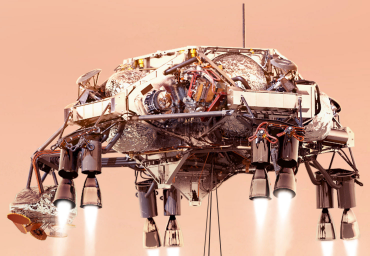
European Space Components Conference (ESCCON)
March 9-11, 2021

National Aeronautics and Space Administration



Standards for Microcircuits NASA's Perspective

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Perseverance Touching Down on Mars (Illustration): An illustration of NASA's Perseverance rover landing safely on Mars. Hundreds of critical events must execute perfectly and exactly on time for the rover to land safely on Feb. 18, 2021. NASA's Jet Propulsion Laboratory in Southern California built and will manage operations of the Mars 2020 Perseverance rover for NASA.

http://nepp.nasa.gov

Image Credit: NASA/JPL-Caltech

www.nasa.gov

This document has been reviewed and determined not to contain export controlled technical data.

- **It's a distinct honor to be invited to make this presentation (this time virtually!).**
- **The European Space Agency is our valued partner in NASA Electronic Parts Assurance Group (NEPAG) activities for the last 20 years!**

2

NEPAG Leadership Transition

- **NASA Electronic Parts Assurance Group (NEPAG)**
  - Leadership transition from Michael Sampson (February 2020)
    - ❖ Shri Agarwal is the new NEPAG Coordinator for the Agency
- **NEPP/NEPAG Leadership**
  - Pete Majewicz – NEPP Manager
  - Jonny Pellish – NEPP Deputy Manager. Also, NASA Parts Manager.
  - Shri Agarwal – NEPAG Coordinator
- **Websites**
  - NEPP: https://nepp.nasa.gov
  - NASA Office of Safety and Mission Assurance (SMA) Parts Website: https://sma.nasa.gov/sma-disciplines/eee-parts

This artist's Concept Depicts Astronauts and Human Habitats on Mars

Image Credit: NASA

ARTEMIS

Image Credit: NASA

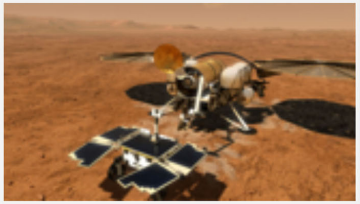
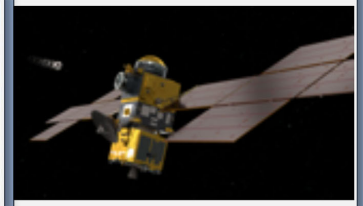
NEPAG

Other NASA News

- **NEPP Electronics Technology Workshop (NETW)**
  - NETW is held in June every year
  - Venue: Goddard Space Flight Center, Greenbelt, MD
  - Past papers posted on NEPP Website: nepp.nasa.gov
  - The next one is during the week of June 14, 2021
- **NASA INST Document**
  - Widely used around the world
  - It is undergoing major changes
  - Telecons are held every two weeks
  - The goal is to have a much leaner and up-to-date document
- **Nepp.nasa.gov has been updated**

Planned MSR Campaign

Mars Sample Return Program

1	2	3	4
			
Sample Caching Rover (Mars 2020) Operations • *Sample acquisition/caching* • *Sample (subset) delivery*	**Sample Retrieval Lander** • *Fetch Rover* • *Orbiting Sample (OS) container* • *Mars Ascent Vehicle*	**Earth Return Orbiter** • *Capture/Containment System* • *Earth Return Vehicle*	**Mars Returned Sample Handling** • *Sample Receiving Facility* • *Curation* • *Sample science investigations*
"Initiates the Campaign"	*"New Element"*	*"New Element"*	*"New Element"*

Ground Element

to be reviewed at a future date

PRE-DECISIONAL INFORMATION – FOR PLANNING AND DISCUSSION PURPOSES ONLY


esa
Mars Sample Return

COVID-19 Impact on Standards Activity

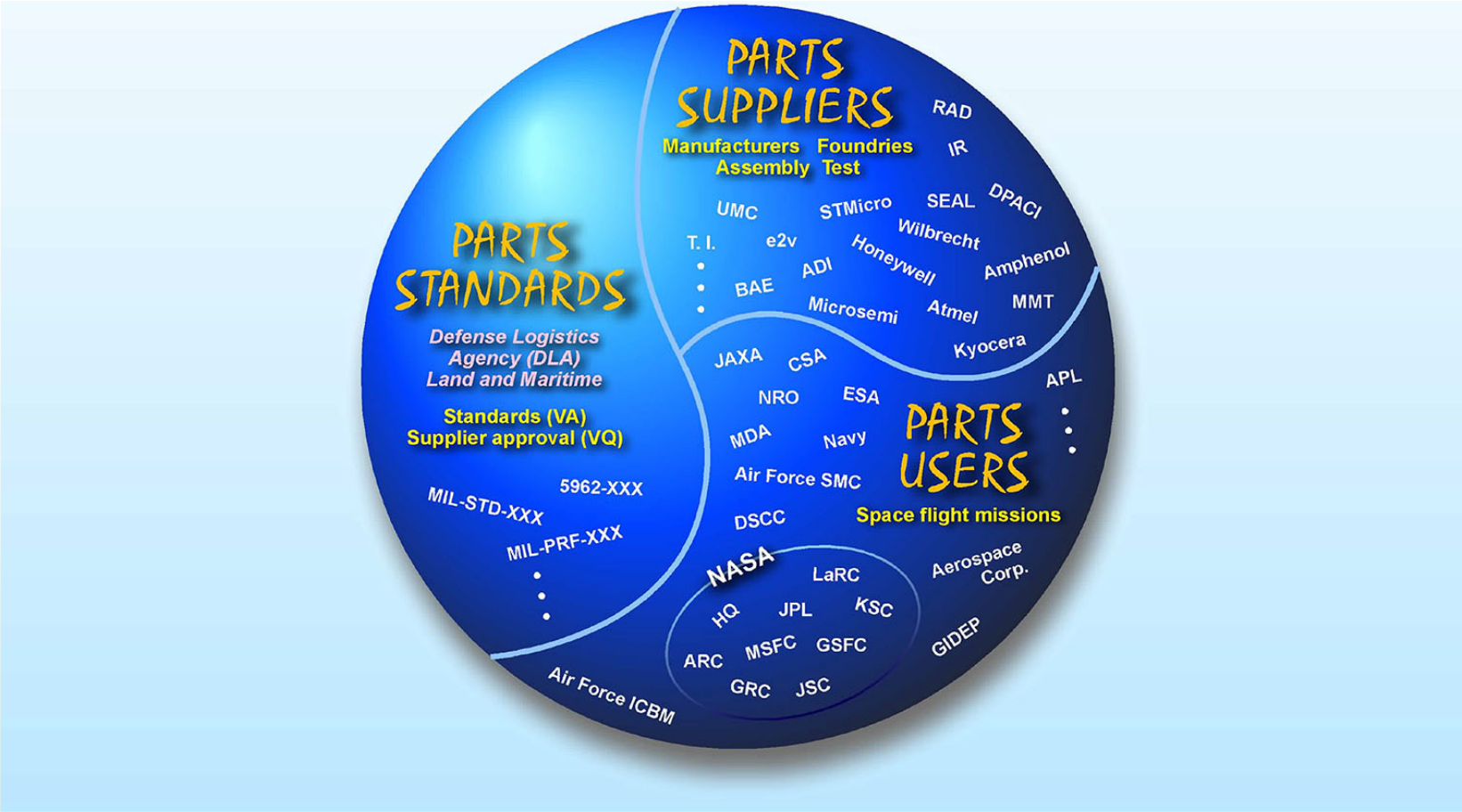
- **Impact of COronaVIrus Disease – 2019, COVID-19 (March 2020 onwards)**
  - Cancelled
    - ❖ May 2020 JC-13/CE-11/CE-12 meetings in Portland, Oregon
    - ❖ May 2020 Space Parts Working Group (SPWG) meeting in Los Angeles, Ca
  - No / Minimal impact
    - ❖ NEPAG, GWG, HWG telecons (No impact)
      - ➢ NEPAG – NASA Electronic Parts Assurance Group, held every week
        - Led by S. Agarwal, NASA/JPL
        - International, first Wednesday of the month
        - Domestic, every Wednesday rest of the month
      - ➢ GWG – Government Working Group, held bi-week
        - Led by K. Laird, NASA/MSFC; Co-Lead: C. Schuler, Navy Crane
      - ➢ HWG – Hybrid Working Group, held monthly
        - Led by J. Pandolf, NASA/LaRC
    - ❖ NEPP ETW (NETW)
      - ➢ Held in June 2020, all virtual
    - ❖ September 2020 and January 2021 JC-13/CE meetings
      - ➢ All virtual

NASA Electronic Parts Assurance Group (NEPAG)

- **NEPAG is about Standards for electronic parts**
  - Maintenance
    - Provide NASA leadership
  - Creation
    - Infuse New Technology, e.g., Class Y for Space
    - Respond to user requests, e.g., a new JC13.2 task group on standard plastic encapsulated microcircuits (PEMs) for Space
  - Related Activities
    - Support Defense Logistics Agency (DLA) audits of supply chain
    - Hold telecons
      - NASA Electronic Parts Assurance Group (NEPAG)
      - Government Working Group (GWG)
      - Hybrid Working Group (HWG)
    - Partnerships
    - Standard microcircuits drawing (SMD) review
    - Outreach (NASA EEE Parts Bulletins)
    - Other

Space Parts World

NEPAG helps to Develop/Maintain Standards for Electronic Parts



The parts users and standards organizations work with suppliers to ensure availability of standard parts for NASA, DoD, and others. **For Space microcircuits, DLA, NASA/JPL (S. Agarwal*) and the U.S. Air Force / Aerospace Corp. (L. Harzstark) form the Qualifying Activity (QA).**

*Also Systems, Standards and Technology Council (SSTC) G-12 Vice-Chair; Chair, Space Subcommittee.

Partnerships

JEDEC JC-13 (Manufacturers)

JC-13	Solid State Devices for Government Products
JC-13.1	Discrete Semiconductors for Government Products
JC-13.2	Microelectronics for Government Products
JC-13.4	Radiation Hardness
JC-13.5	Hybrids and Multi-chip Modules for Government Products
JC-13.7	New Electronic Device Insertion for Government Products

Joint meetings held 3 times a year

SAE CE-11/CE-12 (Industry Users, Primes, Subs)

SAE SSTC CE-11	Users of Passive Components
SAE SSTC CE-12	Users of Solid State Devices
	CE-12 Management:
	Chair – A. Touw
	Vice Chair – (JPL) S. Agarwal
SAE SSTC CE-11 & CE-12	Space Subcommittee Chair – S. Agarwal

NASA Centers:

ARC	JSC
GRC	KSC
GSFC	LaRC
JPL	MSFC

Weekly NEPAG and Biweekly GWG Telecons (Domestic)

Monthly Telecons (International and HWG)

Partners from Outside NASA:

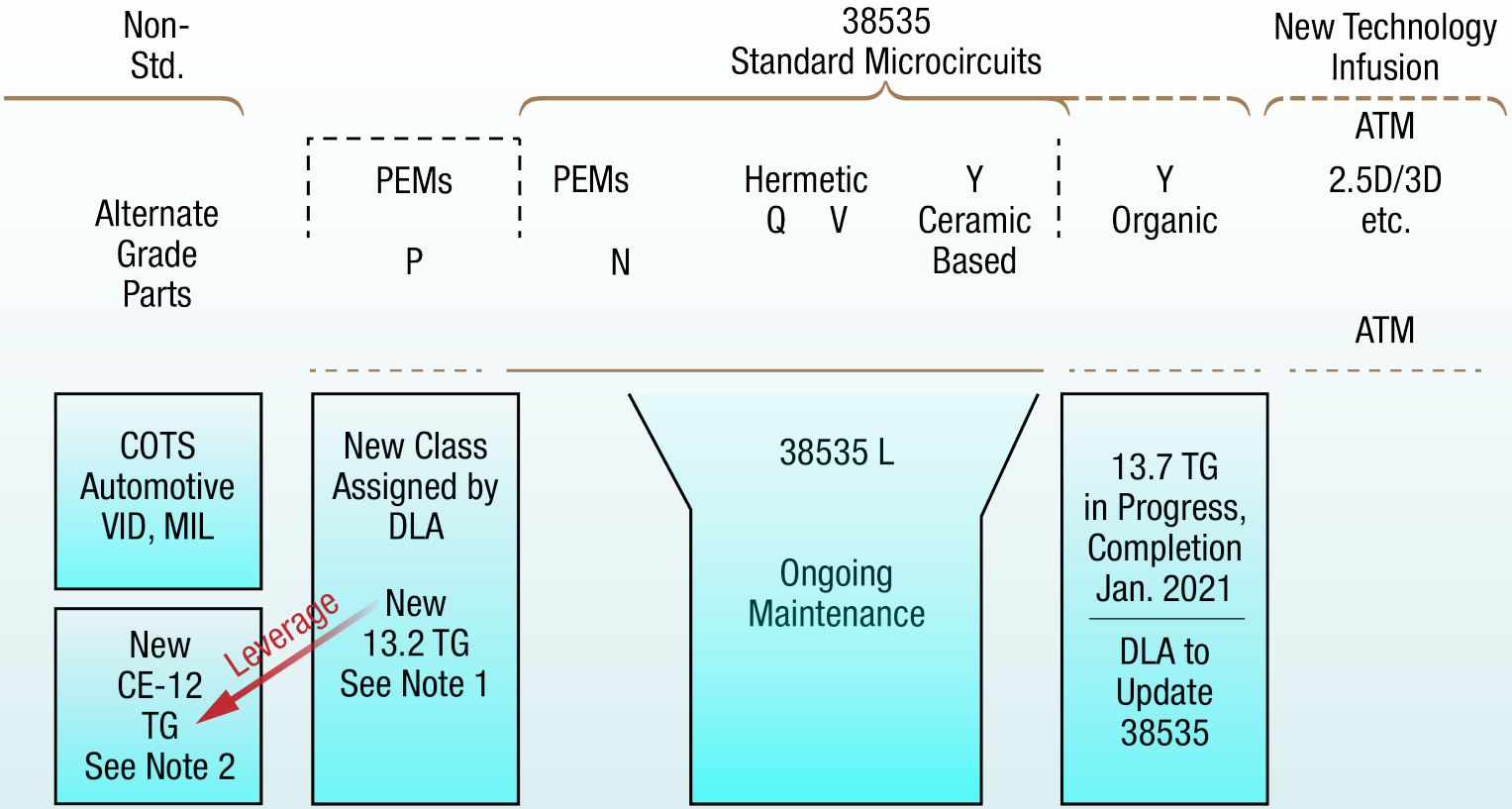
Domestic
- JHU/APL, Others
- The Aerospace Corp,
- U.S. Air Force, U.S. Navy,
- U.S. Army, DLA,

International
- ESA, JAXA, CSA

NEPAG

Options for Microcircuits

Rev. A 12-10-20



- Note 1: Standard PEMs for Space (QMLP) initiative using SAE AS6294 as baseline.
- Note 2: For alternate grade microcircuits, follow the activity in 13.2 TG to avoid any duplication of effort.

Standard RH/RT PEMs for Space

"Taking SAE AS6294 to the Finish Line"

- SAE CE-12 spent considerable effort in developing a PEM flow for space.
  - Developed SAE AS6294, Requirements for Plastic Encapsulated Microcircuits.
    - /1 for space, /2 for terrestrial.
- The SAE AS6294 baselined
  - NASA documents
    - MSFC-STD-3012, GSFC EEE-INST-002, GSFC PEMS-INST-001
  - And, SAE SSB-001
- However, it **never became a standard QML flow**
- Lately, considerable interest in the use of standard plastic parts in space
  - Mainly being driven by **power management** applications
    - Performance, size, weight advantages; slight cost advantage
    - Some applications: Cubesats, smallsats, science instruments
    - New emerging market, does not affect the demand for QMLV products
  - Was discussed on NEPAG (Domestic and International) and GWG telecons
    - We decided to take a fresher look - what would it take for the SAE AS6294 to become a standard PEMs flow for Space.
  - Several manufacturers offering products built to a flow similar to AS6294
  - Actions:
    - **JC13.2 to vote on a TG (September 2020)**
      - T.I. and Boeing to co-lead
      - NEPAG government working group (GWG) to provide support

- **Update (December 18, 2020):**
  - JC-13.2 opened a new Task Group, chaired by S. Williams (T.I.) and R. DeLeon (Boeing).
  - NASA published two parts bulletins on PEMs.
  - DLA assigned a new class letter "P" to standard PEMs in Space.
  - **Goal is for NASA and other agencies/users to be able to procure standard (QMLP) parts for use in space applications without having to worry about upscreening commercial plastic parts.**

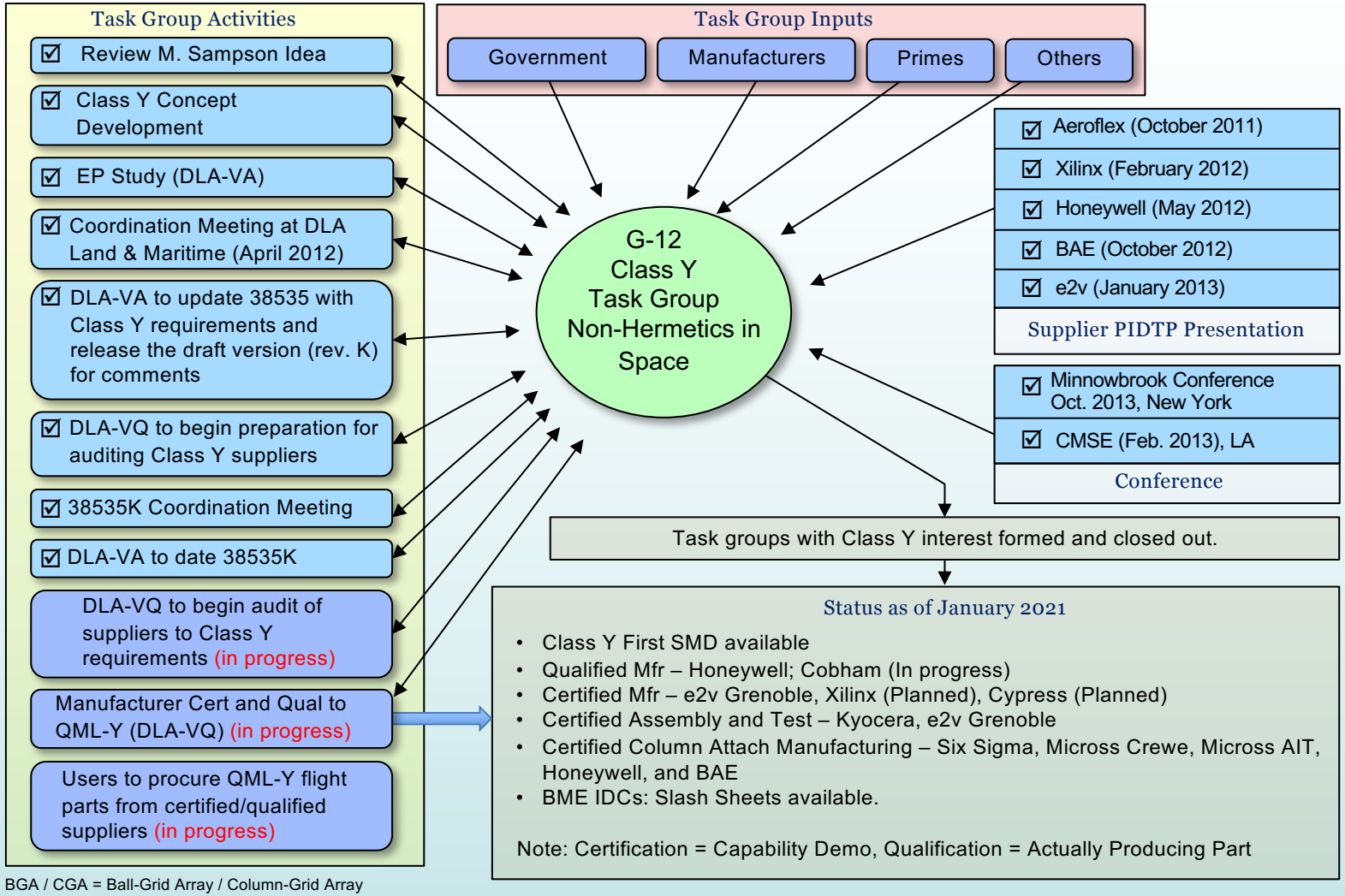
What if A New Product Didn't Fit Any of the Existing Classifications? The "Class Y" Initiative

- It was recognized by the community that packaging and device technology advances are happening rapidly.
- In order to enable space flight projects to benefit from the newly developed devices, e.g., Xilinx Virtex-4 and -5 FPGAs (which are ceramic-based flip-chip nonhermetic parts), a new class was needed.
- NASA led a CE-12 initiative, called Class Y, for infusing Xilinx FPGAs and other similar devices into military/space standards.
- Such an effort must be coordinated with the suppliers and users.
- Need to address all aspects of packaging configuration.
- New test methods must be created and the existing standards updated as necessary.

Class Y, A New Beginning for New Technology Infusion

- **ClassY**
  - It represents advancements in packaging technology, increasing functional density, and increasing operating frequency. These are ceramic based single-die system-on-a-chip (SoCs) with non-hermetic flip-chip construction, in high-pin-count ceramic column grid array (CGA) packages. These products use tiny base electrode metal (BME) capacitors for signal integrity, and vented packages for thermal management. (e.g., Xilinx Virtex-4 FPGAs)
  - To address the manufacturability, test, quality, and reliability issues unique to new non-traditional assembly/package technologies intended for space applications
    - Introduced a new concept called Package Integrity Demonstration Test Plan (PIDTP) – provided flexibility to manufacturers.
  - This initiative resulted in a major overhaul of MIL-PRF-38535, particularly with respect to requirements for flip-chip, underfill, CSAM, column grid arrays, etc. Revision K reflecting these changes was released in December 2013.
- **Started JC-13.7 to address infusion of new technology**

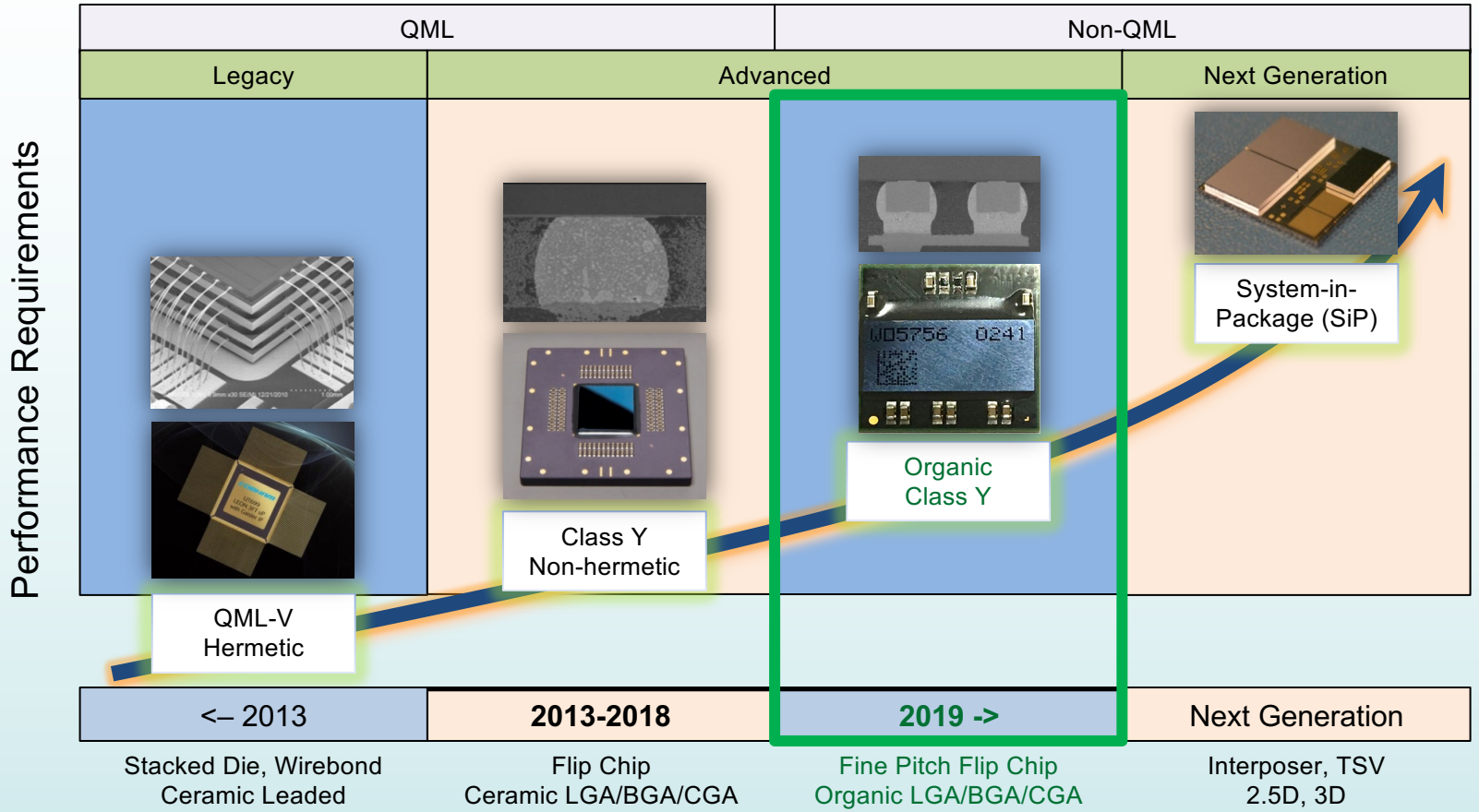
Infusion of New Technology into the Standards
(Ceramic Based) Class Y Status, January 2021



BGA / CGA = Ball-Grid Array / Column-Grid Array
BME = Base Metal Electrode
IDC = Inter Digitized Capacitor

PIDTP = Package Integrity Demonstration Test Plan
SMD = Standard Microcircuit Drawing

Next Generation Package Technology for Space
Development Roadmap for Space Applications



Credit: Scott Popelar, Cobham, 2019 MRQW, February 7, 2019

MIL-PRF-ATM (DLA Proposal)

Background: MIL-PRF-38535 offered traditional hermetic class Q and V (class level B, S) and non-hermetic class N and Y devices for military, terrestrial, avionics and space applications. Design requirements of modern electronic satellite/warfare systems are growing faster and moving forward with newer advanced technologies. Considering the complexity of new technologies and device packaging (i.e. 2.5D, 3D, SIP and MCM type devices) techniques, the current MIL-PRF-38535 may not be the best requirements platform to accommodate for manufacturing these complex and advanced new technology devices.

Accordingly, to bring advancement and adoption of new technologies into the QML system, DLA Land and Maritime is proposing to create a new performance specification, MIL-PRF-ATM applying the Package Integrity Demonstration Test Plan (PIDTP) process to the entire microcircuit manufacturing process. This process was developed for class Y flip chip packages and is successfully used in MIL-PRF-38535 PIDTP requirements.

A JC13.7 task group has started to develop the requirements for MIL-PRF-ATM.

ATM = Advanced Technology Microcircuits

Why Electronic Parts and Electrostatic Discharge, ESD, Need a Fresher Look – Gaps

- NASA has been supporting Defense Logistics Agency (DLA) audits of the supply chain.
- During the audits, it was observed that the ESD requirements in MIL-PRF-38535, specification for microcircuits, were practically nonexistent.
- Microcircuit pin count has increased significantly (e.g., Xilinx Vertex Field Programmable Gate Arrays, FPGAs, have 1752 columns). Manufacturers are striving for still higher counts.
- Current qualification standards were developed years ago with pin counts in the twenties.
- Applying these old device testing standards to modern high-pin count products can cause severe problems (e.g., testing times increase dramatically).
- Furthermore, microcircuit part production is no longer under one roof, but landscape of supply chain is multiple specialty houses.

Need to update standards

NASA ESD Surveys of Microcircuit Supply Chain

- **NASA ESD Surveys**
  - Benefits not only NASA but the whole community
    - ❖ Especially vendors processing very expensive new technology parts (where the **per unit price could approach $200k)**
  - Candidate companies are identified during DLA audits—but not a DLA activity
  - Conducted by NASA ESD experts
    - ❖ The survey findings and corrective actions have been merely suggestions for improvements (but, in all cases, were implemented by the vendors)
  - Very well received
    - ❖ Some vendors have requested re-surveys every two years
  - Working with Suppliers and DLA to incorporate NASA ESD Surveys into DLA audit agendas
    - ❖ Make efficient use of resources
    - ❖ Was done a few times, worked well

NASA ESD Surveys are Meeting Greater ESD Challenges for Electronic Parts

NASA ESD Mitigation Going Forward (Plan)

- **Mitigate Existing and Possible Future ESD Issues by Supporting Efforts in Nine Categories:**

1. NASA ESD surveys
   - We would like to see the ESD requirements to go in MIL-PRF-38535 so DLA can add ESD to their audit of the supply chain.
   - Responsibility for mitigating the risks from non-DLA audited sources will require a different approach. We know in a significant number of cases, we will not be permitted access to monitor such facilities. This is a significant gap!
2. Independent evaluations of new technologies (e.g., GaN, SiC, others) is needed. Determine ESD thresholds per Human Body Model (HBM) and Charged Device Model (CDM).
3. Clarify 883 vs. JEDEC test method equivalencies for HBM
4. Low-ESD-threshold parts mitigation, e.g., very high speed microcircuits (GHz range) -- make recommendations
5. Continue working with industry groups (e.g., JC13, JC14, ESDA, EC-11, EC-12)
6. Harmonize ESDA 20.20 and JEDEC 625 standards
7. Continue updating military standards (Support DLA)
8. Encourage manufacturers to add ESD data to their datasheets
9. Continue outreach (NASA Parts Bulletins, invite speakers, present at meetings)
10. Develop the next generation of ESD specialists

Note: NASA Is Part of the Qualifying Activity (QA) for Space microcircuits.

Wide Band Gap Technologies

- **NASA working group discusses best methods for evaluating new wide band gap technologies for infusion into space**
  - GRC, JPL, JSC, GSFC, AFRL
  - Share resources for radiation effects testing, extreme environment testing and reliability analyses
  - Analysis of current commercial efforts
- **Other Efforts Supported**
  - JC13.1/JC13.7/SAE CE-12 GaN and SiC Working Groups
  - Aerospace-led Telecons
  - SAE CE-11/CE-12 Telecons
- **On going and future efforts**
  - Continues radiation testing and analysis
  - Reliability test screens for new devices
  - Characterization under extreme temperatures
  - Guidelines for implementation and testing
- **Looking at all major providers**
  - GaN Systems (E2V), Panasonic (Infineon), EPC (Freebird Semi)

Counterfeit Parts

- Refers to counterfeit parts awareness and mitigation.
- GIDEPs (Government Industry Data Exchange Program [reports]) on counterfeit parts are reviewed on NEPAG telecons.
- During the DLA audits, the manufacturers are asked for their counterfeit mitigation plans. Most of them have some form of mitigation.
- NASA provides counterfeit training.
- NASA supports the SAE (Society of Automotive Engineers) effort.
- Procure parts, particularly new technology devices, from the authorized sources.

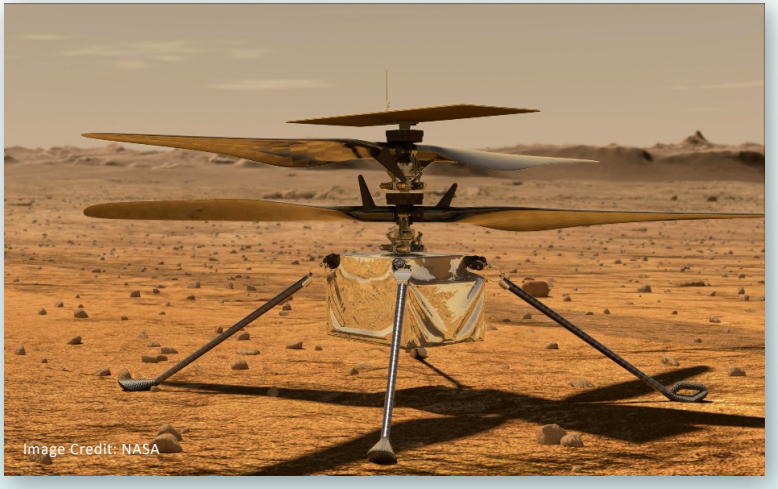
Burn-in, and Life Test
New Comments from NASA

- 1. The regression tables need a fresher look
  - NASA computations show a large variation in the activation energies (Ea). See summary below
- 1a. Regression Table in MIL-STD-883, Test Method 1005 (Life Test)
  - For Class B, Ea range = 0.971eV to 0.986eV
  - For Class S, Ea = 0.292eV to 0.403eV
  - Considerable variation in Ea values
  - For currently quoted Ea of 0.7eV
    - Class B is less conservative
    - Class S is more conservative
- 1b. Regression Table in MIL-STD-883, Test Method 1015 (BI)
  - For Class B, Ea = 0.397eV to 0.409eV
  - For Class S, Ea = 0.383eV to 0.403eV
  - Considerable variation in Ea values
  - For currently cited Ea of 0.7eV
    - Both Class B and Class S are more conservative
- 1c. What is the correct Ea going forward?
  - Different sources list different values.
- 2. For accelerated temperature burn-in, and life test
    - Are the parts characterized for safe operation before they are subjected to elevated temperatures?
    - Recommend making it a requirement
- 3. JEP 163 Document
    - Is there a plan to update this document?

- Credits: (1) S. Agarwal, A. Hanelli, M. Han, D. Gallagher, N. Ovee, S. Khandker, R. Evans of NASA/JPL - Cal Tech (2) Subject discussion in 12 Aug, 2020 NASA Electronic Parts Assurance Group (NEPAG) telecon.

Other JEDEC JC-13/CE-11/CE-12 Major Activities Supported by NASA

- Leak rate and residual gas analysis (RGA)
- New technology insertion (>2D packaging)
- GaN, SiC Working Groups
- Hybrid element evaluation
- Hybrid worse case analysis
- Life Test
- Passives
- Radiation hardness, 1019 update
- Copper bond wires qualification, testing
- Other

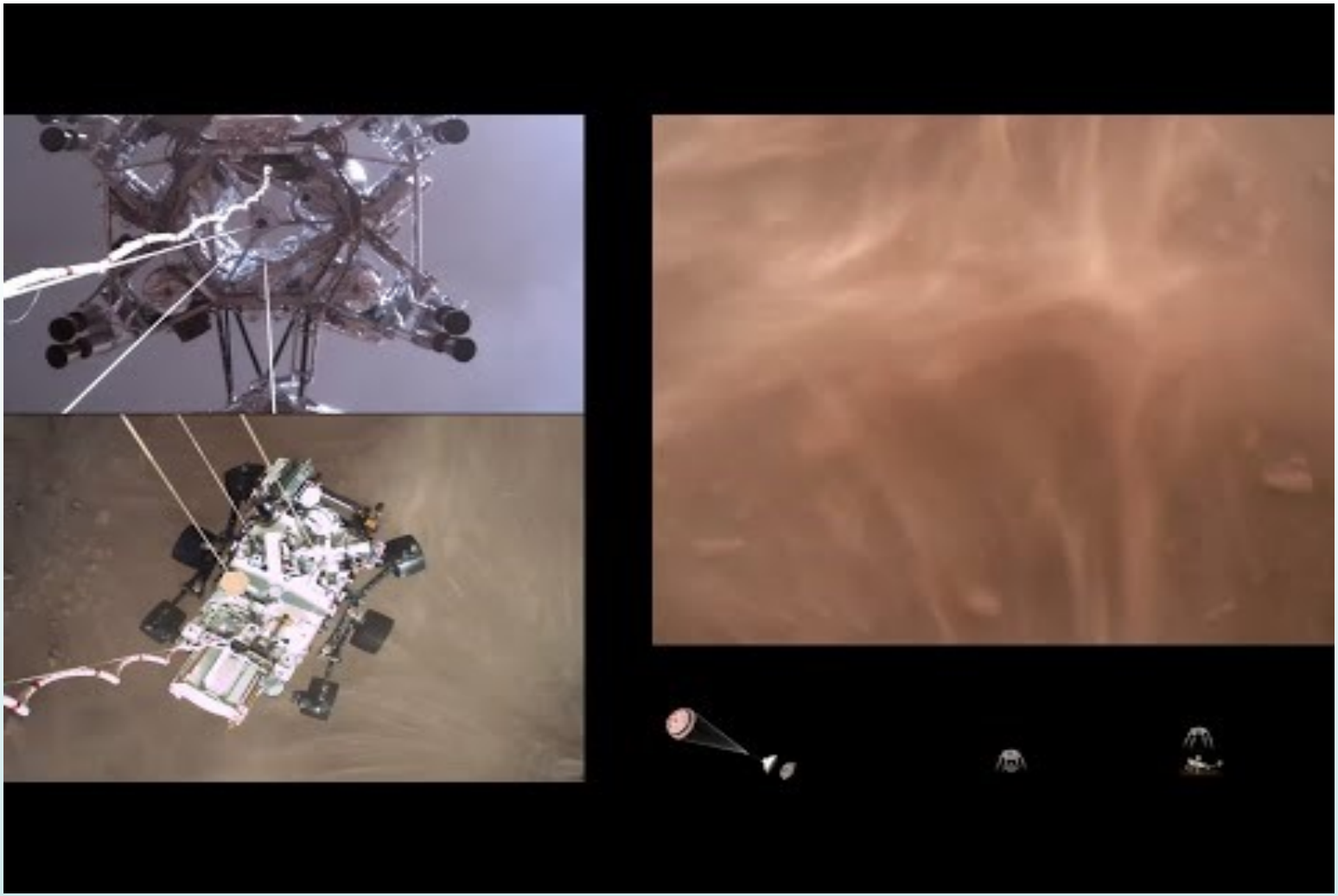


This Artist's Concept Shows the Mars Helicopter on the Martian Surface

Conclusion

- New technology infusion and standards maintenance present on-going challenges.
- NASA supports a wide spectrum of space missions/programs The success of each mission counts.
- NASA is working with the space community to help infuse new technologies into the military standards. ESD aspects should not be ignored. We encourage the world wide space community to get/stay involved in developing/updating standards.
- ESCCON offers an excellent opportunity to work with space organizations around the globe. Thank you, ESA!

Thank you!



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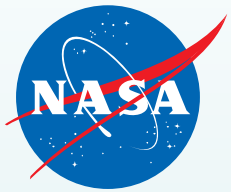

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