RED ATC Radar Harmonised standards

Aeronautical Radar Primary, Secondary and MSPSR for ATM - related EN's

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- 4th November 2015

Agenda

1. Scope of program
2. Radar applications and technology
3. Previous experience - UK 4G program
4. Principles for ATC S-band PSR EN
5. Approach
   - ‘Black box’ system specification and measurement as opposed to RF component requirement
   - i.e. a radar system input / output based standard
6. Summary position

Scope of Program

- Primary Surveillance Radar (ATC) EN 303 364
  - L-band (part 1)
  - S-band (part 2) *
  - X-band (part 3)
- SSR L-band EN 303 363
  - SSR (part 1)
  - Wide Area Multilateration (part 2)
- Multistatic Primary Surveillance Radar (ATC) EN 303 346
  - Unknown frequency

Radar applications and technology

- Radars are complex systems:
  - Radar ATC usage – integration into safety cases
  - Meeting customer safety / regulatory requirements

- Difficulties in:
  - Metrics
  - Measurements
  - Lifecycle management
  - Change cost and rate of change

Radar applications and technology
There are a number of shades of Radar

- Impulse pulse
- Pulse doppler
- FMCW
- FMICW
- Fixed frequency
- Agile frequency
- Multiple frequencies
- Fixed bandwidth
- Variable bandwidth
- Fixed PRF
- Agile PRF
- Beam variations in time, space, in short times
- Rotating radar
- Static phased array
- .... and so on ...

- HF skywave radar
- HF surface wave radar
- L-band long range radar
- S-band ATC radar
- S-band target Indication
- S-band target tracking and engagement
- S-band meteorological radar
- S-band maritime navigation radar
- C-band meteorological radar
- X-band SMR
- X-band surveillance radar
- X-band navigation radar
- K-band short range
- M-band very short range radar
- ..... and so on

So it is a complex subject

Radar applications and technology
What must a radar do

- Radar
  - Detect targets
  - Reject clutter (weather, birds,non targets, etc)
  - Reject interference
  - Determine nature of returns
  - Plot real targets
  - Track real targets
  - Provide data on targets
- ATC
  - Targets typically up to
    - Approach ~ 60 nm
    - En-route >100 nm
    - Small targets (RCS 1 m^2 up to ~ 60 / 80 / 100 nm)

Previous experience - UK 4G program

- UK has significant 4G program experience related to S-band ATM radar and adjacent band communications usage with high levels of 4G signal density
- Two major communications frequency allocations (2.6 GHz, 3.5 GHz)
- Multiple signal combination risks, radar effects at a detailed level (especially IMP's in all parts of radar)
- Metrics to allow confidence the program allowed radar safety contribution to be maintained
- Whilst being robust to interference from the other frequency allocations

Previous experience - UK 4G program

- This is precisely what RED is about in relation to ATM
- The experience is related to:
  - Understanding the signals that might be seen
  - Understanding the contraints and limitations applicable to the new environment that would allow a reasonable radar redesign to accommodate the new environment
  - Understanding of how a delta change in radar performance for current systems might be managed as a consequence of accommodating adjacent band utilisation
  - Understanding lifecycle limitations on radars – there are few radars, replaced infrequently, their life cycle is long (~15-20 years)

Approach
Principles for ATC S-band PSR EN

- Ensure the primary aim of the product is accomodated – the contribution to air traffic safety is not compromised
  - i.e. There is no 'significant effect' on the radars ability to deliver performance in normal deployments in the presence of some other signals
- To establish whether a radar meets its other requirements
  - RF requirements
    - Via currently accepted International standards
  - Meets the ESASSP radar related requirements
  - Safety case
- And RED – the product is spectrally efficient, i.e. the immunity to interference from other users of the spectrum is high

Approach
Method for 'Compliance'

- Metrics / Performance requirements
  - ESASSP is the source ATC PSR requirement
  - 'Significant effect' definition can be derived

- Test signals & targets
  - A number of signals that excersise the robustness of the receiver to other signals
  - Frequency span band, channel bandwith, statistics ($P_{to}av$), duty cycle, power, disposition, modulation, ...
  - Targets can be by the radar operating and in real environment or by test site measurement with target injection (prefered)
  - Test site measurement with target injection (prefered)

Approach - Requirements
PSR reports plot output

Req #	Quality of service	Mandatory performance
SURVSTD_R1	Overall probability of target position detection	Greater than 90 % global
SURVSTD_R2	Average number of false target reports per antenna scan	Less than 20
SURVSTD_R3	Positional Accuracy – Systematic errors: - Slant range bias - Azimuth bias - Slant range gain error - Time stamp error	 Less than 100m Less than 0.1° Less than 1m/NM Less than 100ms
SURVSTD_R4	Positional Accuracy – Random errors: - Slant range - Azimuth	 Less than 120m Less than 0.15°

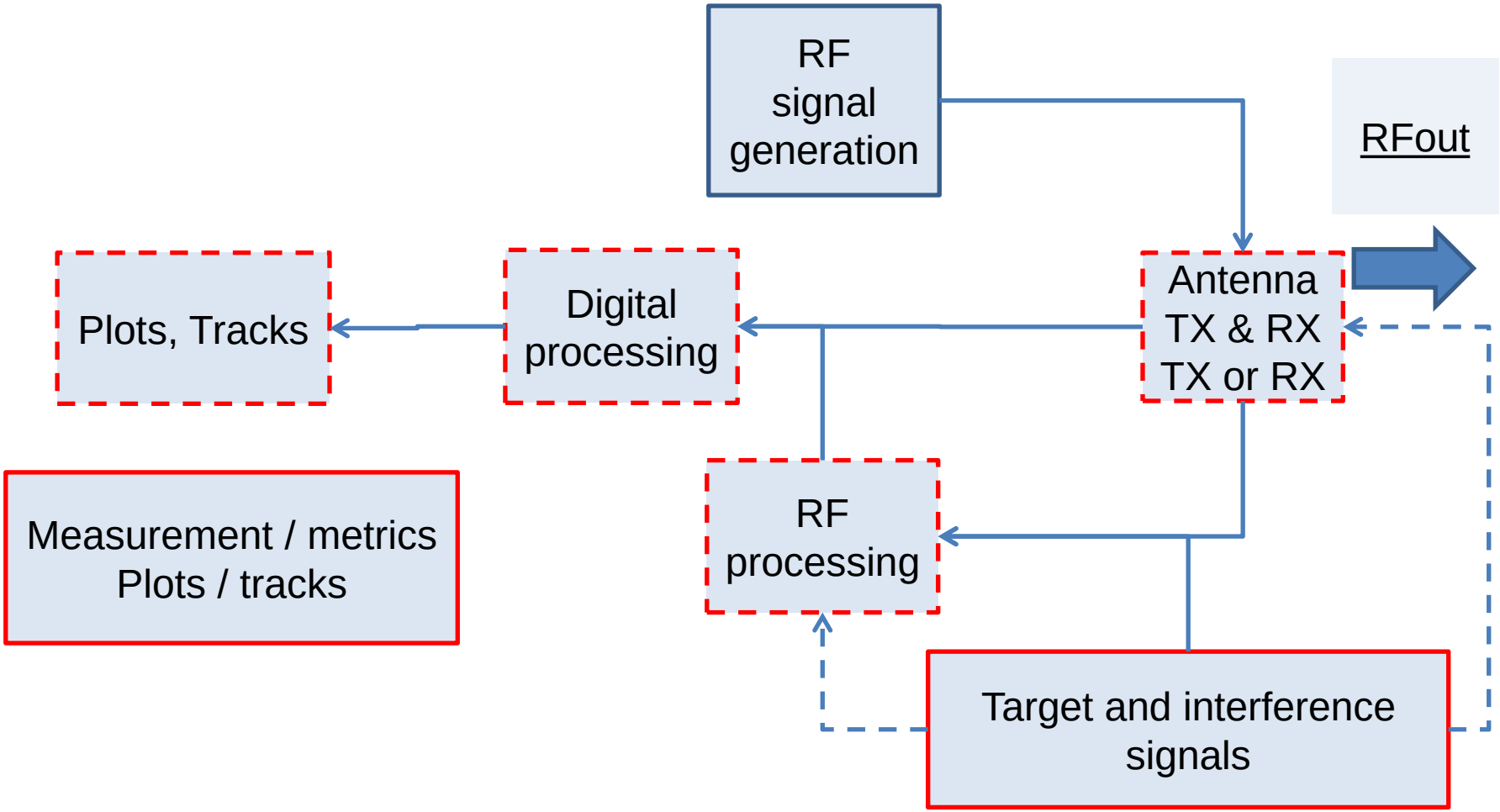
EUROCONTROL STANDARD DOCUMENT FOR RADAR SURVEILLANCE IN EN-ROUTE AIRSPACE AND MAJOR TERMINAL AREAS. MARCH 1997. SUR.ET1.ST01.1000-STD-01-01. PSR sensor performance requirements for supporting 3 NM and 5 NM horizontal separation (SURVSTD)

Approach - Requirements
PSR tracks output – 3Nm separation (selection)

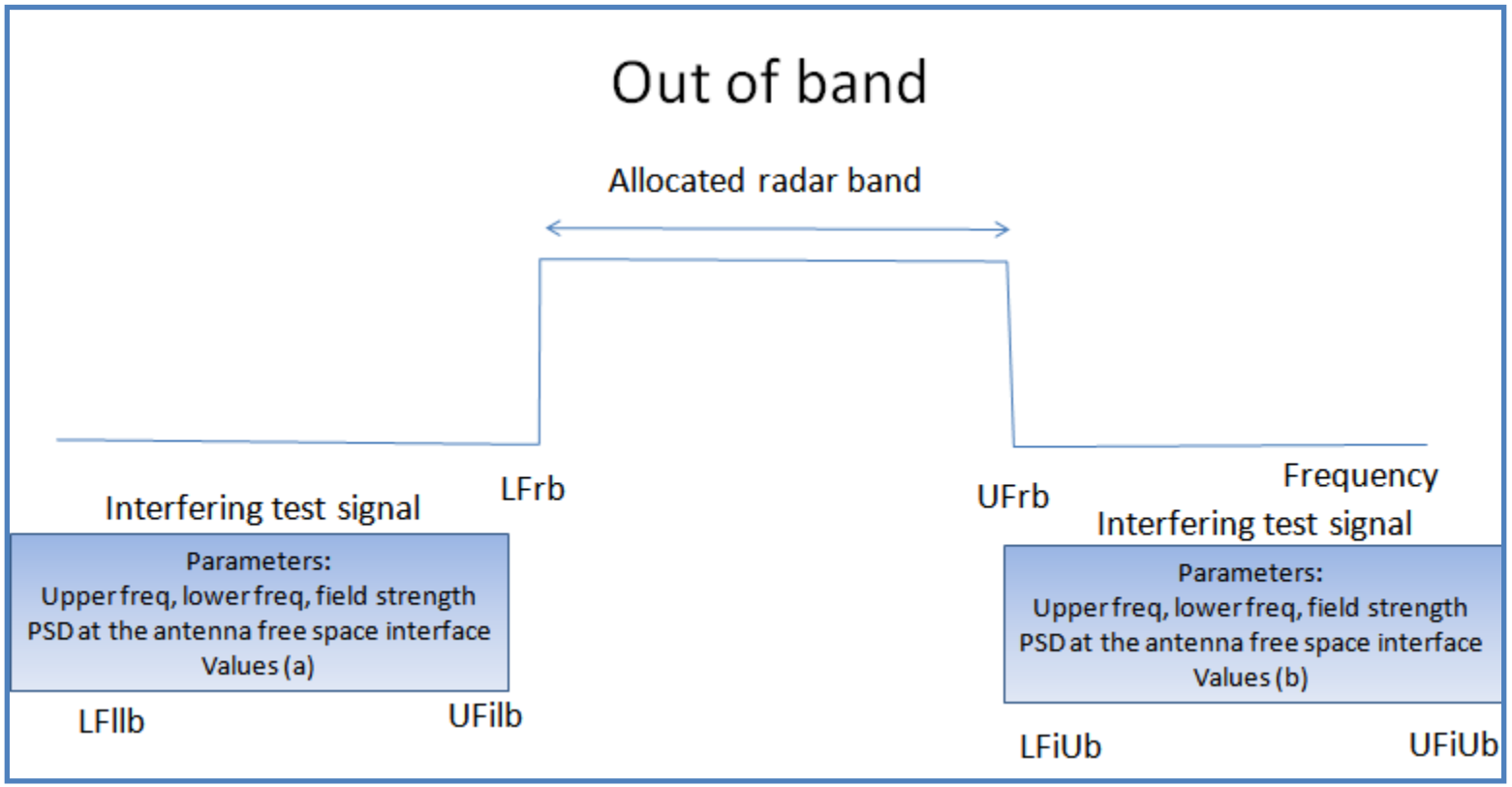
Req #	Quality of service	Mandatory performance	Recommended performance
3N_N -R2	Probability of update of horizontal position in accordance with selected measurement interval	Greater than 90 % global	Greater than or equal to 97 % for 100% of the flights, any flight below 97% shall be investigated as defined in R10
3N_N -R3	Ratio of missed horizontal position involved in long gaps (larger than 16.5 s = 3 x 5 s + 10%)	Less than or equal to 0.5 %	
3N_N -R4	Horizontal position RMS error	Less than or equal to 300 metres	Less than or equal to 210 metres
3N_N -R7	Track velocity RMS error		Less than or equal to 4 m/s for straight line and less than or equal to 8 m/s for turn
3N_N -R8	Track velocity angle RMS error		Less than or equal to 10° for straight line and less than or equal to 25° for turn

Reference: EUROCONTROL SPECIFICATION FOR ATM SURVEILLANCE SYSTEM PERFORMANCE (VOLUME 1). MARCH 2012. EUROCONTROL-SPEC-0147. ISBN 978-2-87497-022-1.Non-cooperative surveillance system requirements for supporting 3 NM horizontal separation (3N_N)

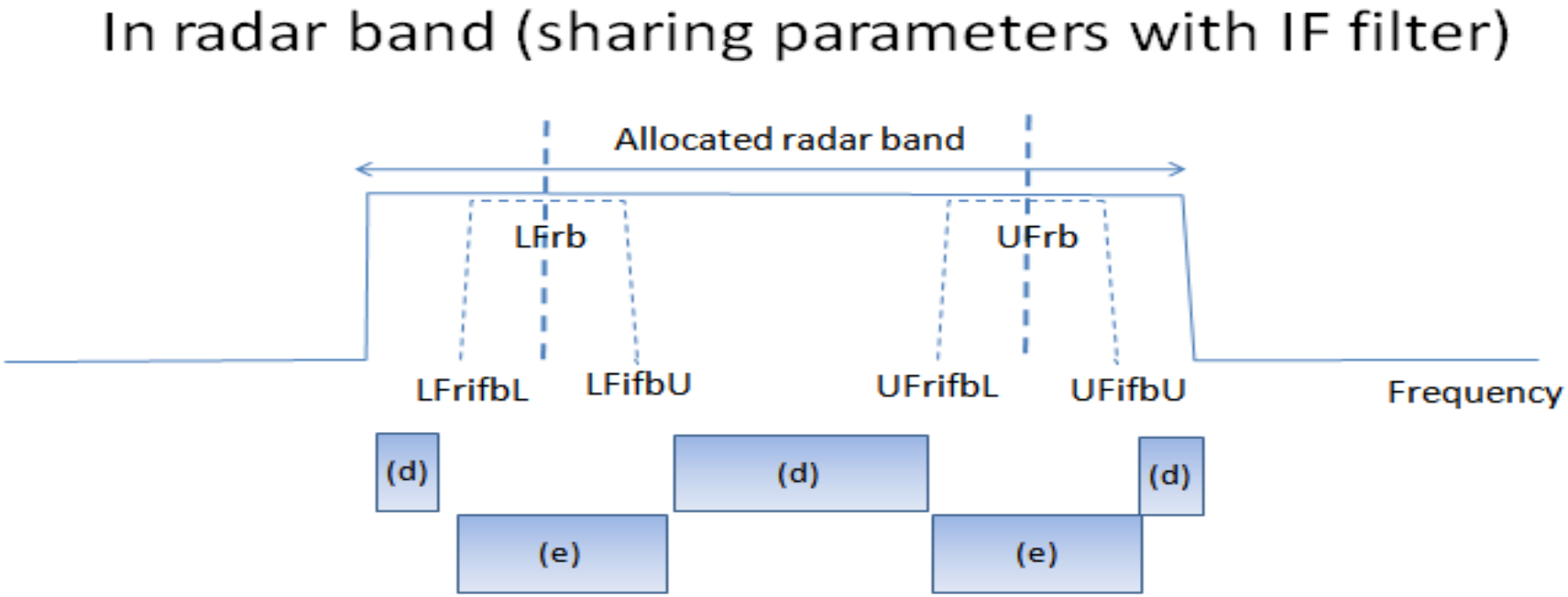
Approach
Test signals and test targets



Approach
Test signals outside the radar band allocation



Approach
Test signals inside the radar band allocation



Parameters:
Upper freq, lower freq, field strength PSD at the antenna free space interface
Values (a),(b),(c),(d),(e)

Summary Position

- There has been a ‘more systems’ approach that encompasses RED needs of spectrum efficiency with the need for the product to be fit for the intended purpose
- EN 303 364 (2) is slowly evolving to become fit for placing on the ETSI JTFEA site for further development and review
- We have an understanding of how EN 303 364 (1) and (3) will be derived from (2)
- We have started to generate draft EN 303 363 (1)