

Enabling Commercial EEEE Parts for NASA Missions

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To be presented by P Majewicz at the NASA 2025 Quality Leadership Forum (QLF)

Acronyms

AEC	Automotive Electronics Council
COTS	Commercial-Off-The-Shelf
Cpk	Process Capability Index
DLA	Defense Logistics Agency
DoD	Department of Defense
DPPM	Defective Parts Per Million
EEE	Electrical, Electronic, Electromechanical
EOL	End-Of-Line
ETW	Electronics Technology Workshop
FAA	Federal Aviation Administration
FIT	Failure-In-Time
FMEA	Failure Mode and Effects Analysis
GSFC	Goddard Space Flight Center
IL	In-Line
ILPM	Industry Leading Parts Manufacturer
JEDEC	Joint Electron Device Engineering Council
MEAL	Mission Environment, Application, and Lifetime
MIL-SPEC	Military Specification
NASA	National Aeronautics and Space Administration
NEPP	NASA Electronic Parts & Packaging (Program)
NESC	NASA Engineering & Safety Center
NSC	NASA Safety Center
PEAL	Parts Evaluation and Assessment Laboratory
PPAP	Production Part Approval Process
PSW	Part Submission Warrant
QML	Qualified Manufacturers List
QPL	Qualified Product List
RHA	Radiation Hardness Assurance
SMA	Safety and Mission Assurance
SMD	Standard Microcircuit Drawing
SME	Subject Matter Expert
SPC	Statistical Process Control

Methods for Selecting Parts

Quality/Performance Expectation

CURRENT METHOD

MIL-SPEC PARTS → MIL-SPECs, Test Methods, SMDs, Slash Sheets, DLA, In-line (IL) and End of Line Testing (EOL)

COMMERCIAL PARTS → Data Sheets / Online info → EOL Testing

PEAL

COMMERCIAL PARTS → Manufacturer Information /Data Sheets (SME's, Parts Lab, ILPM)

ADDED TESTING

Mission
Environment
Application
Lifetime

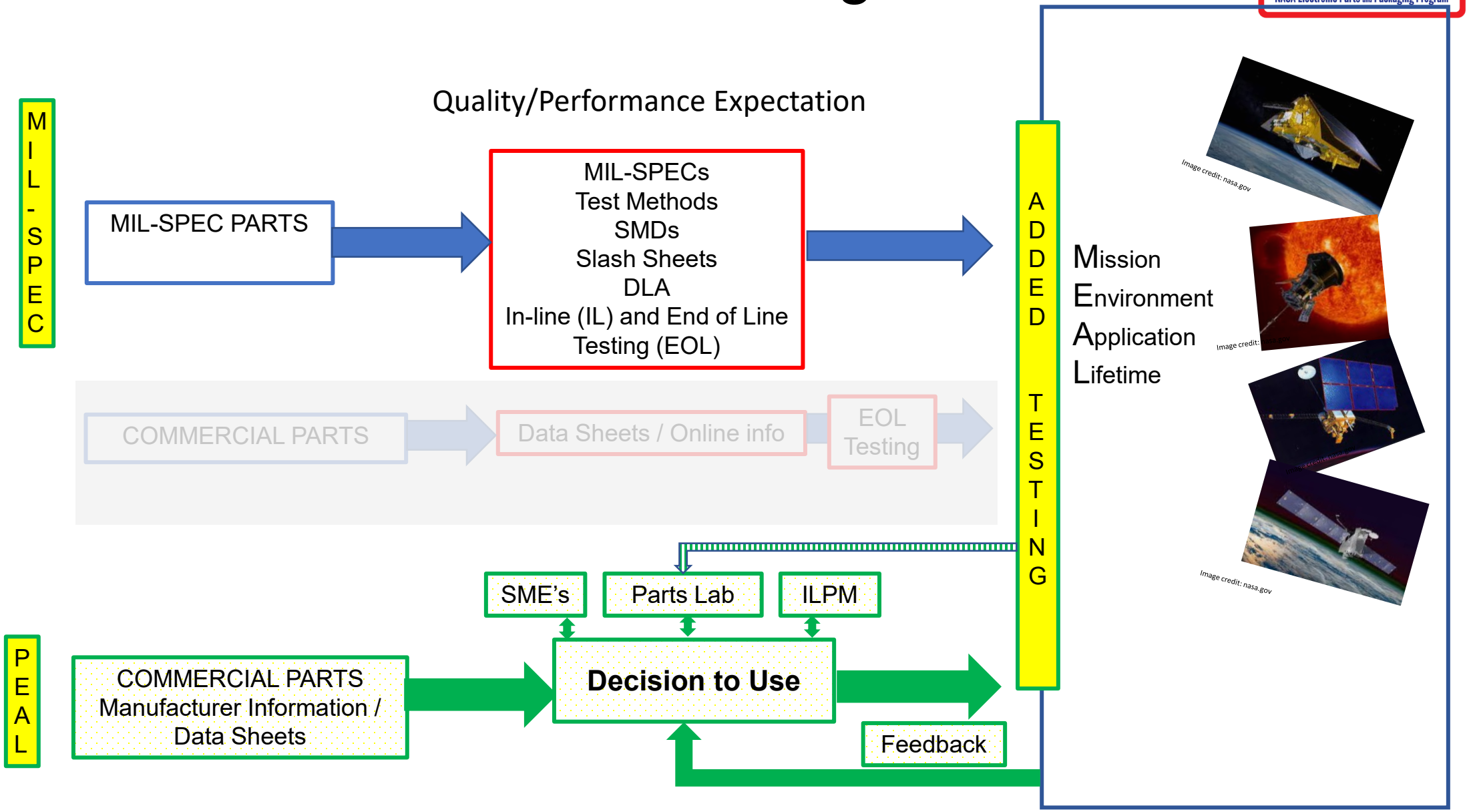


NASA Needs to Use More Commercial Electronics

- NASA missions are being delayed or cancelled
  - Traditional parts assurance practices are leading to **significant project delays** due to EEEE supply chain issues for **space qualified parts (e.g. long lead times)**
  - A business case study revealed these delays are costing NASA hundreds of millions of increased project costs

- Delay in incorporating new technology into MIL-SPECS
  - The high investment for **traditional COTS parts qualification** practices with no guarantee of success has become a major barrier against innovation in the Agency
  - No straightforward path for taking proven technology demonstrations into flagship Class A/B/C and human-rated missions
  - Projects opt to maintain heritage designs

Methods for Selecting Parts

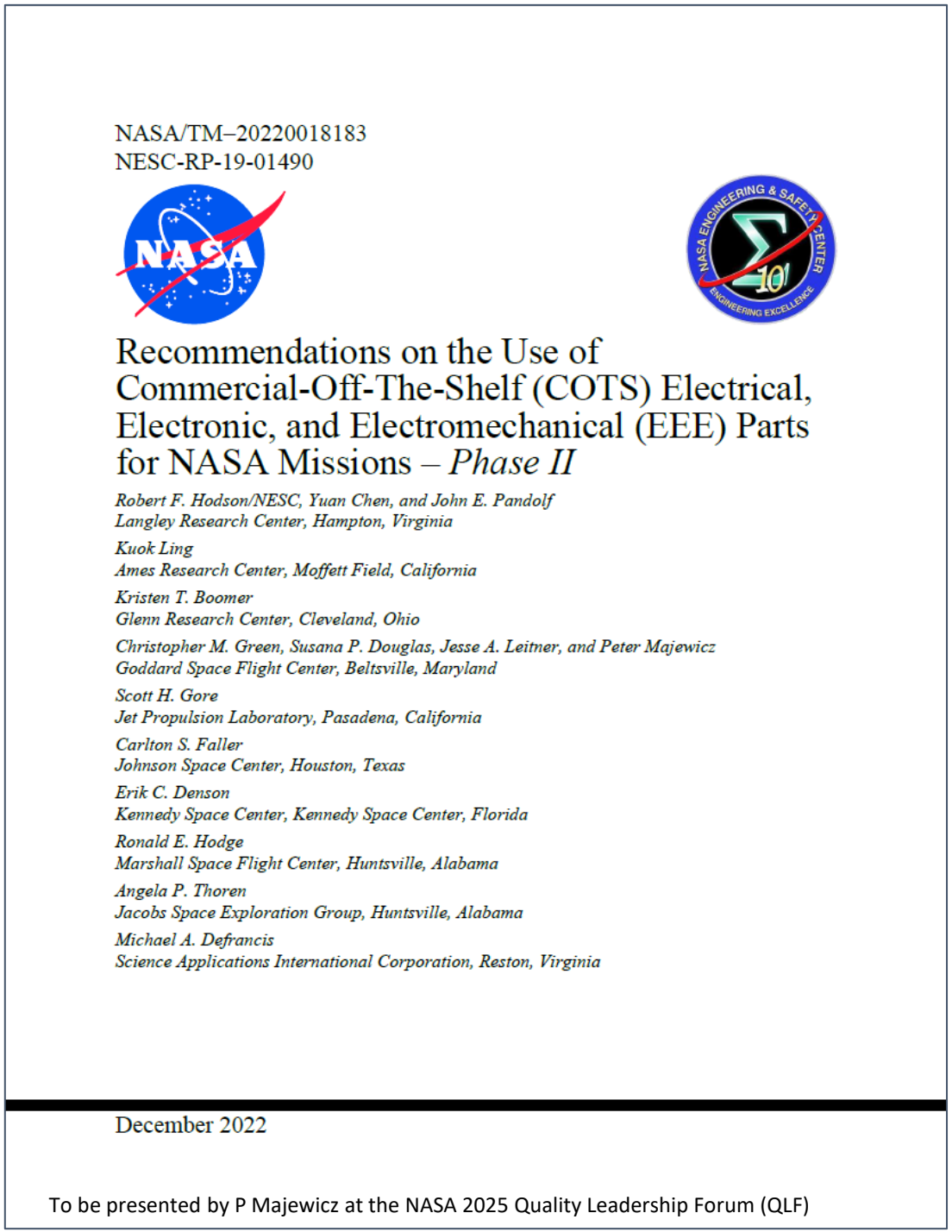


NASA COTS Solution Steps

1) Update NASA EEEE parts standards to provide an alternative approach for COTS parts evaluations, including automotive grade
2) Establish a radiation hardness assurance plan that matches the risk posture for the mission
3) Develop an *Industry Leading Parts Manufacturer (ILPM)* designation program and establish a *Parts Evaluation and Assessment Laboratory (PEAL)* capability within NASA to maximize utilization of high reliability COTS parts that meet mission objectives *at lower cost while minimizing risk*

To be presented by S. Douglas at ACCEDE/ESSCON, Mar 2025

NASA Engineering and Safety Center Recommendations on the Use of COTS EEE Parts for NASA Missions



NASA/TM–20220018183
NESC-RP-19-01490

Recommendations on the Use of Commercial-Off-The-Shelf (COTS) Electrical, Electronic, and Electromechanical (EEE) Parts for NASA Missions – *Phase II*

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December 2022

To be presented by P Majewicz at the NASA 2025 Quality Leadership Forum (QLF)

NESC COTS Study Recommendations

- COTS definition applied:

  A part for which the manufacturer solely establishes and controls specifications for configuration, performance, quality, and reliability. *This includes design, materials, processes, assembly, and testing with no Government-imposed requirements (i.e., no Government oversight). COTS parts typically are available on a manufacturer's catalog (e.g., website) or from various distributors.*

- NESC overall recommendation is to select "Established COTS parts" from Industry Leading Parts Manufacturers (ILPMs) and when doing so, MIL-SPEC or similar screening and lot acceptance testing can be reduced or eliminated where evidence of sufficient quality and reliability exists (https://ntrs.nasa.gov/citations/20220018183)
  - Provides guidance on part- and board-level verification for NASA missions per risk class ***but no implementation details***
  - The extent and nature of the needed evidence will differ by mission, most likely driven by a mission's resources and associated risk posture
  - ***Does not address radiation concerns***

PEAL is the method by which the ILPM methodology can be implemented successfully *and* address radiation concerns

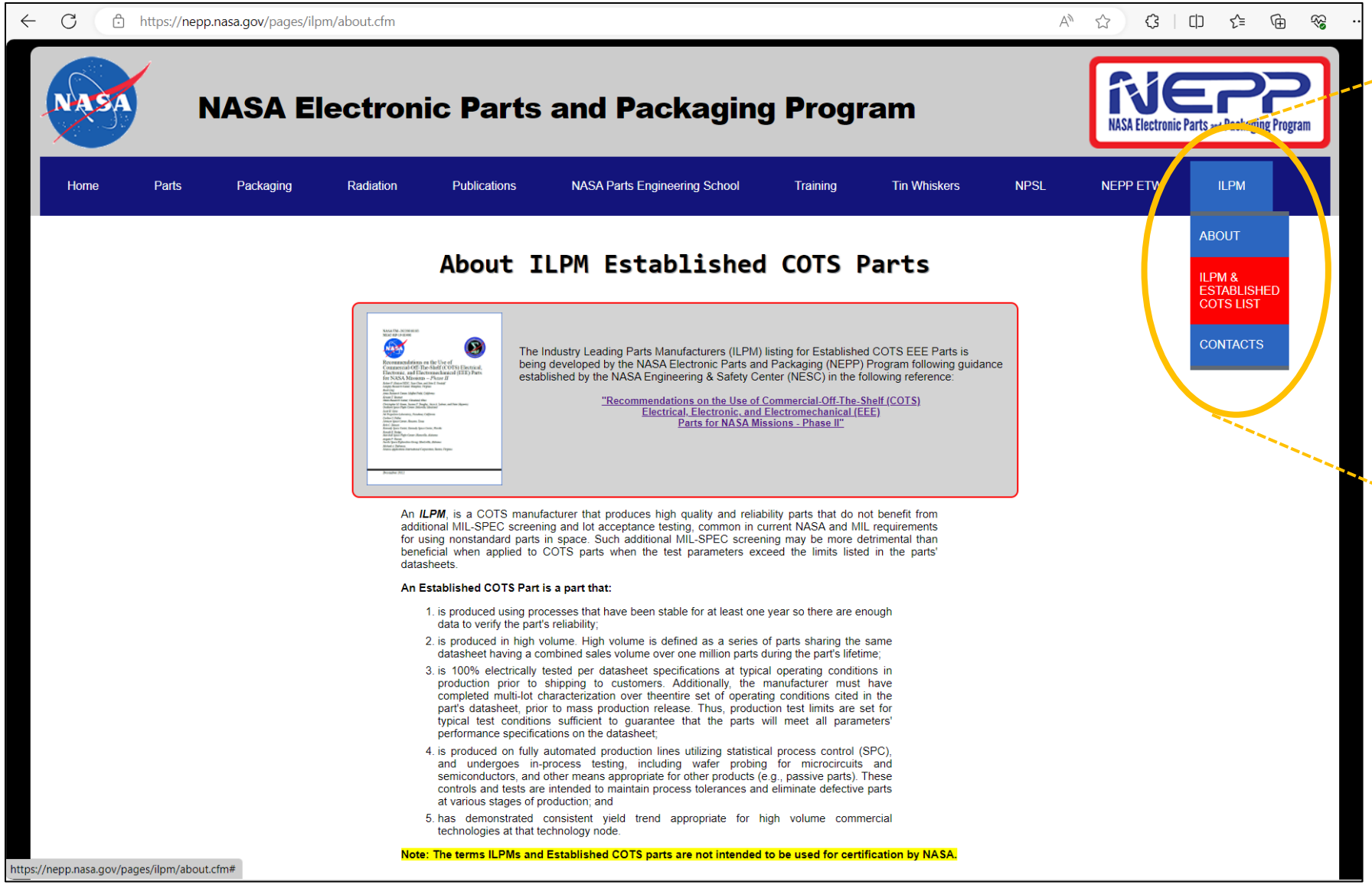
Targeted ILPM / Parts Data Requests

- International Automotive Task Force (IATF) 16949:2016 certification
  - A quality management system (QMS) emphasizing defect prevention and reduction of variation and waste for continual improvement in the supply chain and assembly process
  - Supplement to ISO9001 for the automotive industry
- **Level 3** Production Part Approval Process (PPAP)
  - Automotive Industry Action Group (AIAG) developed data package, specified in the PPAP manual
  - Includes Part Submission Warrant (PSW) to validate AEC requirements have been met, with supporting data and elements specified in the AEC-Q100 Certificate of Design Construction and Qualification (CDCQ) Template
  - Design Failure Mode and Effects Analysis (DFMEA) → typically only shared onsite
  - Process FMEA (PFMEA)
  - Process control plan
  - Engineering change documents
  - Measurement system analyses

Targeted ILPM / Parts Data Requests

- AEC-Q004 Zero-Defect strategy that demonstrates continuous improvement approaches
  - Reliability monitoring program, such as wafer level reliability, daily end of production parts testing, and including testing bias and thermal conditions, sample sizes, failure criteria, etc.
  - Processes and practices for eliminating statistical outlier parts before shipment that are within manufacturer's specification limits but outside the main population distribution
  - Control limit improvement process
- Fabrication processes stability in key processes over **12 months of production**, such as **process capability index** (Cpk) statistics and/or **statistical process control** (SPC) trends
- Parts quality and reliability data, such as estimated production **DPPM**, field failure DPPM and/or part failure rates (FITs), ***and how those statistics are derived***
- Product yield *trends*

ILPM Established COTS List





NASA Electronic Parts and Packaging Program

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ILPM & Established COTS List

The following is a list of Industry Leading Parts Manufacturers (ILPMs) and corresponding "Established COTS Parts", as defined by the NASA Engineering and Safety Center (NESC) Technical Assessment Phase II Report on Recommendations on the Use of Commercial-Off-The-Shelf (COTS) Electrical, Electronic, and Electromechanical (EEE) Parts for NASA Missions (NASA/TM-20220018183). NASA has developed a relationship with the manufacturer to obtain company and product information that verifies the manufacturer and specified product line meets the general criteria outlined in the NESC recommendations. The information contained herein is presented for guidance to projects when considering usage of these products in space applications. The guidance does not distinguish between critical or non-critical systems, and a given project will need to apply the appropriate measures when utilizing these parts based on their risk posture. A mission-specific approach tailored to a project's Mission, Environment, Applications and Lifetime (MEAL) requirements should be developed and approved by program/project managers. Any associated risks should be clearly identified, quantified, mitigated, and/or accepted. Neither the United States Government (USG) nor any person acting on behalf of the USG assumes any liability resulting from the use of the information contained herein.

Date Added ▲	Last ILPM Assessment Date	Manufacturer	Address	CAGE Code	Commodity	Established COTS Part Designation	Comment	NASA POC	Submitted Documents	Manufacturer Internal Qualification Test Periodicity	NASA ILPM Assessment Documents	Links
5/23/2024	5/23/2024	Susumu	Obama, Japan; Suzhou, China	J5312	Resistor, Thin Film, Surface Mount, High Precision	RG series (sizes 0201, 0402, 0603, 0805, 1206)	AEC-Q200 Compliant	TBD	Annotated ILPM questionnaire General ILPM discussion documents, including "Company Presentation Sep 2023" and additional responses to NASA questioning (Oct 2023 thru May 2024) PPAP Level 3: D23-0403, 10-Oct-2023) FIT Rate: RGR-S22005, 30-Aug-2022) Reliability Test Data for all sizes: 1) RG3216: RGR-S22012E, 13-Jul-2022 2) RG2012: RGR-S22011E, 13-Jul-2022 3) RG1608: RGR-S22013E, 13-Jul-2022 4) RG1005: RGR-S21033E, 13-Jul-2022 5) RG0603: RGR-S22029E, 29-Nov-2022 Additional 3000hr life test data at rated power for RG1005, RG1608, RG2012, RG3216: RGR-S21045E, 9-Mar-2022 Design and Manufacturing Change Management Rule (UM4060003-02, Rev Date 2022/12/30) List of items subject to change notification (UM4060015-00, Rev Date 2021/09/02)	Once at product qualification, sample set of reliability tests once per year	ILPM Established COTS Parts Criteria Matrix NASA summary: Susumu Thin Film Chip Resistor FIT Rate Calculation Comparison with MIL-PRF-55342 Established Reliability Failure Rate Level (FRL) Estimate (MIL-STD-690)	Link

ILPM Established COTS Part Criteria Matrix

ITEM #	ILPM ESTABLISHED COTS PART CRITERIA	RG Series Resistors
1	**Established COTS parts criteria**	
1a	Produced using processes stablized for > one year	Yes
1b	Produced and sold in high volume (> 1M)	Yes
1c	100% electrically tested for datasheet parameters + other 100% inspection	Yes (THD, visual, HV test)
1d	Produced on fully automated lines with SPC and in-process testing	Yes based on high volume manufacturing output. SPC and in-process testing discussed in items 3d, 3e, and 4 below.
1e	Consistent yield	Yield is monitored and used for future improvement plans
2	**ILPM Criteria**	
2a	Has at least one Established COTS part	RG series resistors
2b	End of production DPPM and method of derivation	None reported. Susumu does not calculate.
2c	Field failure DPPM and method of derivation	Manufacturer sets PPM target annually (based on confirmed field failures)
2d	Parts failure rate or FIT rate	RGR-S22005E: FIT rate < 0.010 FIT, 60% confidence level, JIS-C-5003 Attachment Table 1 is applied
2e	Designed operating life and method of derivation	FIT rate data is comprised of ~20 years worth of testing using moisture as the primary stress parameter (20C/60%RH test condition). See comparison of Susumu FIT rate calculation to MIL-PRF-55342 Failure Rate Level (FRL) estimate. Activation energy for wearout failure mechanism and method of derivation provided.
3	AEC-Q004 Zero Defect Framework related practices	
3a	Defect Elimination Process / Infant Mortality Detection	Yes per PPAP D23-0403
3b	Statistical outlier part elimination before shipment	Yes per PPAP D23-0403 and additional information provided
3c	Reliability monitoring program (wafer level and daily end of production parts testing, to include testing bias and thermal conditions, sample sizes, and failure criteria)	Tests, conditions, tolerances, sample sizes as detailed in RG52-4005-E. Initial qualification on thousands of pieces, continuous reliability since then done on 10-20 pcs per product. Process maintained through SPC. Tests done on low/mid/high resistance value range. Susumu also conducts a set of reliability tests once a year for every chip size of RG series (0402, 0603, 0805 and 1206).
3d	Control limit improvement process	Yes per PPAP D23-0403, including embedded RG52-4005-E Version 60 Control Plan (amended 13-Sep-2022)
3e	IATF 16949 certification or equivalent	ISO/TS16949 certification Nov 2004 at JQA, Mar 2011 at China Suzhou.
4	Level 3 PPAP	PPAP D23-0403 provided
	OR	
ALT-4a	Construction / Cross-section Analysis	Part construction shared during ILPM discussion documents--no further hard documentation provided. Dimensions/materials detailed on part specification RG00-4146.
ALT-4b	Design FMEA	Confidential--not shared
ALT-4c	Process FMEA, to include wearout mechanisms and associated activation energies	PPAP Process-FMEA: RG05-4004 Rev. 36
ALT-4d	Process Control Plan	Process flow chart: RG52-4005-E Version 60
ALT-4e	Material Performance Test Results	PPAP Reliability Test data document: RGR-S22012E
ALT-4f	Process studies	PPAP Dimensional Results portion of Reliability Test Data RGR-S22012E-1
ALT-4g	Engineering change documents and process	Yes: Design and Manufacturing Change Management Rule UM4060003 Rev. 02 and UM4060015-00 Revision Date:2021/09/02 documents provided
ALT-4h	Measurement system analyses	PPAP page 156: Gage Repeatability and Reproducibility Data Collection Sheet

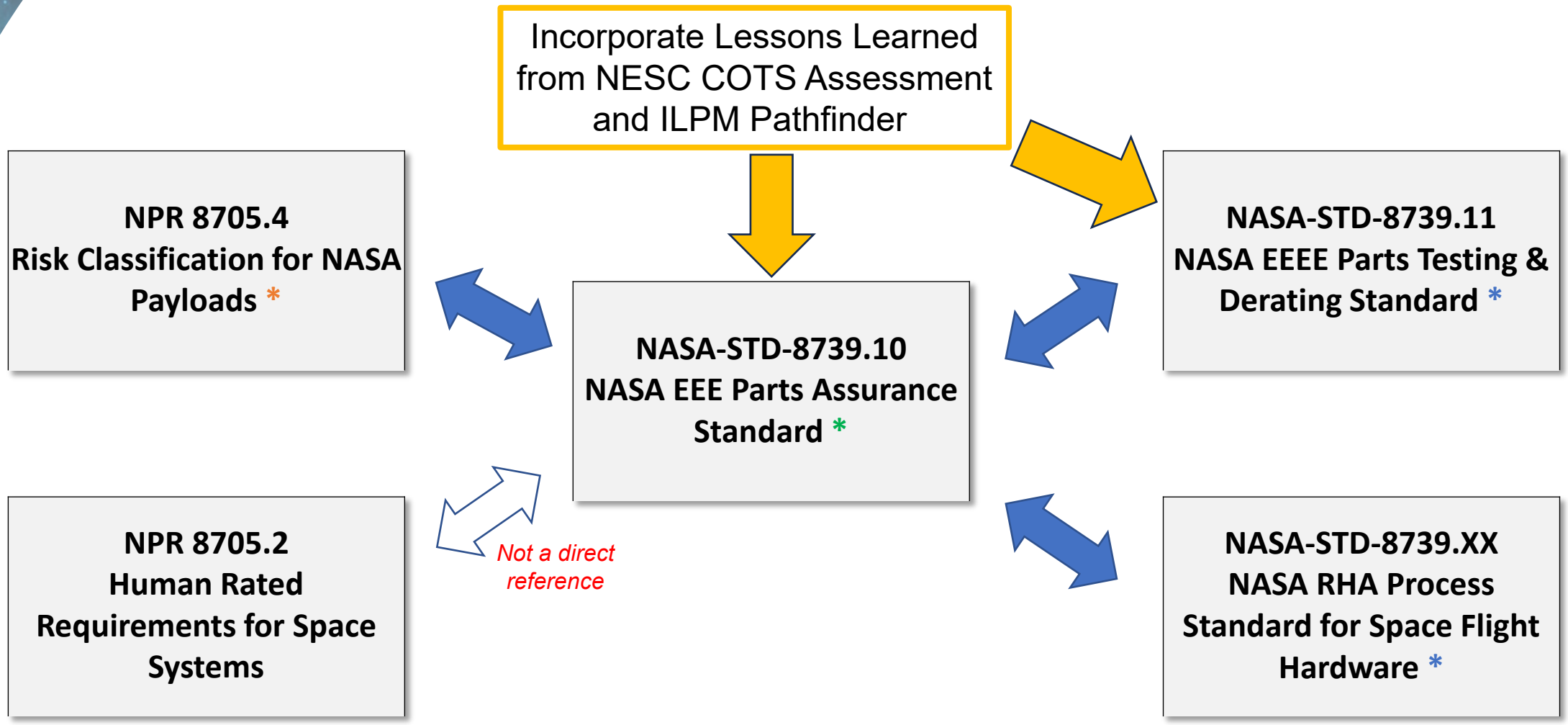
Latest ILPM Update



Onsite meeting at ADI HQ in Wilmington, MA (9 NASA/JPL, 1 Aerospace Corp.)

- In final stages of ILPM discussions with Analog Devices, Inc. (ADI)
- ADI presentations on supply chain, quality processes for their automotive qualified (AEC-Q) product lines, and methodologies for establishing reliability
- Deep dive (PFMEAs and DPPM) on 3 selected products: LT3080, MAX4478, AD8211
- Sharing of PPAPs not an option with ADI—resolving workaround
- A subset of ADI AEC-Q parts to be added to the Established COTS list: https://nepp.nasa.gov/pages/ilpm/establishedparts.cfm
- Some life test condition gaps can only be fully addressed by independent test verification
- In discussions with 3 other manufacturers currently (passives and actives parts suppliers)

NASA Policy / Standards Update



* *Recently updated*

* *Revision planned for 2025*

* *Release in early 2025*

NASA-STD-8739.11 AEC-Q Plan

Table 1. PLASTIC ENCAPSULATED MICROCIRCUIT REQUIREMENTS 1/

Assurance Level	Monolithic Microcircuit Type	Specification	Use as Is	Screening 4/	LAT 4/	DPA 4/
Level 1	QML Class P	MIL-PRF-38535				X
	QML Class N 2/	MIL-PRF-38535		X	X	X
	Automotive, Commercial, SCD 3/	AEC-Q100, VICD, SCD		X	X	X
Level 2	QML Class P or N	MIL-PRF-38535				X
	Automotive, Commercial, SCD 3/	AEC-Q100, VICD, SCD		X	X	X
Level 3	QML Class P or N	MIL-PRF-38535				X
	Automotive, Commercial, SCD 3/	AEC-Q100, VICD, SCD		X		X
Level 4	QML Class P or N	MIL-PRF-38535	X			
	Automotive, Commercial, SCD 3/	AEC-Q100, VICD, SCD	X			

NASA Radiation Hardness Assurance (RHA) Process Standard

Prescribes the process for radiation program integration

Levies requirements for:

- RHA schedule
- RHA deliverables

Requires programs & projects to accept a risk if the schedule / deliverables are not met

Prescribes the process for programs and projects to baseline their RHA approach

- Defines RHA process taxonomy & correlation w/ MEAL*
- Prescribes the program scrutiny required to baseline the RHA approach
  - Up to accepting a risk

- Leverages NASA Risk Management Process
  - Mitigation plan, risk tracking to closure

*Mission, Environment, Application, and Lifetime

RHA Taxonomy Example

Table 6. SEE Taxonomy – RHA Scope and Assurance

RHA Category	S1	S2	S3	S4	S5
Risk tolerance posture	Low	Low-Medium	Medium-High	High	Very High
Purpose of SEE RHA	Assures reliability (DSEE) and	Assures reliability (DSEE) and	Provides targeted assurance	Provides some assurance of	N/A

Table 7. SEE Taxonomy – System-level RHA criteria

RHA Category	S1	S2	S3	S4	S5
RHA integral to the design process	Yes	Yes	Yes	Selectively at project discretion	Not required
System-level LOE	SEE threats to reliability and	SEE threats to reliability and	SEE threats to availability do	None to interface-limited[7-2]	None to interface-limited[7-2]

Table 8. SEE Taxonomy – EEEE-part-level criteria

RHA Category	S1	S2	S3	S4	S5
SEE part selection criteria	**Enforced**	**Enforced**	**Enforced**	**Enforced**	**Not enforced**
SEE data type[8-1,8-2,8-3]	Piece-part	CCA- and/or piece-part	CCA- and/or piece-part	CCA-level test	None
SEGR/SEB/SEDR acceptance criteria[8-4]	Risk avoidance (commonly, 37 MeV·cm²/mg)	Risk avoidance (commonly, 37 MeV·cm²/mg)	Risk avoidance (commonly, 37 MeV·cm²/mg)[8-5]	High energy protons for DSEE[8-6]	None
SEL/other DSEE acceptance criteria[8-6]	Risk avoidance (commonly, 75 MeV·cm²/mg) or quantification	Risk avoidance (commonly, 37 MeV·cm²/mg) or quantification	Risk avoidance (commonly, 37 MeV·cm²/mg) or quantification[8-5]	High energy protons for DSEE[8-6]	None
NDSEE acceptance criteria	Likelihood and criticality assessed and meet project requirements.	Likelihood and criticality assessed and meet project requirements.	Likelihood and criticality assessed and meet project requirements for critical systems.	Likelihood and criticality assessed and meet project requirements for critical systems.	None
SEE data representative of flight parts[8-7]	Required	Required	Recommended	Recommended as feasible	

[8-1]RHA guarantees are provided by US military standard, other government/industry organizations, or manufacturer/vendor. RHA parts are subject to lot traceability and manufacturing process change controls that vendor data may or may not provide. The radiation designator in MIL-PRF-38534/5 and MIL-PRF-19500 refers to TID only and is not indicative of any SEE guarantees. Data sheets often guarantee specific SEE characteristics only (e.g., SEL LET threshold) and must be supplemented by manufacturer/vendor- or application specific testing on flight-lot representative samples.

[8-2]Refer to Appendix G: RHA Evidence Hierarchy and definitions of "acceptable data" available in the literature (e.g., Poivey, 2002; Gonzales, 2018)

[8-3]Compliant to national and international standards to the extent practical

[8-4]Based on structure layout of the device

[8-5]Test LET may be reduced to program-agreed level (e.g., to 20-30 MeV·cm²/mg) due to practical considerations

[8-6]DSEE risk remaining for specific part types e.g., with thick sensitive regions [RHA guidelines]

[8-7]Analysis required to validate applicability of previous test data to the flight design

RHA Taxonomy Example

Table 6. SEE Taxonomy – RHA Scope and Assurance

RHA Category	S1	S2	S3	S4	S5
Risk tolerance posture	Low	Low-Medium	Medium-High	High	Very High
Purpose of SEE RHA	Assures reliability (DSEE) and	Assures reliability (DSEE) and	Provides targeted assurance	Provides some assurance of	N/A
Survival					
A priori will be r					
Availabi product					
A priori availabil					
Anticipa testing[6]					

Table 7. SEE Taxonomy – System-level RHA criteria

RHA Category	S1	S2	S3	S4	S5
RHA integral to the design process	Yes	Yes	Yes	Selectively at project discretion	Not required
System-level LOE	SEE threats to reliability and availability drive the mission success criteria. Systems architecture, circuit design, parts selection, and SW/VHDL are carefully managed throughout project or program lifecycle to meet all SEE requirements.[7-1]	SEE threats to reliability and availability drive the mission success criteria. Systems architecture, circuit design, parts selection, and SW/VHDL are carefully managed throughout project or program lifecycle to meet all SEE requirements.[7-1]	SEE threats to availability do not directly drive mission success. The system's tolerance inherent to the design, rather than extensive part test data, is expected as a primary mitigation for nondestructive SEE. Destructive SEE is managed by a strategic combination of parts testing and system design to assure reliability.[7-1]	None to interface-limited[7-2]	None to interface-limited[7-2]
SEECA	Required for all systems[7-3]	Required for all systems[7-3]	Required for critical systems	Recommended to identify driving risk to reliability, availability, and performance. Required for do-no-harm if not guaranteed by system-level mitigation	Do-no-harm strategy completely relies on system-level mitigation

[7-1] Part selection for risk avoidance (e.g., SEE rad-hard vs. rad-tolerant) lowers the scope of system-level LOE vs. risk quantification and analysis-driven design mitigation implementation
[7-2] E.g., implementation of current monitoring and power cycling capability external to the CCA
[7-3] For equivalent risk posture, decreased assurance at piece-part level requires increased scope at systems level for RHA design and analysis.

[6-1] "Targe
[6-2] Proto
[6-3] This r
[6-4] Risk a
[6-5] See R
[6-6] Refer to Appendix G: RHA Evidence Hierarchy and definitions of "acceptable data" available in the literature (e.g., Poivey, 2002)
[6-7] High energy protons (~200 MeV) often used as the main test solution. Heavy ion testing performed for specific part types e.g., with thick sensitive regions

DRAFT

RHA Taxonomy Example

Table 6. SEE Taxonomy – RHA Scope and Assurance

RHA Category	S1	S2	S3	S4	S5
Risk tolerance posture	Low	Low-Medium	Medium-High	High	Very High
Purpose of SEE RHA	Assures reliability (DSEE) and availability (NDSEE) consistent with the program risk tolerance posture	Assures reliability (DSEE) and availability (NDSEE) consistent with the program risk tolerance posture	Provides targeted assurance of reliability (DSEE) and availability (high impact NDSEE)[6-1]	Provides some assurance of reliability (DSEE) and availability (NDSEE).	N/A
Survivability assurance result	Verified risk avoidance or quantification	Verified risk avoidance or quantification	Limited risk analysis[6-2]	Limited risk analysis[6-2]	None
A priori confidence reliability will be met[6-3]	High[6-4]	Limited[6-4]	Limited[6-4]	None	None
Availability assurance product	Probability quantification of all unmitigated SEE impacting mission success criteria	Probability quantification of all unmitigated SEE impacting mission success criteria	Limited risk analysis[6-5]	Limited risk analysis[6-5]	None
A priori confidence availability will be met[6-3]	High[6-4]	Limited[6-4]	Limited[6-4]	None	None
Anticipated scope of SEE testing[6-6]	Piece-part heavy ion characterization test data if not already available. Additional testing as needed for NDSEE characterization, low-LET-threshold parts proton susceptibility, CCA-level for complex system interactions (e.g., SW and HW) and NDSEE mitigation and correction validation, etc.	Combination of CCA- and piece-part-level, high-energy proton and heavy ion testing. Additional testing as needed for NDSEE characterization, low-LET-threshold parts proton susceptibility, CCA-level for complex system interactions (e.g., SW and HW) and NDSEE mitigation and correction validation, etc.	Combination of CCA- and piece-part-level, high-energy proton and heavy ion testing[6-7]	CCA-level high energy proton testing	None

[6-1] "Targeted" definition: focused on project priorities and within budget and schedule constraints
[6-2] Proton-data-derived heavy ion DSEE susceptibility quantification is unreliable
[6-3] This refers to the ability to guarantee at the inception of the RHA effort that the program required reliability and availability goals will ultimately be met.
[6-4] Risk avoidance provides guarantees. Risk quantification can be effective subject to successful implementation of RHA processes.
[6-5] See RHA Guidelines Document for CCA-level test limitations
[6-6] Refer to Appendix G: RHA Evidence Hierarchy and definitions of "acceptable data" available in the literature (e.g., Poivey, 2002)
[6-7] High energy protons (~200 MeV) often used as the main test solution. Heavy ion testing performed for specific part types e.g., with thick sensitive regions

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Compliance Matrices

If shortcuts are taken at part level (vs. S1), program visibility is needed to ensure compensation at systems level

When loss of life is a potential consequence, radiation effects must be addressed

Table 14. RHA compliance matrix: SEE, Robotic Space Flight

8705.4A Risk Classification	S1	S2	S3	S4	S5
A	Compliant	Provisionally Compliant	Triggers Program Risk	Non-compliant	Non-compliant
B	Compliant	Provisionally Compliant	Triggers Program Risk	Non-compliant	Non-compliant
C	Compliant	Compliant	Provisionally Compliant	Non-compliant	Non-compliant
D	Compliant	Compliant	Compliant	Provisionally Compliant	Non-compliant
Less than D (e.g., 7120.8 or "do-no-harm")	No specific RHA standard is provided for projects operating outside of the 8705.4A risk classification system. Many such projects operate in environments where single-event effects will occur; projects are encouraged to consider mitigation of single-event effects strategically to increase the chance of mission success.				

Table 15. RHA compliance matrix: TID&TNID, Robotic Space Flight

8705.4A Risk Classification	D1	D2	D3	D4	D5
A	Compliant	Provisionally Compliant	Triggers Program Risk	Non-compliant	Non-compliant
B	Compliant	Provisionally Compliant	Triggers Program Risk	Non-compliant	Non-compliant
C	Compliant	Compliant	Provisionally Compliant	Provisionally Compliant	Non-compliant
D	Compliant	Compliant	Compliant	Provisionally Compliant	Non-compliant
Less than D (e.g., 7120.8 or "do-no-harm")	No specific RHA standard is provided for projects operating outside of the 8705.4A risk classification system. TID and TNID are not typically a driving risk for projects organized in this manner, but consultation with radiation effects SMEs is strongly encouraged.				

Table 12. RHA compliance matrix: SEE, Crewed Space Flight

Crewed Space Flight	S1	S2	S3	S4	S5
Crit1	Compliant	Triggers Program Risk	Non-compliant	Non-compliant	Non-compliant
Crit2	Compliant	Provisionally Compliant	Triggers Program Risk	Non-compliant	Non-compliant
Crit3/Non-critical	Compliant	Compliant	Provisionally Compliant	Provisionally Compliant	Non-compliant

Table 13. RHA compliance matrix: TID & TNID, Crewed Space Flight

Crewed Space Flight	D1	D2	D3	D4	D5
Crit1	Compliant	Provisionally Compliant	Triggers Program Risk	Non-compliant	Non-compliant
Crit2	Compliant	Provisionally Compliant	Triggers Program Risk	Non-compliant	Non-compliant
Crit3/Non-critical	Compliant	Compliant	Provisionally Compliant	Provisionally Compliant	Non-compliant

ILPM Pathfinder Lessons Learned

- Manufacturers with an existing space product line will have reservations with participating
  - NASA needs to clearly document the use cases for ILPM Established COTS Parts → parts assurance standard updates in work
  - Buy-in from overall space community allows for increased buying power and manufacturer cooperation
- A shift in mindset for parts assessments in space applications is required
  - Assessing manufacturer test methodologies for COTS, if different than standard MIL-SPEC approaches, is not straight-forward and will require commodity expertise to resolve
  - ILPM Established COTS Parts listing will not directly address how to implement parts usage on all class missions, as a MEAL-driven approach is emphasized
- Further guidance is still needed on how to implement parts usage on all class missions
  - Decision to use is fully project-driven and project parts and systems engineers (and approving management) may not have the know-how to provide recommendations outside of the traditional NASA-screened COTS approach
  - Requires subject matter expertise to support parts usage recommendations
- The ILPM process is best handled through a NASA onsite visit with necessary manufacturing and quality support from the supplier to expedite the assessment process, with prior submission of shareable data to NASA for review
  - Commodity subject matter expertise is needed in the ILPM process to ask the right questions
  - Current infrastructure within NASA is lacking to provide the needed level of support for effective implementation and to provide guidance on ILPM Established COTS Parts implementation for all missions

EEE Parts Assessment Flow Using the ILPM Process

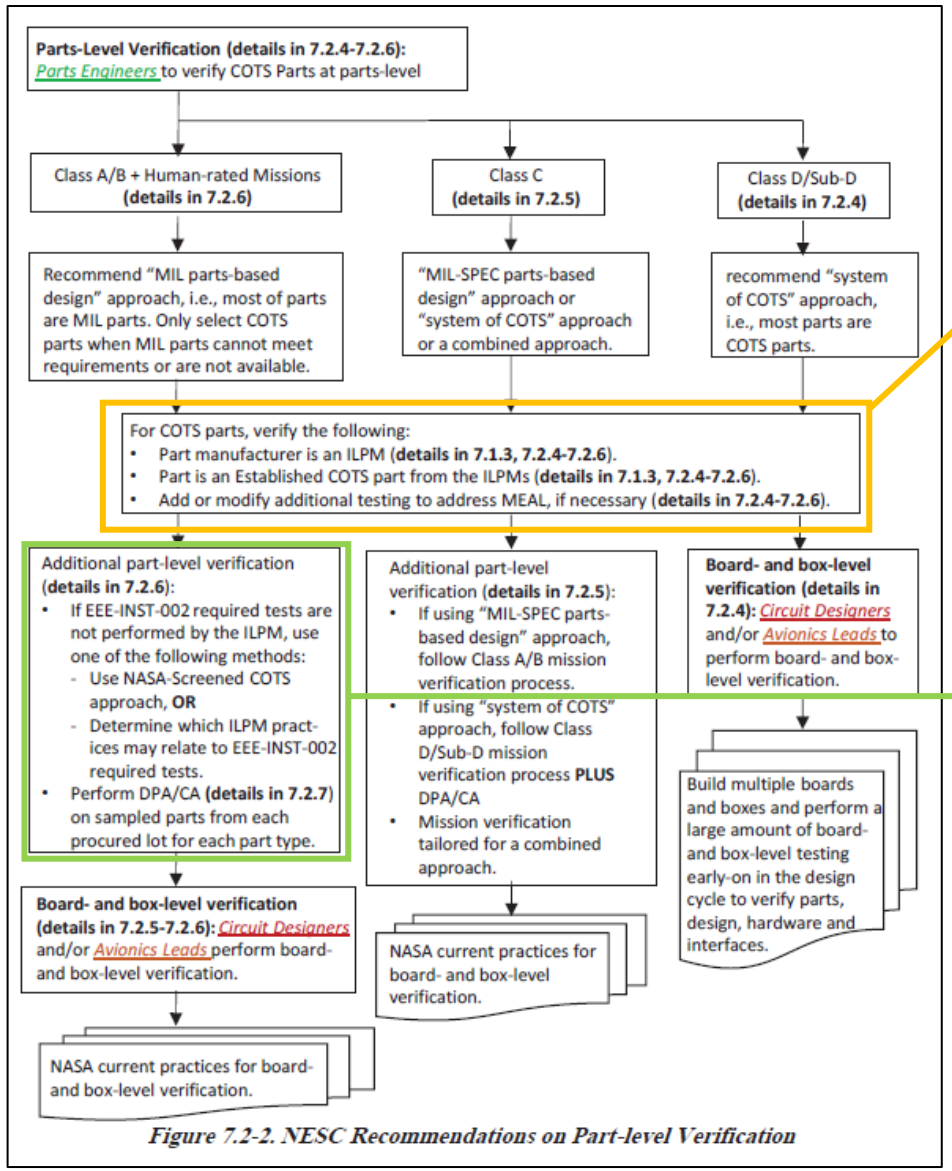


Figure 7.2-2. NESC Recommendations on Part-level Verification

NEPP ILPM Pathfinder activities are targeted here.

For COTS parts, verify the following:
- Part manufacturer is an ILPM (**details in 7.1.3, 7.2.4-7.2.6**).
- Part is an Established COTS part from the ILPMs (**details in 7.1.3, 7.2.4-7.2.6**).
- Add or modify additional testing to address MEAL, if necessary (**details in 7.2.4-7.2.6**).

Additional part-level verification (**details in 7.2.6**):
- If EEE-INST-002 required tests are not performed by the ILPM, use one of the following methods:
  - Use NASA-Screened COTS approach, **OR**
  - Determine which ILPM practices may relate to EEE-INST-002 required tests.
- Perform DPA/CA (**details in 7.2.7**) on sampled parts from each procured lot for each part type.

Implementation of ILPM Established COTS part usage in a mission is project-driven for now.
Executing at an agency-level is best.

PEAL at a Glance

Project Driven Concerns

- Schedule
- Cost
- SWaP
- Technology to meet performance requirements

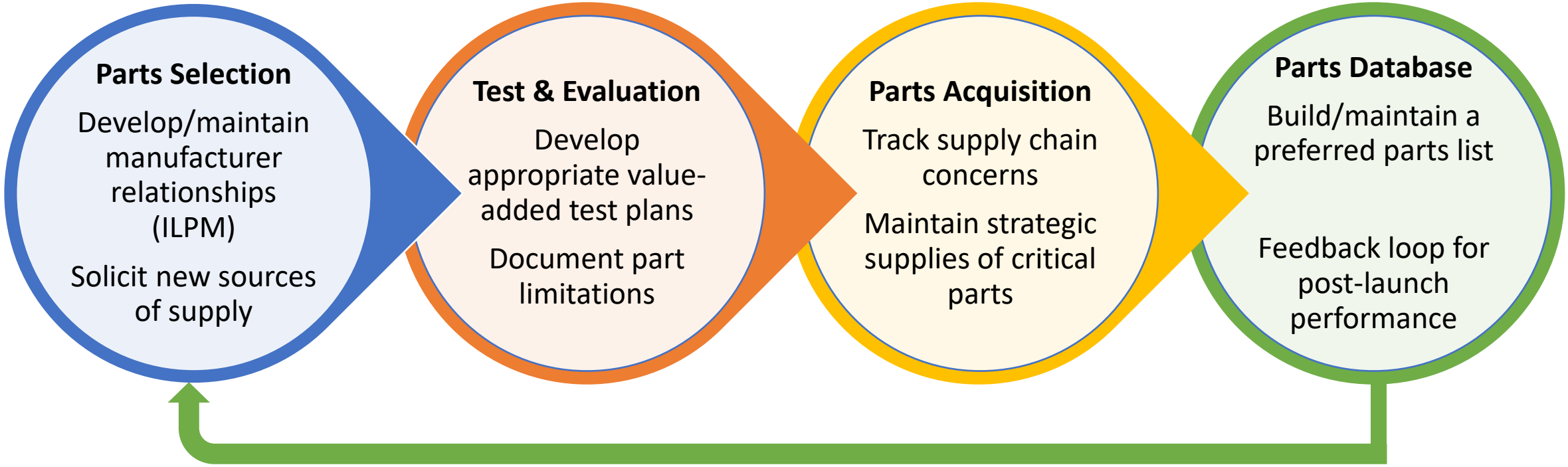
Functions of PEAL

- Test Lab Facility / Team of Subject Matter Experts (SMEs):
  - Parts Commodity Experts
  - Radiation Experts
  - Failure Analysis Experts
  - Test Engineers
  - Procurement and Acquisitions
- Establish and execute testing to meet project needs:
- Develop and maintain manufacturer relationships (ILPM)
- Perform new technology evaluations
- Maintain a NASA-wide parts database
- Develop new skillsets and maintain knowledgebase

Timely delivery of parts to NASA flight projects that meet performance and mission requirements

Delivers a list of preferred parts readily available to projects

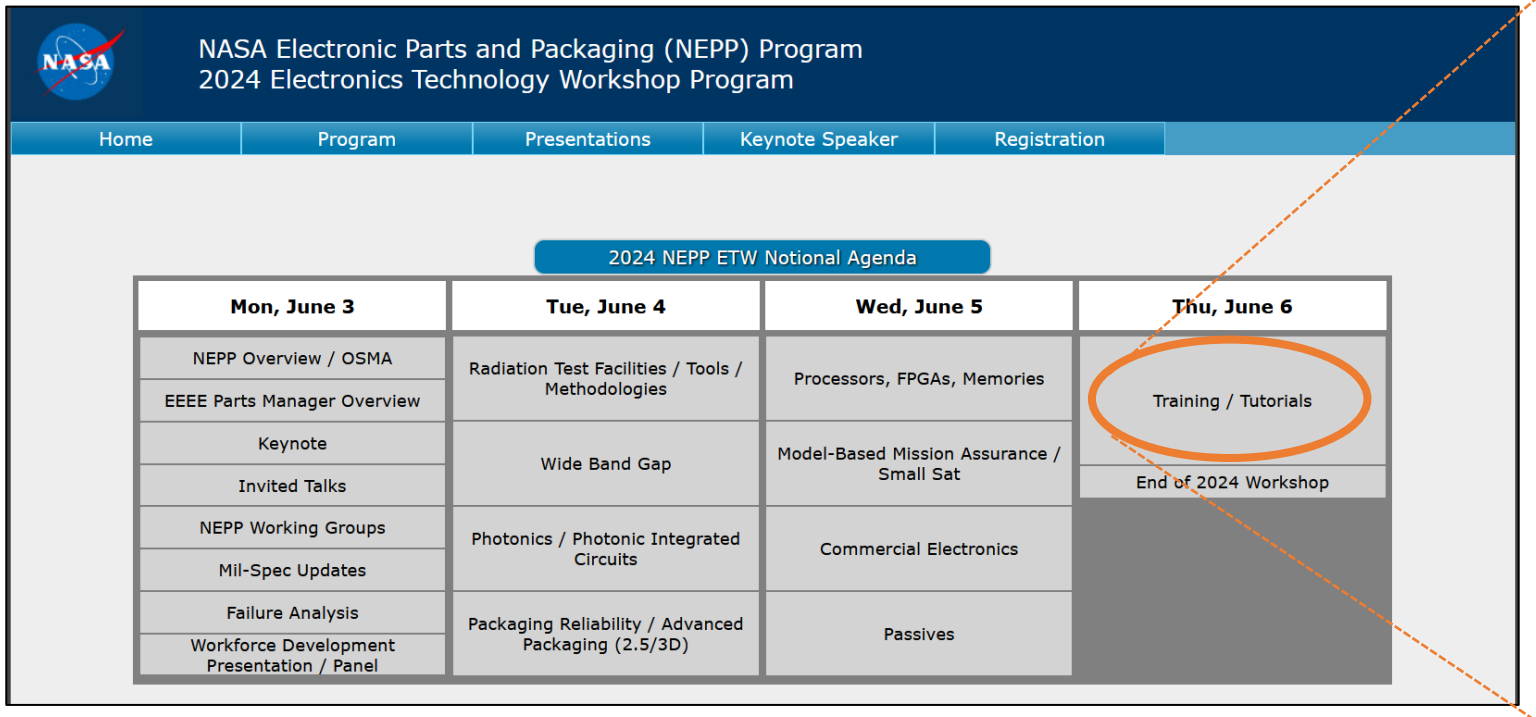
A Future NASA EEE Parts Capability: Parts Evaluation and Assessment Laboratory (PEAL)



PEAL would be an Agency-level capability aimed at developing the strategic use of EEE COTS parts utilizing the ILPM process while also addressing radiation effects, for the benefit of all NASA missions

NASA Workforce Training

Educating the workforce on how to implement the ILPM COTS approach successfully is key!



NASA Electronic Parts and Packaging (NEPP) Program
2024 Electronics Technology Workshop Program

Home | Program | Presentations | Keynote Speaker | Registration

2024 NEPP ETW Notional Agenda

Mon, June 3	Tue, June 4	Wed, June 5	Thu, June 6
NEPP Overview / OSMA	Radiation Test Facilities / Tools / Methodologies	Processors, FPGAs, Memories	Training / Tutorials
EEEE Parts Manager Overview			
Keynote	Wide Band Gap	Model-Based Mission Assurance / Small Sat	End of 2024 Workshop
Invited Talks			
NEPP Working Groups	Photonics / Photonic Integrated Circuits	Commercial Electronics	
Mil-Spec Updates			
Failure Analysis	Packaging Reliability / Advanced Packaging (2.5/3D)	Passives	
Workforce Development Presentation / Panel			

2024 NEPP ETW tutorials in:

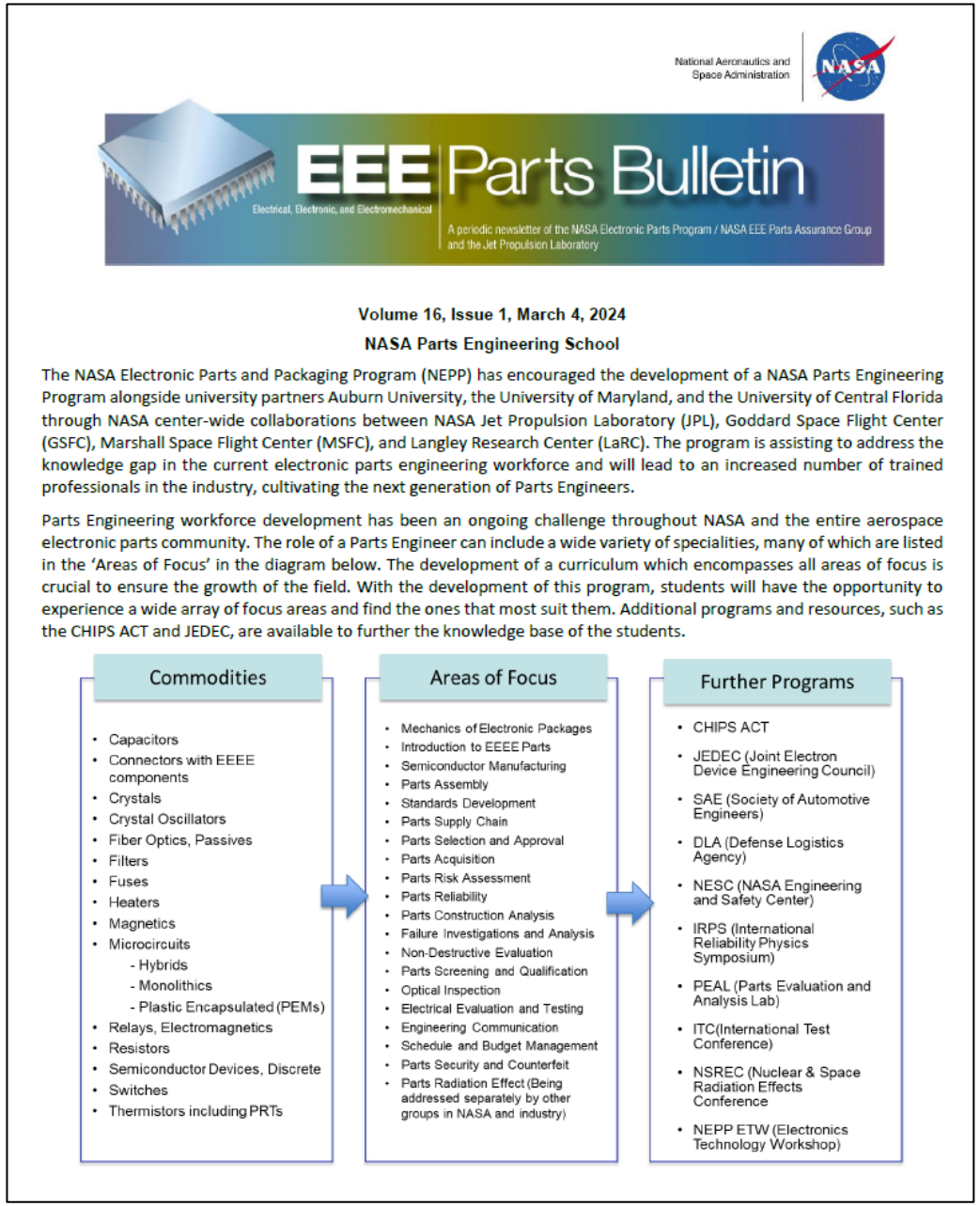
- High Volume Manufacturing Training
- High Volume Defect Prevention
- Designing with COTS

2023 NEPP ETW tutorials in:

- Statistical Interpretation of Life Test: Comparison Between MIL and JEDEC Requirements
- PPAP Tutorial
- Material available at: https://nepp.nasa.gov/workshops/etw2023/program.cfm

NASA / NEPP Parts Engineering School Program

- NASA Parts Bulletin distributed at the NEPP Electronics Technology Workshop (ETW) last year and recently updated. Also posted to the NSC SMA website: https://sma.nasa.gov
- Certificates and Master's Degree program offerings at partnering universities to supply the needed educational basis for the current and future parts engineering workforce
  - Includes coursework in **semiconductor manufacturing** and **parts reliability**
  - University of Central Florida **Electronic Parts Engineering Certificate** now offered!
  - Program website: https://www.jpl.nasa.gov/go/parts-engineering-school



National Aeronautics and Space Administration

NASA

EEE Parts Bulletin

Electrical, Electronic, and Electromechanical

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NASA Parts Engineering School

The NASA Electronic Parts and Packaging Program (NEPP) has encouraged the development of a NASA Parts Engineering Program alongside university partners Auburn University, the University of Maryland, and the University of Central Florida through NASA center-wide collaborations between NASA Jet Propulsion Laboratory (JPL), Goddard Space Flight Center (GSFC), Marshall Space Flight Center (MSFC), and Langley Research Center (LaRC). The program is assisting to address the knowledge gap in the current electronic parts engineering workforce and will lead to an increased number of trained professionals in the industry, cultivating the next generation of Parts Engineers.

Parts Engineering workforce development has been an ongoing challenge throughout NASA and the entire aerospace electronic parts community. The role of a Parts Engineer can include a wide variety of specialities, many of which are listed in the 'Areas of Focus' in the diagram below. The development of a curriculum which encompasses all areas of focus is crucial to ensure the growth of the field. With the development of this program, students will have the opportunity to experience a wide array of focus areas and find the ones that most suit them. Additional programs and resources, such as the CHIPS ACT and JEDEC, are available to further the knowledge base of the students.

Conclusions

- In general, ILPM Established COTS Parts can be used with little to no additional test, given the part reliability and characteristics meet the Mission Environment, Application, and Lifetime (MEAL)
  - Functional criticality may still warrant some level of additional test based on the mission risk posture and part-level verification obtained
- NASA currently lacks the infrastructure to implement ILPM and Established COTS Part acceptance methods into programs effectively
  - A PEAL workforce would provide the high level of strategic ILPM COTS parts implementation needed to enable the success of NASA missions
  - An update to NASA EEE parts assurance standards, in addition to training of the NASA parts engineering workforce and project management, is needed to successfully incorporate the NESC guidance into current practices
- A holistic approach with consideration for radiation hardness assurance, incorporating assembly and system-level mitigation strategies, should be adopted for effective COTS implementation

The End