Designing Resilient Aerospace Electronics Systems:
Navigating Challenges with Modern Methodologies and Resource Optimization

DESIGN

FROM CONCEPT
TO MANUFACTURING

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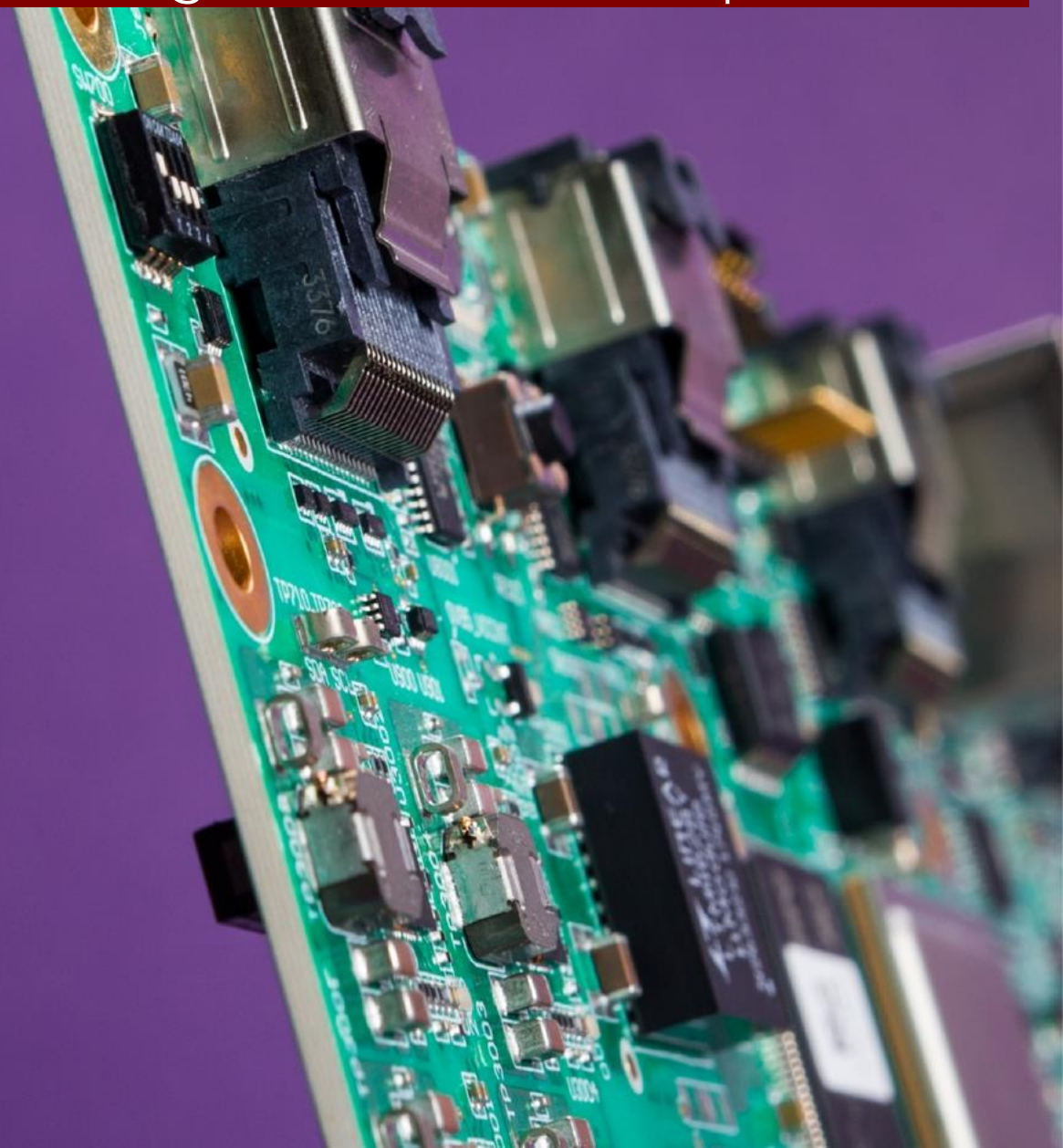


János Lazányi – CEO – PCB Design Kft.

Content

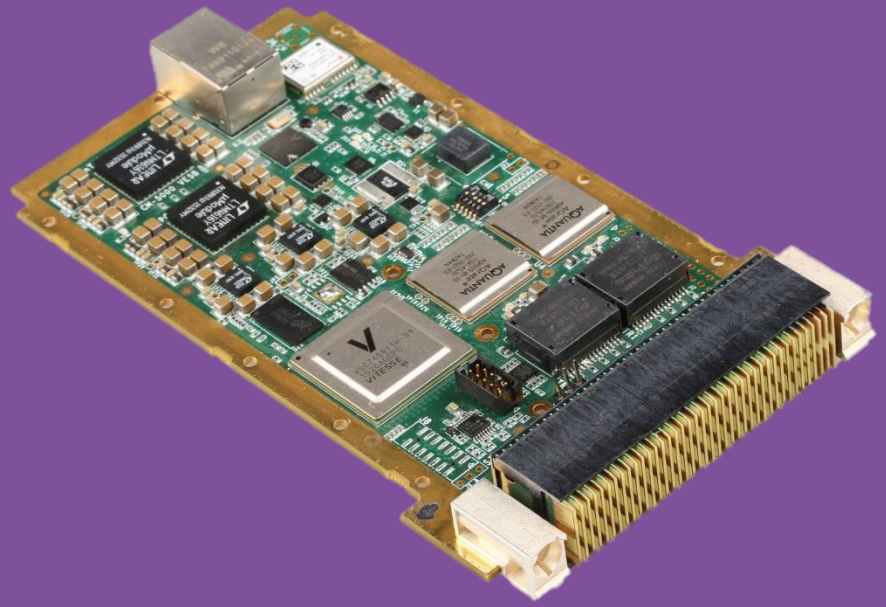
- PCB Design intro
- How to develop “something”
  - Standards, procedures and project management
- System design and EE challenges
- (Project) Management challenges

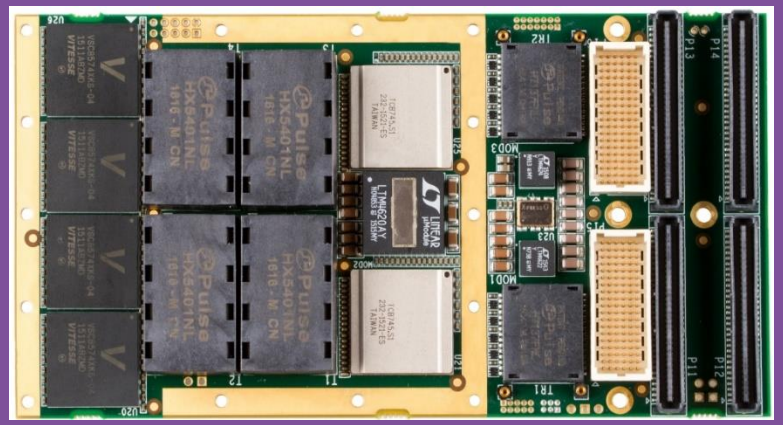
WHO WE ARE

Engineering solution provider
- Major focus on high-speed PCBs
From concept to manufacturing
150 designs/year I 35+ engineers I 70+ customers

DESIGN
FROM CONCEPT TO MANUFACTURING

Reference Project
Rugged Ethernet Switch Family

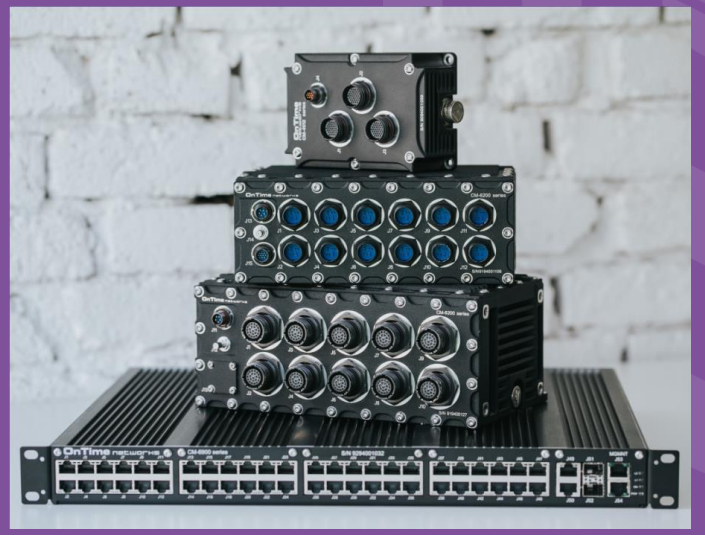


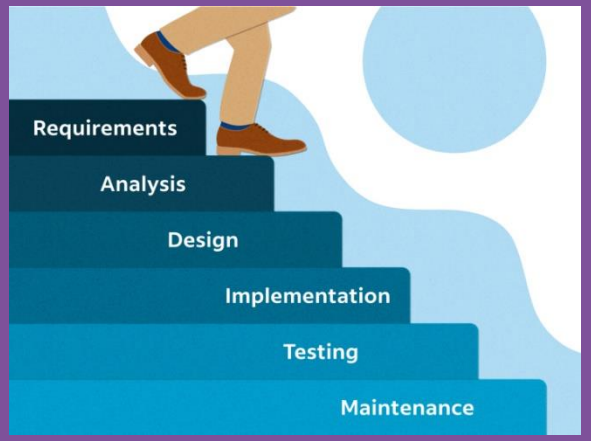


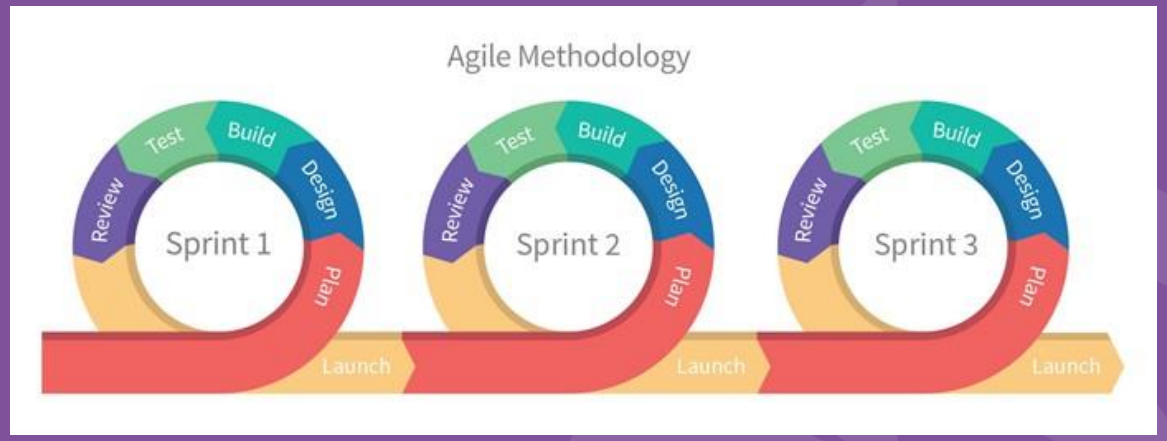
Industrial Ethernet Switch

- System design
- Schematics
- PCB Design
- Simulation
- Prototype manufacturing

Designed using Cadence Allegro







How to develop “something” ?

Something = Aerospace Electronics Systems

Requirement (based) hardware design

Development process in nutshell

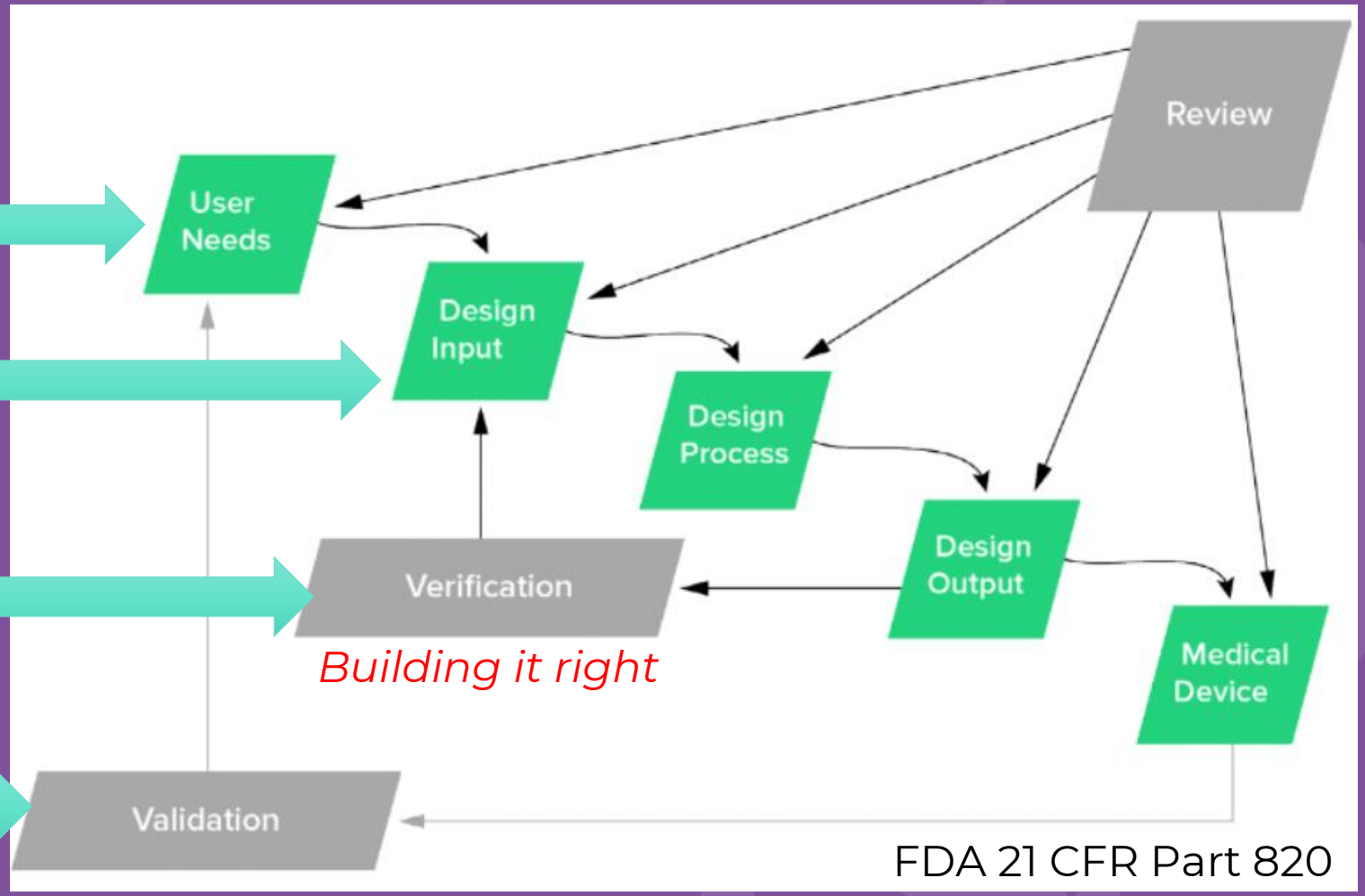
DESIGN

What are we doing?
Who will use ?
Key parameters

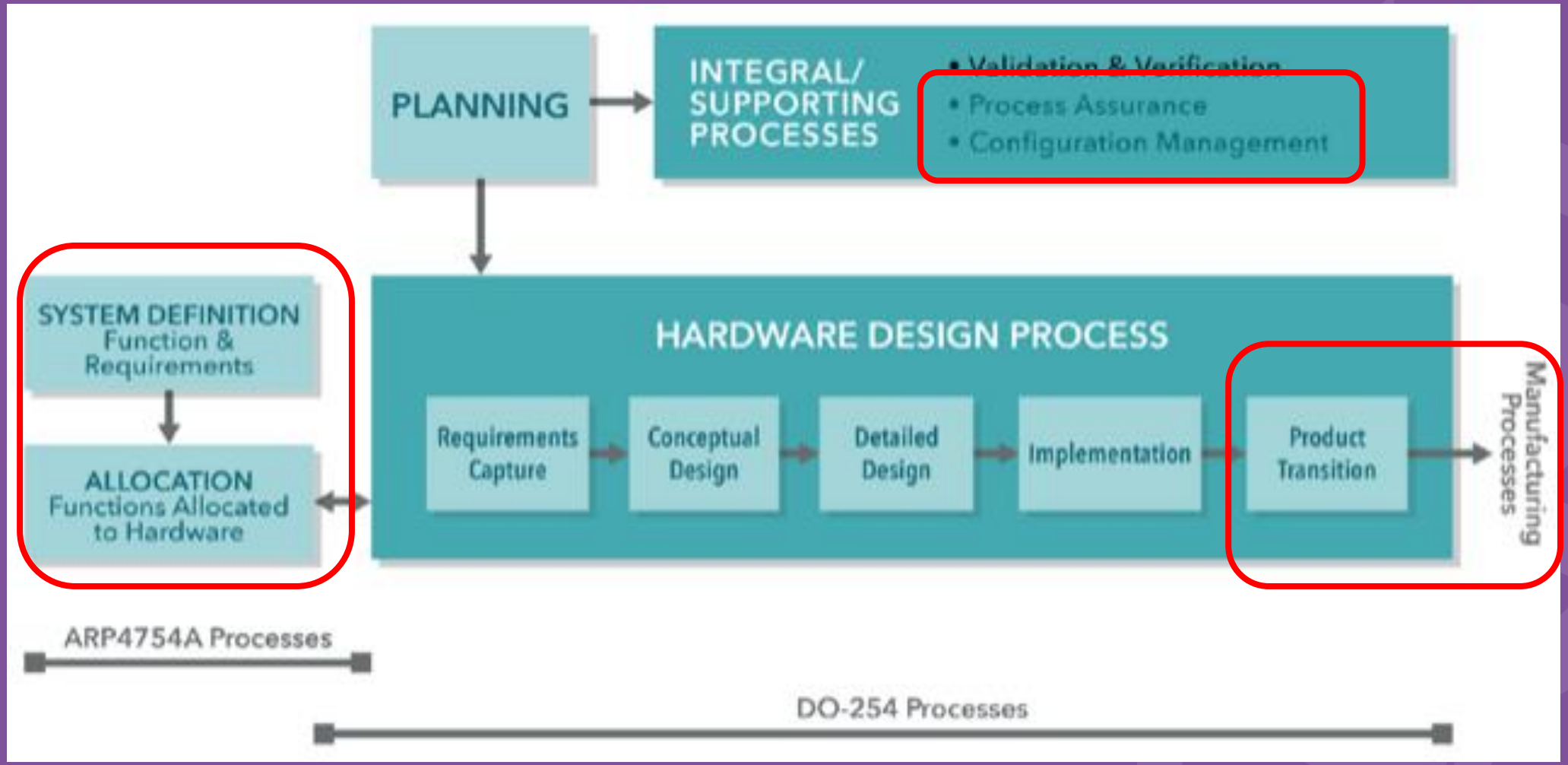
Derived requirements
+ Standards
+ Parameters
+ Risk analysis

Test
Analysis
Review

Evaluating and confirming that a product, meets the actual needs?



DO-254 compliance and life cycle



https://semiengineering.com/

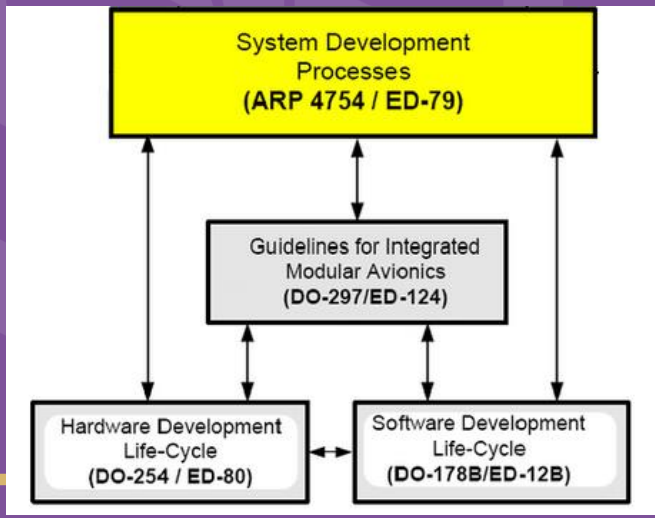
Standards

- **ARP 4754 -** Guidelines for Development of Civil Aircraft and Systems
  - The standard emphasizes system-level activities, including requirements engineering, system architecture, and safety assessment

- **DO-254** - Design Assurance Guidance for Airborne Electronic Hardware
  - Not a quality management system standard;
  - It focuses on the safety aspects of complex electronic hardware used in airborne systems

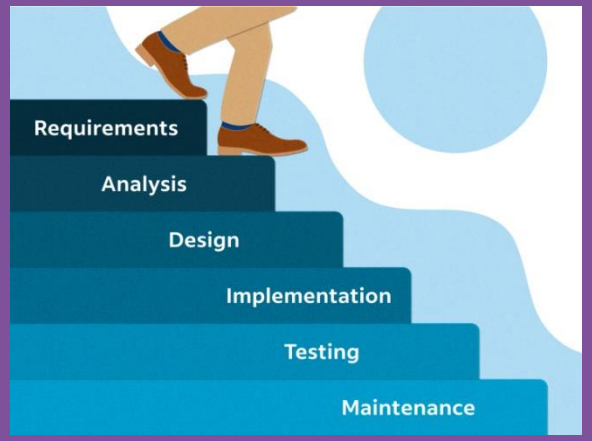
- **AS9100** is a quality management system (QMS) standard specifically designed for the aerospace industry.
  - Based on ISO 9001 standard
  - Additional requirements of AS9100 is to ensure that aerospace products and services meet the highest levels of quality, safety, and reliability.

- **ECSS** standards:
  - M: Space project management;
  - Q: Space product assurance
  - E: Space engineering

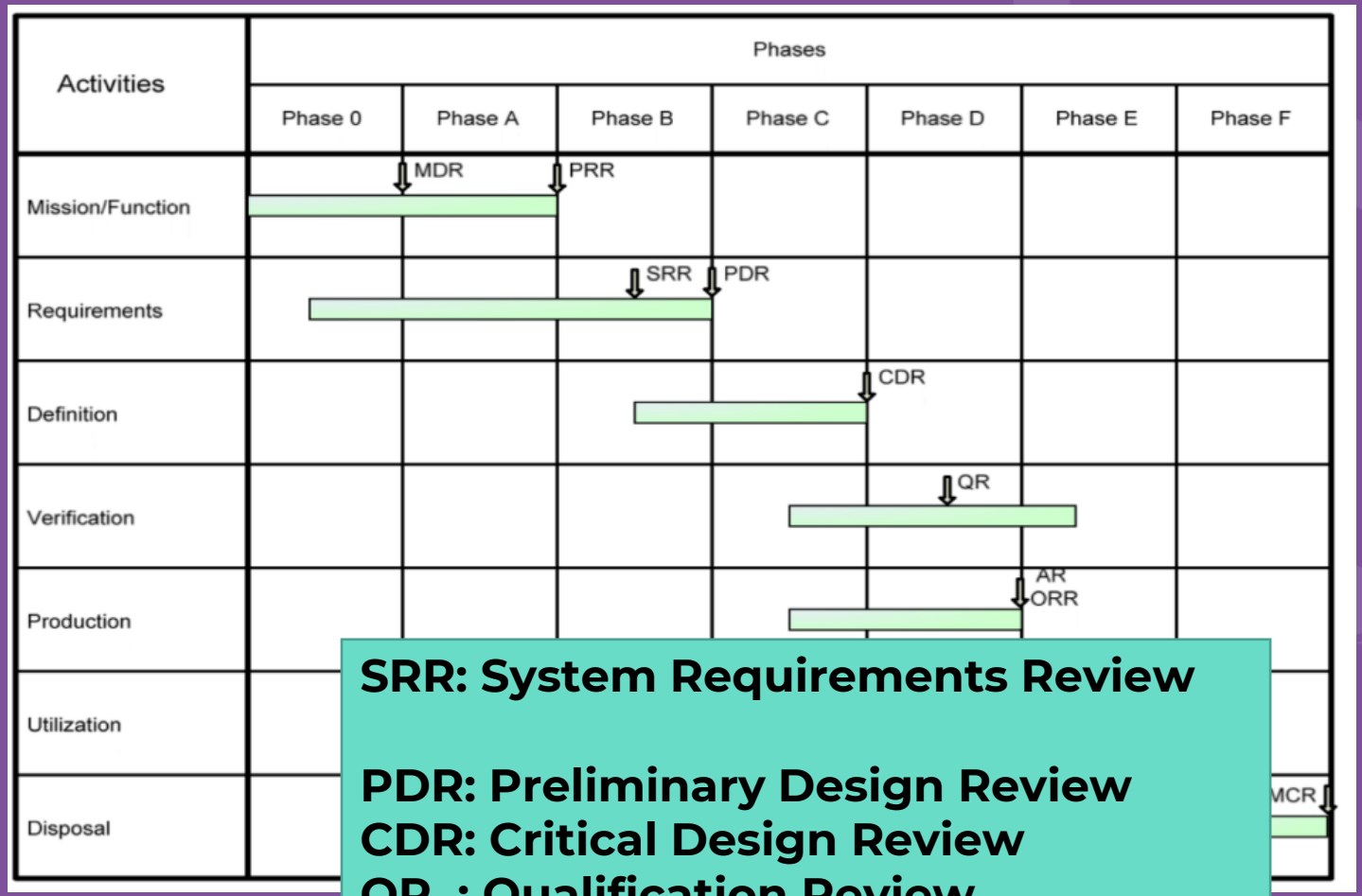


Project planning and execution

- ECSS-M-ST-10C – Project planning and implementation



Phase A – Feasibility
Phase B – Preliminary Definition
Phase C – Detailed Definition



SRR: System Requirements Review

PDR: Preliminary Design Review
CDR: Critical Design Review
QR : Qualification Review

Engineering aspects

Size, Weight, Power & Cost (SWaP-C)

- System Level Requirements → Electrical constraints
  - Size:
    - Physical size of the board -> PCBA orientation / density
    - Mounting directions -> Connector locations
  - Weight
    - Enclosure is not only a structural element
    - Acts as thermal management
    - As EMC/EMI Shield
  - Power
    - Minimizing power usage
    - Maximizing power conversion efficiency (vs. weight+ space)
    - Minimizing losses
  - Cost

- Customized vs COTS (VPX, PC104, COMe)
  - Time to market
  - Component access & availability

Mechanical design

- Typically, machined/diecast aluminum box
  - Constrained space availability
  - Aluminum machining cost can be significant
  - IP6x protection
  - Typically, D38999 connectors

  - **Shall withstand shock and vibration**

  - **Act as cooling infrastructure**
    - Vent screw
    - Special cooling elements (Heat pipes, vapor chamber)

  - **Act as EMI/EMC shield**
    - Passivation where good electrical contact is required
      SurTec

Thermal Management

Thermal Analysis and Simulation

- *Include proper PCB model - copper (10++ layer PCBA)*
- *Proper component modelling – (FPGA power)*

Cooling Systems

- Passive cooling ++
- Active cooling (FANs, TEC)
- Advanced cooling
  - *Vapor chamber, Two phase systems*

Thermal Interface Materials

Health Monitoring

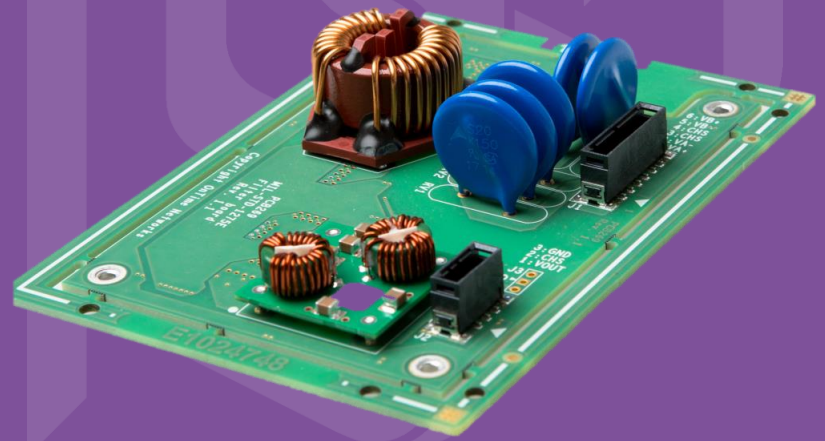
Redundancy (FANs)

Power Supply

- 28V system
  - Typically, “Brick” design

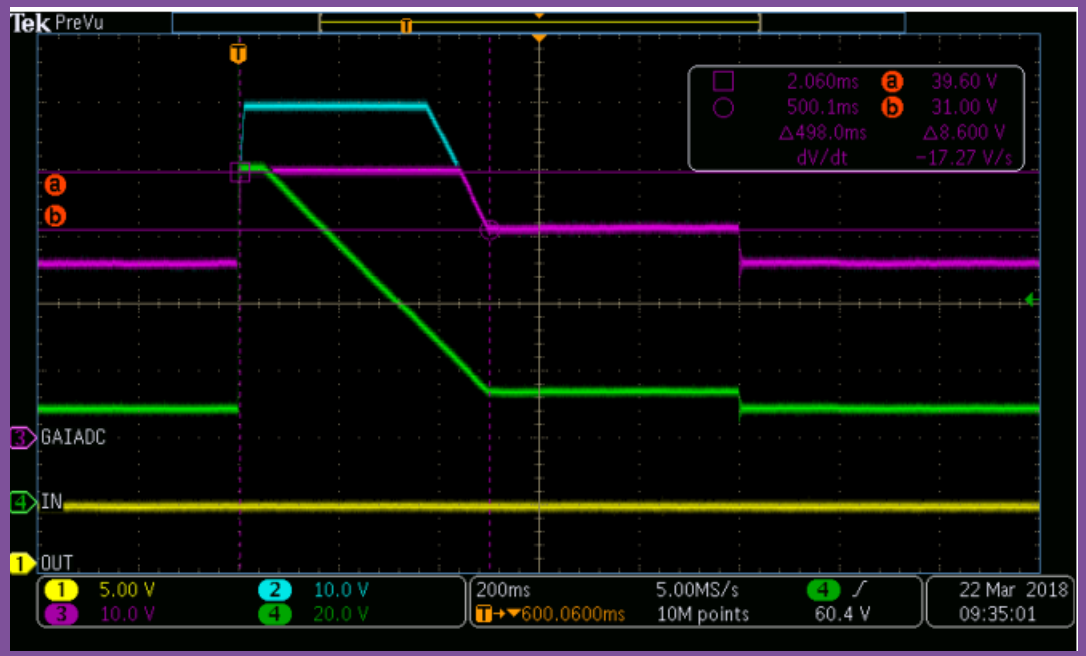
- Redundant input option
  - *Standard diode @ 280 nom. 28V - 10A – (4W)*
  - *Ideal diode input protection*
- Protection
  - Voltage Spikes
  - Surge
- Noise filtering
- Hold up
  - Initial Engagement Surge (IES) / Cranking

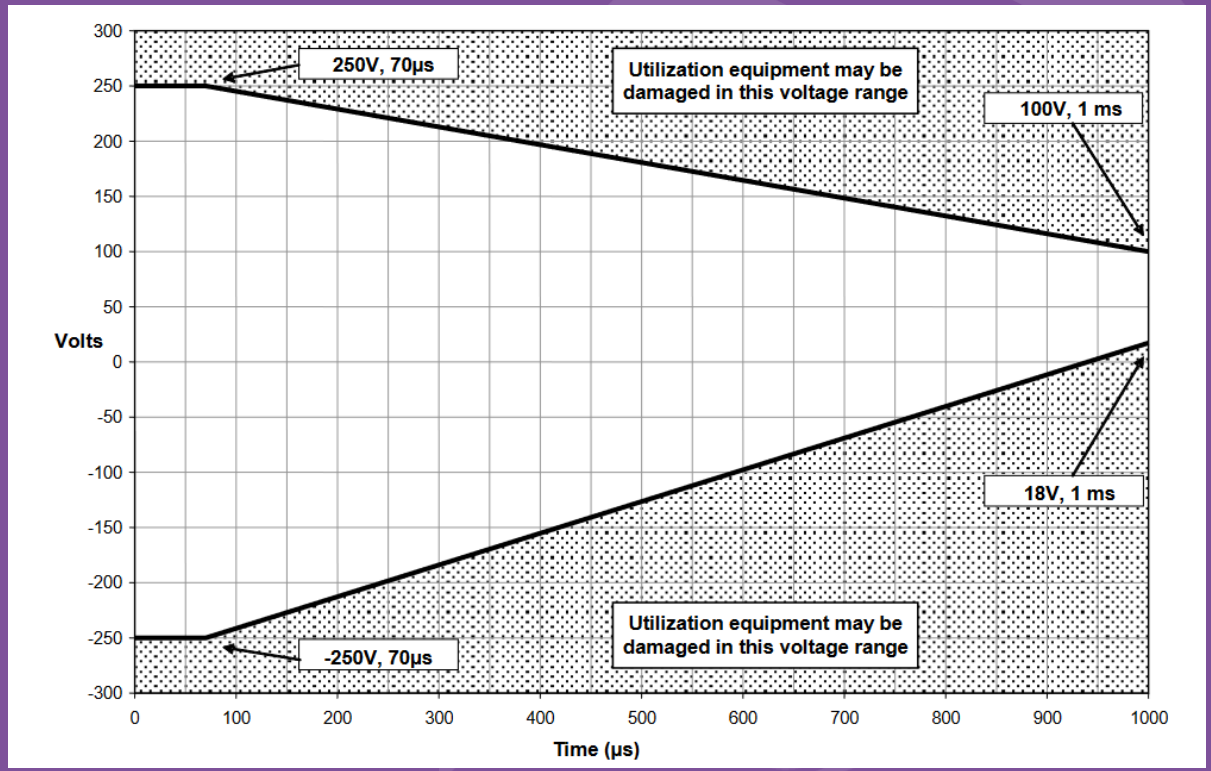
- Standards: DO160, MILSTD 1275, DEFSTAN



MIL STD- 1275 – Voltage spike

- A voltage spike is an energy-limited transient waveform max. 1 ms
  - Typically, passive components
    - MOV
    - TVS

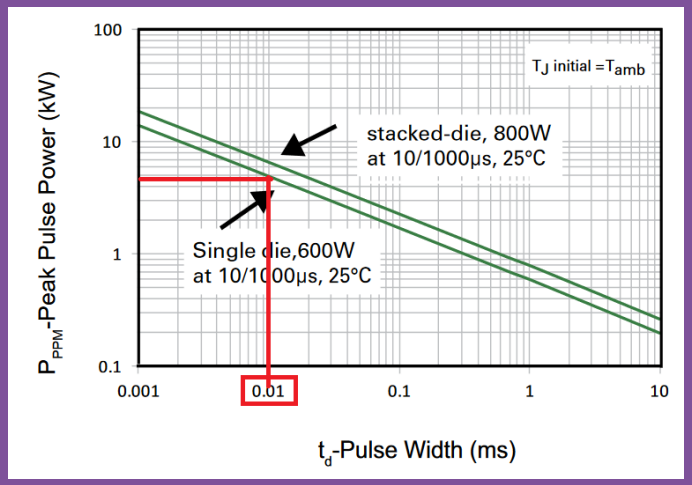


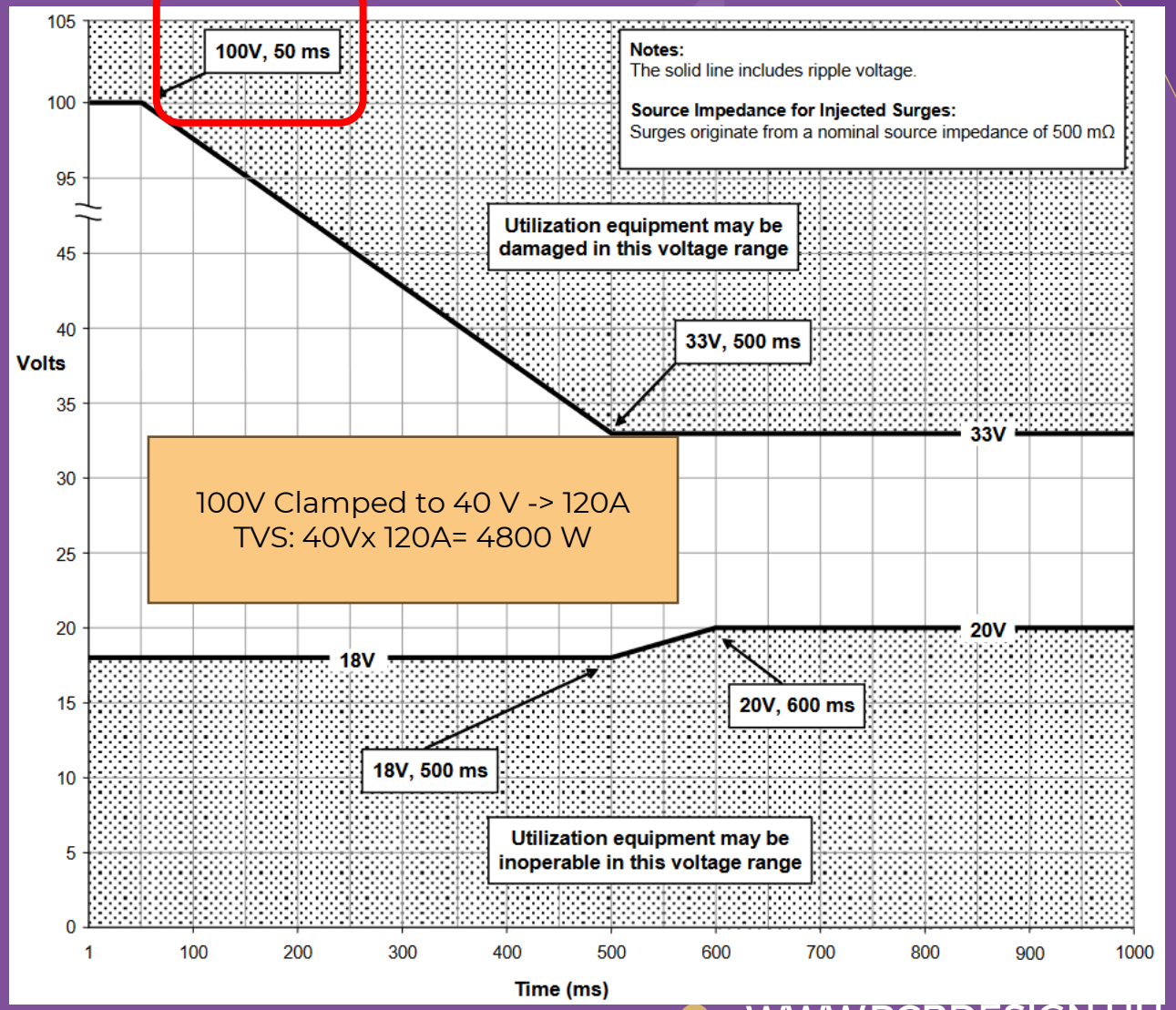


MIL STD- 1275 – Surge

- A single surge is 60 Joule (J)
- Source impedance 0.5 Ohm

- As comparison : **SMBJ28A**
  - ❑ 4800 W - 10 us
  - ❑ 10 us vs 50 ms (x5000)





EMI/EMC Considerations

- Grounding and Bonding
  - Chassis - ground connection - radiated susceptibility would increase
  - Chassis - ground isolation – problems with radiated emission

- Electromagnetic Shielding
  - 360° shield around the connectors
  - Enclosure + cable →Perfect Faraday cage

- Filtering and Isolation
  - Efficient filtering of D38999 connectors
  - Internal cabling
  - PCBAs
    - Design & Floorplan & Layout

MIL STD- 461 – EMC Standard Comparison

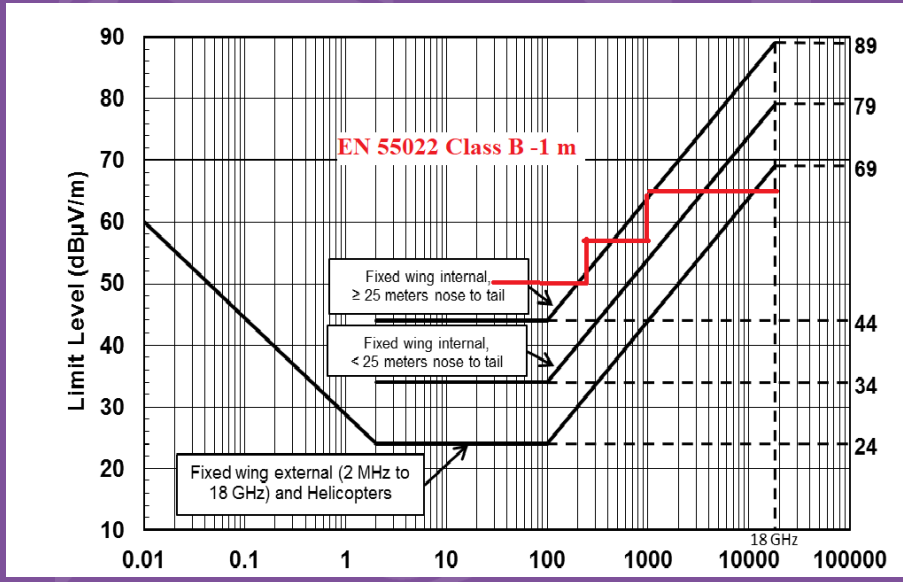
- Electromagnetic interference (EMI)
- Electromagnetic susceptibility (EMS)

	Commercial (EN 55022)	Military (MILSTD 461E)
Emission	Radiated electric field emissions, 30 MHz to 1 GHz	Radiated E-field Emissions, 10 kHz to 40 GHz
	Conducted emissions on AC mains, 150 kHz to 30 MHz	Conducted emissions,10 kHz to 10 MHz
	Conducted emissions on telecomm ports, 150 kHz to 30 MHz	No 461E equivalent
	AC Power Line Flicker	No 461E equivalent
	AC Power Line Harmonics	No 461E equivalent
Immunity	Power frequency H-field immunity	RS101
	Radiated RF immunity	RS103
	Conducted RF immunity	CS114
	Surge immunity	CS116 cca.
	Electrical fast transient	CS115
	Electrostatic discharge	No 461E equivalent
	Voltage dips and interruptions	Not in 461

EMC - MIL-STD 461 – RE102

- Different requirements for different applications
- Stringent EMI/EMS Limits
- Broad Frequency Range
- Different test setup compared to FCC/CE
  - Grounded test table, 1m distance

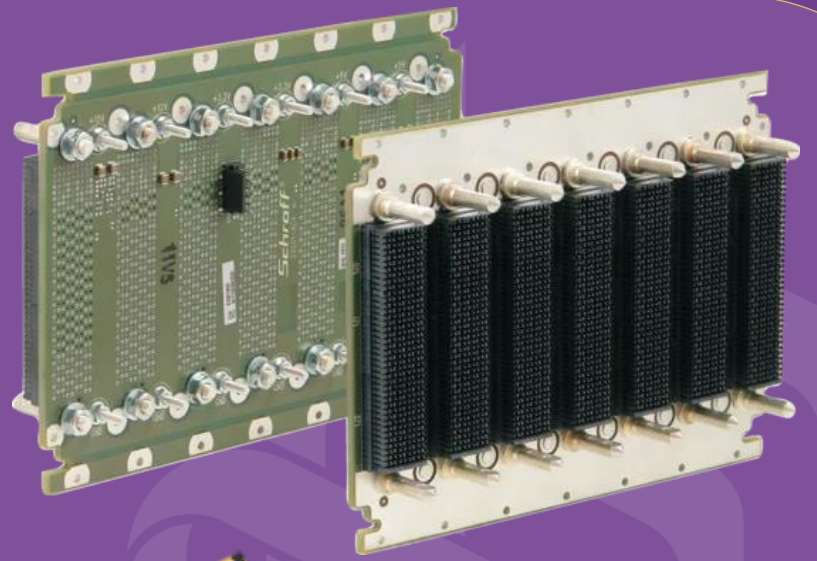
- Integration of Multiple Systems
- Size and Weight Constraints



RE102 limit for aircraft and space system

Aerospace PCBA Engineering

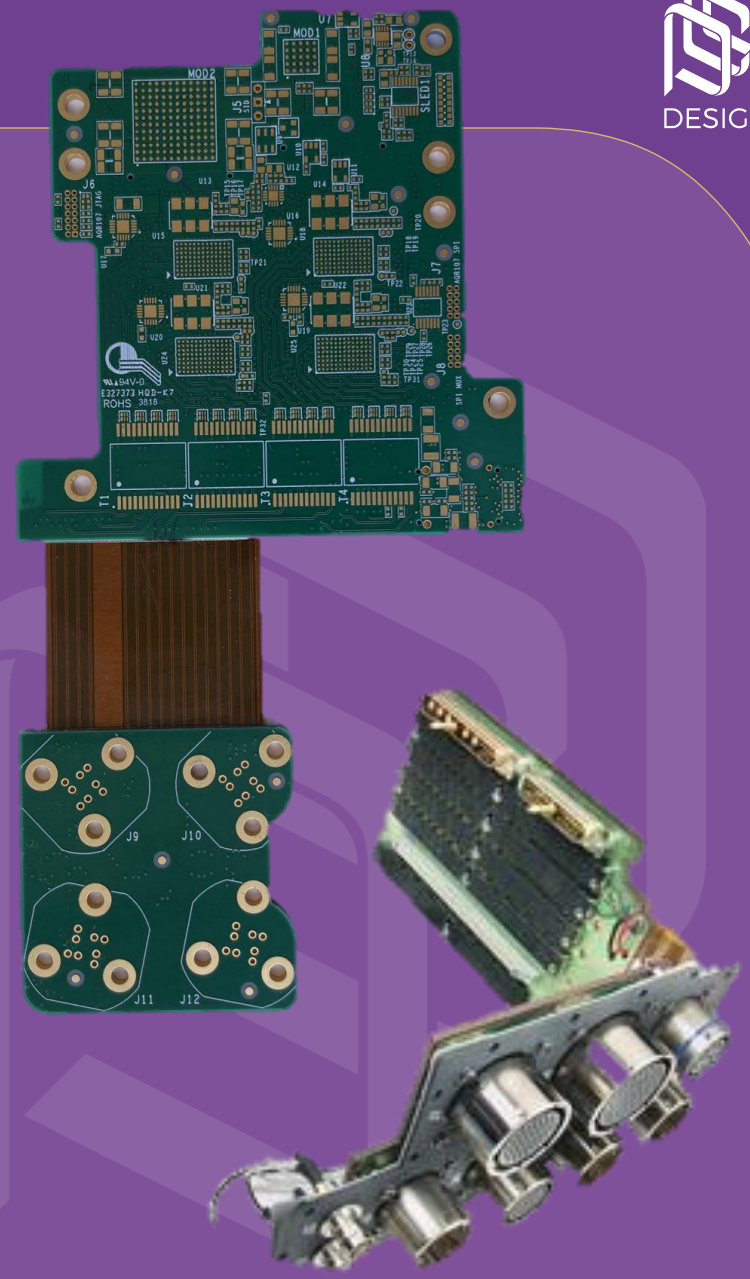
- Conformal coating
- Special stack-up
  - Advanced Materials
  - Backplane (Thick) PCBs
  - Complex VIA structures
- Thermal Management
- Quality Assurance and Testing
  - IPC 600/610 Class III production
- Traceability and Documentation
- High Reliability
  - FMEA - Failure Modes and Effects Analysis
  - MTBF – Mean Time Between Failures



Symbol	Thermal Impedance at Nominal Trim (°C / W)			
	Input Voltage			
	40V	44V	54V	60V
$\theta_{SIGNALS}$	19			
θ_{+OUT}	12			
θ_{+IN_+INV}	24			
θ_{PGND_BOTTOM}	2.4	1.9	1.8	2.1
θ_{PGND_TOP}	1.9	1.6	1.4	2.3
$\theta_{PGND\_TOP\text{-}PGND\_BOTTOM}$	7.9	6.4	9.3	3.6

Rigid - Flex designs

- Space-saving and weight reduction
- High Reliability
- (Mechanical) Flexibility
- Reduced Assembly Time
- Enhanced Signal Integrity
- EMI/EMC Benefits
- Easy customization



DESIGN

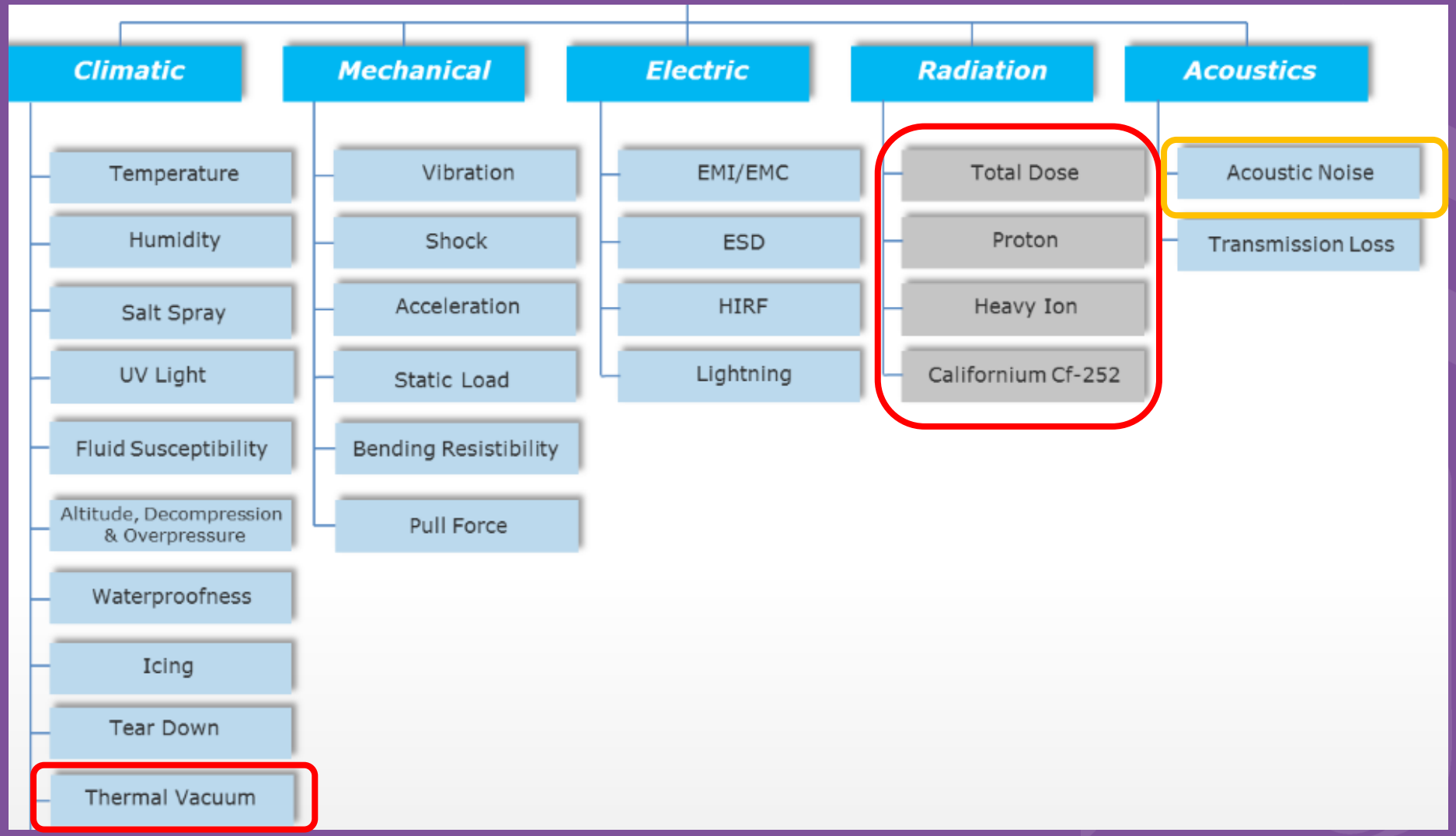
Testing and Verification

- Environmental Testing
- EMI/EMC Testing

- Functional Testing
- Reliability Testing
- Performance Testing
- Software Verification
- Flight Testing
- Certification and Compliance

MTBF	• DSF100: 2496 kHrs, DSF200LV: 2218 kHrs, DSF500: 573 kHrs, FSO461: 8737 kHrs, to MIL-HDBK-217F at 40 °C, GB
Environmental	
Operating Temperature	• -40 °C to +100 °C baseplate
Storage Temperature	• -55 °C to +100 °C
Salt Atmosphere	• MIL-STD-810G method 509.4
Humidity	• MIL-STD-810G 507.4
Altitude	• MIL-STD-810G 500.4
Shock	• MIL-STD-810G 516.5 function test for ground equipment 40 g in 3 axes
Vibration	• MIL-STD-810G method 514.5C-17. Minimum integrity test for military equipment (1 Hr/axis, 3 axes). Vibration 5-33 Hz, 0.5 mm displacement
EMC & Safety	
Safety Approvals	• CE & UKCA meets all applicable directives & legislation
Immunity	• MIL-STD-1275A-E, MIL-STD-461E/F/G (CS101, CS114, CS115 & CS116) MIL-STD-704A, DEF-STAN 61-5 part 6 issue 5 Contact Sales when DEF-STAN-61-5 part 6 issue 6 is required
EMC Performance	• DSF100 & DSF200LV: MIL-STD 461E/F CE102 & DEF STAN 59-411 DCE01/DCE02 is achieved with external components. DSF500: Compliance to MIL-STD 461E/F/G CE102 & DEF STAN 59-411 DCE01/DCE02 is achieved when used in conjuction with FS0461. See longform datasheet for more information.

Test facilities



Management aspects

Technology Transfer and Dual-Use Applications

Dual-use items refer to products, technologies, or materials that have both civilian and military applications.

LTC2000ACY-14#PBF

Digi-Key Part Number	LTC2000ACY-14#PBF-ND
ECCN	3A001A5B2
HTSUS	8542.39.0001

- Export Control
  - Export Control Classification Number (“ECCN”)
  - EAR 99
- Ethical and Legal Considerations

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Restriction of Weapons of Mass Destruction and ...

Murata requests customers to ensure that no **Murata** products are used or sold, t
channels, for use in the design, development, production, utilization, ...

Challenges in HR

- **Skill Shortages**
  - Skill shortages can arise due to the high level of technical expertise required.
  - System level knowledge is required (SWAP-C)
  - Rapid technological advancements in the past years
    - Communication and compute
  - Skill shortages can hinder growth, innovation, and competitiveness

- **Addressing Skill Shortages**
  - COTS based solution
  - Talent Acquisition
  - **Outsourcing**

Why PCB Design ….

- Outstanding experience in:
  - High speed PCB development from specification to manufacturing
  - Turnkey product development
  - Embedded firmware
- Experience in complex product development
  - More than 800 PCBs designed
- Cross- industry knowledge
- Well established company
  - 35 + engineers, 10 years on the market, 2 M€ revenue
- Strong presence in Western Europe

Q & A

DESIGN

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