National Aeronautics and
Space Administration

NASA EXPLORES

The Pursuit of a Parts Evaluation and Assessment Laboratory (PEAL) to Support Future NASA Missions

Susana Douglas
NASA Electronic Parts Manager & NEPP Deputy
Goddard Space Flight Center

June 3, 2024

Acronyms

ABH	Associate Branch Head
AEC	Automotive Electronic Council
BME	Base-Metal Electrode (Capacitor)
CDR	Critical Design Review
COTS	Commercial-Off-The-Shelf
DLA	Defense Logistics Agency
DPA	Destructive Physical Analysis
EEEE	Electrical, Electronic, Electromechanical, Electro-optical
EOL	End-Of-Line
EOL	End-Of-Line
ETW	Electronics Technology Workshop
FA	Failure Analysis
GSFC	Goddard Space Flight Center
HQ	Headquarters
IL	In-Line
ILPM	Industry Leading Parts Manufacturer
JEDEC	Joint Electron Device Engineering Council
JPL	Jet Propulsion Laboratory

LaRC	Langley Research Center
LCC	Life Cycle Cost
MEAL	Mission Environment, Application, and Lifetime
MIL-SPEC	Military Specification
NASA	National Aeronautics and Space Administration
NEPAG	NASA Electronic Parts Assurance Group
NEPP	NASA Electronic Parts & Packaging (Program)
NESC	NASA Engineering & Safety Center
PDR	Preliminary Design Review
PEAL	Parts Evaluation and Assessment Laboratory
SMA	Safety and Mission Assurance
SMD	Science Mission Directorate
SMD	Standard Microcircuit Drawing
SME	Subject Matter Expert
SoC	Silicon on Chip
SPC	Statistical Process Control
SSAI	Science Systems and Applications, Inc.
SWaP	Size, Weight, and Power

Background

- Majority of the content in this presentation was pulled from a report that summarized the results of a 4-month effort funded by the NASA Science Mission Directorate (SMD)
- Study was aimed at building the business case for investment into the establishment of a Parts Evaluation and Assessment Laboratory (PEAL)
- PEAL is being proposed as the capability within NASA to maximize utilization of high reliability COTS parts that meet mission objectives at lower cost while minimizing risk

Problem Statement No.1

- NASA EEEE parts requirements are tied to mission risk classification
- Traditional parts assurance guidance documents recommend MIL-SPEC or similar testing for the use of COTS in all space missions above Class D
- Widespread COTS usage on a project requires significant investment (time and money) for Class A/B/C and human-rated missions
  - ➢ No easy path for taking proven tech demos into flagship missions
  - ➢ Projects opt for the easiest path and maintain outdated heritage designs
  - ➢ Evaluation of next generation technologies of increasing complexity (e.g., advanced packaging, integrated SoC's) can cost millions for a single part

Major barrier against innovation in the Agency

Problem Statement No.2

- 40 to 50-week lead times have become the norm for many common MIL-SPEC microcircuits, discrete semiconductors, and passives, with peak lead times at 80 to 100 weeks
- Typical mission electronics build schedule is planned for 1 to 2 years (from engineering design to flight assembly and test)
  - ➢ Planned electronics flight schedule unattainable with current lead times
- A 1-year delay in the electronics build between engineering and flight assembly incurs additional costs of 20 to 40% of the total project life cycle cost (LCC)

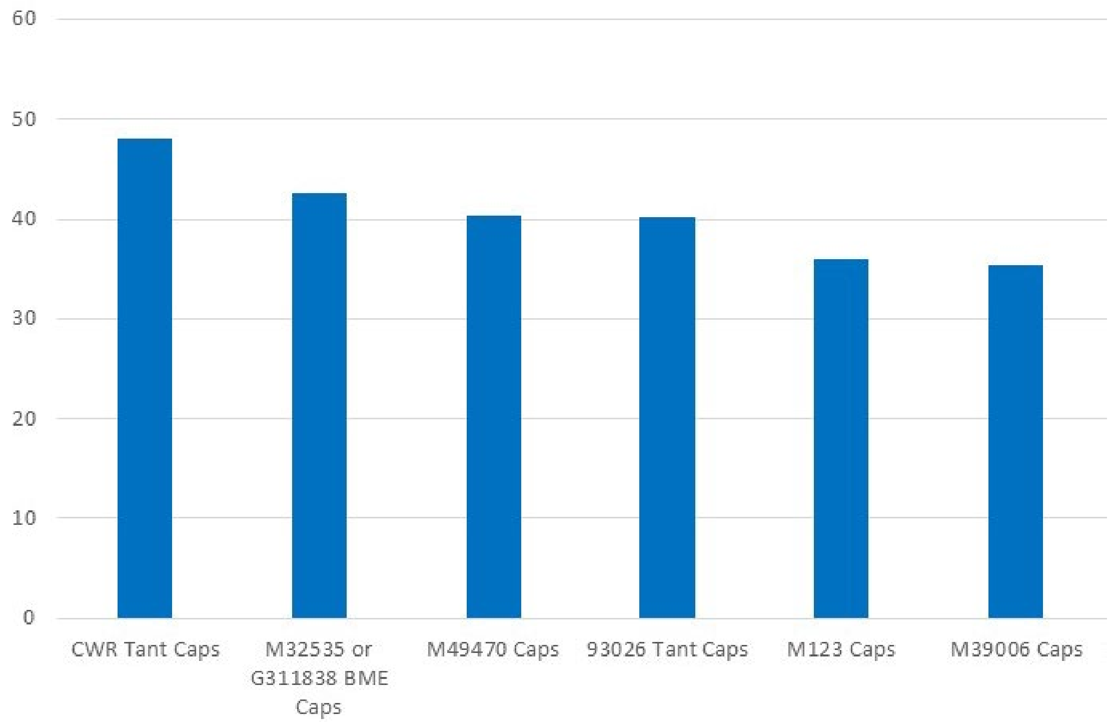
↓

Millions to hundreds of millions added cost for a single mission

Capacitor Leadtime Example

Standard MIL-SPEC capacitor lead times are averaging 40 weeks

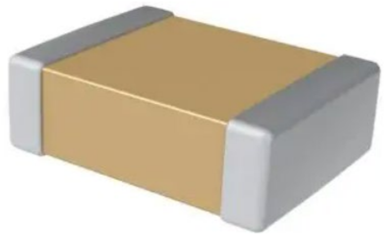
Recent Average Lead Times (Weeks)

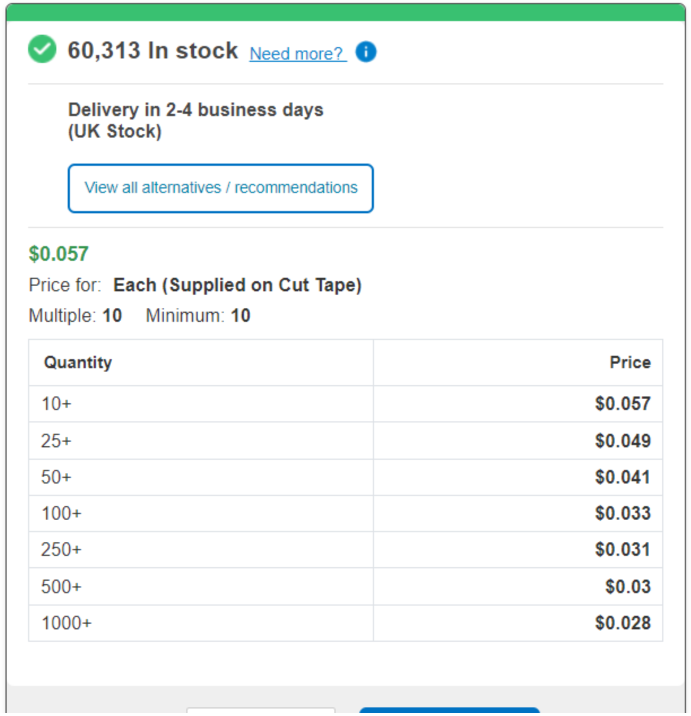


Compare to automotive grade capacitor at < $0.05/pc and in stock

CAP, 1µF, 16V, 10%, X7R, 0603

Date/Lot Code





60,313 In stock Need more?

Delivery in 2-4 business days (UK Stock)

View all alternatives / recommendations

$0.057

Price for: Each (Supplied on Cut Tape)

Multiple: 10 Minimum: 10

Quantity	Price
10+	$0.057
25+	$0.049
50+	$0.041
100+	$0.033
250+	$0.031
500+	$0.03
1000+	$0.028

Pros & Cons of MILSPEC & COTS EEEE Parts

	MILSPEC	COTS
Pros	• Increased operational and environment testing • Traceability requirements • Government control • Controlled changes	• Increased functionality • SWaP benefits • **Availability** • Significantly higher manufacturing quantities • **Reliability can be assured directly through volume and statistical process controls**
Cons	• Delay in qualifying newest technologies • Bulkier construction • Limited number of certified manufacturers / long lead times • Smaller lot sizes – reduced statistics for reliability • **Performance limitations**	• Reduced testing (on finished product / prior to shipping) • Limited communications with manufacturers • Self-certification (limited 3rd party assessments) • Part changes can occur w/o notification • **Knowledgeable buyer/user essential**

PEAL will remove current performance constraints and ensure we are smart buyers and users

EEEE = Electrical, Electronic, Electromechanical, Electro-optical

NESC COTS Key Considerations

- 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

PEAL at a Glance

Considerations

- Project Driven Concerns
  - Schedule
  - Cost
  - SWaP
  - Technology to meet performance requirements

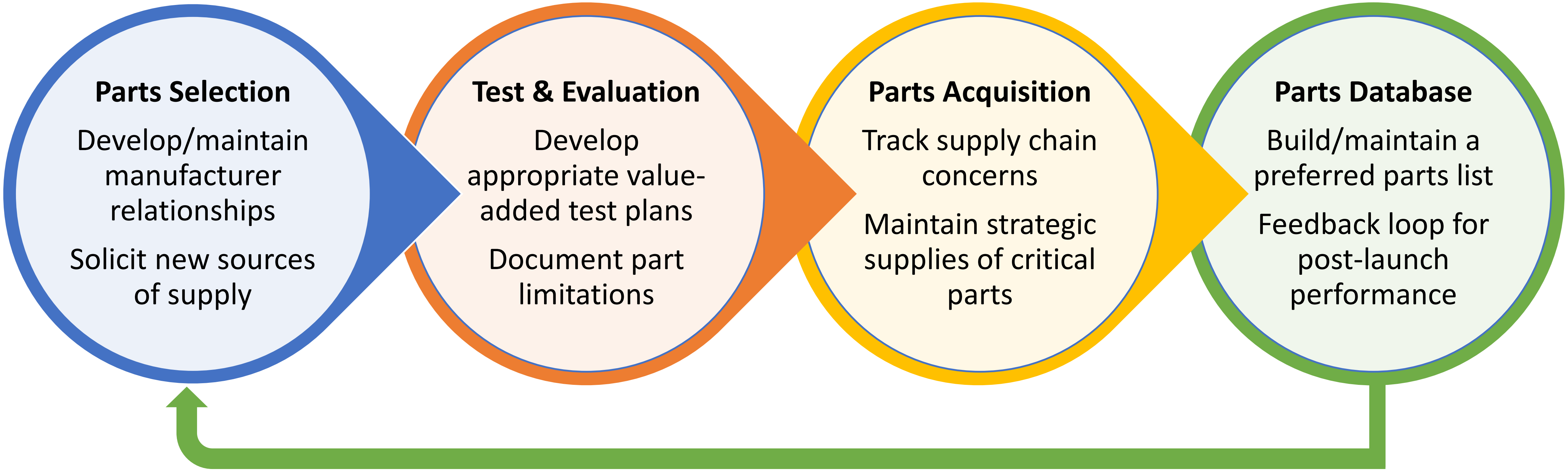
Enable timely delivery of parts to NASA flight projects that meet the performance and mission requirements

Functions of PEAL

- Test Lab Facility
- Establish and execute testing to meet project requirements. Personnel involved:
  - Parts Commodity Experts
  - Radiation Experts
  - Failure Analysis Experts
  - Test Engineers
  - Procurement and Acquisitions
- Develop and maintain manufacturer relationships
- Perform new technology evaluations
- Maintain a NASA-wide parts database
- Develop new skillsets and maintain knowledgebase

Deliver a preferred list of available parts to projects

PEAL Scope



$22M estimated cost to stand up, $10M per year to maintain thereafter

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 →

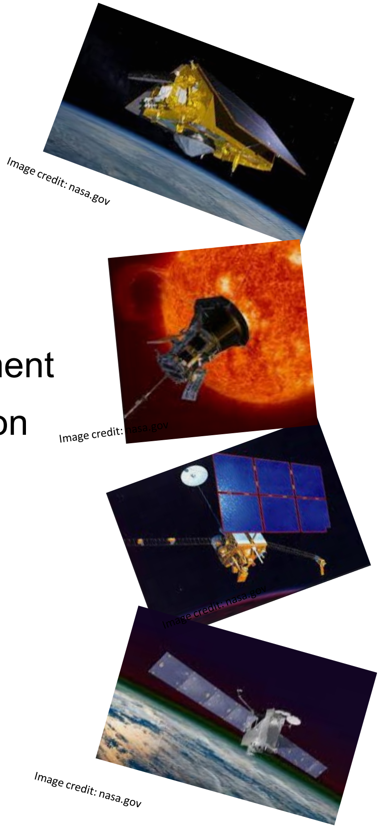
PEAL

COMMERCIAL PARTS → Manufacturer Information /Data Sheets →

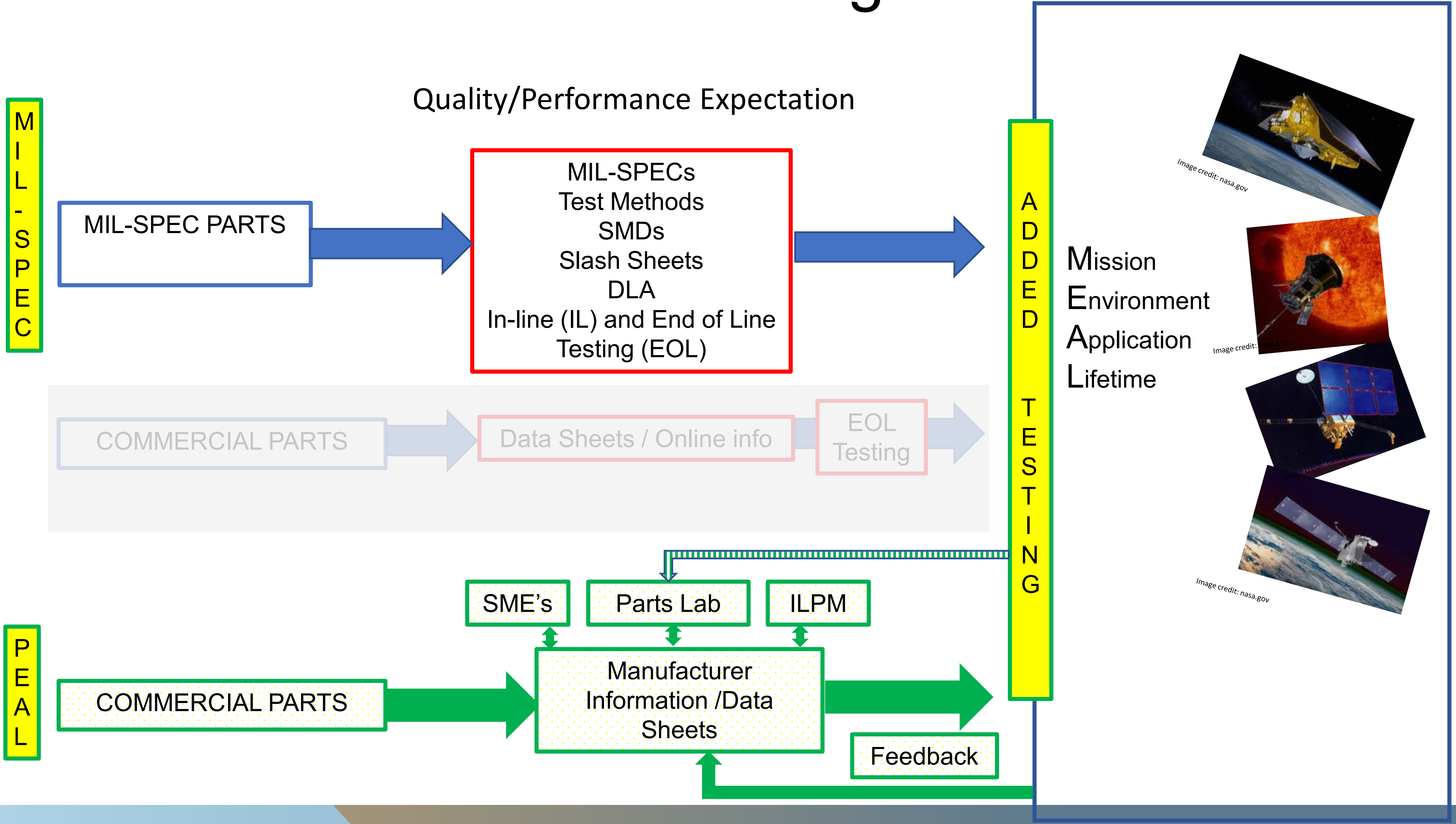
SME's | Parts Lab | ILPM

ADDED TESTING

Mission
Environment
Application
Lifetime



Methods for Selecting Parts



Parts Testing Cost Analysis

- A group of parts and radiation engineers researched all available project data over the last 5 years at GSFC and JPL
- Finding: Total direct costs of almost $40M over 5 years ($8M/year average) was spent for EEEE parts (*lot-based*) testing
  - $28M for parts screening, qualification, DPA, or other non-radiation testing
  - $11.6M for radiation testing
  - Research included costs performed for parts testing at GSFC and JPL laboratories or by the parts manufacturer
- Limitation: **This analysis covers in-house testing only which is the tip of the iceberg!** Could not account for costs incurred by projects due to part testing performed by subcontractors on procured flight hardware → Expect a significant impact here

This $8M/year can instead be spent on PEAL strategic testing where analysis results could benefit all programs

Estimates of EEEE *Direct* Parts Cost Savings

SMD FY23 budget:	$7.8B/yr
60% is flight projects:	$4.7B/yr
20-40% of that is electronics:	$0.9-1.9B/yr
10-20% of that is EEEE parts:	$94-374M/yr
95-99% alternative savings:	$88-371M/yr

} EEEE parts are 2-8% of LCC

Analysis

- Subset of project parts passives (common chip capacitors and resistors) and discrete semiconductors for a large Class B mission (spacecraft and payload) showed 200x (99.5%) reduction in costs for high reliability alternate grade parts
  - ➢ Procurement costs reduced from $2M to $10k
- 200+ lines of newly designed-in EEEE parts (of all types—actives + passives) for a sub-assembly on a Class B mission showed 96% cost reduction when using alternate grade parts
  - ➢ Procurement costs reduced from $1.2M to $44k

High reliability alternative grade parts can save SMD missions $100-400M per year

Estimates of *Cost Avoidance* from Schedule Slips

SMD FY23 budget:	\$7.8B/yr
60% is flight projects:	\$4.7B/yr
Flight projects BCD schedules:	3-6 years
Current electronics schedule:	24-42 months
PEAL electronics schedule:	12-24 months
Schedule “savings”:	12-18 months
% time electronics on critical path:	50-75%
% total BCD cost avoidance:	8-25%
Cost avoidance from schedule slips:	**\$392M-1.18B**

Delays in electronics occur during peak burn rate between PDR and CDR

High reliability alternatives to traditional parts can avoid SMD project overruns from \$400M to >\$1B per year through prevention of schedule slips

Parts Radiation Test Cost Analysis Takeaways

- Parts testing count per project has decreased substantially over last 15 years as projects adopt more RHA parts and heritage designs
  - ➢ **Many projects in development avoid adopting newer technologies but default to heritage parts usage and designs to avoid cost of radiation characterization and assuming it's the best solution**
- Radiation testing costs were highest for projects that had a large amount of complex COTS parts that required substantial investment in parts characterization
  - ➢ Current trend for new projects is similar to these examples: *unsustainable model for the success of future NASA programs*

Failure Investigation Case Studies

A review of 3 failure investigations revealed:

- Failures were a result of significant gaps in inspection/test by the manufacturer for which NASA did not have insight
- $100k to > $3M spent in each case for root cause investigations

PEAL SMEs would perform parts analyses in close work with the manufacturers to gain insight into the fabrication and test practices prior to implementation on NASA programs, for verification of quality and reliability

Future Approach with PEAL

- Perform top-level circuit designs based on performance objectives
- Choose the best parts for the job that are readily available with maximum performance margin (e.g., 10 weeks or less)
  - Utilize PEAL preferred parts list to choose the best available parts rather than sticking to traditionally compliant parts. Make copious use of AEC-qualified and space-enhanced plastic parts.
  - PEAL strategic reliability and radiation characterization will be made available to projects, with a feedback loop back to PEAL on any additional application needs
  - Integrated reliability engineering into the process
- Procure available parts and boards and begin testing. Iterate as needed.

It is likely that for many designs the traditional path will not be viable even with only one design iteration

Summary

- Project overruns are becoming the norm, leading to cancellations, pauses, and other extreme measures
- A major contributor is a fairly strict reliance on old part technologies with substantial lead times that are prohibitive to maintaining mission cost or schedule objectives
  - ➢ The problem becomes insurmountable when several design iterations are required
- We propose a phased in approach that emphasizes the use of new and available part technology
  - ➢ Parts and radiation concerns are addressed by integrating PEAL into the design activity
- The approach allows multiple design iterations and substitutes many traditional rules with modern engineering practices

PEAL Business Case Study Contributors

	Name	Organization	Technical Discipline/Role
CORE TEAM	Susana Douglas	GSFC	Technical Lead, NASA Electronic Parts Manager
	Pete Majewicz	GSFC	Technical Lead, NEPP Program Manager
	Lyudmyla Ochs	GSFC	GSFC Parts Analysis Laboratory Task Monitor / FA Engineer
	Chris Tiu	GSFC	GSFC Acting ABH / Project Parts Engineer
	Kimberly Kirschke	SSAI/GSFC	GSFC Parts Material Coordinator
	Ted Wilcox	GSFC	GSFC ABH / Radiation Engineer
	Jason Osheroff	GSFC	GSFC Radiation Engineer
	Donna Cochran	SSAI/GSFC	GSFC Radiation/NEPP Program Support
	Shri Agarwal	JPL	JPL Technical Lead / NEPAG Lead
	John Puckett	JPL	JPL Project Parts Engineer
	Seraina Murphy	JPL	JPL Engineering FA Team Lead
	Greg Allen	JPL	JPL Radiation Engineer
	Dori Gallagher	JPL	JPL Parts Interface Engineer
	Vincent Elliott	GSFC	GSFC Administrative Manager
CONSULTANTS	Jesse Leitner	GSFC	GSFC SMA Chief Engineer
	Tupper Hyde	GSFC/HQ	GSFC/HQ Chief Engineer
	Florence Tan	HQ	HQ SMD Deputy Chief Technologist
	Carolyn Mercer	HQ	HQ SMD Chief Technologist
	Mark Porter	JPL	JPL Chief Engineer
	Robert Hodson	NESC/LaRC	NESC Avionics Technical Fellow
	Yuan Chen	NESC/LaRC	NESC Avionics Technical Fellow Deputy / EEE Parts Lead
	Shanta Arur	GSFC/HQ	GSFC/HQ Administrative Manager