

# ENGAGED COMPLIANCE FOR DO160 AND OTHER STANDARDS

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SEPTEMBER 2022



# ENGAGED COMPLIANCE FOR AEROSPACE AND OTHER STANDARDS

## Introduction

- BSEE and MSEE from Capital College in Laurel, Maryland focusing on RF and microprocessors.
- 20 year career in electronic hardware design and compliance for Military and Aerospace applications
  - SAIC - Maryland RF vehicle tracking product line.
  - Collins Aerospace/Raytheon wireless design (both cellular and 802.11x wifi)
  - EMI/EMC engineer
  - Full circle, testing intentional radiators
- Overseen thousands of tests products from tip to tail and top to toilet tank.
- Collins Aerospace Subject Matter Expert for EMI/EMC working toward Fellow.
- Engineer and intern EMC trainer, have produced EMI/EMC experts for other top Minnesota companies.
- Attend RTCA/DO160 Special Committee 135 for Environmental and Electrical Test Conditions activity in the User's Guide
- Developed and taught college level Intro to Designing for EMI/EMC Compliance
- Authored ~100 technical and entertaining articles for NERD magazine

# TOPICS

CRITICAL THINKING – DOES IT MAKE SENSE  
NEXT: QUESTIONS GET ANSWERS AND MAKE CHANGE

1. THE ORIGIN OF REQUIREMENTS
2. DO THE LEVELS MAKE SENSE?
3. DISTANCE VS  $\lambda$  ARGUMENT
4. BRAIN TEASERS
  1. ESD
  2. BAD POWER
  3. MILSTD461 CE102 VERIFICATION
5. CHANGE PROPOSAL PROCESS
  1. WHO
  2. HOW
  3. WHAT HAPPENS NEXT

# THE ORIGIN OF REQUIREMENTS

**MYTH: REQUIREMENTS ARE KNOWN FACTS, BLACK AND WHITE, A.K.A. THE LAW**

**FACTS:**

- A. REUSE AS A BASIS - THE LAST WIDGET WAS LIKE THE NEW WIDGET**
- B. THE SPECIFICATIONS TO THE NEW MODEL ARE RARELY KNOWN – IT HASN'T BEEN BUILT YET**
  - A. WATCH FOR THE STRATEGY OF SHOOT FOR THE MOON**
  - B. OPPOSITE: BUILD IN FOR SCOPE CREEP**
- C. IT'S A QUESTION OF INTENT**

**\*All examples are purely fictional, meant for illustration only, and not based upon any real person, product, or thing living or dead**

# THE ORIGIN OF REQUIREMENTS

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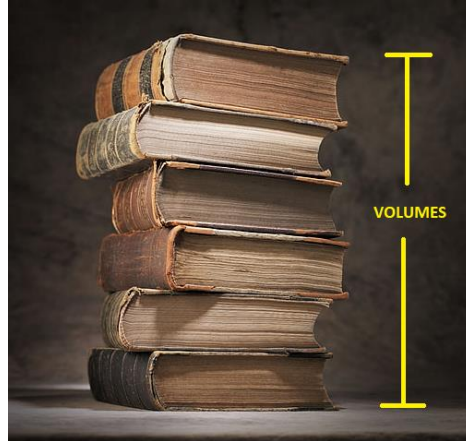
**FACTS:**

**A. REUSE AS A BASIS - THE LAST WIDGET WAS LIKE THE NEW WIDGET**

- 1) Necessary
- 2) Short staff
- 3) Time to market
- 4) Scheduling pressure
- 5) New and unfamiliar team members

**Down side**

- 1) Mistakes propagate – setup common
- 2) Levels carry over
- 3) References other customer



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- B. OPPOSITE: BUILD IN FOR SCOPE CREEP**

**Shoot for the moon examples**

- 1) CS highest category is Cat Y – they spec Cat Y +6dB**
- 2) RS spec high for internally mounted systems – see reuse or presence of radar**
- 3) Indirect Lightning Cat 5A because it is the most powerful**

**Scope Creep**

- 1) Tested per DO160 originally changed to point at airframer spec later – voltage spike example**
- 2) Provide USB port, assume data design phone charger**

Envisioned



Req propeller aircraft



Desired

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# THE ORIGIN OF REQUIREMENTS

## Shoot for the Moon – High E-Field Level for Interior Environment

PLATFORM		AIRCRAFT (EXTERNAL OR SAFETY CRITICAL)	AIRCRAFT INTERNAL
FREQ. RANGE			
2 MHz ↓	A	200	200
	N	200	200
30 MHz	AF	200	20
30 MHz ↓	A	200	200
	N	200	200
1 GHz ↓	AF	200	20
	A	200	200
1 GHz ↓	N	200	200
	AF	200	60

So many questions

Table VII, Mil Std 461 RS103



Is it hot in here?

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# THE ORIGIN OF REQUIREMENTS

## Scope Creep Before and After – Voltage Spike

Time ( $\mu$ s)	Amplitude of positive and negative spikes (Volts)
10	600

Test to DO160

Time ( $\mu$ s)	Amplitude of positive and negative spikes (Volts)
0	600
10	600
20	428
30	327
50	200
100	140
200	80
300	44
500	0

Test to DO160?

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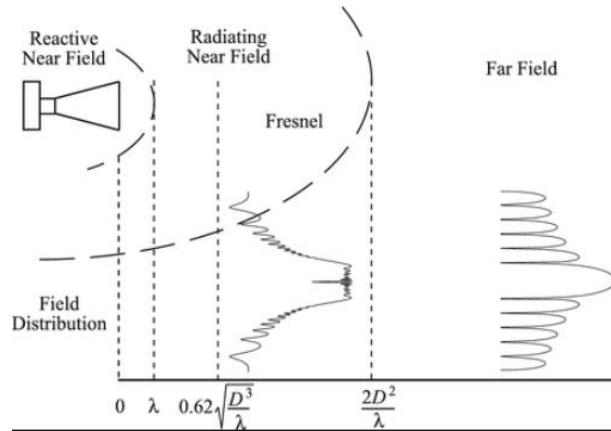
# THE ORIGIN OF REQUIREMENTS

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**FACTS: These are the rules, but they are head scratchers**

**IT'S A QUESTION OF INTENT**

- 1) CE102 verification of LISNs – intent to show LISNs aren't blown
- 2) Near or Far field – the Efield probe doesn't care
- 3) Power Input testing dirty power – accurate dirty power doesn't exist
- 4) ESD pin injection – what is the intent?



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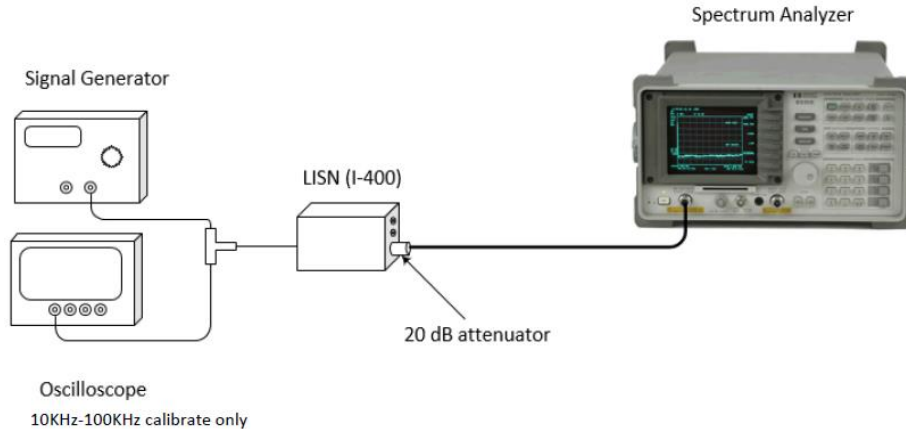
# THE ORIGIN OF REQUIREMENTS

## IT'S A QUESTION OF INTENT

### 1) CE102 verification of LISNs – intent to show LISNs aren't blown

The verification method given in Mil Std 461 contains error which the tester must quantify ( $A_{in} \neq A_{out}$ ) and is very laborious!

Send signal, measure closed loop, change connections, measure again @ LISN port, do math, repeat for numerous frequencies



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#### Supporting material

The discrete values and equation for the slope are: 1.) section 5.5.3.4.a.2 calls out two values -14dB @ 10kHz and -3dB @100kHz 2.) section 5.5.3.4.a.4 mentions the attenuation of the cap, but you will find the equation in Appendix A.5.5.  $20\log_{10}((1+5.6 \times 10^{-9}f^2)^{1/2}/(7.48 \times 10^{-5}f))$

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MIL-STD-461G

- (2) Apply a signal level of 90 dB $\mu$ V at 10.5 kHz and 100 kHz to the power output terminal of the LISN. At 10.5 kHz and 100 kHz, use an oscilloscope, in high impedance mode, to verify that there is a proper signal level at the LISN and verify that it is sinusoidal. After establishing the proper signal at the LISN, disconnect LISN and measure resulting voltage using an oscilloscope with 50 ohm input impedance. The ratio of the LISN voltage to the 50 ohm voltage measurement must be within the following tolerances: at 10.5 kHz = -14 dB (+1 dB/-2 dB) and at 100 kHz = -3 dB (+1 dB/-2 dB).

# THE ORIGIN OF REQUIREMENTS

## IT'S A QUESTION OF INTENT

### 1) CE102 verification of LISNs – intent to show LISNs aren't blown

The verification method given in Mil Std 461 contains error which the tester must quantify (because  $A_{in} \neq A_{out}$ ) Supporting material A.5.5.2

A correction factor must be included in the data reduction to account for the 20 dB attenuator and for voltage drops across the coupling capacitor. This capacitor is in series with a parallel combination of the 50 ohm measurement receiver and the 1 kilohm LISN resistor. The two parallel resistances are equivalent to 47.6 ohms. The correction factor equals:

$$20 \log_{10}((1 + 5.60 \times 10^{-9} f^2)^{1/2} / (7.48 \times 10^{-5} f))$$

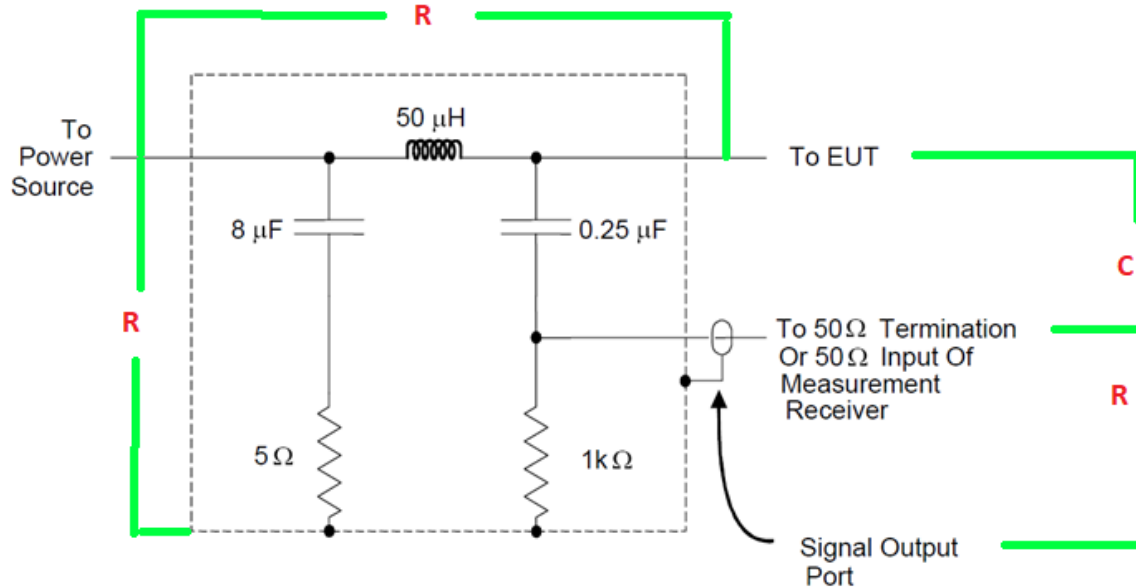
where  $f$  is the frequency of interest expressed in Hz. This equation is plotted on Figure [A-11](#). The correction factor is 4.45 dB at 10 kHz and drops rapidly with frequency.

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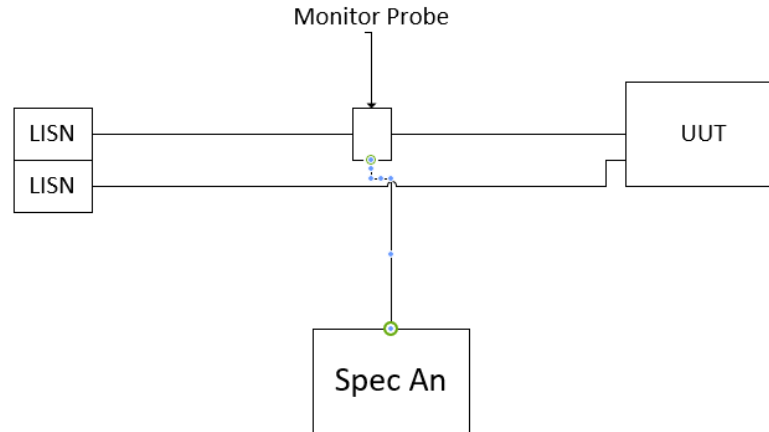


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# THE ORIGIN OF REQUIREMENTS

## IT'S A QUESTION OF INTENT

1) CE102 verification of LISNs – intent to show LISNs aren't blown  
Last Shot



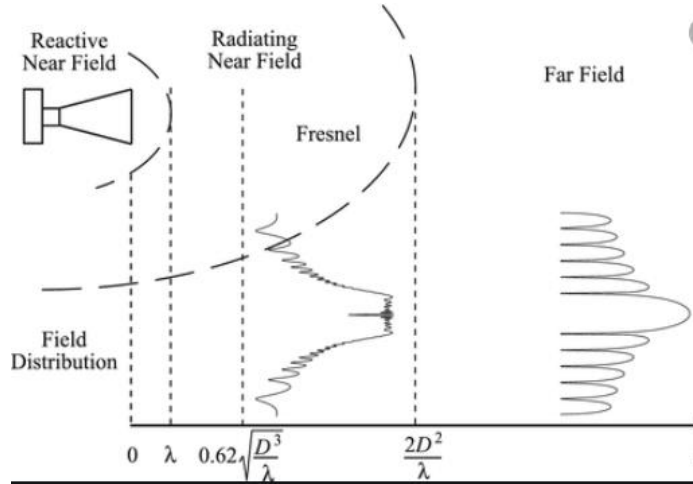
At least offer the current clamp method as an alternate...

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# THE ORIGIN OF REQUIREMENTS

## IT'S A QUESTION OF INTENT

### 1) Near or Far field – the Efield probe doesn't care



DO160 RE and RS tested with antenna at 1 meter. Aggressor in the far field is not likely. Have you been in an E and E Bay?

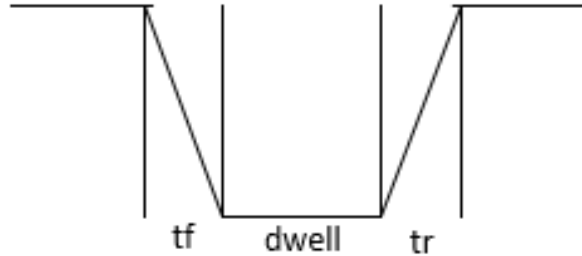
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# THE ORIGIN OF REQUIREMENTS

## IT'S A QUESTION OF INTENT

### 1) Power Input testing dirty power – accurate dirty power doesn't exist



Example of Momentary Trapezoidal Interrupts.  
What precision is required? We are testing the UUT not the programmable power supply. Ask about “nominal” power.

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# THE ORIGIN OF REQUIREMENTS

## IT'S A QUESTION OF INTENT

### 1) ESD pin injection – what is the intent

The explicit intent is to air discharge to case to simulate a discharge which may occur during installed use or maintenance.

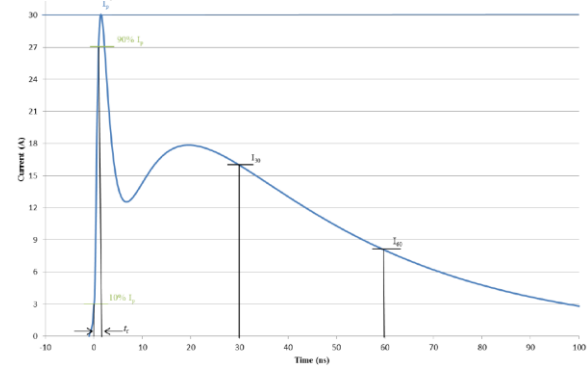
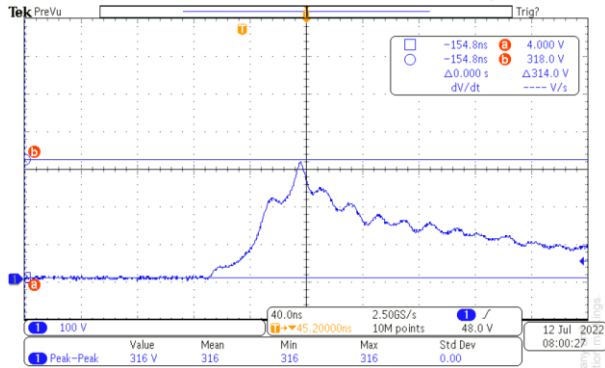
Story of one reported ESD event which had nothing to do with pin injection



# IS IT A PROBLEM?

## ESD – Insensitive

### The Mil Std 461 Human Body Model Yesterday and Today



- Parts tested 20 years ago used first waveform and they have been flying ever since
- Around 2002 it was discovered that the waveform had a leading <math><1\text{nS}</math> peak
- The fast rise time and amplitude are damaging, but the same parts tested with the old waveform may not be damaged
- Does that mean that the parts are insensitive or that ESD doesn't exist – discuss

# CALL TO ACTION

## Four Sections of DO160 Relate Specifically to Power: Sections 16-19

**Power Input**

**Voltage Spike**

**Audio Frequency Conducted Susceptibility**

**Induced Signal Susceptibility**

Power source specific – poorly behaved power

Electric motors relays

Coupling and Compatibility

Designers: use the AMA approach and treat the symptoms

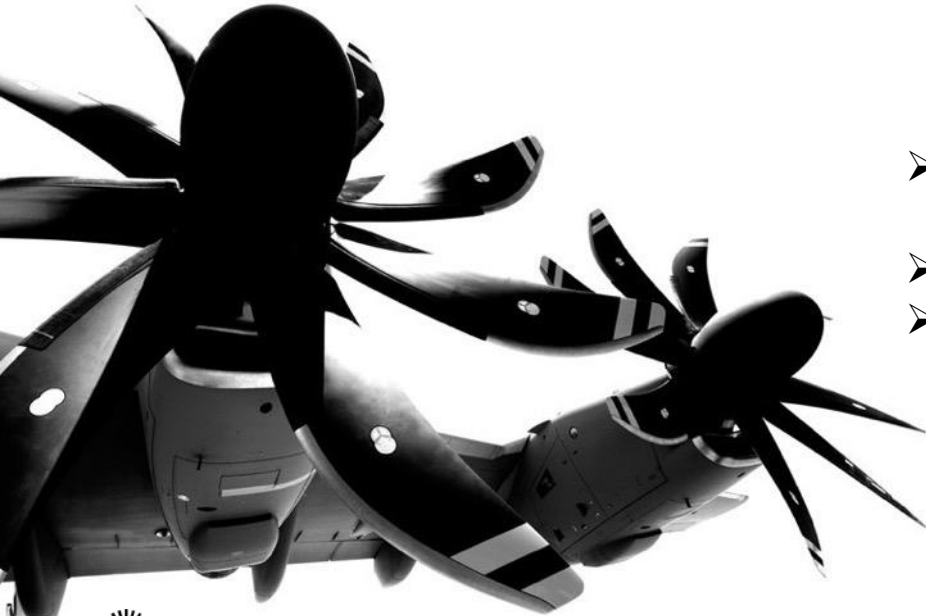
In our case consume 25% of board space with capacitors, filters, and protection

OR

Find, redesign, or eliminate the source of the issue – think of the savings in weight, size, and cost (and testing)

# RTCA DO160 SC135 CHANGE PROPOSAL PROCESS

YOU CAN HELP IMPROVE THE STANDARD



- Participating in the committee is illuminating
  - Members (Air framers, Industry, FAA)
  - Tasks/Work
  - Networking and deja vu
- Great insights are gained from the submissions of the users
- Setup examples
- Contacts

# SUMMARY

Stay Engaged  
Doing So: Helps you, helps your  
customer, saves money, saves time  
Offering your insight to the committee  
does the same

THANK YOU

**QUESTIONS ?**