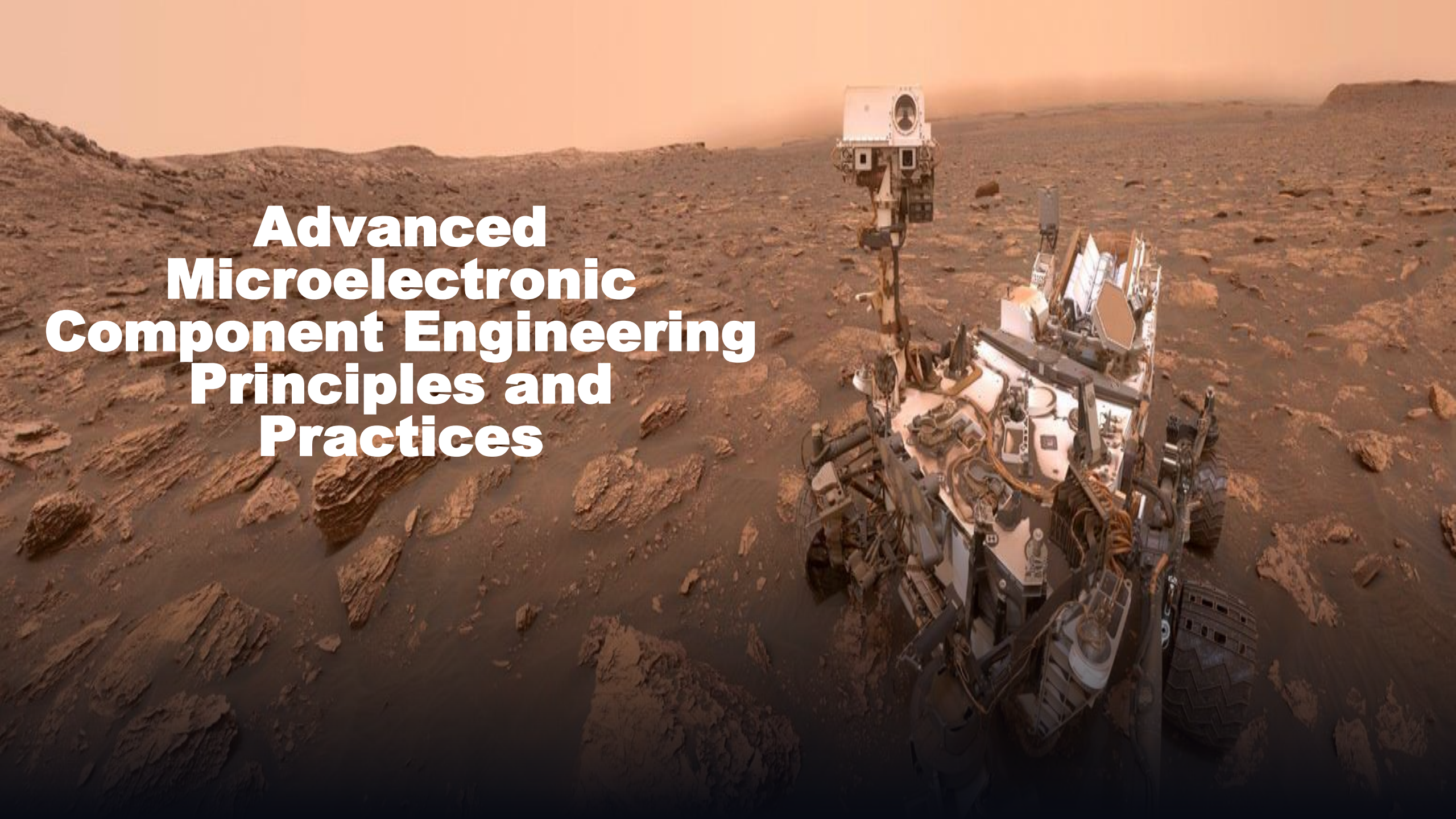
Welcome to CMSE 2026 LA

Advanced Microelectronic Component Engineering Principles and Practices

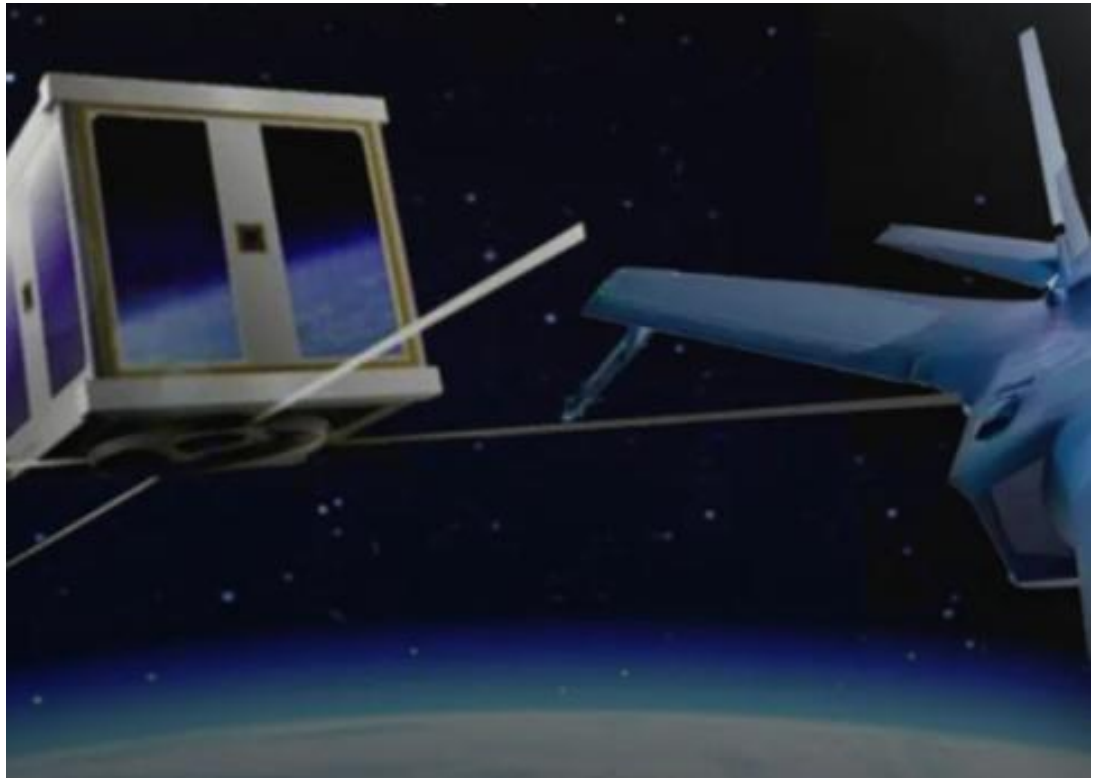


CE Principles & Practices Goal:

Theme: Accelerating change impacts CE Role

Goal is to answer

- AI & Modeling
- Component Grades
- Component Trends
- New Areas of Component performance
- Part failure mode discussion
- Helpful Links



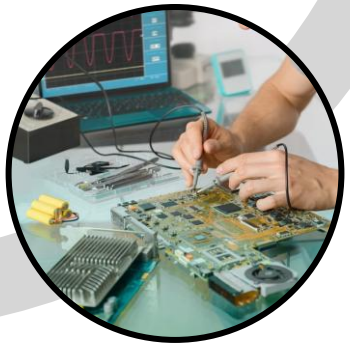
Component Engineering

- Gateway for new Technology to hit engineering
- Engineering resource for cost reduction
- Major contributor to risk reduction
- Defining partner to gain manufacturing efficiency
- Historical center of excellence & knowledge

Component Engineering

Selection

Design



Life Cycle Management

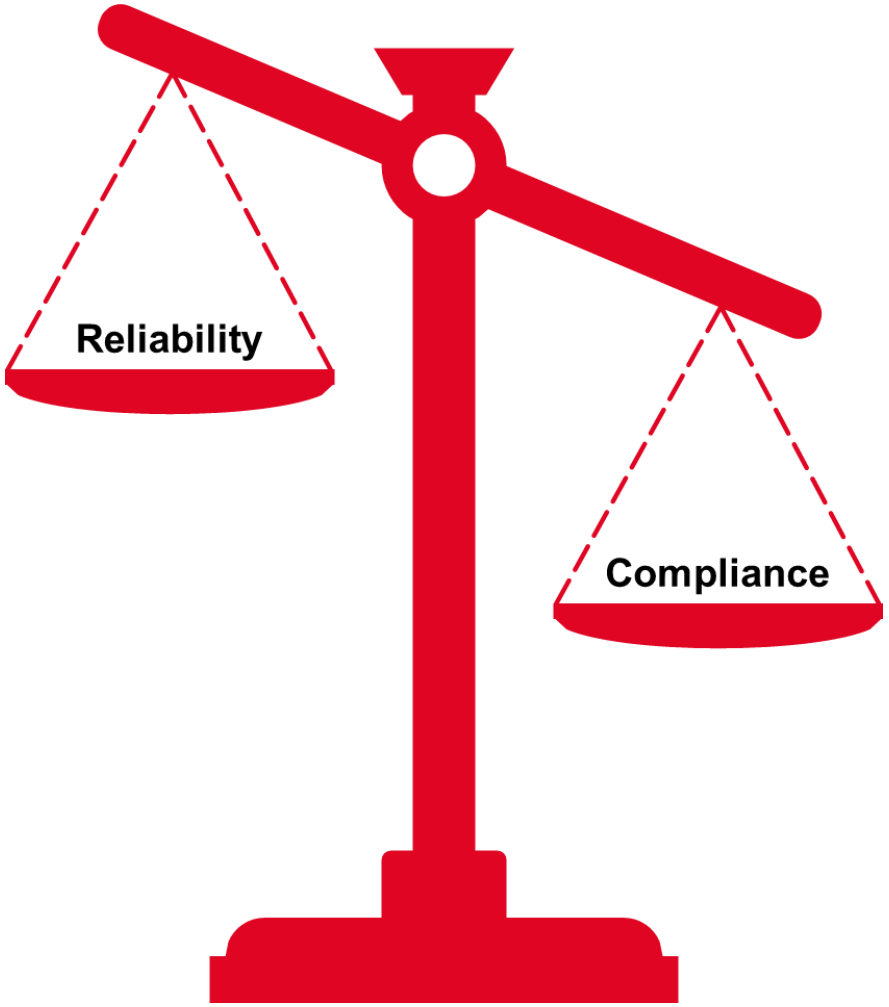
Greatly impacted by

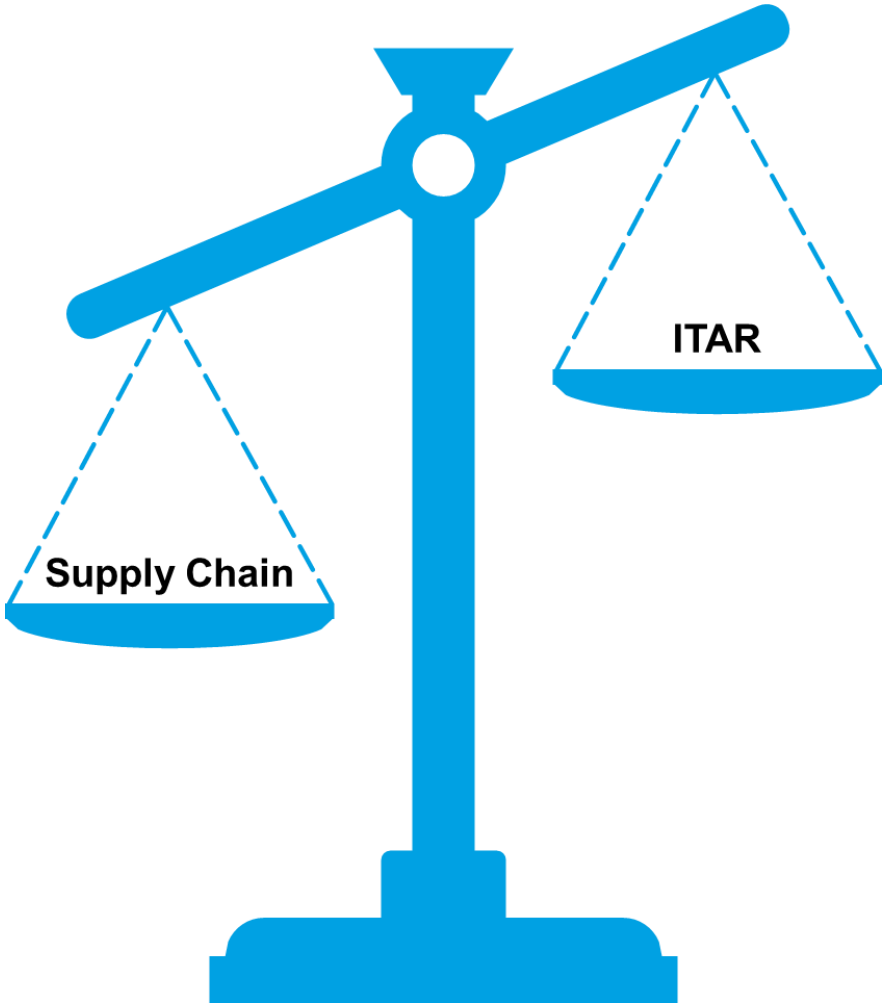
Environmental
&
Government Regulation

PLUS Tech Trends & Evolution

Environmental & Government Regulations

Examples:





Environmental & Government Regulation

Condition	Intent	Constraint
Military Standards	Define performance with implied reliability	Performance levels guaranteed but limit or exclude COTS parts. Increase cost, lead times and limit cutting edge technology
RoHS, REACH, Conflict Minerals	Reduce hazardous materials used in end devices or component level manufacture, CoO concern	End performance may be limited by modified material systems. CoO requirements and full understanding of traceable supply chain
WEEE, EPA RCRA	Recycling & proper disposal	Understanding of recycling and a general concern towards toxic chemistry needed
Energy Efficiency & Sustainability, Energy Star	Create reduced energy use consumer devices	Though not specific to military, this tends to push certain electronic component growth & designs thus impacting the types of parts available
PFAS	Reduce or eliminate forever chemical use	PFAS elimination is a trend. Design, Test, qualify alternates now
ITAR International Traffic in Arms Regulations	Restricts the export of military electronics and sub-components outside the USA	Component Engineers must ensure components aren't sourced from or designs aren't shared with non approved countries. This may limit the use of cheaper and potentially faster sources of supply

Advanced Technology Trends Within the Active Supplier Community greatly Impact Component Engineers job

- Ai
- Miniaturization
- Wide-bandgap semiconductors
- 2.5d / 3d Integration – RF/Digital/Analog
- New package types
- New test types
- Heat Concerns

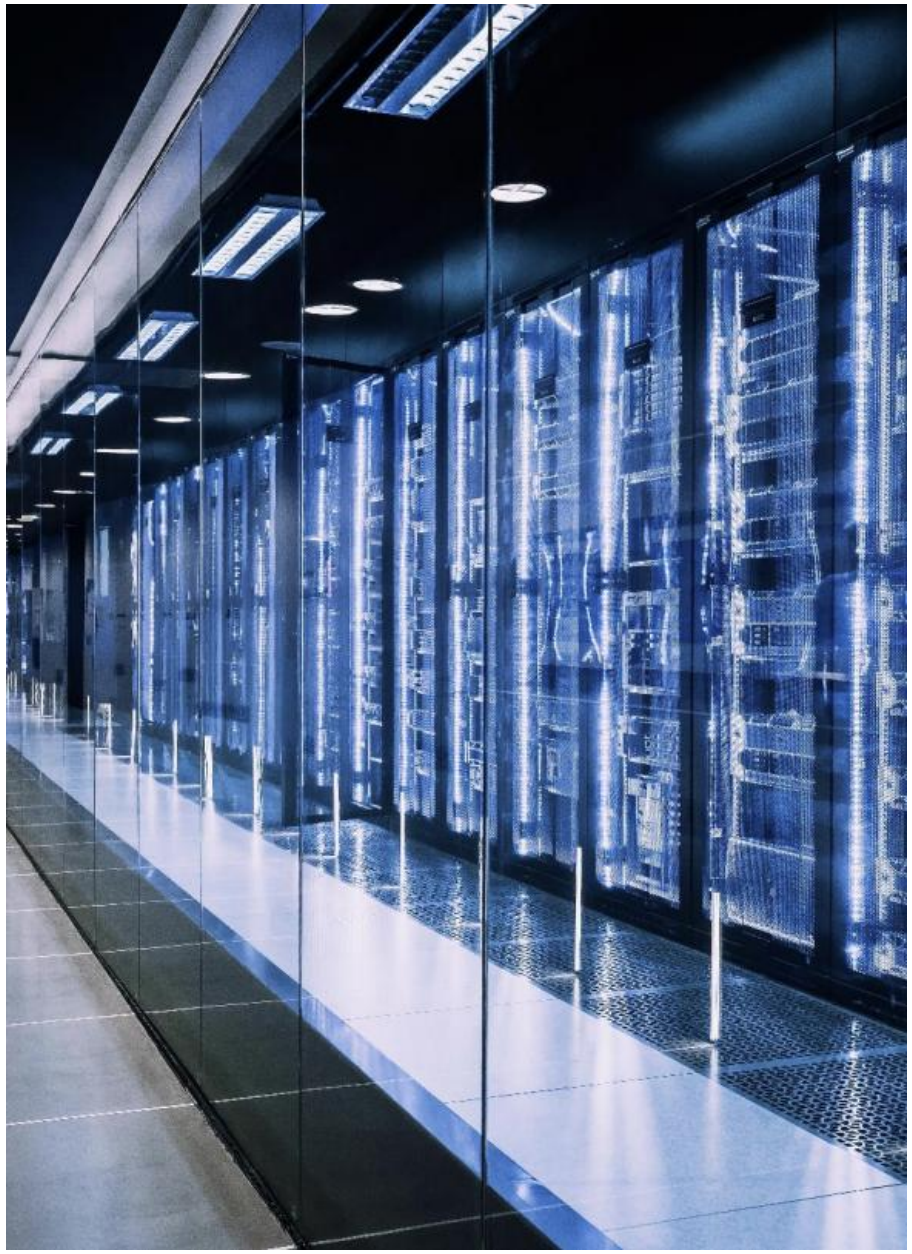
Component Engineering
&
AI 2026

The following is a Real-World Example:

Component Engineer asked CHATGPT for a detailed list of Low ESR capacitor options.

RESULT:

Technology	Series	ESR Profile	Typical Space Applications
MLCC C0G	MIL-PRF-123	Ultra-low ESR	RF, timing, filtering
MLCC X7R	MIL-PRF-55681 / SL	Low ESR	Power filtering, decoupling
SMPS MLCC	C0G/X7R	Extremely low ESR	DC-DC converters, POL regulators
Polymer Tantalum	TCS, TCQ/TCP	Very low ESR	FPGA rails, digital power
Wet Tantalum	TWA/TWC/TWD	Low ESR	Bulk storage, spacecraft buses
Film Capacitors	Space-Grade Film	Very low ESR	DC-link, snubber, EMI filtering



In this instance – Chat GPT was correct

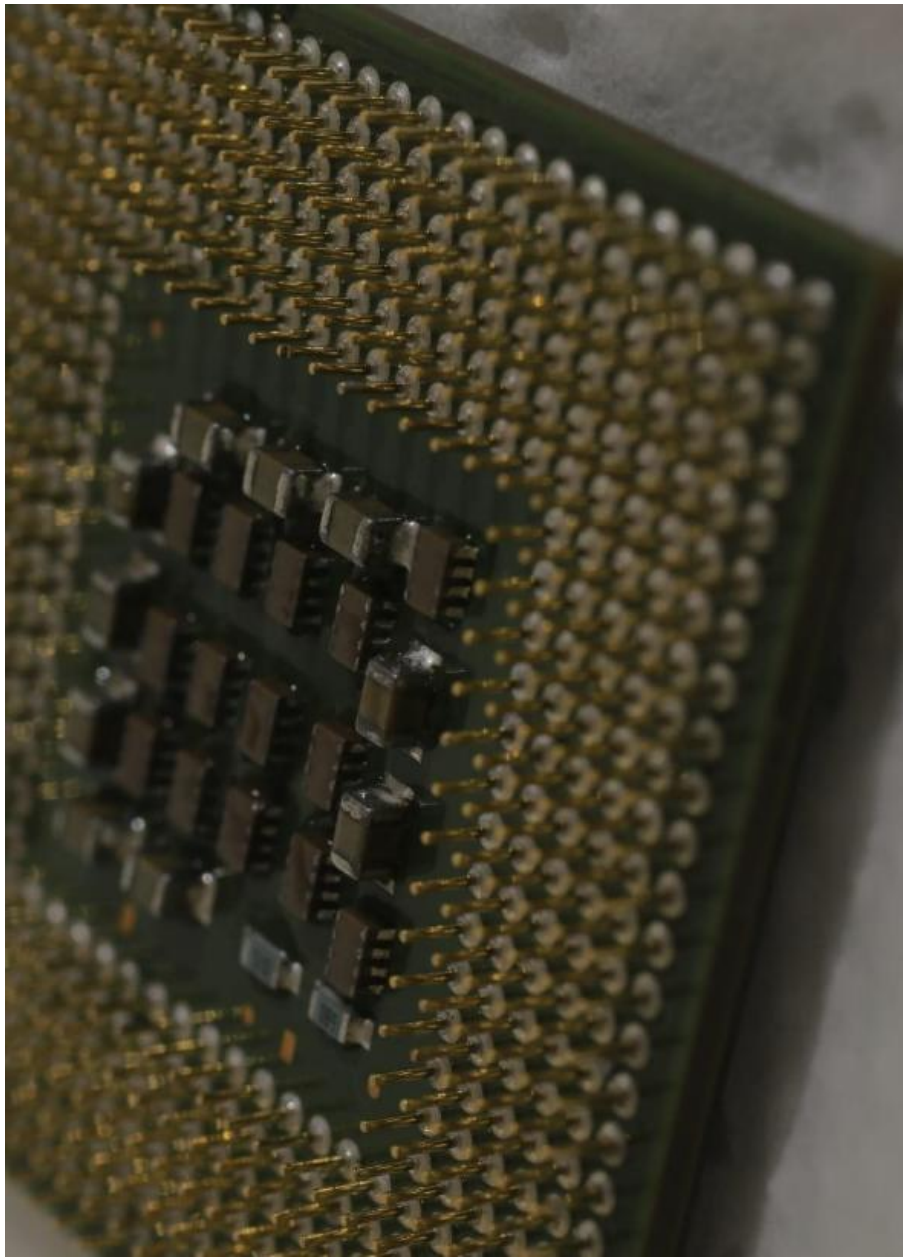
Design Engineering & AI 2026

AI agents are analyzing and performing deep design reviews on broad ranges of hardware

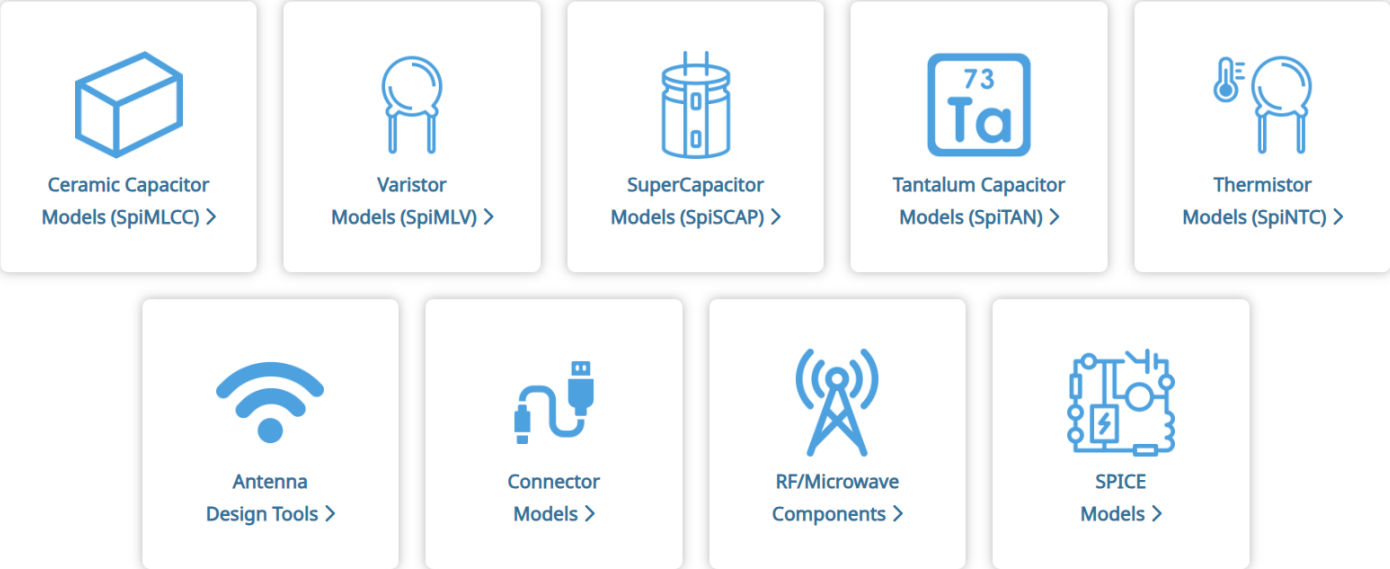
Result:
Security & IP concerns

Component Suppliers trends in supporting AI Agents

1) *Expanding online simulation software capability*
2) *Creating dedicated engineering circuit studies*
3) *Expanding selection guides*



Example of part simulation



- Pad Dimension - **MnO2 + POLY**

- CSV Chart Data - **Capacitance**
- CSV Chart Data - **Impedance & ESR**
- CSV Chart Data - **DF (Dissipation Factor)**
- CSV Chart Data - **Ripple Voltage**
- CSV Chart Data - **Ripple Current**
- CSV Chart Data - **DCL (Leakage Current)**

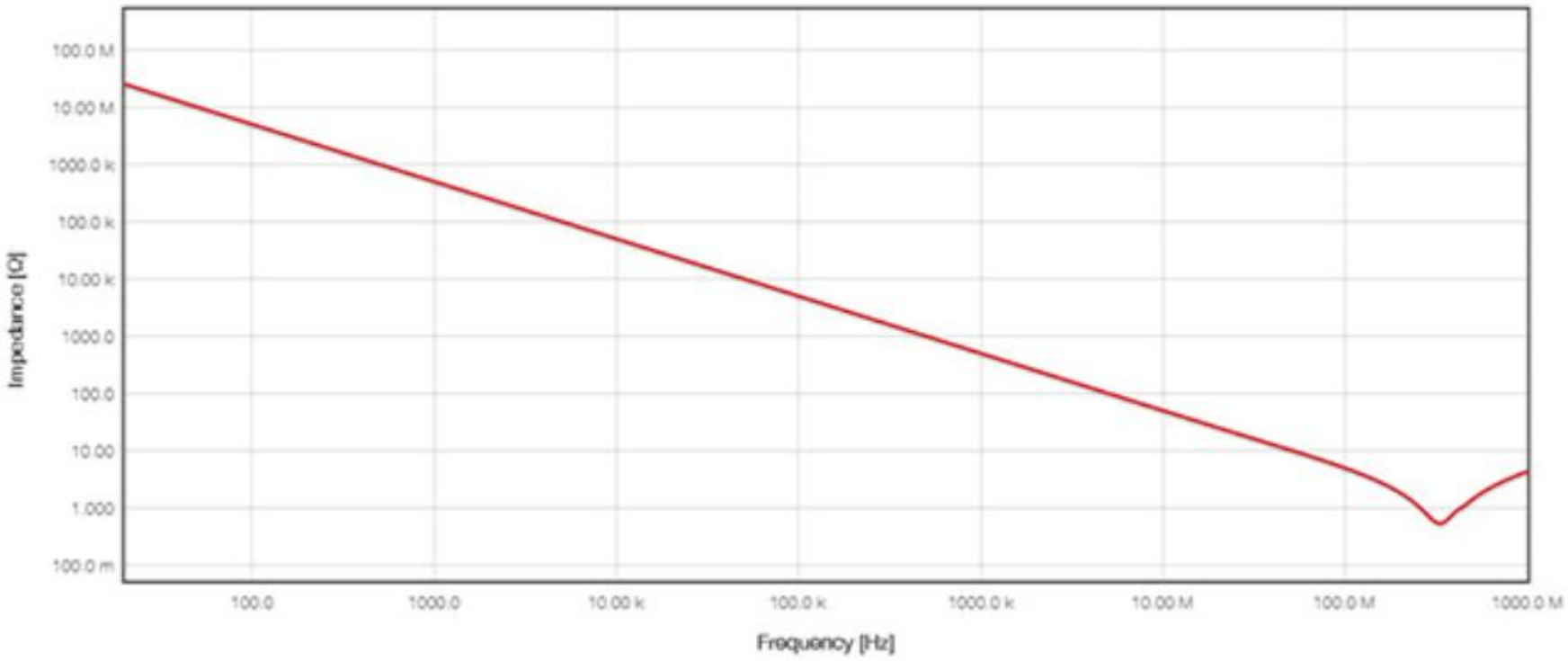
- Series S-parameters
- Shunt S-parameters

- PN SPICE Model
- SPICE Models Bundle

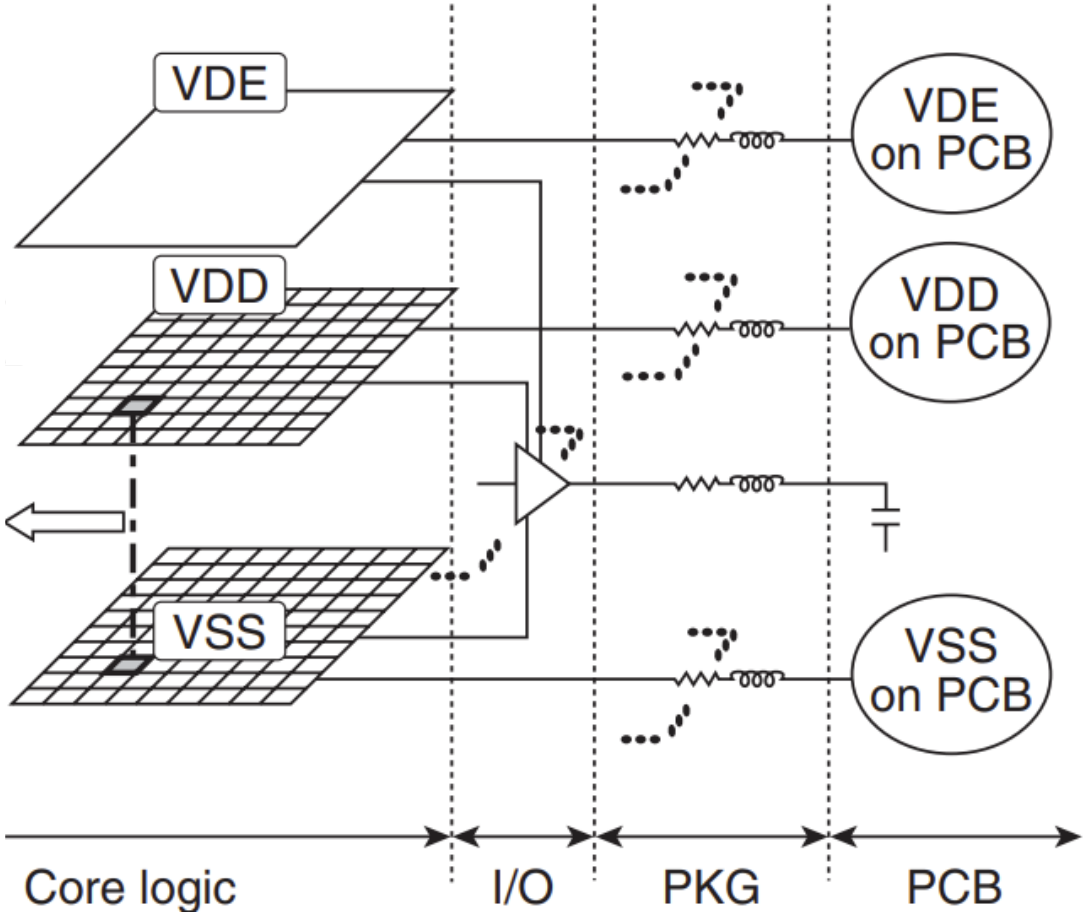
- 3D STP Model

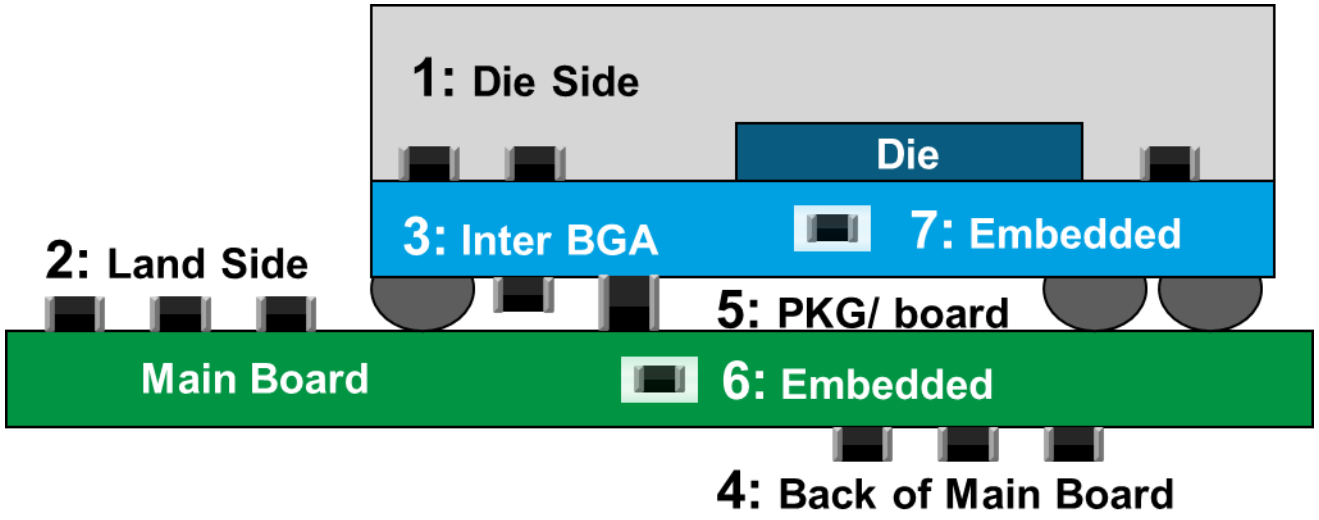
Example of part simulation

IMPEDANCE | ESR | TEMPERATURE | DC BIAS | RIPPLE CURRENT | EQ CIRCUIT DIAGRAM | CASE DIMENSIONS



Simulation driven by system & IC complexity



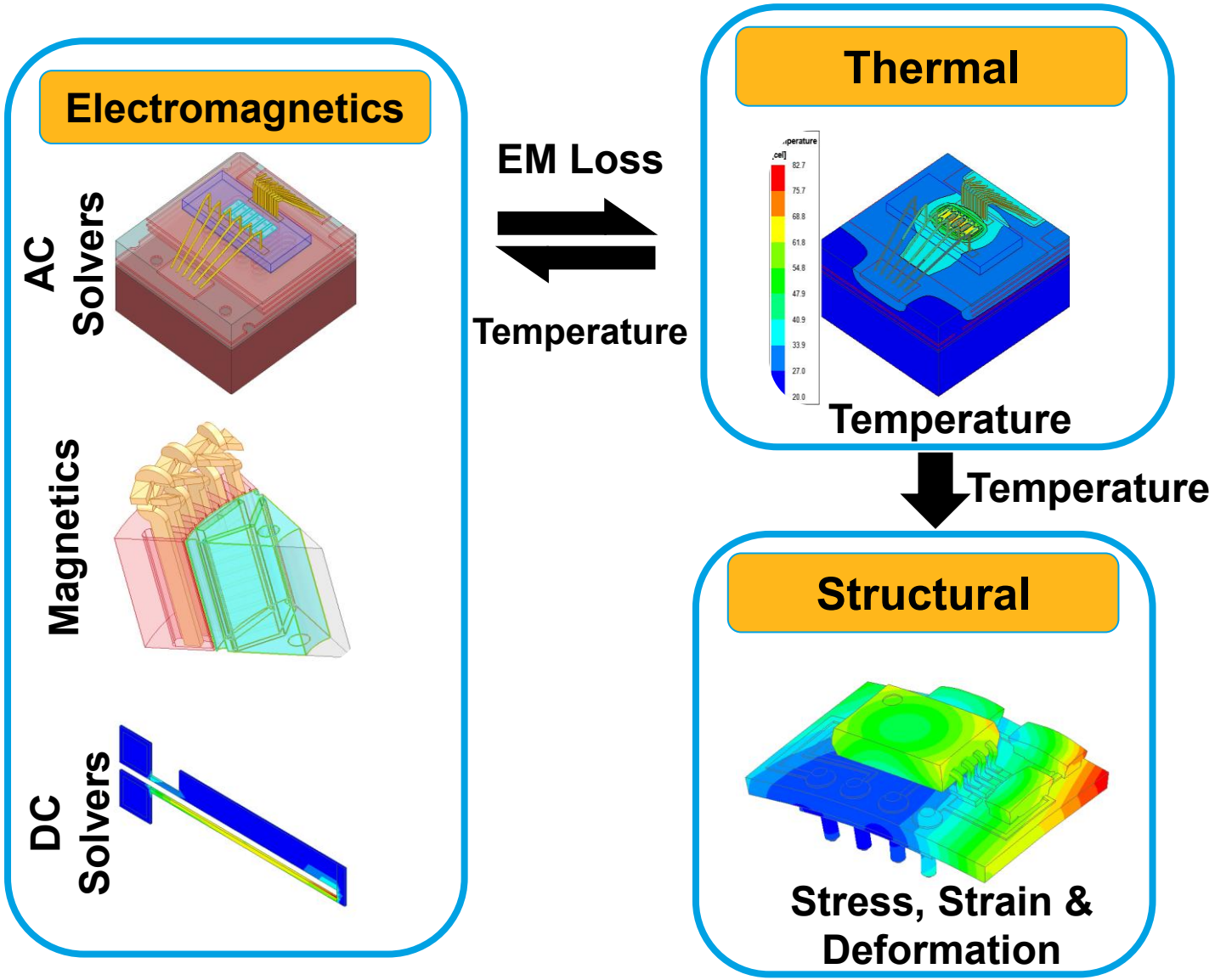


Modeling software packages are critical:

Ansys Example

Multiphysics Workflows

- Multiphysics workflows are becoming more necessary than ever due to:
  - Component Performance Increases
  - Reduction in Size
  - Higher Power consumption
  - Higher Power Densities
  - Reliability Requirements
  - Materials

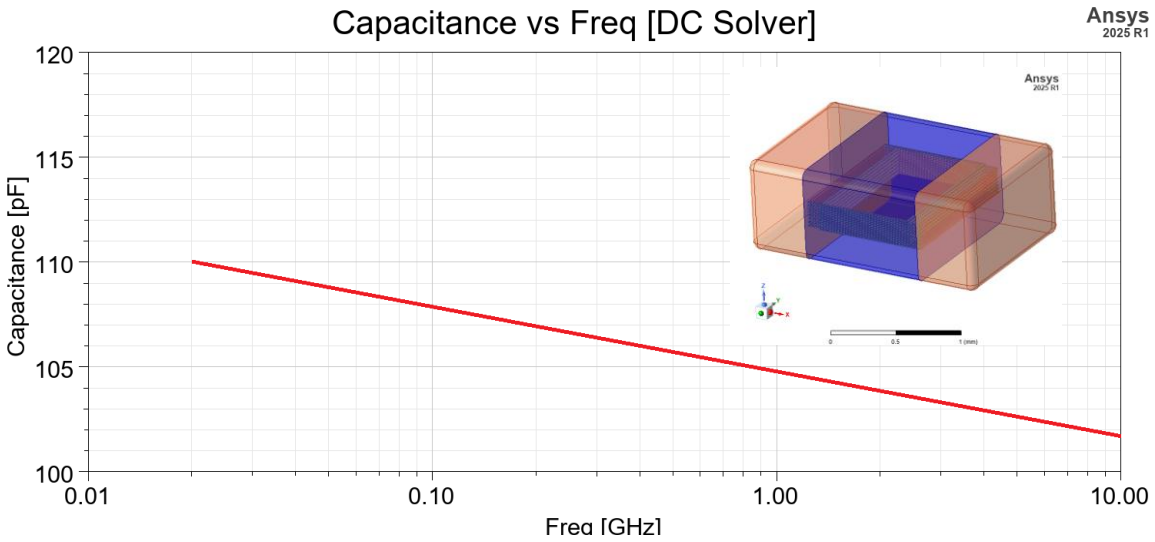


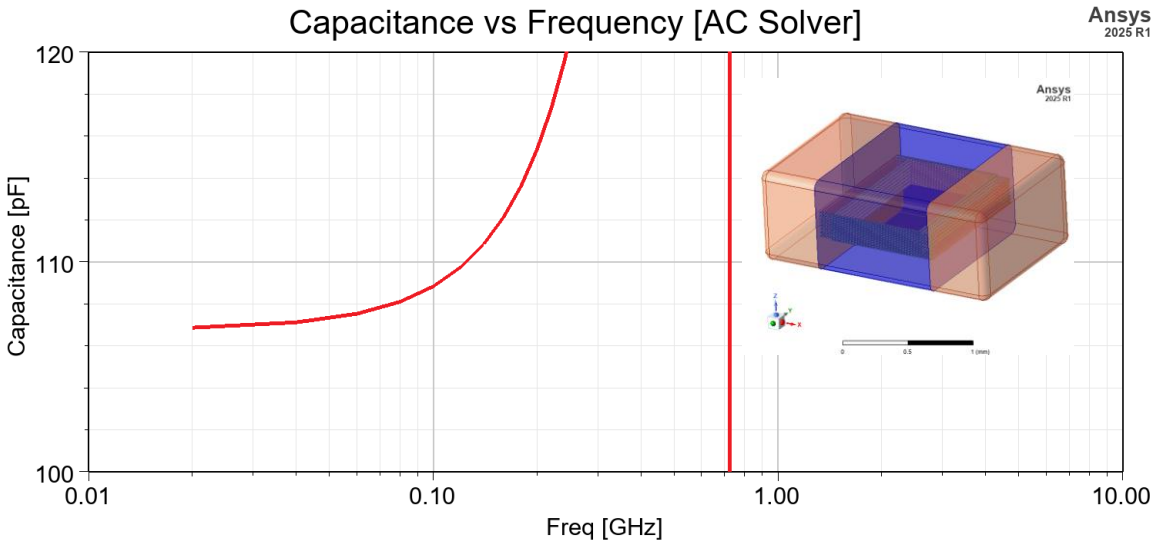
Electromagnetic Simulation

Surface Mount Devices are simulated frequently for electrical performance

- DC solvers: Capacitance and Inductance
  - Provide generally easy & fast simulations and reliable low frequency values
  - No Self Resonance extraction as Capacitance and Inductance are solved independently

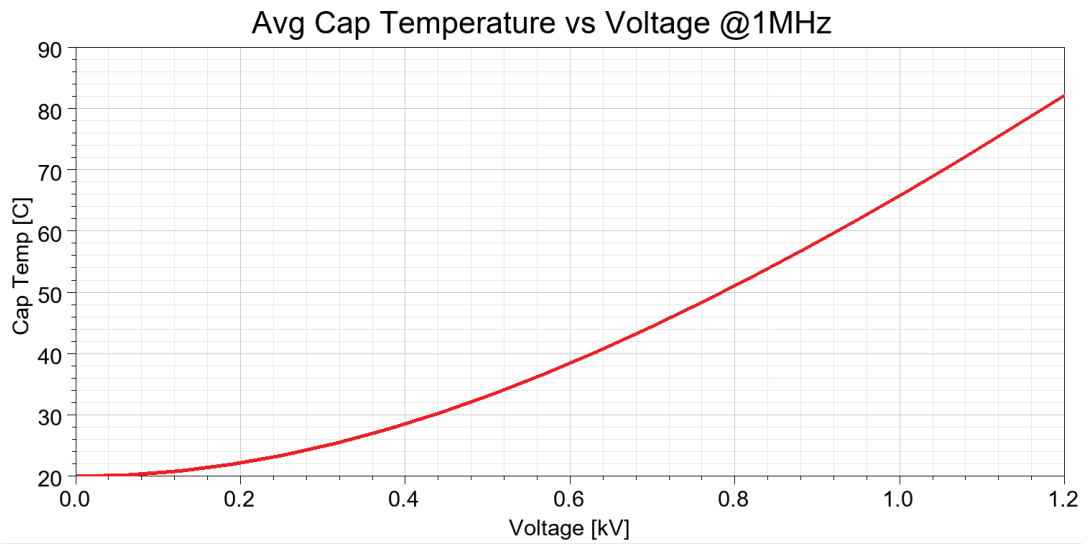
- AC solvers: Coupled E & H Fields
  - Provide fast simulations and accurate dispersive values across spectral domain
  - Successfully extract self-resonances
  - Note the self-resonance ~7GHz for this Capacitor

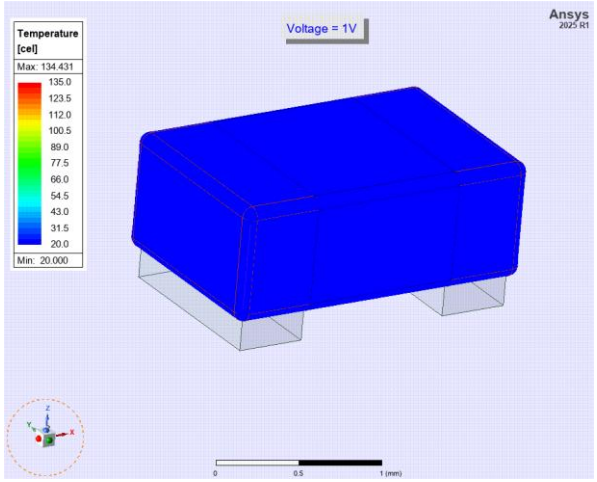


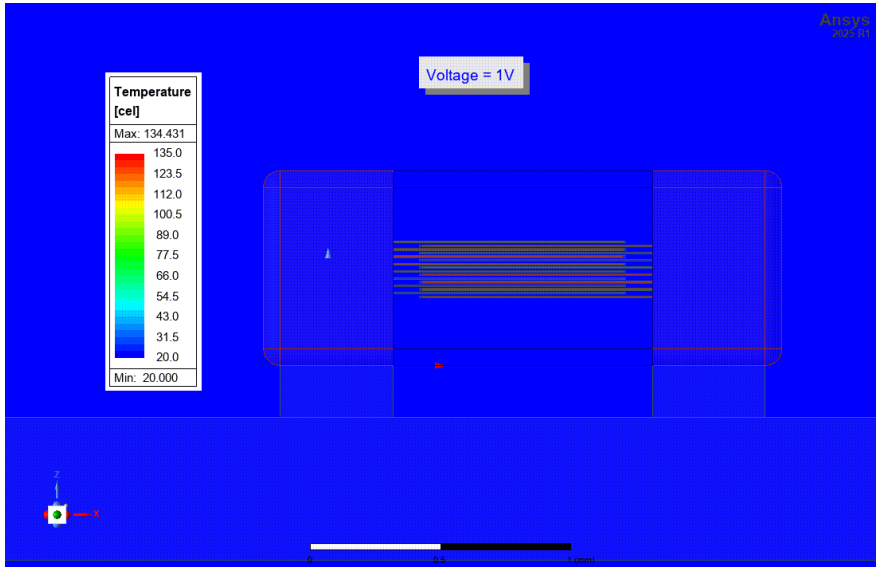


Thermal Simulation

- Accurate thermal simulations are necessary for a wide array of requirements
  - Solving SteadyState thermal for this Capacitor
- This simulation loads the capacitor with increasing distributed loss loads from the electrical simulation
  - The Power loss densities [Volume & Surface] are mapped as initial conditions
  - Using a Computational Fluid Dynamic solver, the accurate convection is captured for accurate temperature
- Note that resulting temperature is non-uniformly distributed

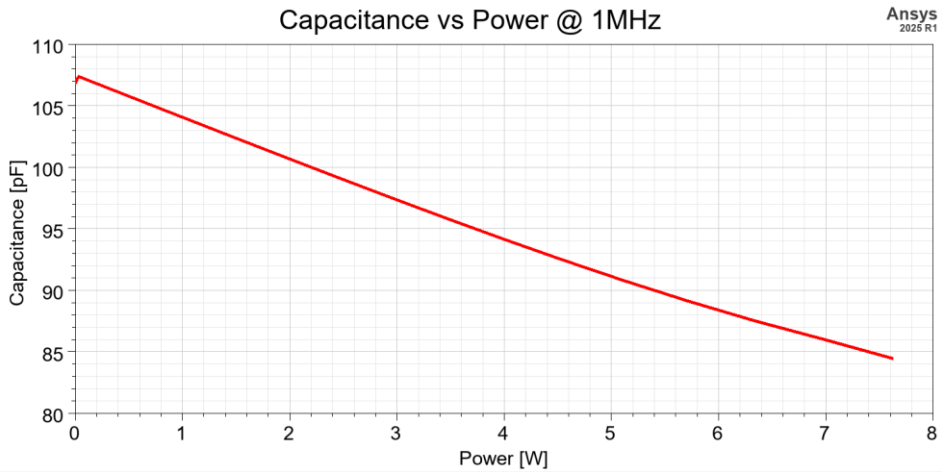


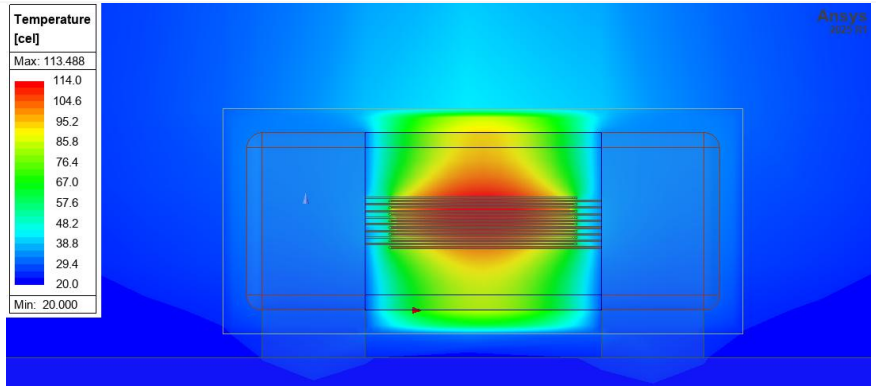


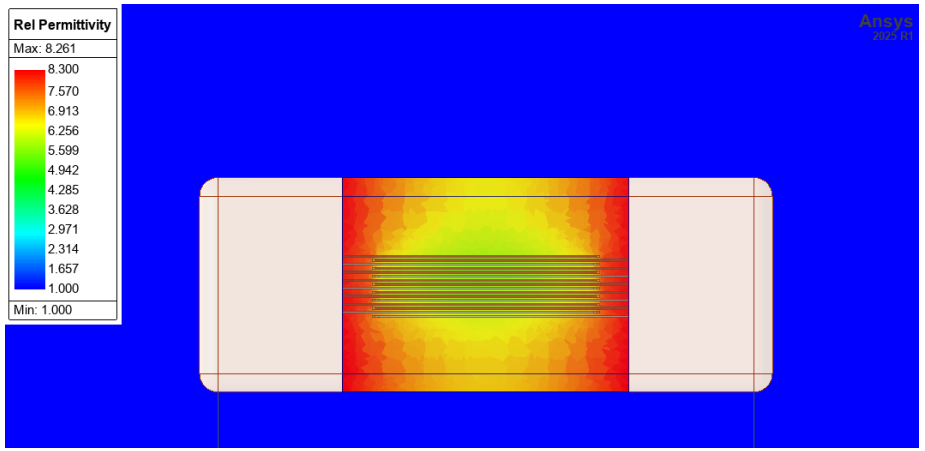


Electrothermal Simulation

- Material Electrical properties are inherently dispersive with temperature
  - Requires an electrothermal analysis
    - In this case, a power source varying to 7.6W
    - One expects Capacitance to decrease as temperature increases
      - Ceramic atomic Lattice spacing will increase with temperature, causing permittivity to decrease
    - This simulation spatially varies the material's electrical properties non-uniformly based on the temperature distribution and re-simulates EM to recompute the capacitance at this operating temperature
      - This simulation shows 6.6W load @ 1MHz

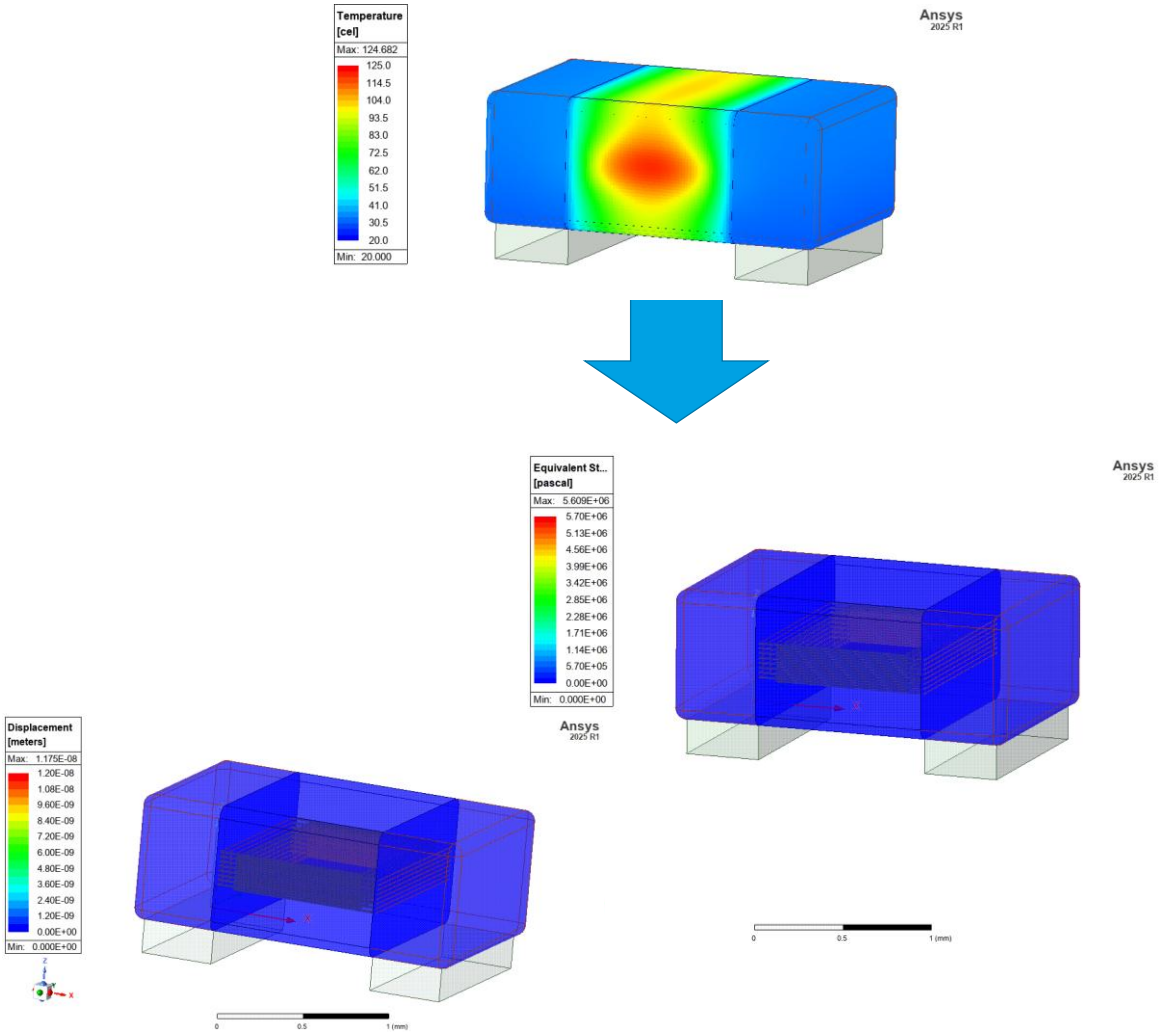






CTE Deformation Simulation

- Coefficient of Thermal Expansion due to Thermal
  Load simulations
  - Important to ensure material properties are
    both thermally and structurally matched for
    maximum integrity
- This simulation takes the spatially varying temperature with a 7.6W load @ 1MHz and
  maps this as an initial condition
- Resulting stress, strain & deformation analysis



Ansys CTE simulation addresses a concern of CTE induced failures

Manufacturers are providing solutions as well with ‘Flexible’ terminations

Potentially some failure modes and concerns Component Engineers have will go away or at a minimum will be exponentially reduced

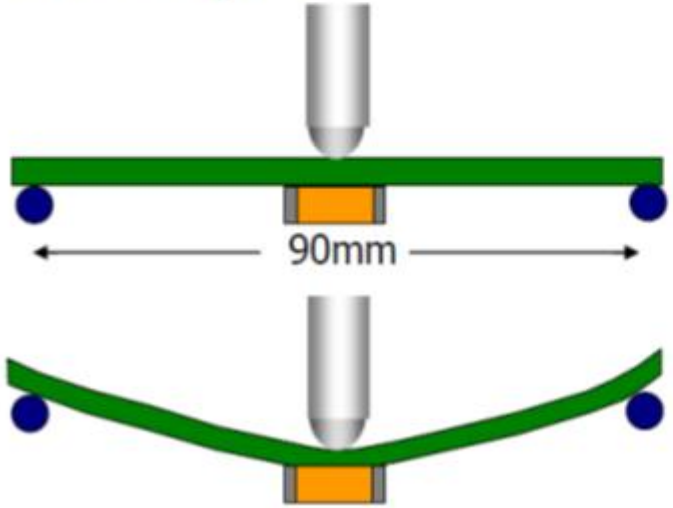
Modeling & Component Suppliers jointly eliminate problems

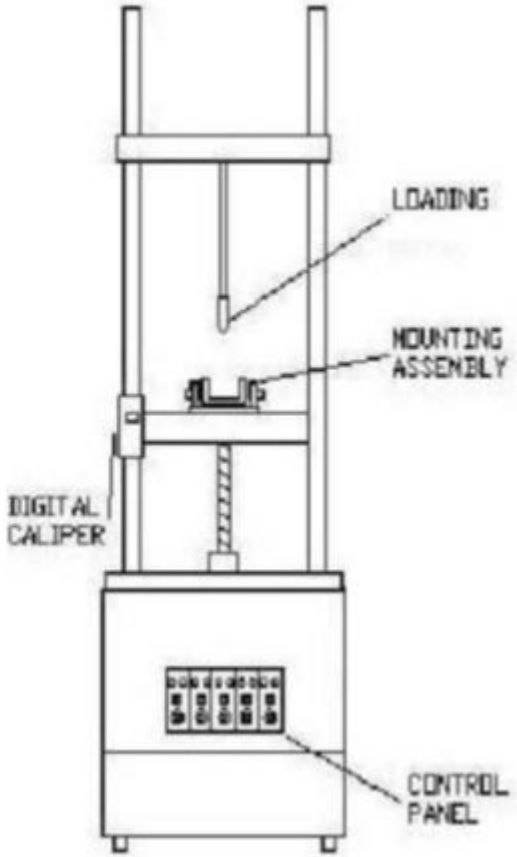
Board Bend Flex Test Procedure

Test Procedure as per AEC-Q200:

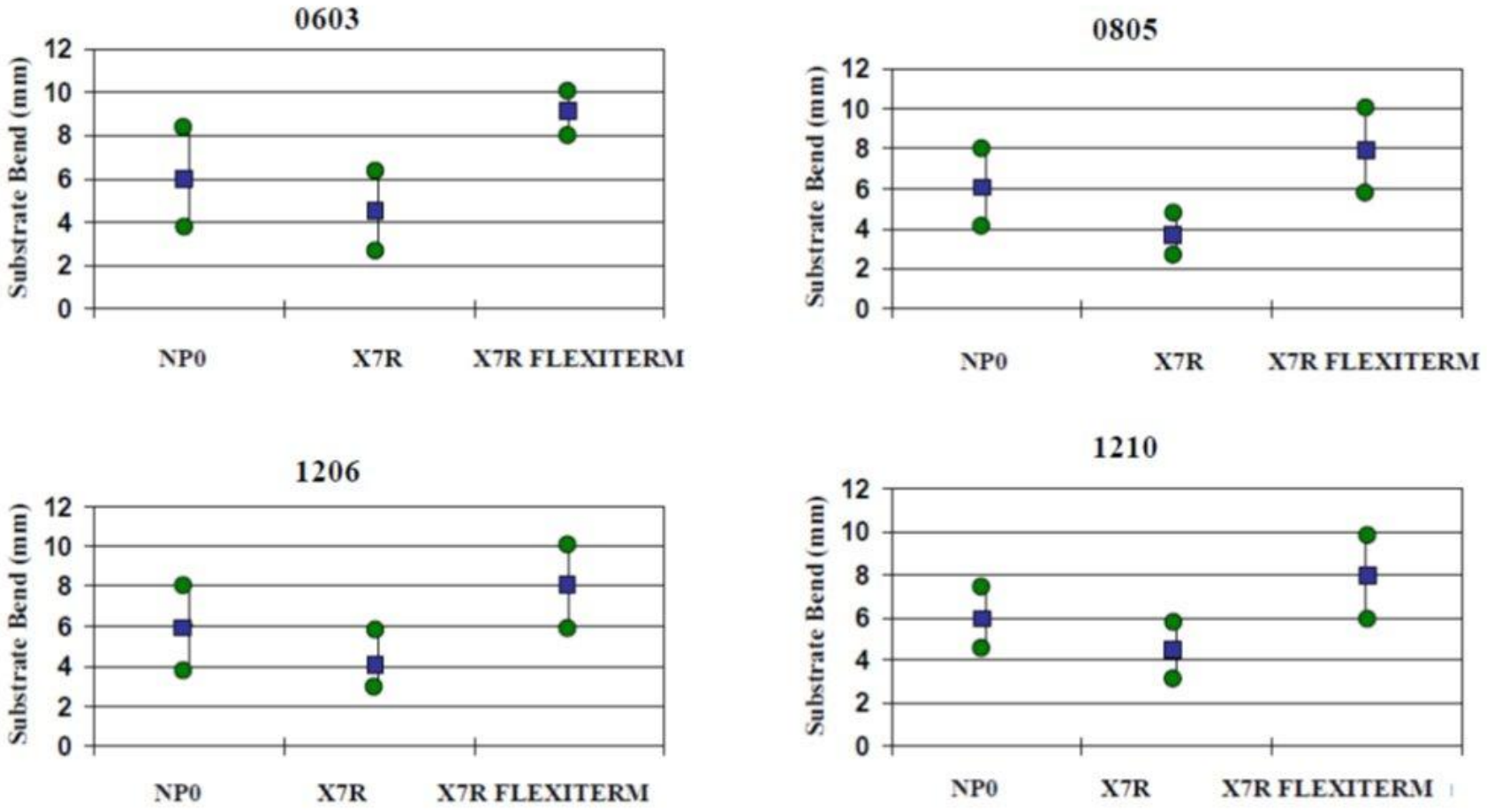
Minimum deflection spec: 2 mm (Class 2)

- Components soldered to FR4 PCB
- Board connected to the test equipment
- Motorized Moving Ram





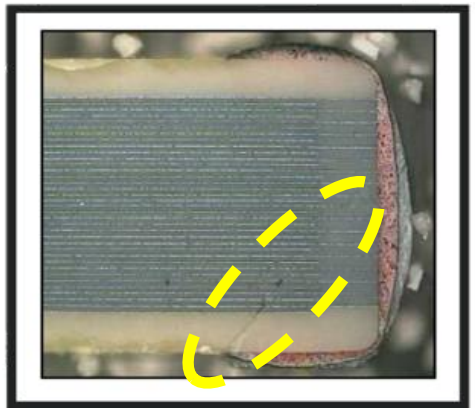
2026: Whole failure modes can be eliminated by the correct part selection



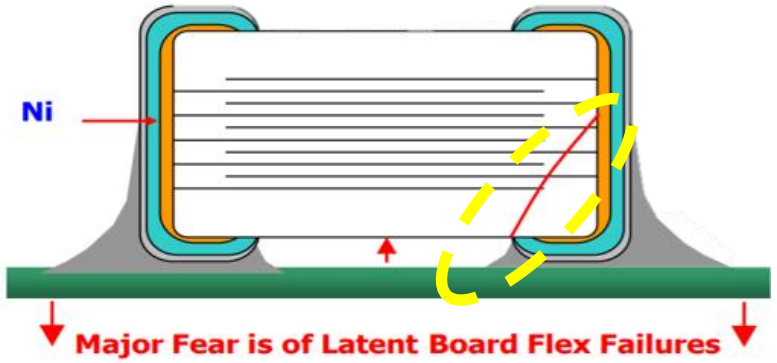
Board flex test is directly proportional to strain measurements on PCB

Mechanical Performance

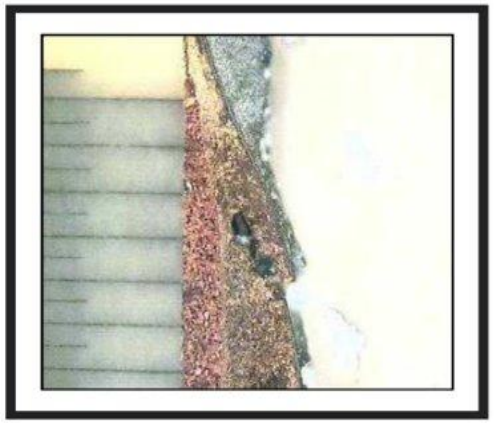
Cu Termination

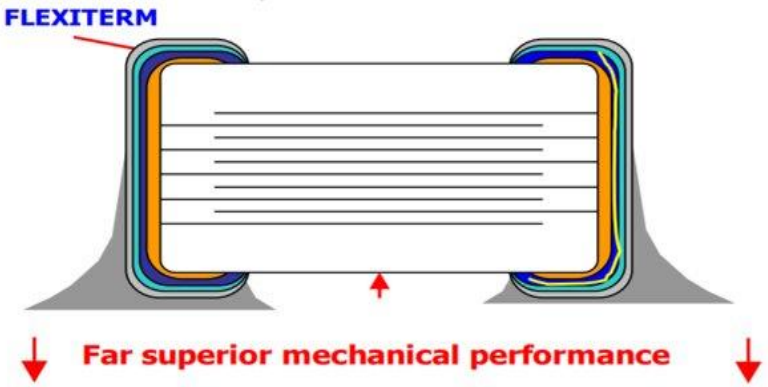


Standard MLCC termination



Flexible Termination

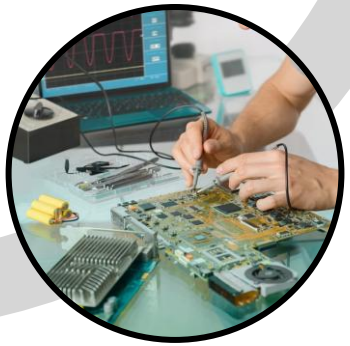




Component Engineering - Trends are changing the job

Selection

Design



Life Cycle Management

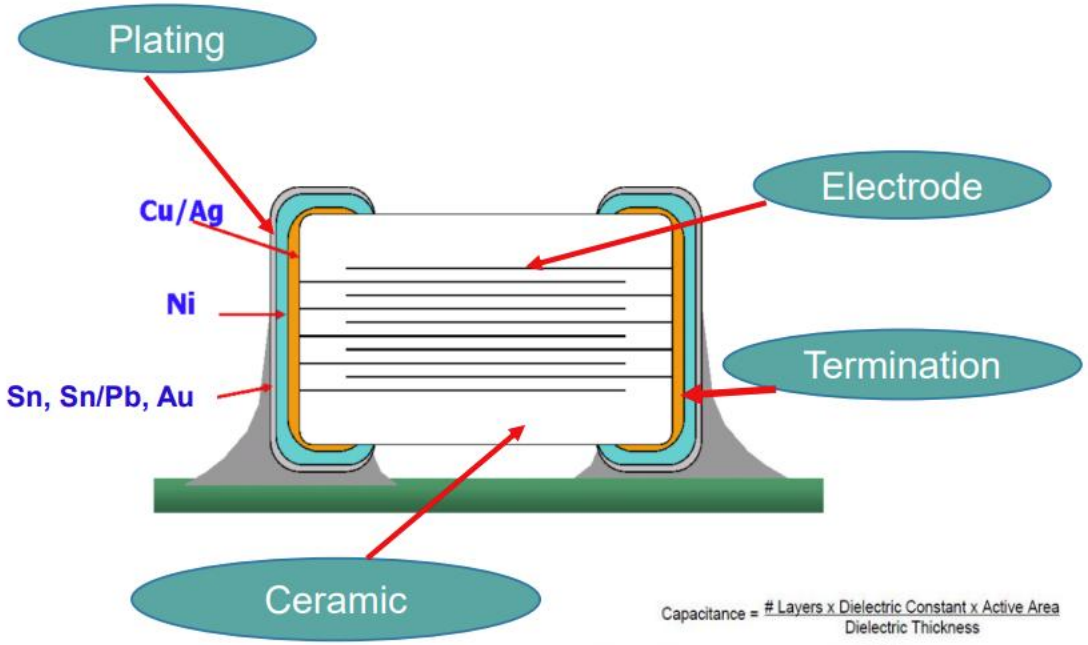
Greatly impacted by

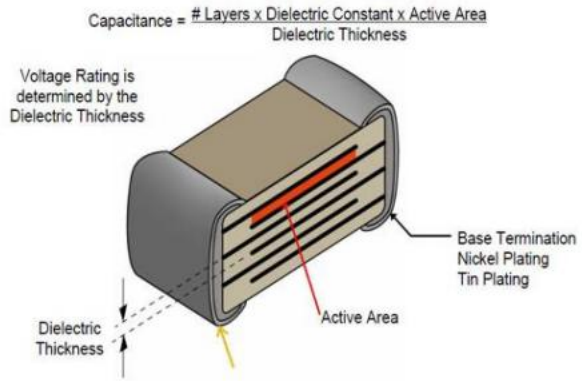
Environmental
&
Government Regulation

PLUS Tech Trends & Evolution

End use trends force production & design changes

MLCC Construction





Ceramic
- BaTiO3 or CaTiO3 based
- Composition depends on:
  - Electrode Material
  - Firing Atmosphere
  - Temperature Coefficient
  - Layer Thickness

Electrode
- BME (Base Metal) or PME (Precious Metal)
- Matched to Ceramic Composition
- Additives used to control physical defect potential

Termination
- BME (Cu) or PME (Ag or Pd/Ag)
- FlexiTerm® option
- Matched to Ceramic and Electrode

Plating
- Ni undercoat
- Sn, Sn/Pb, or Au outer coating

MLCC TRENDS

Commercial

- Designed for consumer and industrial applications
- Generally small sizes (<=0603)
- Generally lower voltage (<=16V)
- Development focused on very high CV

Automotive

- Designed for automotive applications
- 0402 – 2220 Sizes
- Emphasize 25 – 100 Volt; 250-1000V also available
- Emphasis on reliability (AECQ-200 Qualified)

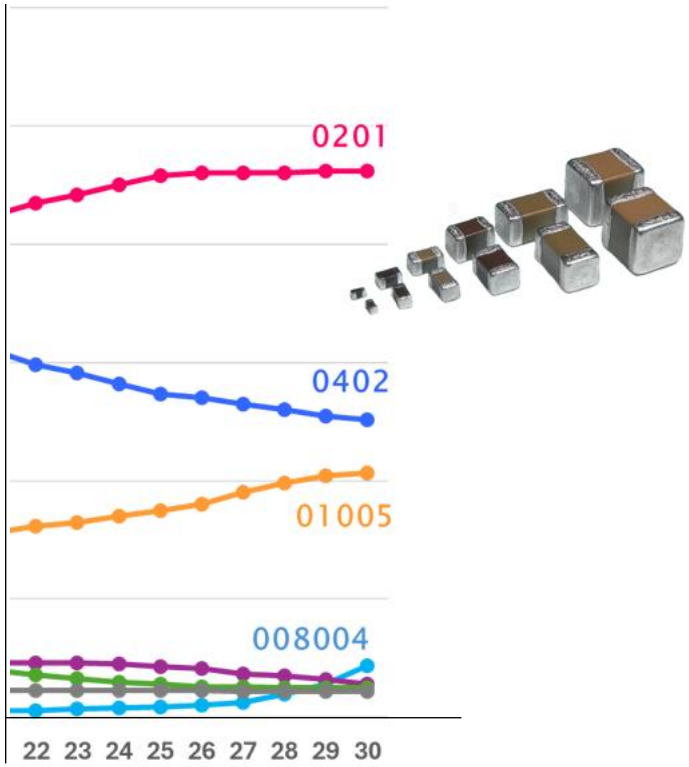
Space / Military

- Designed for Highest Reliability Applications
- Passes Mil… , ESA, and NASA qualifications
- Smaller Range than Automotive (but expanding)
- Lot Release Testing and Burn-In

Non-ER industry trends impact our ER world

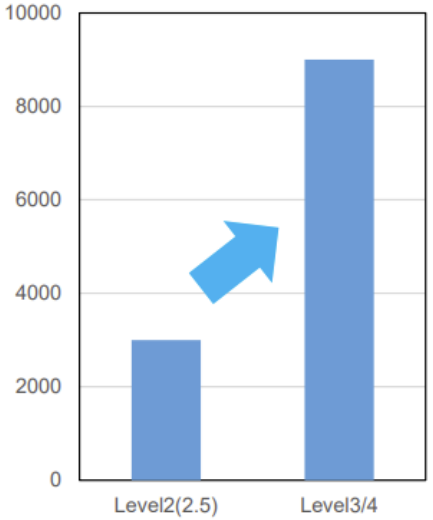
Size Trends:

Consumer World

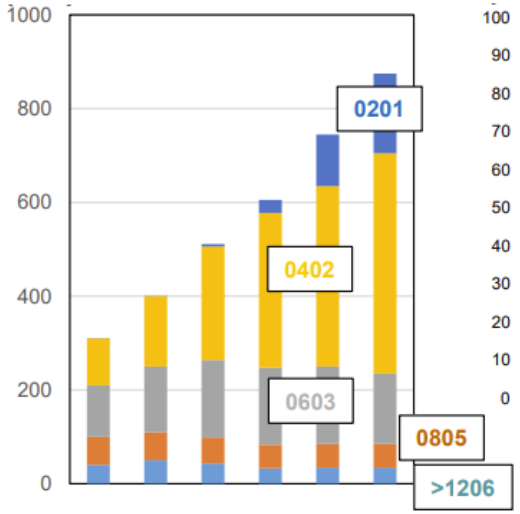


Automotive World

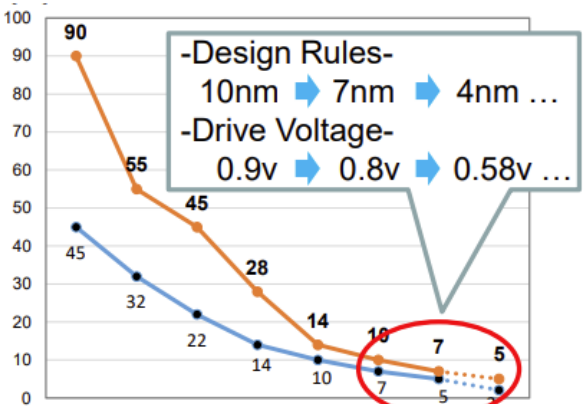
1) Increase in Cap needed per rail = more parts



2) MLCC Case size trends



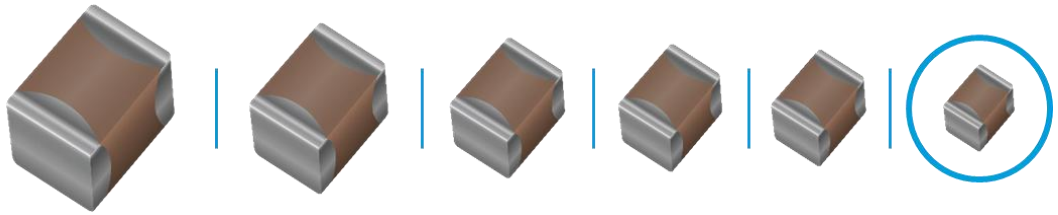
3) Increase in demand for Low Voltage MLCCs



Passive Component Technology Trend:

Miniaturization

- impact of miniaturized passives is of extreme importance
- 10 x 10 part use example is shown below:



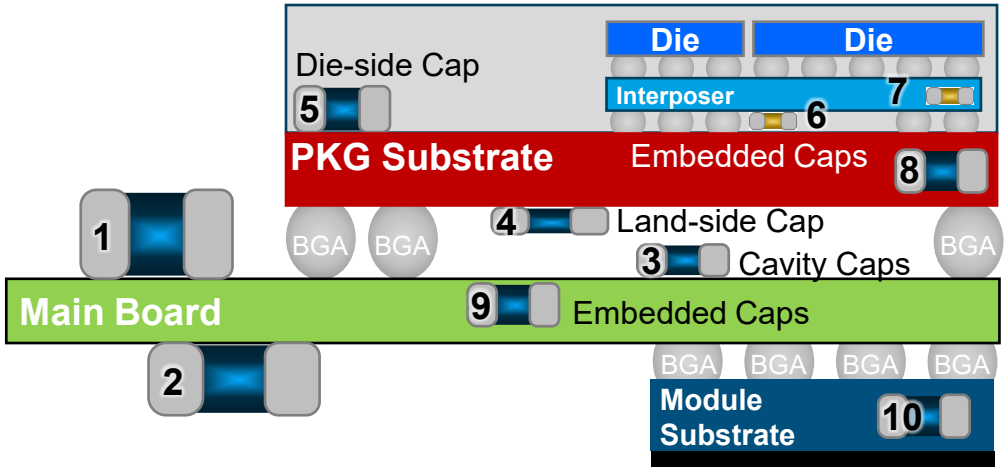
Size	Typical Chip Size (mm)	Mounting Area Ratio*	Weight (g/100pcs)	Weight Down Ratio
0805	2.0 x 1.25	100.0%	2.346	100.0%
0603	1.6 x 0.8	56.0%	0.901	38.4%
0402	1.0 x 0.5	25.7%	0.281	12.0%
0201	0.6 x 0.3	12.0%	0.043	1.8%
01005	0.4 x 0.2	7.1%	0.010	0.4%
008004	0.25 x 0.125	4.2%	0.001	0.1%

This technology advancement will impact military & COTS parts

MLCC Placement Locations

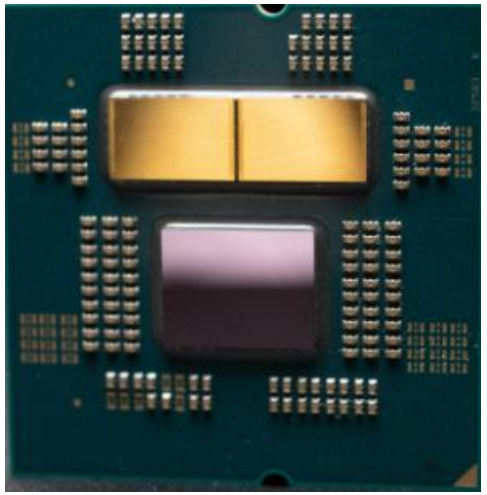
Component placements sites are expanding:

MLCCs (Side View)

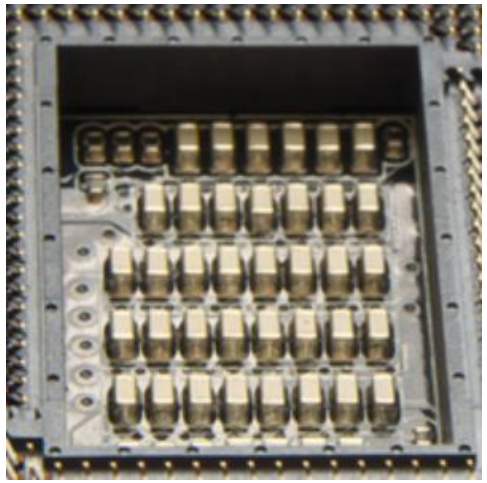


Land-side Cap

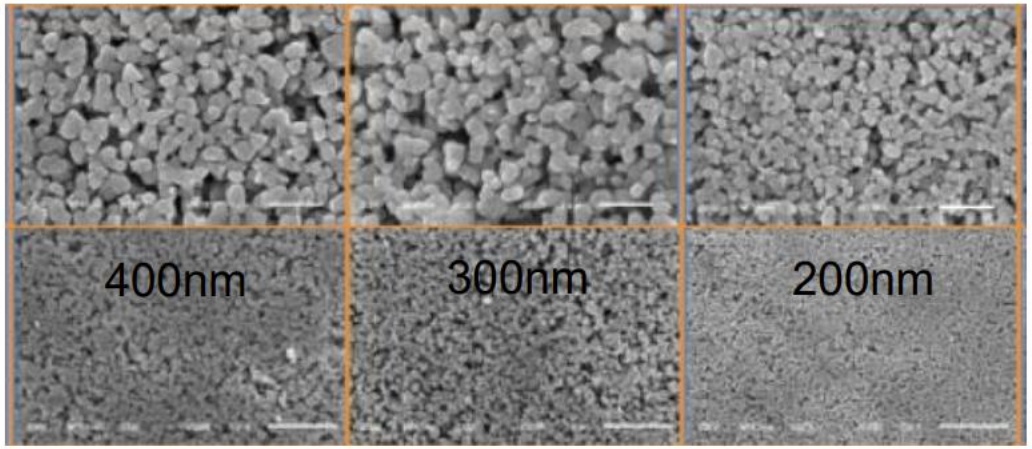
Die-side Cap



Cavity Cap

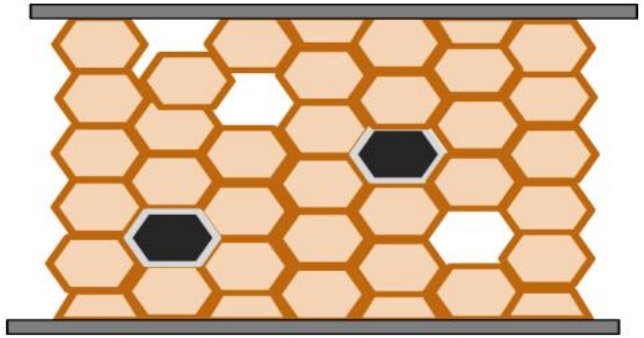


MLCC TRENDS

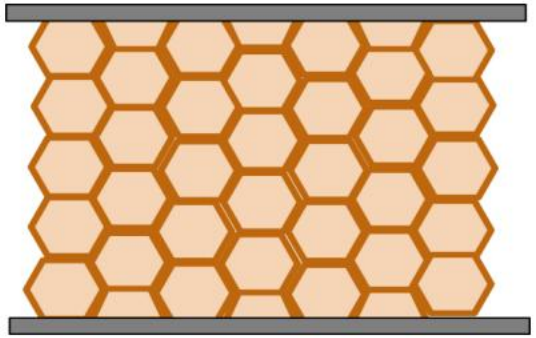


DEVELOPMENT: Continue to increase volts/um through equipment, process and material improvements (nano-size).

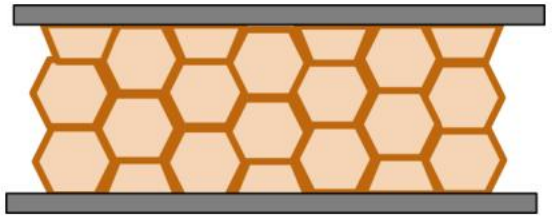
Higher V/um – Higher Reliability, Increased Voltage Ratings



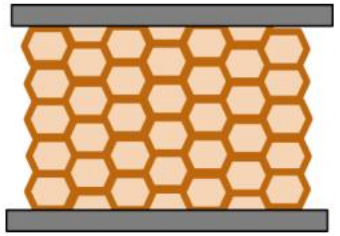
1 – 3 Volts/um



5 – 10 Volts/um

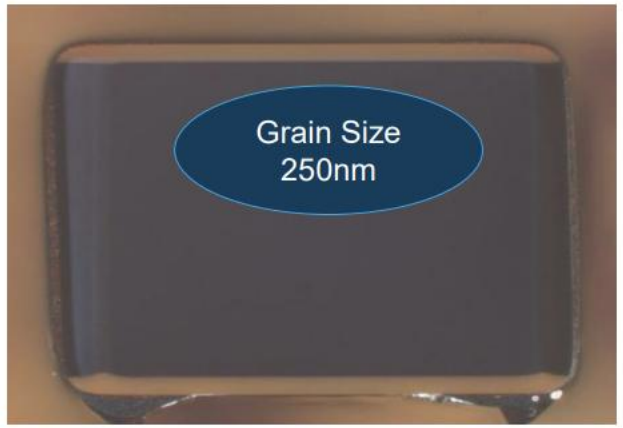


5 – 8 Volts/um

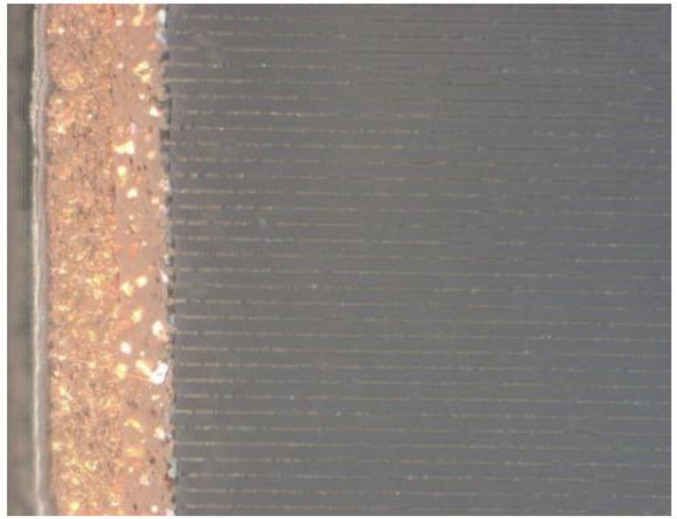


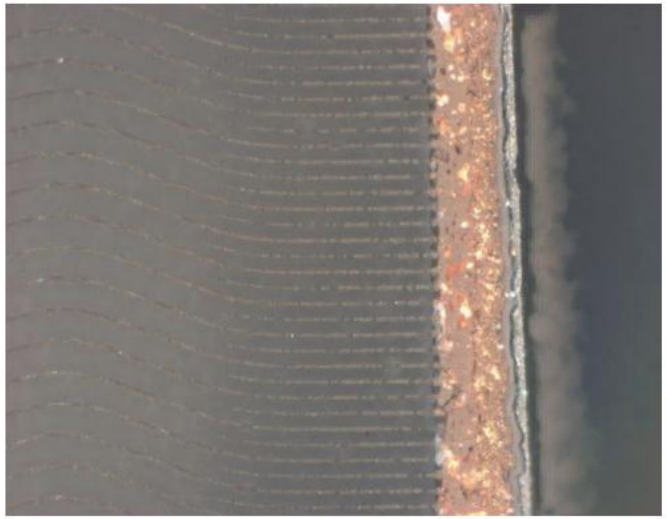
10 – 20 Volts/um

MLCC TRENDS



No of Electrodes	376
Fired dielectric thk (um)	4.1
End margins (um)	270 - 290
Cover Layers (um)	117



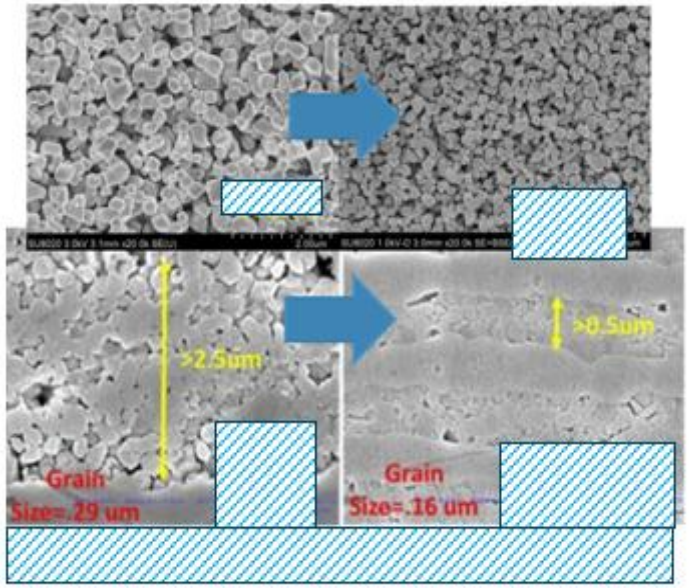


1210 50V 10uf

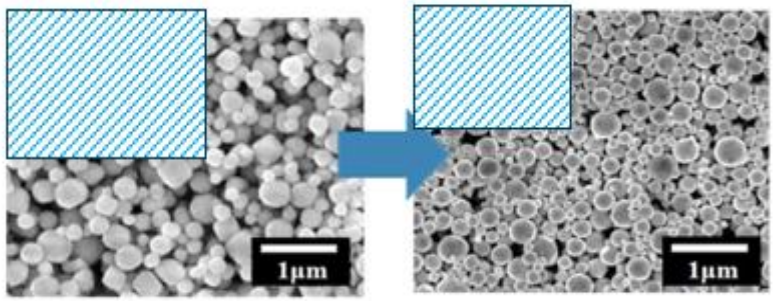
Automotive Grade

MLCC TRENDS

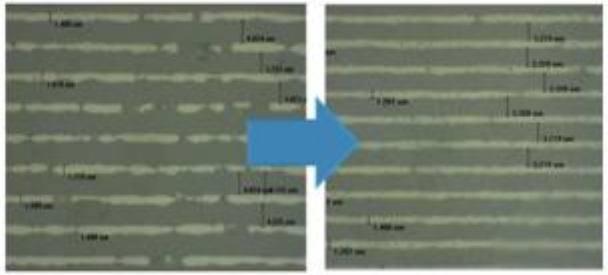
Dielectric



Improved V/um
Better reliability

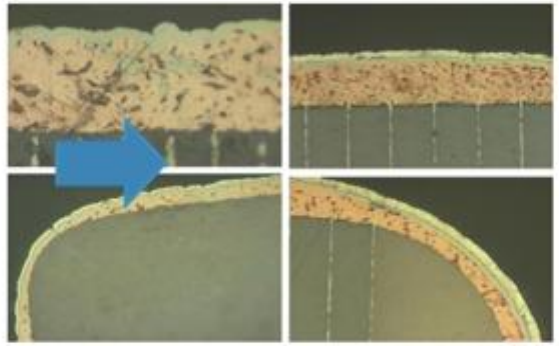


Electrode



Finer Ni Powders – Improved Electrode continuity and cap.

Termination



Cu Termination improvements
Better density, protects the MLCC from water/plating penetration

Speaking of Change:

TARIFFS

Impact the supply chain:

Cost
Availability
Continuity
Compliance
Obsolescence

Component Engineers role is more important than ever

Component Engineers:

- called upon to guide designers
- provide management options

IN THESE CONDITIONS COMPONENT ENGINEERS MUST WATCH FOR:

Problem / Action	Impact
Sudden supplier changes	New supplier qualification & audits may cause delays. Plan for possible failures
Cost Reduction Fast Tracks	Changes in material and alternate parts may fail internal compliance requirements
Regulatory Risks	New supplier may fail RoHS etc.
Lack of visibility	Problems will creep up with little to no warning

Source: Compliancequest Blog

Preparing for Obsolescence

CREDITED SOURCE – William Wong Blog Electronic design February 2024

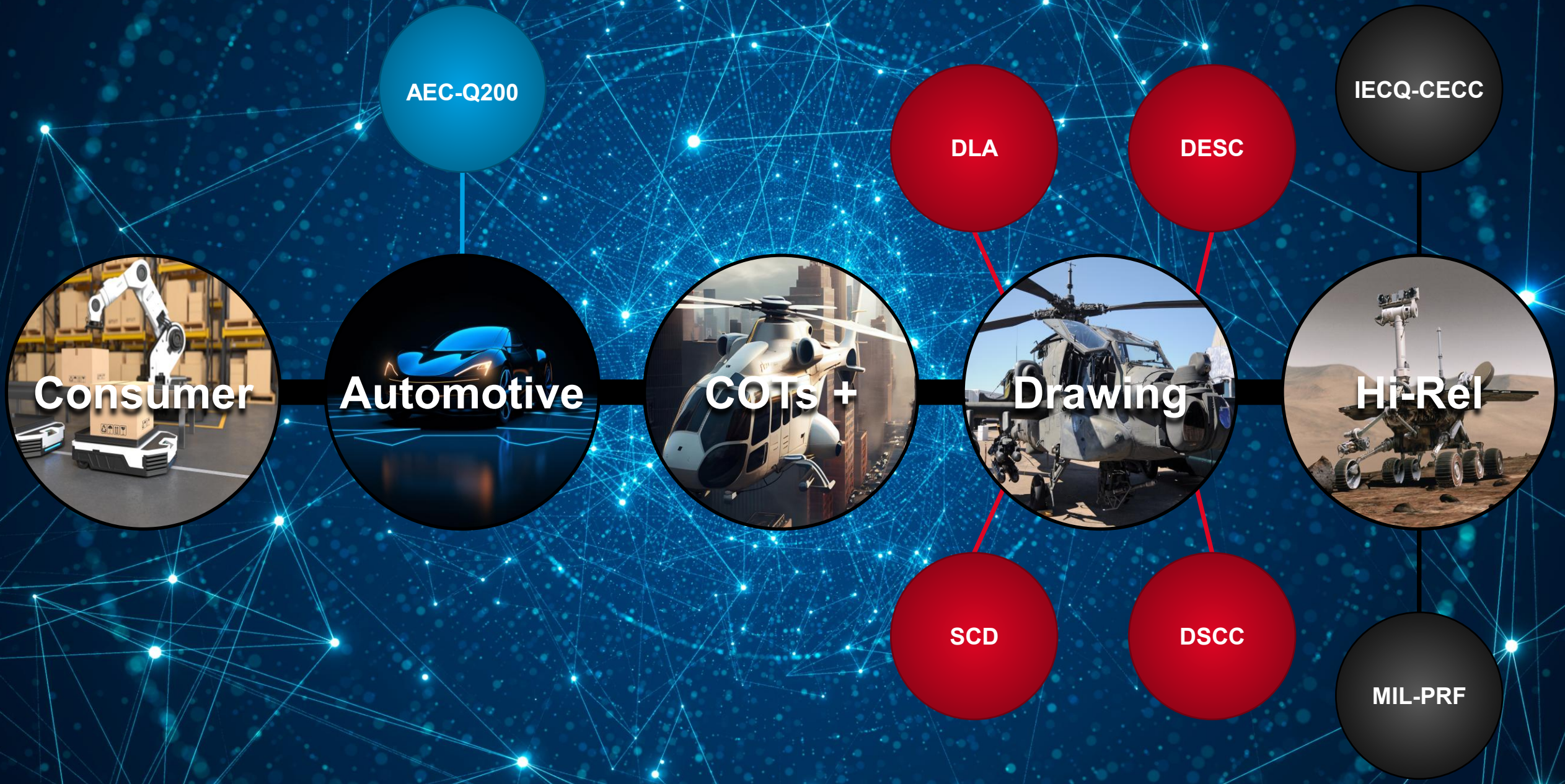
Preparing for Obsolescence

1) You are not alone

2) Dedicated conferences

3) Understand Component grades

Component Grades



SPECTRUM of COMPONENTS

Commercial Grade

- Manufactured to datasheet specifications only
- Flexibility surrounds the design, materials, processes, and testing
- Manufacturers can and will change designs, materials, processes
- Qualification or testing requirements tend not to be mandatory, components are designed and manufactured for the best performance, cost, or a ratio of both.

Automotive Grade

- AEC-Q200 is a Stress Test Qualification for Passive Components per Automotive Electronics Council (AEC)
- AEC-Q200 qualified parts require the manufacturer to test parts & save results as outlined in AEC - Q200
- Tests are performed at different temperatures and dependent on the ability of the passive component to pass or fail at a particular temperature will result in a grading between Grade 0 -> Grade 4. These grades correspond with different automotive applications from Non-Automotive to All Automotive.
- **IF changes are made to either the product or process NOTIFICATION, ACCEPTANCE AND REQUALIFICATION ARE REQUIRED to supply AEC-Q200 qualified passive Electronic Components**

EDITED SOURCE – EPCI
https://passive-components.eu/wp-content/uploads/2021/03/COTS-Automotive-Capacitors-Procurement-and-Evaluation-Case-Study-for-SME-Space-Hardware-Manufacturer.pdf

SPECTRUM of COMPONENTS

IECQ-CECC

- Historically preference of European companies designing products for an intended use in Hi-Rel markets
- Common for multiple manufacturers to provide parts to a particular CECC specification therefore providing consistent quality and performance specifications. Some reduction in the number of suppliers due to limited business levels.
- Qualification granted BY IECQ-CECC system when the manufacturer can meet the specification plus routine periodic testing such as: Visual, Dimensions, Value, Destructive Physical analysis, Solderability.
- Once qualified a periodic test program requires mandatory tests such as: High Temperature Exposure, Temperature Cycling, Operational Life, Thermal Shock, etc. Plus, periodic audits of the manufacturers quality management systems are required by an independent certification body.
- CECC qualified parts can only be sold and released by authorized distributors which the manufacturers appoint.
- Only distributors who are appointed by the manufacturer and audited can sell products to CECC

EDITED SOURCE – EPCI
https://passive-components.eu/wp-content/uploads/2021/03/COTS-Automotive-Capacitors-Procurement-and-Evaluation-Case-Study-for-SME-Space-Hardware-Manufacturer.pdf

SPECTRUM of COMPONENTS

DLA Land and Maritime, DESC, and DSCC Drawings

- Intended for use when military QPL products are not available
- Part must be purchased to DSCC part numbers to assure that all performance requirements and tests are met.
- DESC & DSCC suppliers are typically listed on the QPL or has agreed on an inspection program to the referenced MIL- PRF and is detailed in the scope of the drawing.
- ESCC QPL The ESCC QPL (European Space Components Coordination, Qualified Parts List) makes available space components which have been fully evaluated, qualified and maintained with regards to the required standards for use in European Member states space programs.
- Qualified Component types and Manufacturers must meet strict controls the design, process control, inspection and documentation.
- Additional testing can be stipulated via the part number or on the purchase order in the form of LVT (Lot Validation Testing) and LAT (Lot Acceptance Test) EPPL

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SPECTRUM of COMPONENTS

MIL-PRF

- Developed & Maintained by United States Military
- Performance Specifications for the Functional Requirements + Predictable Quality Levels
- MIL PRF Parts are Listed on a QPL (Qualified Product List). Manufacturers QA Systems, Manufacturing & Performance Must be DLA Approved.
- Subsequent Lot Basis Testing is Mandatory for the Manufacturer to Maintain Qualification.
- Designs are not Allowed to Change Without Extensive Testing, Documentation and DLA Approval

Exponential Failure Rate [Level % per 1000 hr]	M = 1%	P = 0.1%	R & U = 0.01%	S & V = 0.001%	
Weibull Failure Rate [Level % per 1000 hr]	A = NON ER	B = 0.1%	C = 0.01%	D = 0.001%	T = 0.01% Space

E.R Customers Using Solid Tantalum Capacitors Typically Add a Surge Current Screening.

This Test Subjects Tantalum Capacitors to a Peak Current to Remove Parts Which May Fail on Start-Up

Screening Options	A = 10 Cycles, +25°C	B = 10 Cycles, -55°C & +85°C	C = 10 Cycles, -55°C & +85°C Before Weibull	Z = None Required

EDITED SOURCE – EPCI
https://passive-components.eu/wp-content/uploads/2021/03/COTS-Automotive-Capacitors-Procurement-and-Evaluation-Case-Study-for-SME-Space-Hardware-Manufacturer.pdf

Alternate Part Comparison
– NOTE NOT EQUILIVANT PARTS

	Commercial	Automotive	Space
Mechanical	• 2mm Board Flex • Smallest margins and Cover Layer	• 2mm Board Flex • Superior Material Set • Balanced Dimensions for Performance and Cost	• 5mm Board Flex as Standard • Conservative Design Employs Largest margins / Cover Layers, and Thick Dielectric Layers
Electrical	• Highest CV Range per Case Size • High Voltage Coefficient Factor VC • Voltage Breakdown Closer to V_R	• Consistent Temperature and Voltage Characteristics • Reasonable CV Range	• Lower CV Range • Good Ripple Current Handling • Higher Breakdown Voltage • Best VC Performance
Reliability	• No Ratings. 1000 hr Life Test for Small Sample • No PCN Process	• Ratings Based on 1000 hr Life Test and Generic Data for a Family of Parts • PCN Process	• Ratings Based on 4000 hr Life Test and Lot Group B Test (100hrs) • No Changes: Full Qualification

Automotive vs ESCC Specifications Delta Analysis

Tantalum and MLCC Class II Capacitors

Tantalum	AECQ-200	Tantalum ESCC 3012	MLCC ESCC 3009
Burn-In	Not Required	168h level B with Serialisation	96h 2xVr
100% X-Ray	Not Required	Level B	Not Required
Electrical Measurement RT	At 25±5°	At +22 ± 3°C	At +20 ± 2°C
Storage 1000hrs, no BIAS	Hi Temp 125°C	-55/85/125	Not Required
Temp Cycling -55/+125°C	1000 cycles	5 cycles	10 cycles
Humidity	85/85 1k hrs, Vr biased	56days damp heat	85/85 1k hrs, 1.5V
Operation Life	125°C, 2/3Vr Ta; 125°C Vr MLCC, 1k hrs	125°C, 2/3Vr and 85°C Vr 2k hrs	125°C 2xVr 2k hrs
Mechanical Shock	1500g for 0.5s	50g 11ms	Not Required
Vibration	5g 20 min 12 cycles	20g 20min 12 cycles	Not Required
Resistance to soldering heat	260°C for 10s	Not Required	Not Required
Solderability	+235°C 4s	+235°C 4s	+235°C 4s
Electrical Characterization	-55/85/125°C Ta, 125°C MLCC	-55/85/125	125°C
Terminal Strength	17.7N 60s	5N 10s	5N 10s
Climatiq Sequence	Not Required	Dry Heat, Damp Heat, Cold, Low Air Pressure	Not Required
Board Flex	MLCC only, 60s holding time	NA	Not Required
Beam Load Test	MLCC only	NA	Not Required
Surge Voltage	Not Required	1000 cycles 33Ω	Not Required

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https://passive-components.eu/wp-content/uploads/2021/03/COTS-Automotive-Capacitors-Procurement-and-Evaluation-Case-Study-for-SME-Space-Hardware-Manufacturer.pdf

MIL-PRF-32535: A List of Alternate Parts

– NOTE NOT EQUILIVANT PARTS

Institution	Spec. Name	Specification Details
NASA	S-311-P-838	Space-Level BME X7R MLCC
ESA / ESCC*	ESCC QPL 3009/04	0402 to 2220 SMT MLCC
Automotive Electronics Council	AEC-Q200	Auto Grade MLCCs

Description	Commercial	Automotive	ESCC-Space
Material	No Restrictions, Frequent Changes	Change Notice Requires PCN	**No Change Allowed:** Requalification / Re-Audit
Chip Dimensions	No Restrictions	Minimum Thickness Constraint	Minimum Thickness **No Change Allowed:** Requalification
Design	No Restrictions, Frequent Changes	Major Changes Requires PCN	**No Change Allowed:** Requalification / Re-Audit
Margins	≥ 75 µm	≥ 100 µm	≥170 µm
Cover Layers	≥ 75 µm	≥ 100 µm	≥112 µm
Dielectric Thickness	No Restrictions, Frequent Changes	Major Change Requires PCN	**No Change Allowed:** Requalification

Alternate Part Comparison

– NOTE NOT EQUILIVANT PARTS

Test	Commercial	Automotive	M32535-Level
Operating Temperature	-55°C to +125°C	-55°C to +125°C	-55°C to +125°C
Capacitance	Within Specific Limits	Within Specific Limits	Within Specific Limits
Dissipation Factor	≤ 10% (≥ 50 RV), ≤ 12.5% (< 50 RV)	≤ 10% (≥ 50 RV), ≤ 12.5% (< 50 RV)	≤ 3% (≥ 50 V), ≤ 5% (16 - 25 V), ≤ 7.5% (10 V), ≤ 10% (4 - 6.3 V)
IR (+25°C)	100,000 MΩ or 1000 MΩ-μF	MIL-STD-202	MIL-STD-202
Hot IR (+125°C)			MIL-STD-202
Dielectric Withstanding V	250% of RV for 1-5 Seconds	250% of RV	250 - 400% of RV for 5 +1 Seconds
Board Flex	2mm Deflection for 30 Seconds	AEC-Q200-005, 60 Seconds	2mm $_{min.}$ for 60 Seconds
Solderability	≥ 95% Coverage	J-STD-002	MIL-STD-202
Solder Heat Resistance	C ≤ +7.5%, DF, IR, DWV Meets IL	J-STD-002	MIL-STD-202
Thermal Shock	C ≤ +7.5%, DF, IR, DWV Meets IL, 5 Cycles		MIL-STD-202, 100 Cycles
Operational Life	C ≤ 12.5%, DF ≤ 2 x IL, IR > 0.3 x IL, (1.5x or 2x RV) 1000 hrs	MIL-STD-202, 1000 hrs	MIL-STD-202, 4000 hrs, C ≤ 20%, DF ≤ IL, IR / Hot IR hrs. > 0.3 x IL
Temp. Humidity Bias	C ≤ 12.5%, DF ≤ 2 x IL, IR > 0.3 x IL, (85/85) 1000 hrs	MIL-STD-202, (85/85) 1000 hrs	MIL-STD-202, (85/85) 1000 hrs
DPA		EIA-469	EIA-469
Visual Examination		MIL-STD-883	MIL-PRF-32535 Appendix B
Physical Dimension	Within Specific Limits	JESD22	MIL-PRF-32535 Appendix B

Alternate Part Comparison

– NOTE NOT EQUILIVANT PARTS

Test	Commercial	Automotive	M32535-Level
Material			MIL-STD-790
Design			MIL-PRF-32535 Appendix B
Construction		MIL-STD-883	MIL-PRF-32535 Appendix B
Marking		MIL-STD-883	MIL-PRF-32535 Appendix B
Workmanship		MIL-STD-883	MIL-PRF-32535 Appendix B
Terminal Strength		MIL-STD-202 (Leaded), AEC-Q200-006 (SMD)	MIL-STD-202
Mechanical Shock		MIL-STD-202	
Vibration		MIL-STD-202, 5g's, 20 Minutes, 12 Cycles, 10 - 2000 Hz	
ESD		AEC-Q200-200 or ISO / DIS 10605	
Beam Load Test		AEC-Q200-003	
Resistance to Solder Heat		MIL-STD-202	MIL-STD-202
Shear Stress		AEC-Q200-006	MIL-PRF-32535, 60 Seconds
Csam			2x 100% Acoustic Micro Inspection
Thermal Shock / Cycle			100% x 20 Cycles
Voltage Conditioning (125°C)			100% 2x RV for 168 - 264 hrs
Hot IR (125°C)			100% @125°C
Dielectric Voltage Breakdown			6x Rated Voltage or 1,200 V_{DC}, Whichever is Less

SPECTRUM of COMPONENTS

COTS, COTS-Plus

- Designed and Manufactured to Commercial Standards
- ADDITIONAL Up-Screening

  AND/OR

  - Typically in “Accordance” to a Particular MIL-PRF Specification
  - May Include Known Methods Specific to the Manufacturer Resulting Increased Reliability
- Manufacturers Publish Expected Failure Rates of the COTS Part and Compare to Commercial Alternates Typically, Infant Mortality Failures are Reduced Thus Providing a Higher Reliability Component
- Further Options for Reliability Grading, Surge Current Tests, Group Tests etc. are Typically Offered as Options

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https://passive-components.eu/wp-content/uploads/2021/03/COTS-Automotive-Capacitors-Procurement-and-Evaluation-Case-Study-for-SME-Space-Hardware-Manufacturer.pdf

SCD

Why?

TECHNOLOGY HAS EVOLVED FASTER THAN MIL PRF DOCUMENTATIONS
APPLICATION HAS SPECIAL NEEDS WELL BEYOND E.R. DOCUMENTS

AN SCD PROVIDES:

Detailed Description of a Commercially Created Part

To the Supplier

- Requirements of expected device performance, qualification, maintenance of qualification & shipment

To the End User

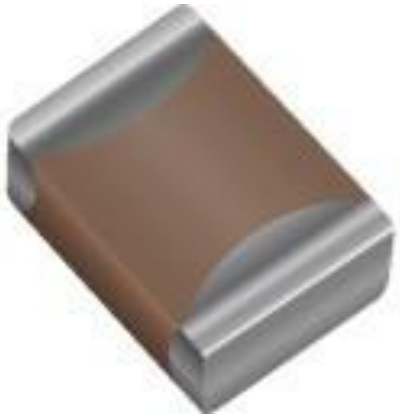
- Way to ID parts from multiple suppliers all capable of meeting an ‘ADVANCED specification’
- Reference doc for engineering/design and purchasing to ensure part(s) meet end needs
- Platform for further development or possible standardization:
    - SCDs can evolve into the basis of a PRF (given time, need and DLA efforts)

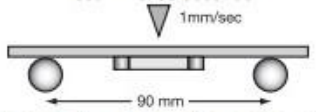
Source Control Drawing Differs:

Source Control Drawing Section	Application	Requirements	Qual Procedure	Acceptance Criteria	P/N Definition	Supply Sources
Details Contained Within Drawing Section	If Contractually Allowed- Provide a Brief Description of End Use	End Use Performance Defined in All Use Conditions- e.g. Radiation, Temperature, Transient Fields etc.	Qualification Procedure: Tests, Test Sequences, and Conditions Fully Defined. In Some Cases, Test Equipment Listed	Accept / Reject Criteria Fully Defined	Possibly Contract Defined or Manufacturer Defined. Typically, Concentrated on Date Code Tracking	P/N to Fully Reflect Component Manufacturer-Source of Supply to the End User

EXAMPLE:
SCD on ‘Certain’ NP0 MLCCs

	Commercial	MM Series
Administrative	Standard part numbers; no restriction on who purchases these parts	Specific series part number, used to control supply of product
Lot Qualification Destructive Physical Analysis (DPA)	As per EIA RS469	Increased sample plan – stricter criteria
Visual/Cosmetic Quality	Standard process and inspection	100% inspection
Application Robustness	Standard sampling for accelerated wave solder on X7R dielectrics	Increased sampling for accelerated wave solder on X7R and NP0 followed by lot by lot reliability testing
Design/Change Control	Required to inform customer of changes in: form fit function	KYOCERA AVX will qualify and notify customers before making any change to the following materials or processes: Dielectric formulation, type, or supplier Metal formulation, type, or supplier Termination material formulation, type, or supplier Manufacturing equipment type Quality testing regime including sample size and accept/ reject criteria



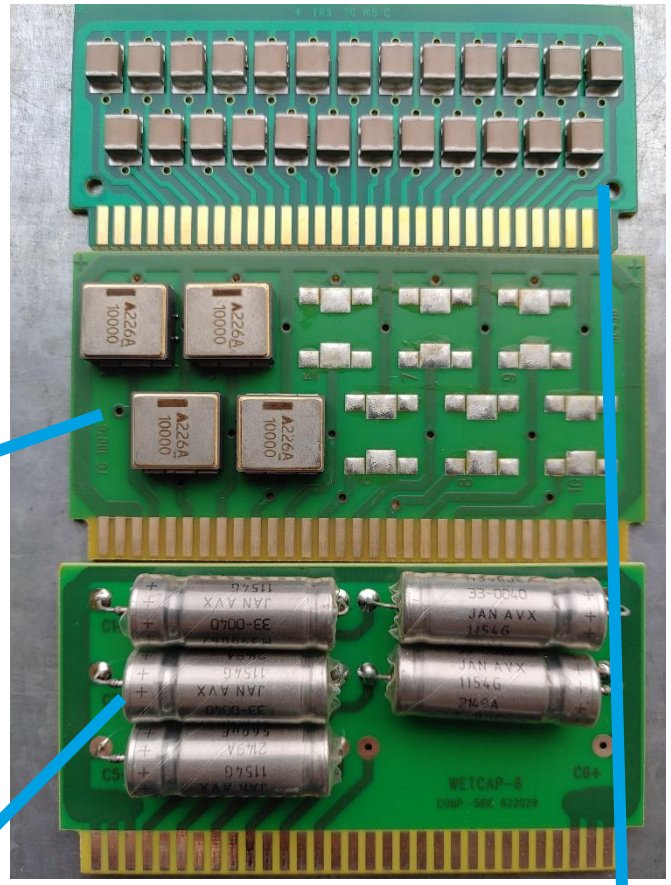
Parameter/Test		NP0 Specification Limits	Measuring Conditions	
Operating Temperature Range		-55°C to +125°C	Temperature Cycle Chamber	
Capacitance		Within specified tolerance	Freq.: 1.0 MHz ± 10% for cap ≤ 1000 pF 1.0 kHz ± 10% for cap > 1000 pF Voltage: 1.0Vrms ± .2V	
Q		<30 pF: Q≥ 400+20 x Cap Value ≥30 pF: Q≥ 1000		
Insulation Resistance		100,000MΩ or 1000MΩ - µF, whichever is less	Charge device with rated voltage for 60 ± 5 secs @ room temp/humidity	
Dielectric Strength		No breakdown or visual defects	Charge device with 300% of rated voltage for 1-5 seconds, w/charge and discharge current limited to 50 mA (max) Note: Charge device with 150% of rated voltage for 500V devices.	
Resistance to Flexure Stresses	Appearance	No defects	Deflection: 2mm Test Time: 30 seconds 	
	Capacitance Variation	±5% or ±.5 pF, whichever is greater		
	Q	Meets Initial Values (As Above)		
	Insulation Resistance	≥ Initial Value x 0.3		
Solderability		≥ 95% of each terminal should be covered with fresh solder	Dip device in eutectic solder at 230 ± 5°C for 5.0 ± 0.5 seconds	
Resistance to Solder Heat	Appearance	No defects, <25% leaching of either end terminal	Dip device in eutectic solder at 260°C for 60 seconds. Store at room temperature for 24 ± 2 hours before measuring electrical properties.	
	Capacitance Variation	≤ ±2.5% or ±.25 pF, whichever is greater		
	Q	Meets Initial Values (As Above)		
	Insulation Resistance	Meets Initial Values (As Above)		
	Dielectric Strength	Meets Initial Values (As Above)		
Thermal Shock	Appearance	No visual defects	Step 1: -55°C ± 2°	30 ± 3 minutes
	Capacitance Variation	≤ ±2.5% or ±.25 pF, whichever is greater	Step 2: Room Temp	≤ 3 minutes
	Q	Meets Initial Values (As Above)	Step 3: +125°C ± 2°	30 ± 3 minutes
	Insulation Resistance	Meets Initial Values (As Above)	Step 4: Room Temp	≤ 3 minutes
	Dielectric Strength	Meets Initial Values (As Above)	Repeat for 5 cycles and measure after 24 hours at room temperature	
Load Life	Appearance	No visual defects	Charge device with twice rated voltage in test chamber set at 125°C ± 2°C for 1000 hours (+48, -0). Remove from test chamber and stabilize at room temperature for 24 hours before measuring.	
	Capacitance Variation	≤ ±3.0% or ± .3 pF, whichever is greater		
	Q	≥ 30 pF: Q≥ 350 ≥10 pF, <30 pF: Q≥ 275 +5C/2 <10 pF: Q≥ 200 +10C		
	Insulation Resistance	≥ Initial Value x 0.3 (See Above)		
	Dielectric Strength	Meets Initial Values (As Above)		
Load Humidity	Appearance	No visual defects	Store in a test chamber set at 85°C ± 2°C/ 85% ± 5% relative humidity for 1000 hours (+48, -0) with rated voltage applied. Remove from chamber and stabilize at room temperature for 24 ± 2 hours before measuring.	
	Capacitance Variation	≤ ±5.0% or ± .5 pF, whichever is greater		
	Q	≥ 30 pF: Q≥ 350 ≥10 pF, <30 pF: Q≥ 275 +5C/2 <10 pF: Q≥ 200 +10C		
	Insulation Resistance	≥ Initial Value x 0.3 (See Above)		
	Dielectric Strength	Meets Initial Values (As Above)		

New Performance Characterization

Passive component suppliers increasingly have data base performance available

Typical Passive supplier Radiation test card

- FR 5 testing boards
  - ~ 3.00 x 9.00 x 0.15 cm
  - woven glass reinforced material and an epoxy resin binder



Hermetic Non-Hermetic

conductive polymer apacitors

Wet-tantalum capacitors

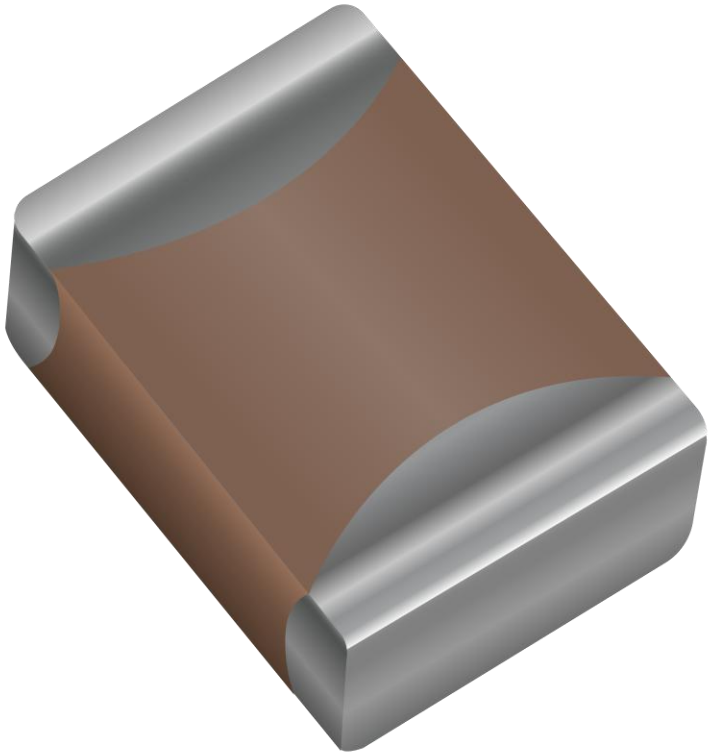
Ceramic capacitors

M32535

Counterfeit Products

Buyers

- Responsibility to only purchase products from:
  - Authorized distributors
  - Manufacturers directly



Manufacturers:

- Have detailed lot tracking and date code schemes
- Even with the above – manufacturers are unable to take responsibility for products that are not purchased from authorized distributors or from the manufacturer directly
- Manufacturers can not assist in evaluating questionable products with no supply pedigree

Counterfeit Products:

Use Tools Such As:

- External test labs
- Visual Inspection - Look for clear marking, physical deformities, signs of resurfacing
- Increased electrical inspection
- X-Ray – Look for consistent die size, wire bond integrity, case integrity, markings
- Scanning Acoustic Microscope – look for signs of blacktopping (overcoating sanded surfaces)

Links

Military Specification

https://landandmaritimeapps.dla.mil/programs/milspec/DocSearch.aspx

DEFENSE LOGISTICS AGENCY
DLA Land and Maritime
Mil Spec

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The NEPP Program generates technical knowledge and recommendations about electrical, electronic, electromechanical (EEE) part performance, application, failure modes, test methods, reliability and supply chain quality within the context of NASA space flight missions and hardware. This information is made available to the NASA and high-reliability aerospace community through publications, web pages and links published on this website.

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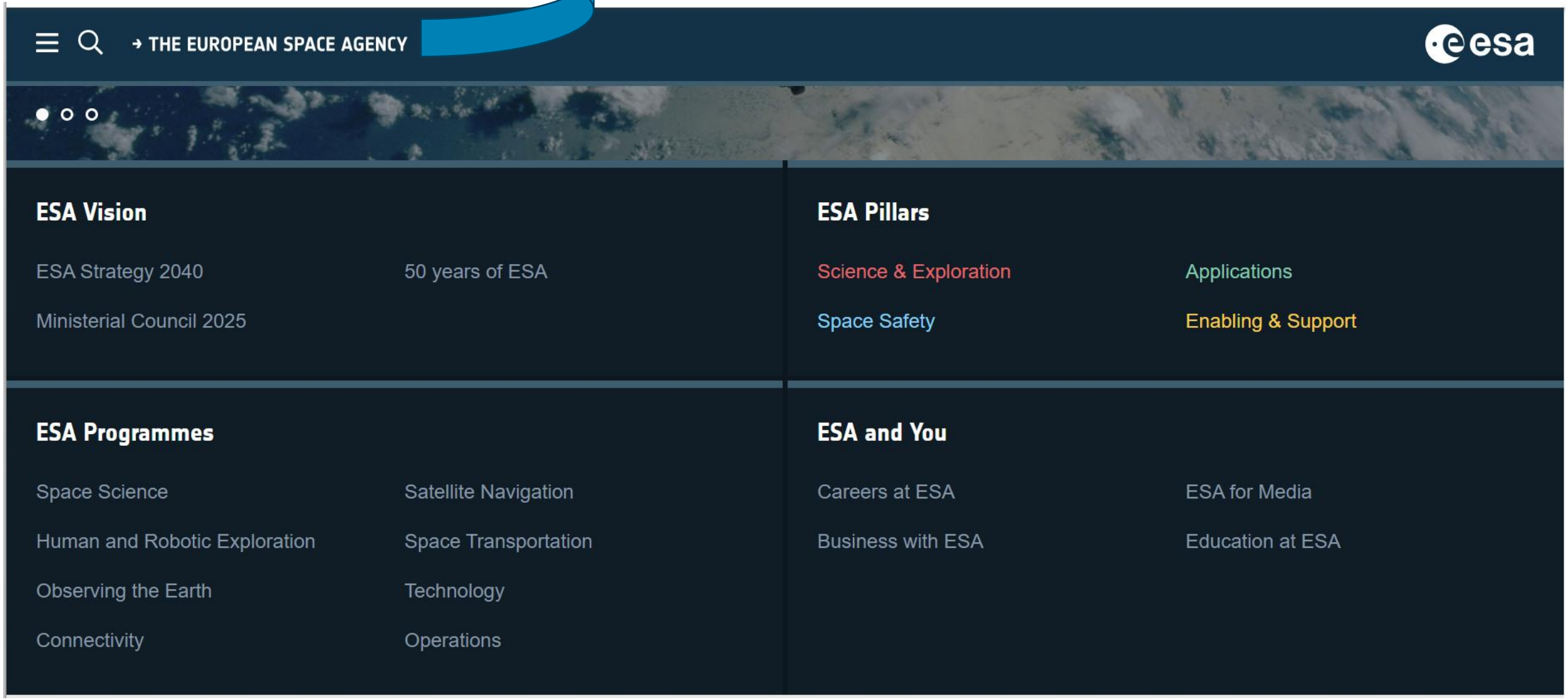

Links

RoHS Directive - Environment - European Commission

European Commission

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Energy, Climate change, Environment

Environment

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Restriction of Hazardous Substances in Electrical and Electronic Equipment (RoHS)

EU rules restricting the use of hazardous substances in electrical and electronic equipment to protect the environment and public health.

The amount of waste electrical and electronic equipment (WEEE) generated every year in the EU is increasing rapidly. It is now one of the fastest-growing waste streams.

Electrical and electronic equipment (EEE) can also contain hazardous substances.

Links

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U.S. DEPARTMENT OF STATE
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Arms Export Control Act (AECA)

International Traffic in Arms Regulations (ITAR)

Federal Register Notices (FRNs)

ITAR & Export Controls

Some key laws and regulations that govern commercial defense trade include the Arms Export Control Act (AECA), the International Traffic in Arms Regulations (ITAR), and the United States Munitions List (USML).

The Directorate of Defense Trade Controls (DDTC) administers the ITAR (22 CFR parts 120-130), which implements section 38 of the AECA.

THE ITAR & USML

The International Traffic in Arms Regulations (ITAR) & United States Munitions List (USML)

The ITAR (22 CFR parts 120-130) governs the manufacture, export, and temporary import of defense articles, the furnishing of defense services, and brokering activities involving items described on the USML**(ITAR section 121.1).**

Summary

Component engineering is a critical function

CE job requirements are driven by technology, design trends and regulations

CE function will be relied upon massively in 2026 & beyond

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