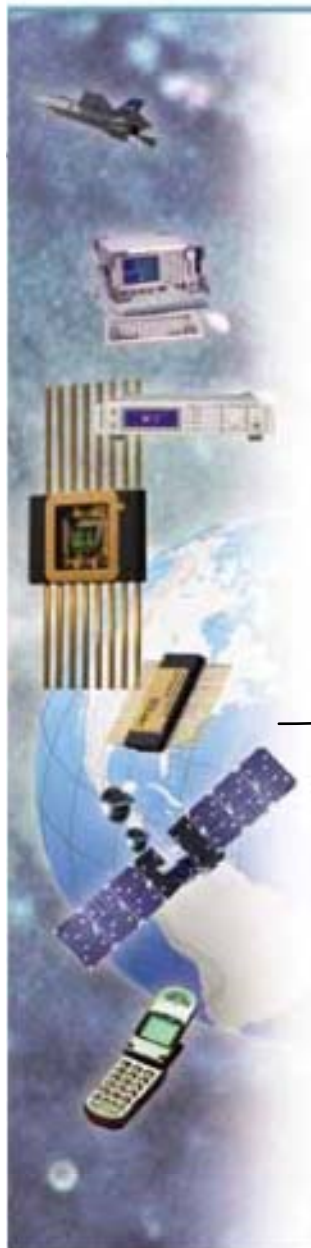
Basic performance parameters laid out  
in ICAO Annex 10 volume 4



## Main parameters

Radio Frequency

RF Power



## Other Considerations

TCAS logic - the key to TCAS

Requires the accurate simulation of both  
ATCRBS and Mode S targets

Provision of both pre-set scenarios and  
manual control of target position

Feedback to operator of TCAS status for  
ease of testing.



## SUMMARY OF TESTING REQUIREMENTS

Transponder

Complex and sophisticated

DME

Relatively straight forward but many channels

TCAS

Needs to be sophisticated and flexible





## OTHER SYSTEMS

ADS-B

TIS

TIS-B



Can all these systems be tested thoroughly? **YES**

Can testing be simple for the operator? **YES**

Does it need separate test sets for each system? **NO**

Can the test results be displayed in plain English, without unnecessary abbreviation? **YES**

Can all this be done in a lightweight tester? **YES**

**HOW?**

See us at Stand 2U/B16



AEROFLEX IFR 6000

```
XPDR-AUTO TEST TEST BAT 2.5 HV
CONFIG:MODE S CLASS A LUL 4
ANTENNA: TOP
REPLIES=A/C/S FREO =1090.12 MHz
TOP ERP=57.1 dBm TOP HTL=73.2 dBm
BOT ERP=57.3 dBm BOT HTL=73.4 dBm
A CODE =1234 ID C ALT = 10000 Ft
AA=3AC421 (16542941)S ALT = 10000 Ft
S CODE =1234 ID DF17 =DETECTED
TAIL =N12345 COUNTRY=USA
US =AIR FLT FLT ID =BA234
```

POWER CHARGE

INTERR REPLY

DISPLAY

XTNS

BKLT

XPDR TCAS

DME SETUP

FREQ DME RF LVL

RANGE RATE

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AEROFLEX

XPDR - AUTO TEST **PASS** BAT 2.5 Hr  
CONFIG: GENERIC MODE S LEVEL=4  
ANTENNA: BOTTOM  
REPLIES= A, C, S      FREQ =1090.00 MHz  
TOP ERP= 57.1 dBm      BOT MTL=-73.0 dBm  
BOT ERP= 56.0 dBm      BOT MTL=-74.6 dBm  
A CODE = 1234 ID      C ALT = 35000 ft  
S CODE = 1234      S ALT = 35000 ft  
TAIL = N12345      DF17= DETECTED  
FLIGHT ID= AA-50      AA=AC3421(53032041)  
FS= 5-ALERT:NO      SPI: YES      AIR FLT  
VS= AIR FLT      COUNTRY= USA

RUN  
TEST

TEST  
LIST

CONFIG

SELECT  
ANT

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AEROFLEX



## The NEW IFR 6000

The future of  
Transponder/DME/  
TCAS testing