Aircraft and Portable Electronic Devices – A New Approach

Federal Aviation Administration

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Presentation Topics

- History of PED interference issues
- Interference mechanisms
- Design for aircraft tolerance to PEDs
- PED emissions statistics
- Recommended aircraft design standards

Consumer Electronics Trends

Ubiquitous

Pronunciation: yü-'bi-kw&-t&s
Definition: existing or being everywhere at the same time : constantly encountered : WIDESPREAD

From the Merriam-Webster Online Dictionary

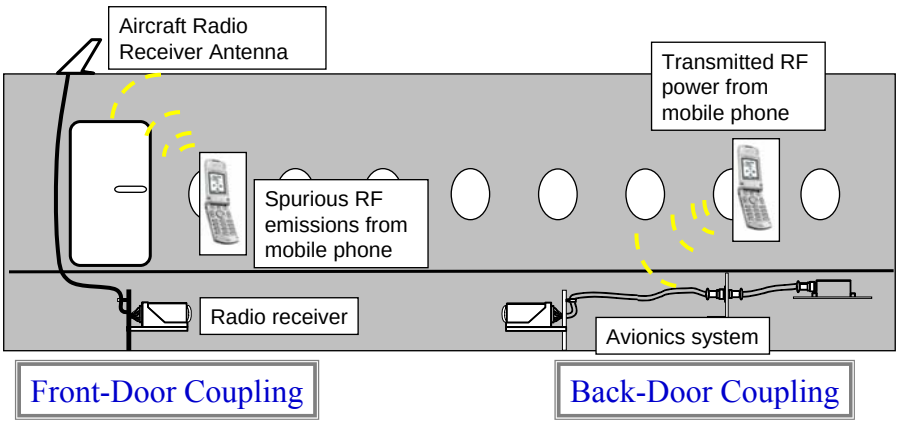
Current Airplane PED Operation Policies

- **Most airlines allow use of non-transmitting PEDs except during takeoff and landing**
- **Most airlines now allow use of mobile phones during taxi-in after landing, but prohibit use of transmitting PEDs during taxi-out, takeoff, cruise and landing**

Trends for Use of Wireless Devices on Aircraft

- Many 802.11a/b/g wireless access point installations in business jets and air transports
- Aeromobile has certified an airplane picocell for in-flight use of GSM mobile phones
- Wireless handsets, remote controls, and headsets commonly used on business jets

Portable Electronic Device Interaction with Aircraft Systems



Backdoor Coupling Susceptibility

- **Primary concern is from intentional PED transmitters**
  - Mobile phones, wireless RF network radios, wireless PDAs, two-way pagers, walkie-talkies
  - Effective radiated powers range from a few milliwatts to several watts
- **Aircraft systems have a wide range of immunity to backdoor RF coupling**

Front-Door Coupling Susceptibility

- **PED spurious emissions can couple into aircraft radio receivers directly through the receiver antenna**
- **Dependent on:**
  - Frequency of spurious emissions
  - Strength of spurious emissions
  - Path loss between PED and receiver antenna
  - Sensitivity of aircraft radio receiver

Controlling Potential PED Interference – Today

- **Current FAA regulations put responsibility for PED control on aircraft operator**
  "no person may operate … any portable electronic device on … U.S.-registered civil aircraft… [except] any portable electronic device that the operator of the aircraft has determined will not cause interference with the navigation or communication system of the aircraft on which it is to be used." 14 CFR 91.21
- **Wide variation in policies among airlines and general aviation operators**
- **Enforcement is very difficult**
  - Portable electronic devices may have several transmitters – some unknown to the user

RTCA Studies

- **Studies over past 40 years have focused on controlling passenger and crew use of PEDs**
  - RTCA Special Committee Reports DO-119 (1963), DO-199 (1988), DO-233 (1996), DO-294 (2004)
- **Airline reports indicate that use of transmitting PEDs is common**
  - NASA Aviation Safety Reporting System (ASRS)

A New Approach – Design Aircraft for PED Tolerance

- **Aircraft can be designed and tested to demonstrate PED tolerance**
  - Address both transmitting PEDs and spurious PED emissions
- **RTCA Special Committee SC-202 developed new approach to address aircraft design requirements for PED tolerance**
  - Published DO-307– 'Aircraft Design and Certification for Portable Electronic Device (PED) Tolerance' in October 2007

Aircraft PED Tolerance Concepts

Aircraft design can address two separate issues

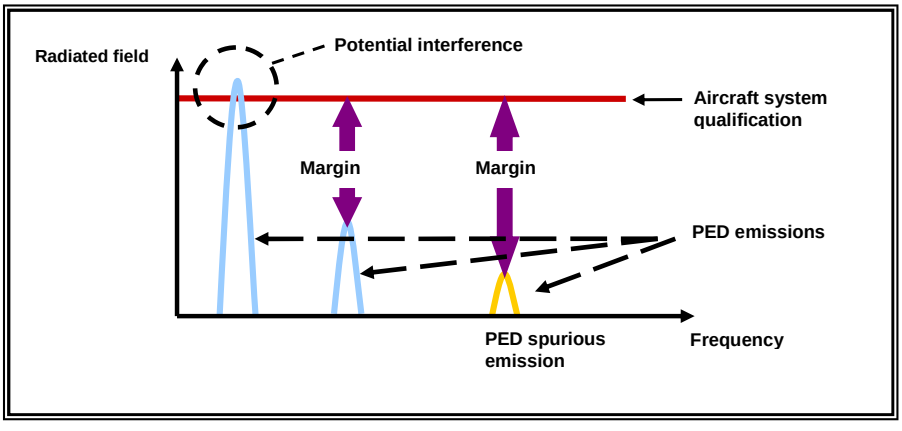
- **Immunity to <u>intentional PED transmissions</u>**
- **Primarily a concern for back door coupling to aircraft systems**

- **Immunity to <u>spurious PED emissions</u>**
  - from both transmitting and non-transmitting PEDs
- **Primarily a concern for front door coupling to aircraft radio receivers**

Approach for Transmitting PED Tolerance

- **Focus on setting standard for aircraft avionics and electrical system immunity**
- **Required immunity depends on:**
  - Effective radiated power from transmitting PEDs
  - Separation distance between PED and aircraft systems and associated wiring
  - Modulation characteristics of PED transmissions

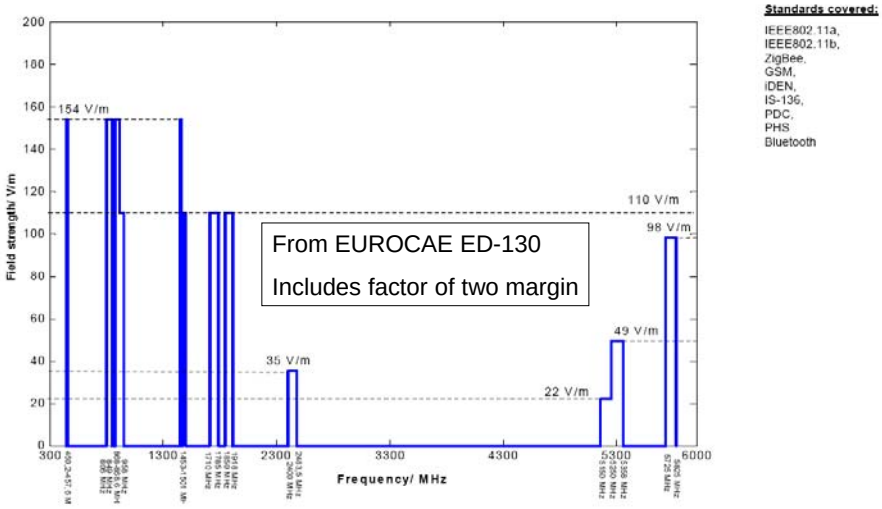
Back Door Coupling of Radiated Emissions



Aircraft System RF Immunity

- **System RF immunity is related to system criticality**
  - **Avionics systems with potentially catastrophic failure effects have immunity on the order of 100 v/m rms for CW and square wave signals, and higher for lower duty cycle pulsed signals**
  - **Systems with hazardous and major failure effects have demonstrated immunity on the order of 5 to 20 v/m rms for aircraft designed since the early 1990s**
  - **Prior to the early 1990s, systems with hazardous and major failure effects have demonstrated immunity on the order of 1 v/m rms**

PED Field Strength at 10 cm - Examples



DO-307 Back Door Recommendations

- **Back door interference immunity requirements very similar to HIRF requirements**
- **DO-160 Section 20 categories and test methods can be used**
- **Only radiated susceptibility tests recommended**

DO-307 Recommendations

System Functional Failure Condition Classification	Distance Between T-PED and System LRU ≥ 20 cm	Distance Between T-PED and System LRU < 20 cm
Catastrophic	RTCA DO-160 Section 20 Category XR (20 v/m average)	RTCA DO-160 Section 20 Category XW limited to 8 GHz (100 v/m average)
Hazardous	RTCA DO-160 Section 20 Category XR (20 v/m average)	RTCA DO-160 Section 20 Category XR (20 v/m average)
Major	RTCA DO-160 Section 20 Category XR (20 v/m average)	RTCA DO-160 Section 20 Category XR (20 v/m average)
Required by regulation and not covered above	RTCA DO-160 Section 20 Category XR (20 v/m average)	RTCA DO-160 Section 20 Category XR (20 v/m average)
Minor and no safety effect and not required by regulation	No requirement	No requirement

Front Door Interference from PEDs

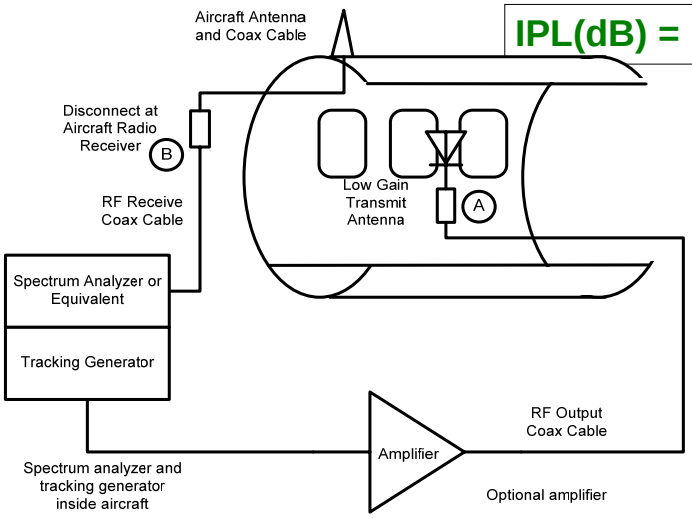
- **Potential for interference depends on:**
  - Amplitude of PED spurious emissions
  - Frequencies of the spurious emissions
  - Sensitivity of the aircraft radio receiver
  - Path loss between the PED and the aircraft radio receiver antenna

Front Door RF Immunity

- **Aircraft designers cannot control:**
  - PED spurious RF emissions (frequency or amplitude)
  - Aircraft radio receiver sensitivity
- **Aircraft designers can control:**
  - Interference path loss between the PED and the aircraft radio receiver antenna
- **This is the approach taken by RTCA SC-202**

Interference Path Loss (IPL)

$$IPL(dB) = P_{Tr(A)} - P_{Rec(B)}$$



Approach

Goal is to determine aircraft *Target IPL* which, if achieved, provides tolerance to PED spurious emissions

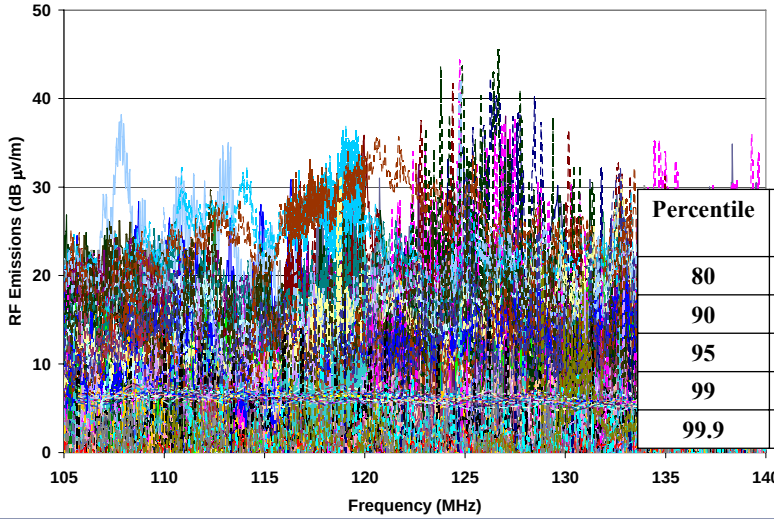
$$IPL_{target} = P_{RF\ emissions} + MEF - P_{rcvr\ thresh}$$

IPL_{target}	Target IPL in dB
$P_{RF\ emissions}$	Power spectral density of PED emissions in dBm/Hz
MEF	Multiple equipment factor in dB
$P_{rcvr\ thresh}$	Threshold for receiver interference susceptibility in dBm/Hz

PED RF Emissions Characteristics

- **Determined RF emissions characteristics of PEDs**
  - Analyzed RF spurious emissions measured on 150 PEDs
  - Measured by Boeing, NASA, and Cessna
- **Developed statistical representation of emissions for aircraft radio receiver frequency bands**

Measured Spurious RF Emissions – VHF Band



Percentile	Emissions (dBµv/m)
80	16
90	20
95	24
99	30
99.9	37

PED RF Emission Characteristics

Frequency Band (MHz)	Single PED Emissions (dBµV/m)					DO-160E Section 21 Limits (dBµV/m)	
	80th %-ile	90th %-ile	95th %-ile	99th %-ile	99.9th %-ile	Cat M	Cat H
105-140	16	20	24	31	39	35	25
325-340	18	22	26	42	68	53	38
960-1250	32	37	41	50	59	50	46
1565-1585	15	19	23	30	42	53	49
4200-4400	57 (test equipment noise floor)					71	71
5030-5090	26	27	32	42	57	72	57

Multiple Equipment Factor (MEF)

- Many similar PEDs can operate simultaneously on aircraft
- RF emissions from the devices can combine resulting in higher emissions received by the aircraft radios
- The multiple equipment factor accounts for the contributions from multiple PEDs

Radio Receiver Interference Threshold

- **Aircraft radio receivers analyzed for interference thresholds**
  - These were documented in RTCA/DO-294B
  - Expressed in terms of power spectral density (PSD)
- **Specific interference thresholds determined for each aircraft radio receiver type**

Receiver Susceptibility Threshold - Examples

Receiver	Operational Frequency Range (MHz)	Receiver Susceptibility Threshold PSD (dBm/Hz)
Localizer (Cat I DH)	108-112	-154
VOR	108-118	-165
VHF Comm.	118-137	-155
VDL Mode 2	118-137	-162
Glide Slope (Cat I DH)	329-335	-145
DME	962-1213	-167
Mode S Transponder	1030	-162
TCAS	1090	-167
GNSS L1	1559-1610	-181

Target IPL Results - Examples

Receiver	Operational Frequency Range (MHz)	Receiver Susceptibility Threshold PSD (dBm/Hz)	Single PED Percentile EIRPSD (dBm/Hz)	MEF for Large Aircraft (dB)	Target IPL For Large Aircraft (dB)
Localizer (Cat I DH)	108-112	-154	-124	14	44
VOR	108-118	-165	-131	14	48
VHF Comm.	118-137	-155	-131	13	37
VDL Mode 2	118-137	-162	-131	14	45
Glide Slope (Cat I DH)	329-335	-145	-113	14	46
DME	962-1213	-167	-134	10	43
Mode S Transponder	1030	-162	-134	10	38
TCAS	1090	-167	-134	10	43
GNSS L1	1559-1610	-181	-145	10	46

Aircraft Certification Implications

- **RTCA/DO-307 recommendations address aircraft design considerations, not aircraft operator requirements**
- **Most useful during new aircraft design**
- **DO-307 provides test methods**
  - To verify system RF immunity for intentional transmitting PEDs
  - To verify interference path loss for PED spurious RF emissions

Where to Go From Here?

- No plan at this time for mandatory aircraft PED tolerance
- Aircraft PED tolerance can be demonstrated for independently for transmitting PEDs and PED spurious RF emissions
- Aircraft operators will still need to comply with operating regulations for PEDs