Recent NEPP Program Work and Fiscal Year 2023 Plans

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To be presented by P. Majewicz at the 2023 Microelectronics Reliability & Qualification Workshop (MRQW), 8Feb23

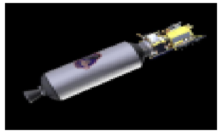
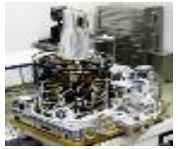
Agenda

- FY22 Highlights
  - Standards & Guidelines
  - NESC COTS Assessment
- FY23 Plans
  - Topics in NEPP Five Focus Areas
- NASA NEWS

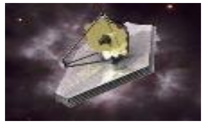
FY22 Highlights

Standards & Policy and Guideline Development

CLASS D | CLASS C | CLASS B | CLASS A





Development of a NASA Engineering and Safety Center (NESC) Technical Assessment Report

- Title: ***Recommendations on Use of Commercial-Off-The-Shelf (COTS) Electrical, Electronic, and Electromechanical (EEE) Parts for NASA Missions***
- Phase II of Assessment includes more government agencies (FAA, NAVSEA, MDA, etc.) and manufacturers to discuss COTS manufacturing
  - Objectives are to define term *Industry Leading Parts Manufacturers,* understand methods that manufacturers use to measure quality, assurance, and reliability, and to develop flows for part verification based on mission classification.
  - Phase II Report: https://ntrs.nasa.gov/citations/20220018183

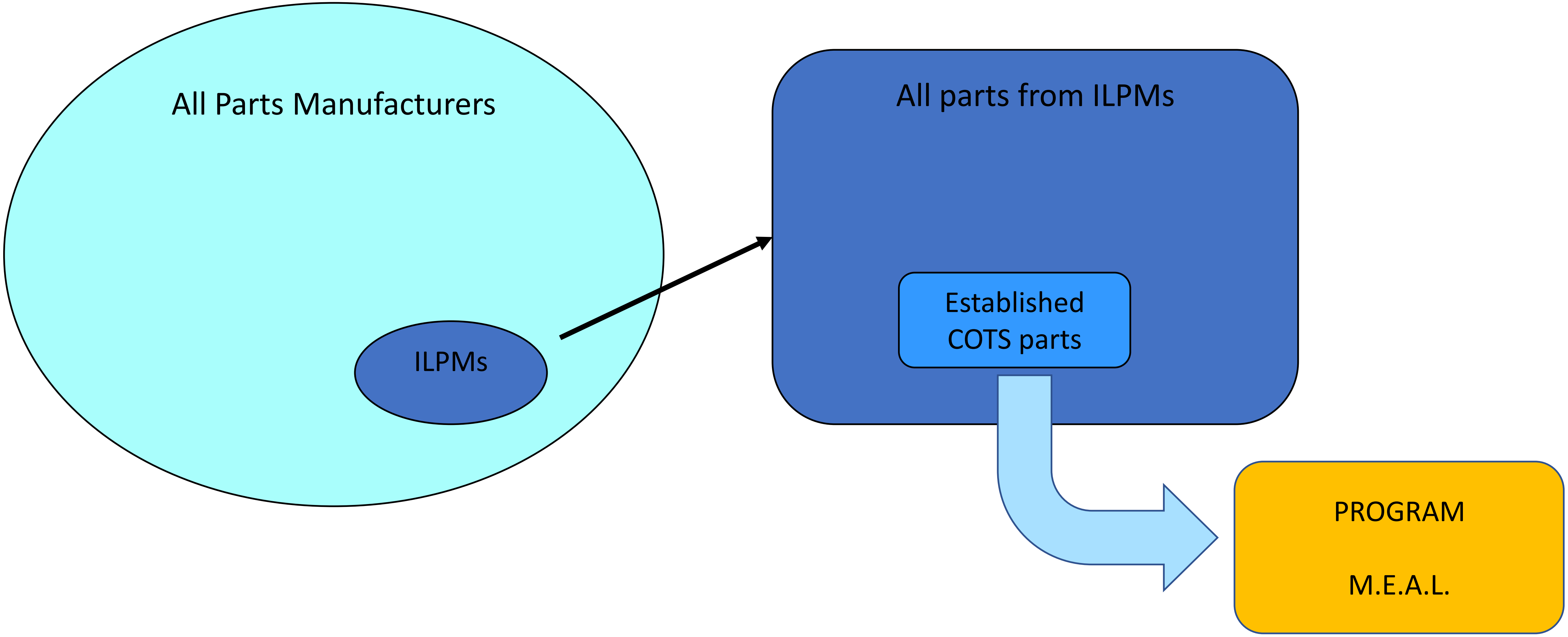
NASA Current Practice/Approach

- **Definitions**
  - **COTS Part**: 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).
  - **NASA-screened COTS part**: A COTS part that, after procurement, is screened, and in many cases qualified, per NASA Agency, Center, or Program parts requirements documents, such as EEE-INST-002 or equivalent documents, by NASA, NASA contractors, a third-party, or the part manufacturer.
- **Process for Standard vs non-standard parts**
  - Primarily specific classes of MIL-SPEC parts, are considered "standard“. Standard parts typically are used without further testing (“use-as-is”).
  - All other parts, including COTS parts, are nonstandard. Nonstandard parts are subjected to initial screening and subsequent lot acceptance testing of representative samples from each procured lot per MIL-SPEC or similar requirements. Parts that pass these screens are then considered NASA–screened COTS parts.

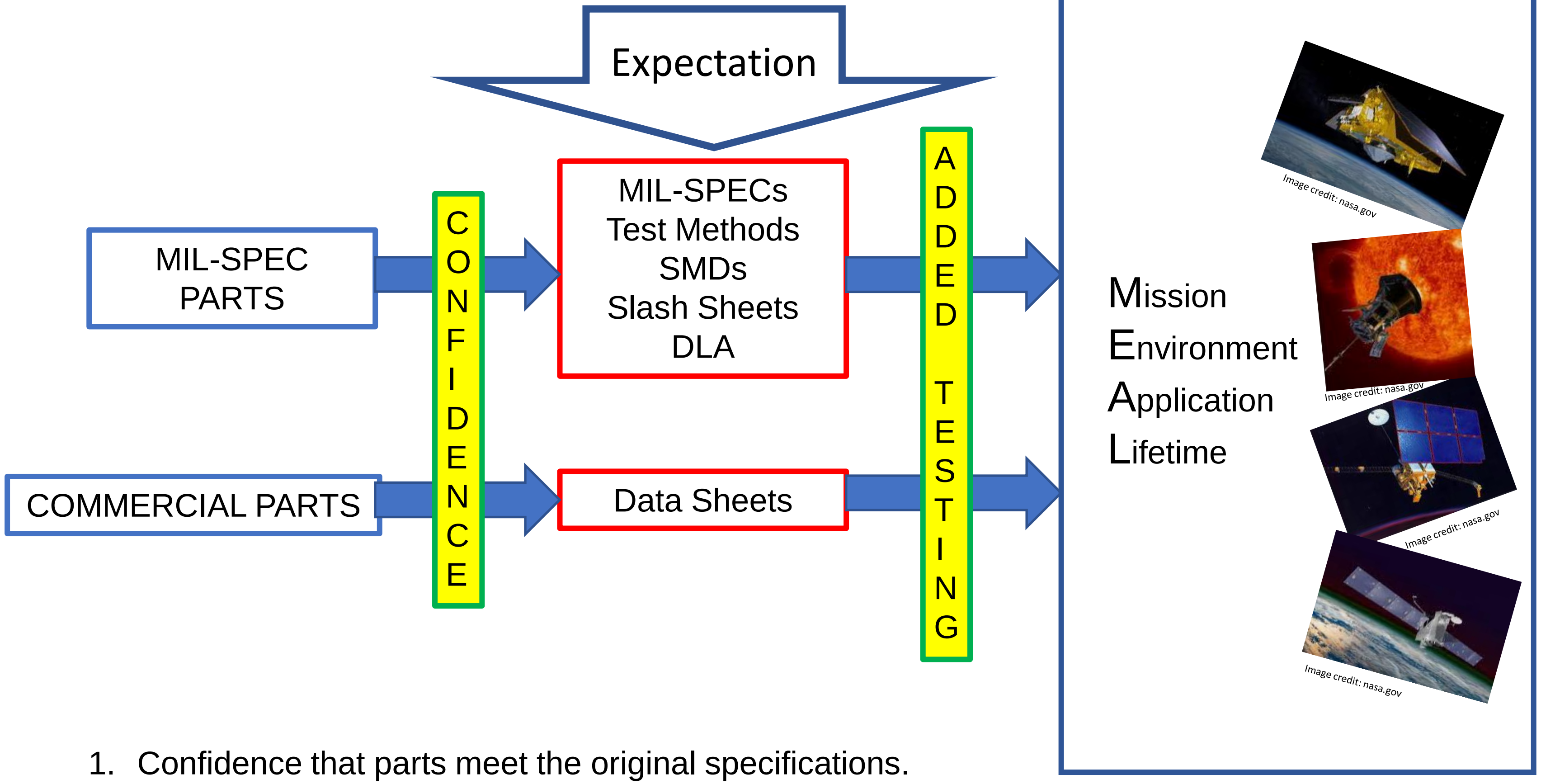
New Terminology Defined

- Phase I defined an *Industry Leading Parts Manufacturer (ILPM)*
  - A parts manufacturer with high volume automated production facilities and which can provide documented proof of the technology, process, and product qualification, and its implementation of the best practices for “zero defects” for parts quality, reliability and workmanship.
  - Take advantage of what commercial industry does the best - high volume automated production and best practices for “zero defects.”
- Phase II
  - Define additional terminology “Established COTS parts.”
  - Provide characteristics and criteria of an ILPM and part-level verification criteria for NASA missions.
  - Phase II recommendation is to select Established COTS parts category from ILPMs; updated from Phase I recommendation of “select parts from ILPMs”.

Big Picture


All Parts Manufacturers
ILPMs
All parts from ILPMs
Established
COTS parts
PROGRAM
M.E.A.L.

Concerns for Picking Parts



1. Confidence that parts meet the original specifications.
2. Analysis to ensure mission requirements are being met, especially if requirements are above data sheet/SMD limits.
3. Added testing should be done with extreme caution

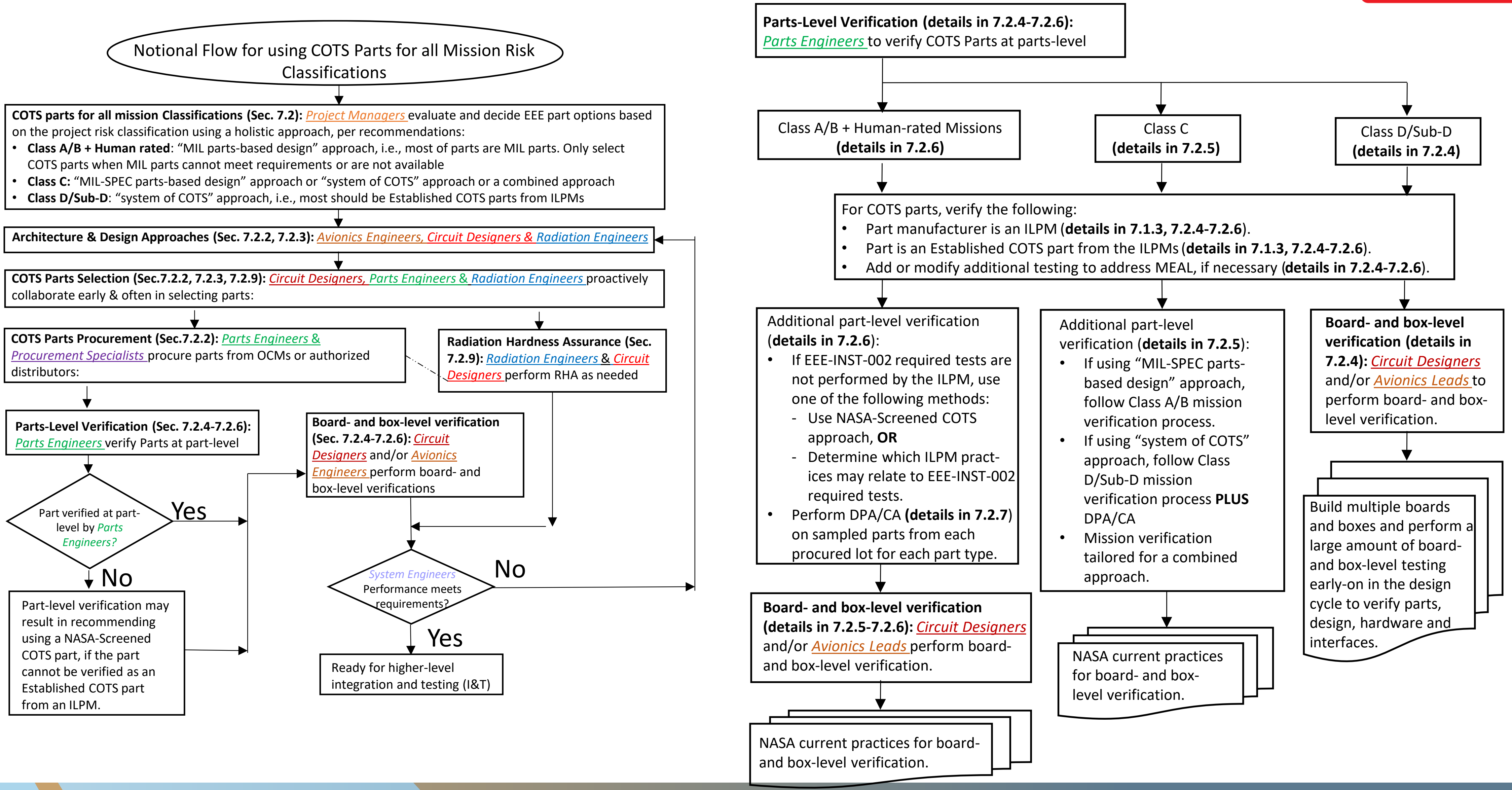
Criteria for an ILPM

1. An ILPM may have various COTS part categories and must have at least one Established COTS Part category.
2. An ILPM is willing to share parts quality and reliability data with NASA, including estimated production DPPM (defective parts per million), field failure DPPM and/or part failure rates (FITs), and how those statistics are derived.
3. An ILPM is willing to provide NASA documents substantiating parts quality and reliability.
4. An ILPM is willing to allow NASA to visit on-site and/or to work with NASA or prime contractors to maintain a strong customer-manufacturer relationship.

New Terminology Defined - Established COTS Part

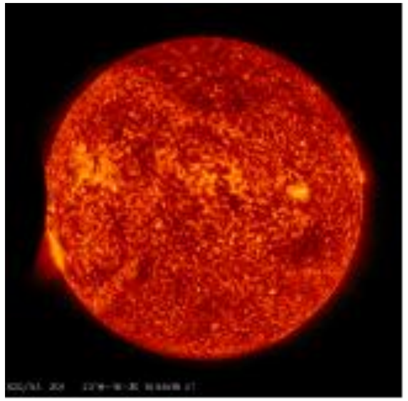
1. Produced using processes that have been stable for at least **one year** so there are enough data to verify the part's reliability;
2. Produced in **high volume**. High volume is defined as a series of parts sharing the same datasheet having a combined sales volume over **one million parts** during the part's lifetime;
3. **100% electrically tested** per datasheet specifications at typical operating conditions in production prior to shipping to customers. Additionally, the manufacturer must have completed multi-lot characterization over the entire set of operating conditions cited in the part's datasheet, prior to mass production release. Thus, production test limits are set for typical test conditions sufficient to guarantee that the parts will meet all parameters' performance specifications on the datasheet;
4. Produced on **fully automated production lines** utilizing statistical process control (SPC), and undergoes in-process testing, including wafer probing for microcircuits and semiconductors, and other means appropriate for other products (e.g., passive parts). These controls and tests are intended to maintain process tolerances and eliminate defective parts at various stages of production
5. Demonstrated **consistent yield** trend appropriate for high volume commercial technologies at that technology node.

Flow for Using COTS Parts for All Mission Risk Classifications



Radiation Concerns

- Parts levels in EEE-INST-002 and equivalent documents do not indicate the level of radiation tolerance, and thus the selection of parts level 1, 2, or 3 does not imply or provide any type of radiation hardness or mitigation of radiation effects.
- MIL-SPEC parts may or may not include a radiation hardness designator signifying TID performance but may be sensitive to SEE.
- Lot-to-lot variation of radiation sensitivity may be larger for non-radiation-hardness-assured (non-RHA) parts than for RHA parts, since space radiation tolerance is typically not designed and optimized for parts without radiation addressed in their datasheets.
- RHA mitigations must include system-level techniques and solely depend on part-level robustness.



Credit: NASA/GSFC

Conclusion

Properly selected COTS parts in appropriate applications can offer performance and supply availability **advantages compared to MIL-SPEC parts**. Their utility and demonstrated reliability results from large volumes and automated production and testing processes. However, careful review and a thorough **understanding of their specifications (i.e., datasheet limitations)** is needed, and verifying that manufacturer specifications and reliability **meet space hardware application needs** is necessary.

This report proposes

- MIL-SPEC screening and non-radiation-related lot acceptance testing be reduced or eliminated in cases where evidence of sufficient quality and reliability exists for COTS parts.
- The extent of NASA's insight into COTS manufacturers and the amount and nature of the needed evidence will differ by mission and will likely be driven by a mission's resources and associated risk posture.

Standards & Policy and Guideline Development

- Title: *Avionics Radiation Hardness Assurance (RHA) Best Practices*
- https://ntrs.nasa.gov/
- Covers total ionizing dose, total non-ionizing dose, and single-event effects

- Title: *NASA Technical Standard for RHA* *****In Progress*****
- ToC: 1. Scope 4. RHA Fundamentals 5. RHA Process Req's
  6. RHA Process Taxonomy 7. Rad Threats & Hardness Assurance
  Appendix (Example RCP's)

Risk tolerance posture	Highest	High	Medium-High	Medium-Low	Low
Anticipated scope of SEE testing	None	CCA-level high energy proton testing	Combination of CCA- and part-level, high-energy proton and heavy ion testing[4]	Piece-part heavy ion characterization test data should be available. Additional testing as needed for NDSEE characterization, low-LET-threshold parts proton susceptibility, and CCA-level for complex system interactions (e.g., SW and HW) validation.	

- Includes deliverables throughout Project Development Lifecycle
- Scheduled to be complete in FY23

2022 NEPP Electronic Technology Workshop Presentations

MILSPECs – Incorporation of Plastics (4)

Processors, FPGAs & Memories (6)

Photonics (4)

Collaborations/Working Groups (4)

WBG (3)

Advanced Packaging (2.5/3D, etc.) (5)

Passives: Capacitors and Resistors (5)

Training / Tutorials (2)

Small Sats & COTS Utilization (5)

Model Based Mission Assurance (MBMA) (4)

All NETW presentations for 2022 and past years are at https://nepp.nasa.gov/

FY23 Plans

COTS UTILIZATION STEPS

- Relationship with COTS manufacturers
  - Industry Leading Parts Manufacturers (ILPM)s
  - Data sheets
  - Process control data
  - Qualification & Screening
  - Sampling
  - Process for implementing changes

- Parts Evaluation & Analysis Capability
  - Initial motivation for NEPP Program's predecessor in the 70s
  - Failure rate determination
    - Failure mechanisms/Physics of Failure/Acceleration Factors
  - Environmental testing geared towards NASA missions (MEAL)
  - Not re-inventing the wheel
  - Attempt at "Standardization" for generic mission profiles

Hermetic Al Electrolytic Capacitors

Evaluation of 600V GaN FETs

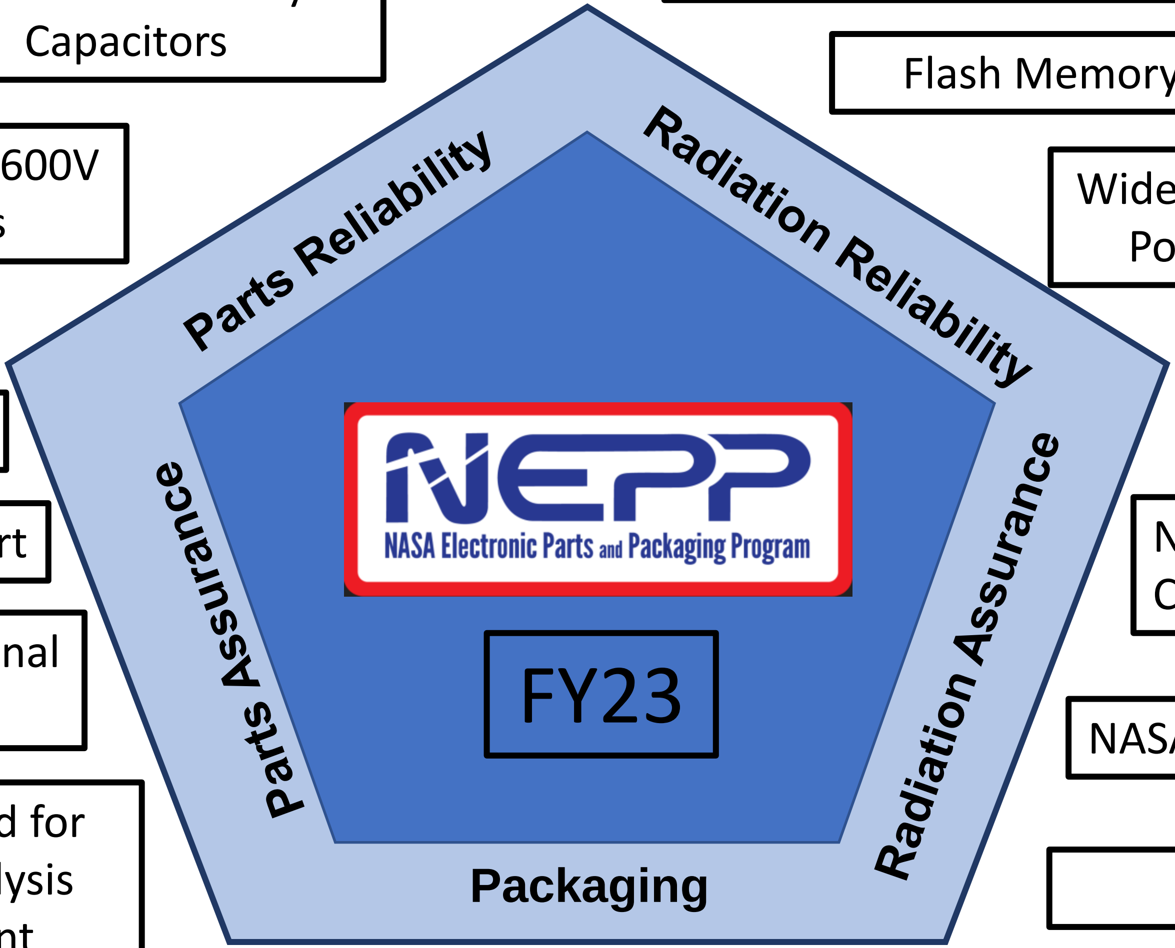
NASA Standards

MILSPEC / DLA Support

Domestic & International Teleconferences

Moisture standard for Internal Gas Analysis (IGA) equipment

PEM Fracture Mechanics



NEPP Processor Enclave

Flash Memory RHA

Wide Bandgap & SOA Si Power Device RHA

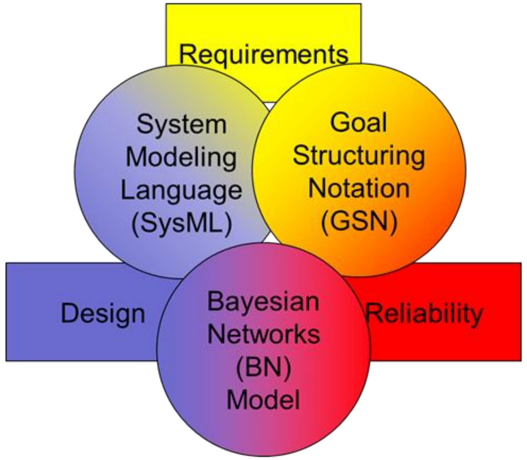
Heavy Ion Testing Bootcamp

NASA Support of NRL Pulsed Laser Comprehensive Handbook

NASA technical standard for RHA

SmallSat RHA

Continued collaboration with GA Tech EPICA regarding radiation tolerant Photonic Integrated Circuits (PIC)s



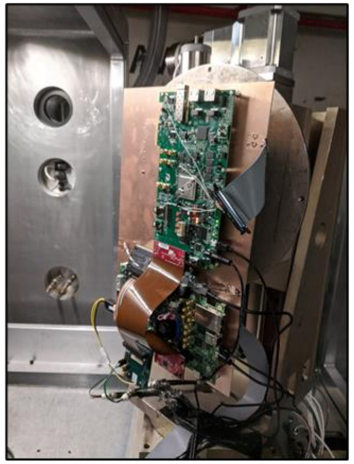
Emerging Assurance Methods
Image Credit: Vanderbilt University

14^{th} Annual NEPP Electronics Technology Workshop (ETW)

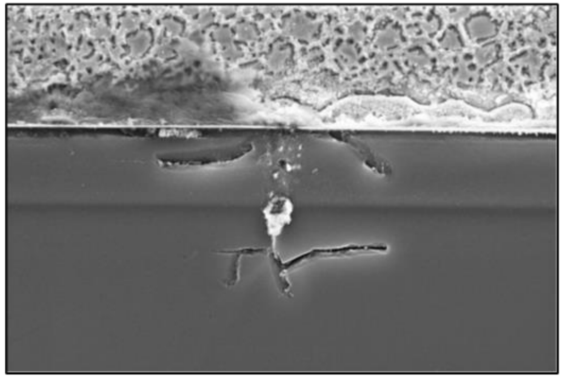
Scheduled dates:

June 12-15, 2023

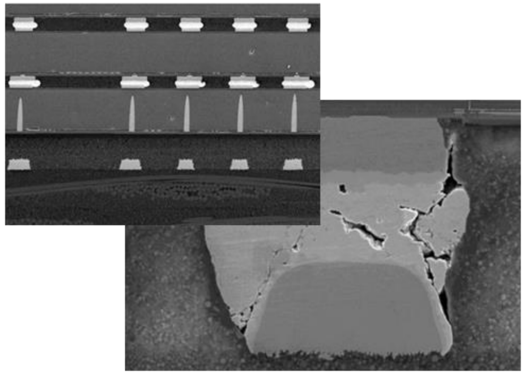
https://nepp.nasa.gov/



Radiation Testing & Analysis
Image Credit: NASA



Advanced Technology Reliability
Image Credit: NASA



Advanced Microelectronics Packaging
Image Credit: NASA

NASA News

Latest images from JWST

Image credit: NASA

Image credit: NASA

Image credit: NASA

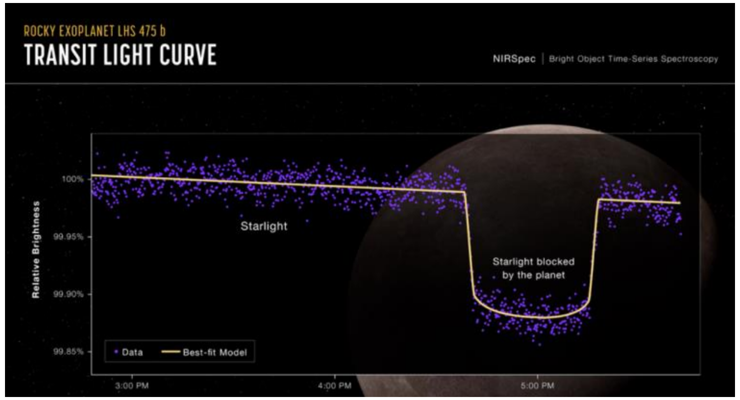
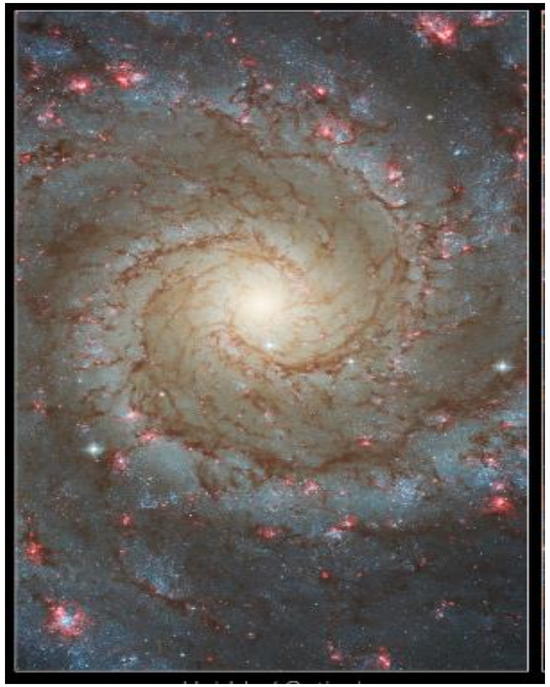


Image credit: NASA

Latest images from JWST

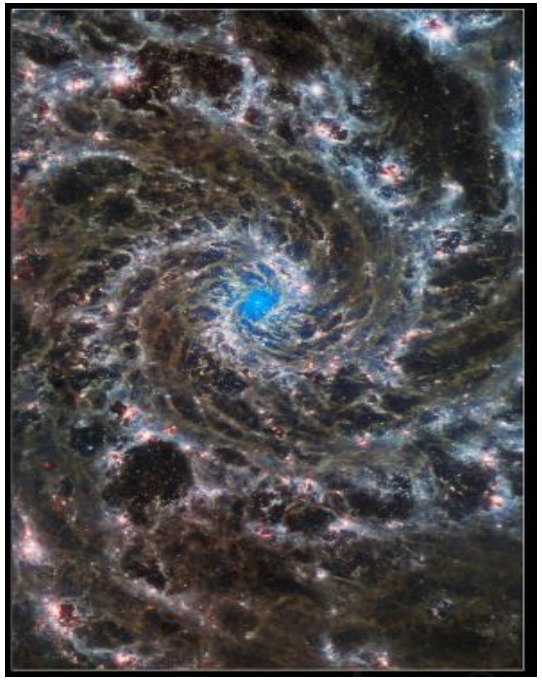
Comparison

Image credit: NASA



Hubble optical

Image credit: NASA

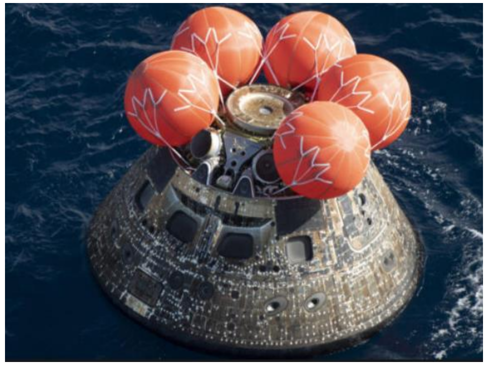


JWST Infrared

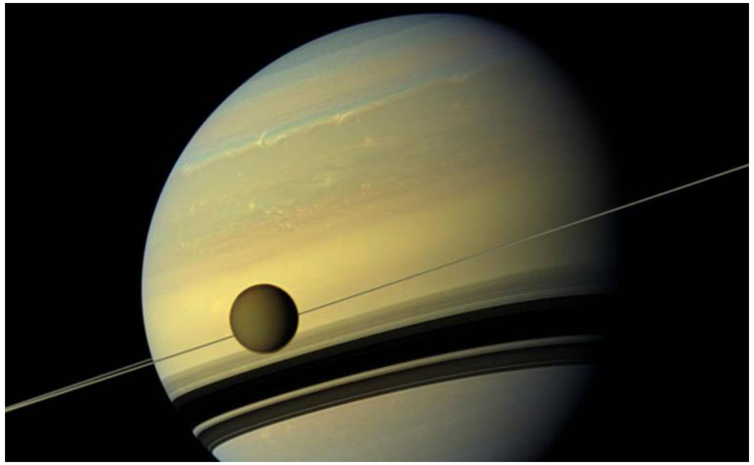
ARTEMIS I

Launch:
Nov 16, 2022

Splash Down:
Dec 11, 2022



Dragonfly Will Fly Around Titan Looking for Origins, Signs of Life



Scheduled Launch: 2027, Reach Titan: 2034

The End