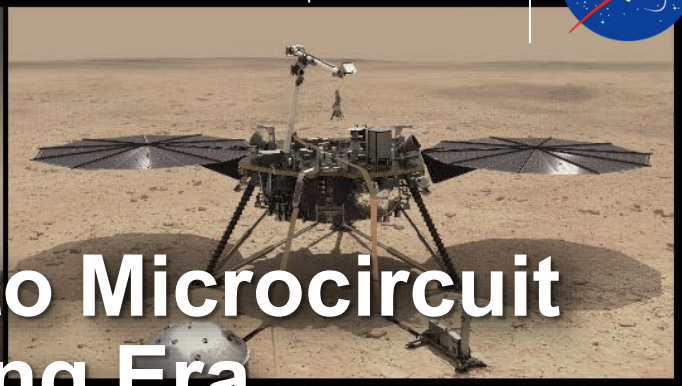
Japan Aerospace Exploration Agency (JAXA)
The 34th Microelectronic Workshop (MEWS34)
October 21-22, 2021

National Aeronautics and Space Administration



Infusing New Technology into Microcircuit Standards: An Exciting Era

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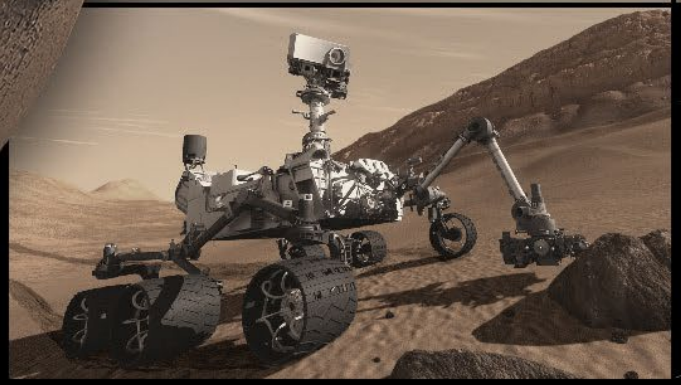


NASA's Mars missions, clockwise from top left: Perseverance rover and Ingenuity Mars Helicopter, InSight lander, Odyssey orbiter, MAVEN orbiter, Curiosity rover, and Mars Reconnaissance Orbiter.
Credits: NASA/JPL-Caltech

http://nepp.nasa.gov

- **Thank you, Shindou-san, for your invitation. It's always a great pleasure to visit Tsukuba (once again virtually!).**
- **Congratulations on the 34th anniversary of the MEWS Workshop!**
- **JAXA is our valued partner in NASA Electronic Parts Assurance Group (NEPAG) activities for the last 21 years!**

COVID-19 Impact

- Impact of COronaVIrus Disease – 2019, COVID-19 (March 2020 onwards)
  - Cancelled
    - NASA ESD surveys
    - DLA audits
  - No / Minimal impact
    - NEPAG, GWG, HWG telecons (No impact)
      - NEPAG – NASA Electronic Parts Assurance Group, held every week
        - Led by S. Agarwal, NASA/JPL, supported by R. Swain, R. Salallandia Valenzuela
        - International, first Wednesday of the month
        - Domestic, every Wednesday rest of the month
      - GWG – Government Working Group, held biweekly
        - 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 2021, all virtual
    - Learn@Lunch Webinars with Supply Chain
      - Changed to virtual only
    - September 2021 JC-13/CE-11, -12 meetings in Columbus, Ohio
      - All virtual
      - Held over a period of 3 weeks

An Exciting Next Decade

- **Exciting times ahead for mission assurance at NASA, a couple of examples:**
  - **Upcoming launch of JAMES Webb Space Telescope (Scheduled for December 18, 2021)**
  - **Recent successes of Mars 2020 rover, Mars Helicopter**
    - **On September 6, 2021, the Perseverance rover completed acquisition, sealing, and storage of the first rock core sample on another planet (Source: Email from JPL Office of the Director, September 7, 2021).**
      - **Mars Sample Return (MSR) has begun!**

- **NASA Mission Assurance strives to find solutions for a wide spectrum of applications, from Cubesats to Europa Clipper.**
  - **Success of each of these missions, whether large or small, is important.**
  - **We count on this community to make that happen.**

James Webb Space Telescope Mirror Seen in Full Bloom

Using its WATSON camera, NASA's Perseverance Mars rover took this selfie over a rock nicknamed "Rochette," on Sept.10, 2021, the 198th Martian day, or sol, of the mission. Two holes can be seen where the rover used its robotic arm to drill rock core samples.

Credits: NASA/JPL-Caltech/MSSS

Partnering with the Community

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)

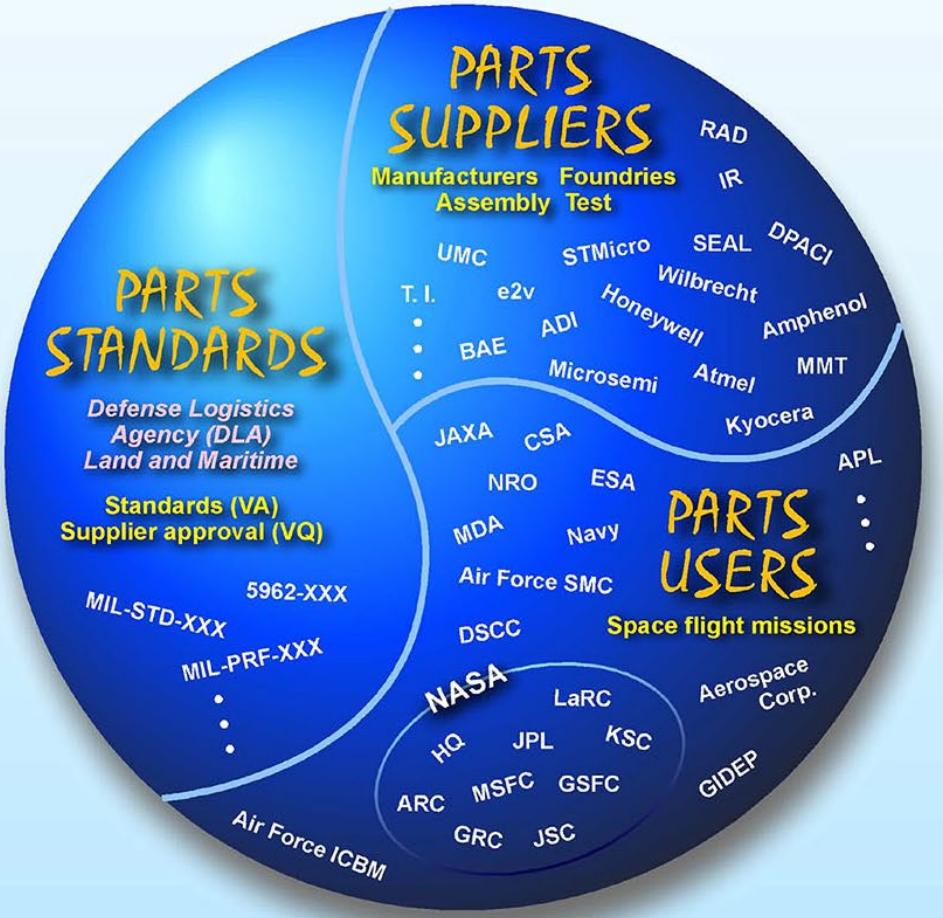
Partners from Outside NASA:

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

International
- ESA, JAXA, CSA

Space Parts World

NEPAG helps to Develop/Maintain Standards for Electronic Parts



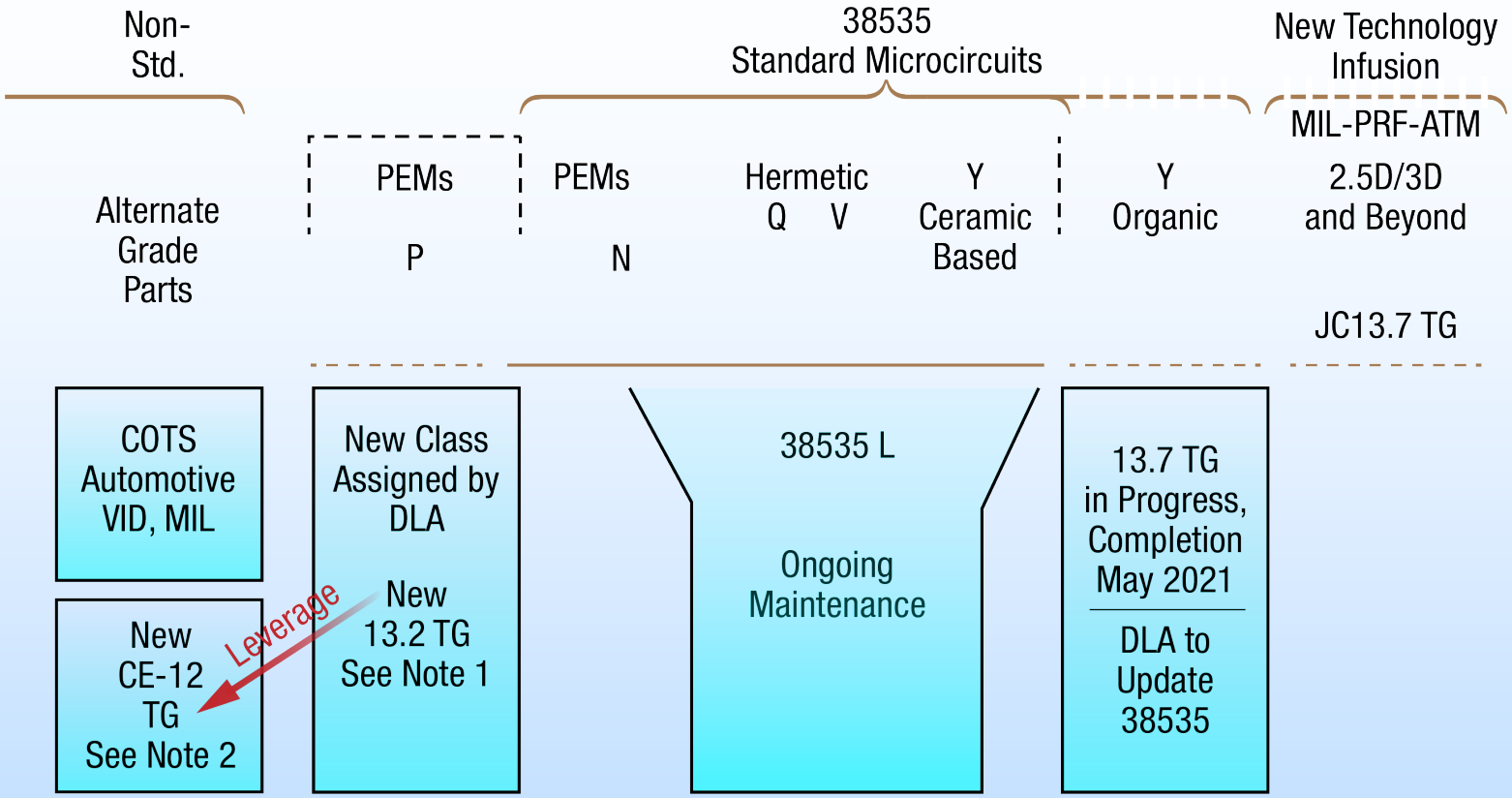
The parts users and standards organizations work with suppliers to ensure availability of standard parts for NASA, DoD, and others. **For Space microcircuits, DLA, NASA/JPL (S. Agarwal*) and the U.S. Air Force / Aerospace Corp. (L. Harzstark) form the Qualifying Activity (QA).**

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

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 Workshop is during the week of June 13, 2022.
- **NASA INST Document**
  - Widely used in the United States
  - It has undergone major changes.
  - The goal is to have a much leaner and up-to-date document.
  - The document will be renamed 8739.11.
  - Planned release: FY22
- **Released Documents**
  - GaN Body of Knowledge document (GRC)
  - Recommendations on use of COTS EEE parts for NASA missions, Phase 1 (NESC)
    - Now in Phase 2 – starting with Supplier survey
  - Avionics radiation hardness assurance best practices (Pellish)
  - NASA EEE Parts Bulletin on KGD (Hanelli/Khandker)
    - To support (a) NASA projects transitioning designs from packaged parts to die versions, (b) MIL-PRF-ATM TG
    - Next one in this series: NASA Bulletin on Chiplets – to provide continuing support to MIL-PRF-ATM TG (Agarwal/Ovee/Khandker)

Options for Microcircuits Rev. E, 8-31-21



- **Note 1: Standard PEMs for Space (QMLP) initiative using SAE AS6294 as baseline. Supported by NASA Parts Bulletins on PEMs.**
- **Note 2: For alternate grade microcircuits, follow the activity in 13.2 TG to avoid any duplication of effort.**
- **Note 3: ATM = Advanced Technology Microcircuits. Supported by NASA parts bulletin on KGD.**
- **Note 4: VID = Vendor Item Drawing. Contact DLA for latest information.**
- **Note 5: The boundaries separating various classes/grades must be clearly defined - future outreach activity.**

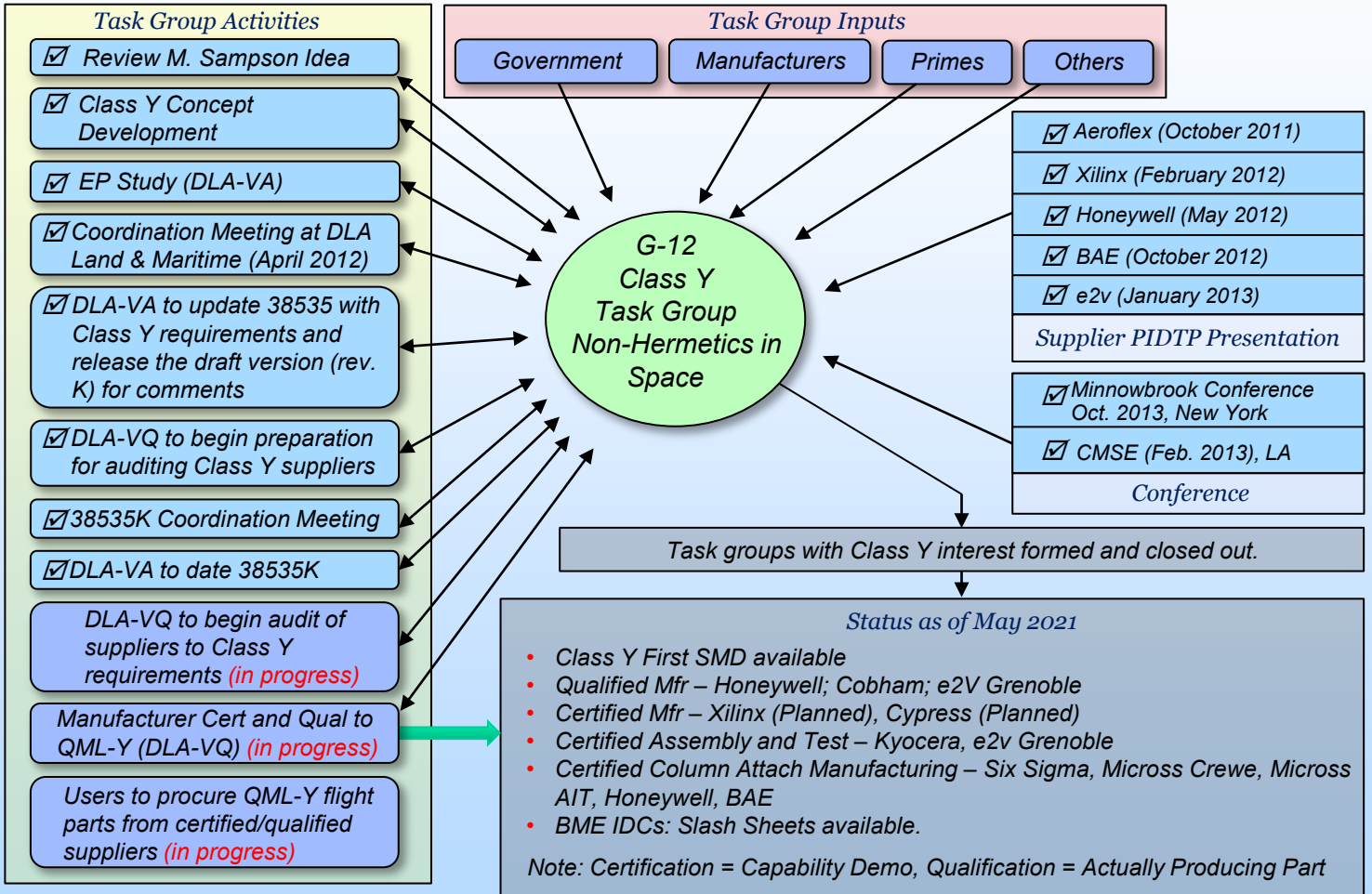
What if A New Product Didn't Fit Any of the Existing Classifications? The "Class Y" Initiative

- 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

- **Class Y**
  - **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, May 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

An Example of SMD Boiler Plate Update

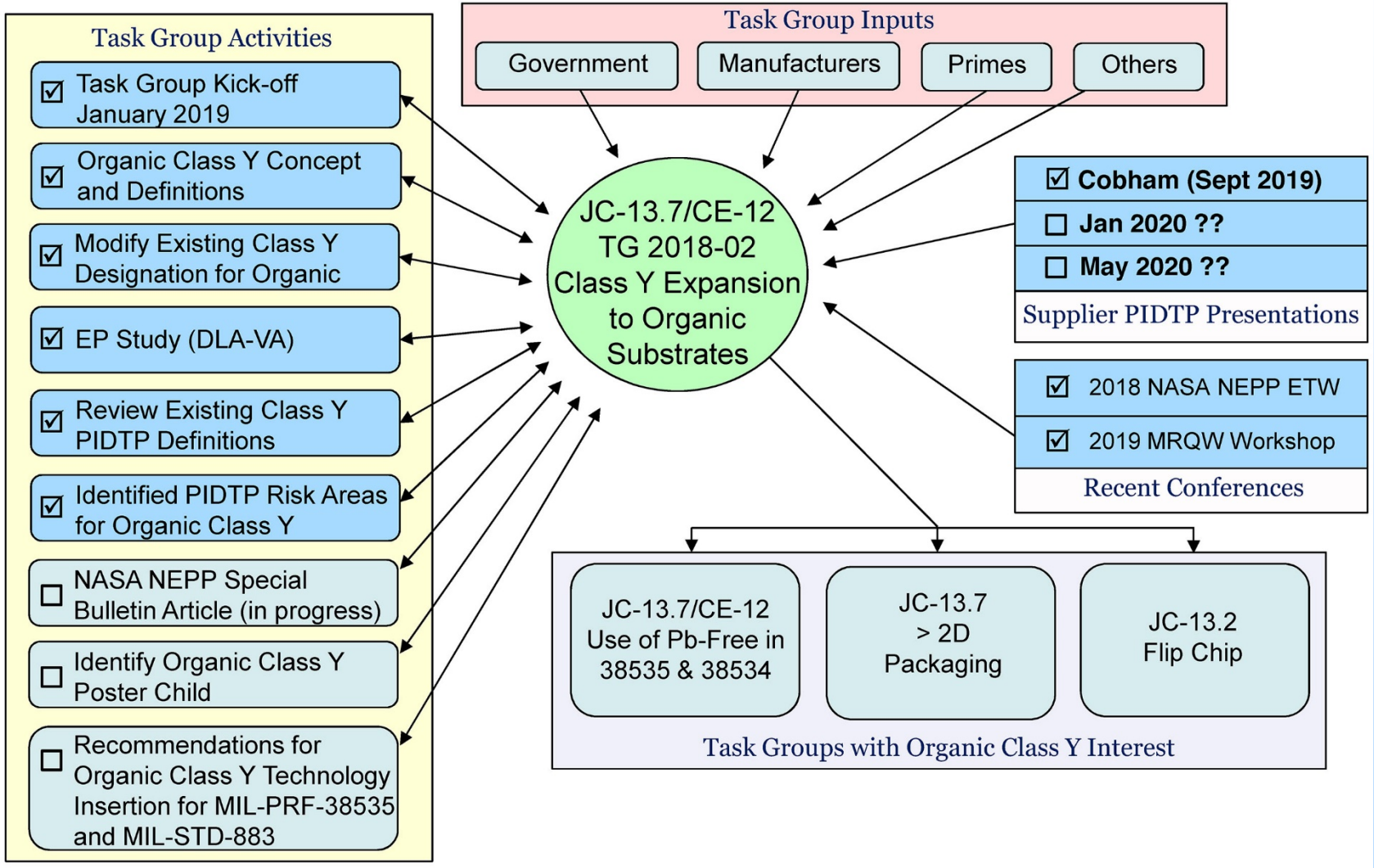
TABLE IIA. Electrical test requirements.

Line Number	Test requirements	Subgroups (in accordance with MIL-PRF-38535, table III)	
		Device class Q	Device class V
1	Interim electrical parameters (see 4.2)	1,2,3,7,8A, 8B,9,10,11 1/	1,2,3,7,8A, 8B,9,10,11 1/
2	Static burn-in I and II (method 1015)	Not required	Required
3	Same as line 1	- - -	1, 7 Δ 1/ 2/
4	Dynamic burn-in (method 1015)	Required	Required
5	Same as line 1	1, 7 Δ 1/ 2/	1, 7 Δ 1/ 2/
6	Final electrical parameters	1,2,3,7,8A,8B,9, 10,11 1/	1,2,3,7,8A,8B,9, 10,11 1/
7	Group A test requirements 3/	1,2,3,4,7,8A,8B,9,10 ,11 4/	1,2,3,4,7,8A,8B,9, 10,11 4/
8	Group C end-point electrical parameters 3/	1,2,3,7,8A,8B, 9,10,11 Δ 2/	1,2,3,7,8A,8B, 9,10,11 Δ 2/
9	Group D end-point electrical parameters 5/	2,3,8A,8B	2,3,8A,8B
10	Group E end-point electrical parameters 3/	1,7,9	1,7,9
11	Column attach 6/	1,7,9	1,7,9

- **For Flip-chip column attach**
  - **Add room temperature electricals (subgroups 1, 7, 9) after column attach – step 11 above**

JC-13.7/CE-12 Task Group 2018-02

Organic Class Y Status Slide (updated September 2019)



Slide courtesy COBHAM

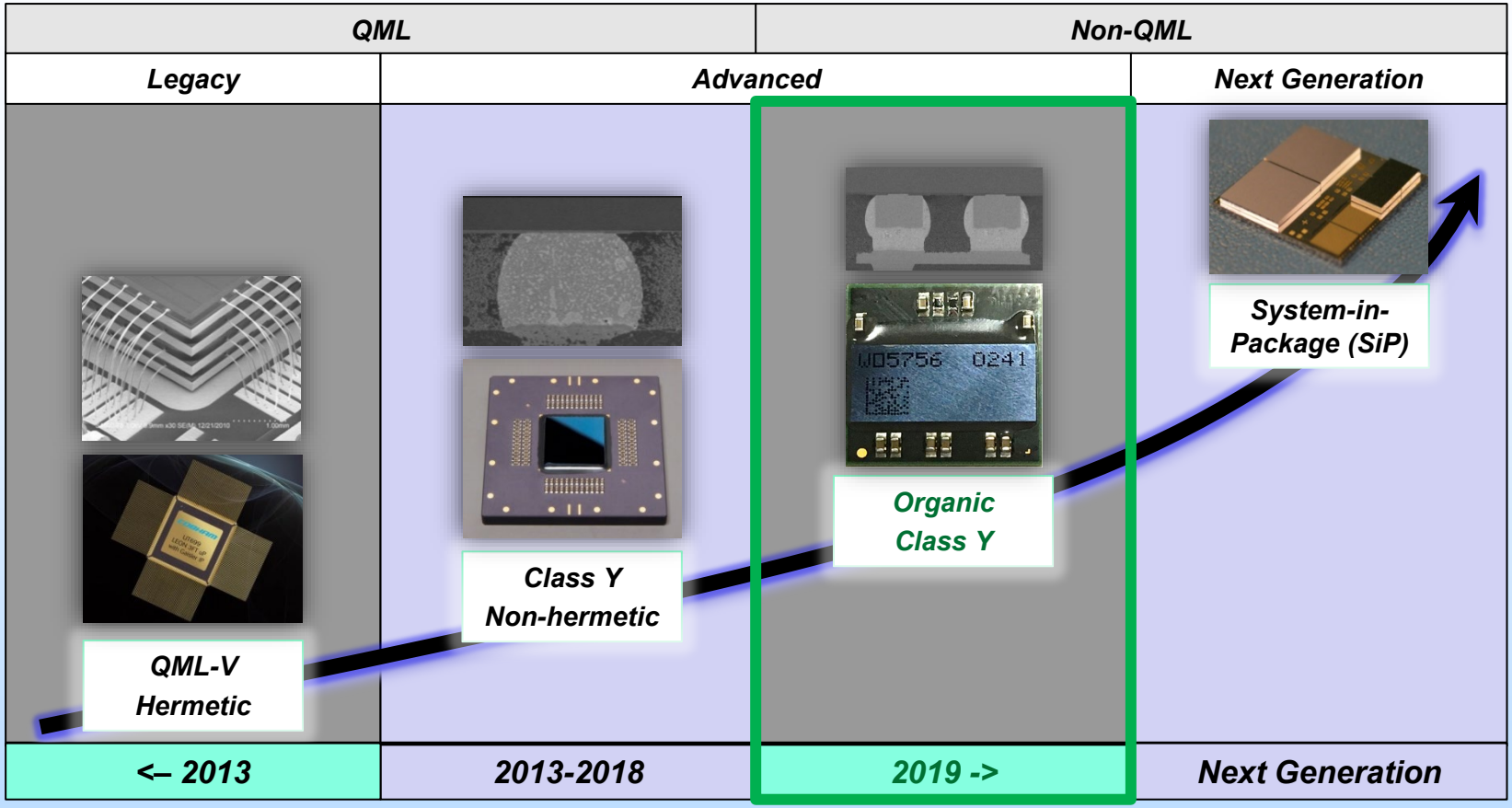
Developing Requirements for Organic Class Y

Screening Tests	MIL-STD-883, test method (TM) and conditions			
	Class Q (class level B)	Class V (class level S)	Class Y (class level S)	**Organic Class Y (class level S)**
1. Wafer lot acceptance test	QM plan (see H.3.2.1.4) 1/	QM plan (see H.3.2.1.4) 1/ or TM 5007 of MIL-STD-883 (all lots)	QM plan (see H.3.2.1.4) 1/ or TM 5007 of MIL-STD-883 (all lots)	**No change recommended**
2. Nondestructive bond pull (NDBP) test 2/		TM 2023	TM2023	**No change recommended**
3. Internal visual inspection 3/	TM 2010, condition B	TM 2010, condition A	TM 2010, condition A	**No change recommended**
4. Temperature cycling 4/	TM 1010, condition C, 10 cycles minimum	TM 1010, condition C, 10 cycles minimum	TM 1010, condition C, 10 cycles minimum	**Alternate Condition B for 15 cycles**
5. Constant acceleration 5/	TM 2001, condition E (minimum), Y1 orientation only	TM 2001, condition E (minimum), Y1 orientation only	TM 2001, condition E (minimum), Y1 orientation only	**No change recommended**
6. Visual inspection 6/	100%	100%	100%	**No change recommended**
7. Particle Impact Noise Detection (PIND) test 7/ 8/		TM 2020, test condition A on each device	TM 2020, test condition A on each device	**No change recommended**
8. Serialization 9/	**In accordance with device specification (100%)**	**In accordance with device specification (100%)**	**In accordance with device specification (100%)**	**No change recommended**

- **Partial Screening table shown**
- **Credit: JC13.7 TG 2018-02**

Next Generation Package Technology for Space

Development Roadmap for Space Applications



Package Technology Availability

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

NASA's Involvement in Developing New Space Products

- With the Defense Logistics Agency (DLA) and the Aerospace Corporation, NASA participates in the review and approval of new space products:
  - Standard Microcircuit Drawings (SMDs)
  - Characterization and qualification data per Appendix H of MIL-PRF-38535 (for the monolithics)
- In FY21, a total of 11 microcircuit SMDs were approved for release. The mix of new product types included:
  - DC/DC Converters
  - D/A
  - Processor
  - Inverters
  - And others
- Per manufacturers, there is a continuing strong demand for standard space products.

New Technology Evaluation
A Multi-pronged Effort

- New Technology Evaluations
  - There are NEPP (NASA Electronic Parts and Packaging)–funded evaluations.
  - NEPP also joins hands with other organizations.
- The JC-13 Effort
  - A few years back, JC-13 created a new committee, JC-13.7.
    - The JC-13.7 charter is to look into next generation technologies.
      - List of top candidates
        - Organic Substrate Class Y
          - ✓ A new task group was started (Sept 2018).
          - ✓ Will be completing its work by December 2021
        - Others: SiC, GaN; Copper wire bonds; 2.5D and 3D microcircuits
    - What would it take to infuse new technologies into QML standards?
      - Identify the gaps
    - It is supported by NASA, JAXA, and ESA, among others.

New Technology Evaluation
A Multi-pronged Effort (Cont.)

- **Preparing to embrace advanced technologies**
  - **Continually Improving the Existing Infrastructure**
    - **The role of Microcircuits Qualifying Activity (QA)**
    - **QML Classes**
      - **Is the current set of Q, V, and Y sufficient to cover new devices?**
    - **Specifications and Standards**
      - **Bring them current**
    - **Some of the side issues**
      - **Handling/packaging/ESD (electrostatic discharge)**
      - **Burn-in of high speed devices**
      - **Usefulness of the Qualified Products List (QPL) program**
        - **QPLS (space grade) crystal oscillators**
          - ✓ **No one was buying QPL space oscillators**
          - ✓ **DLA updated MIL-PRF-55310 specification – reflecting users' needs**
          - ✓ **Supported by space community and most manufacturers**

New Technology - Some Major Activities

- **Technical support to the Defense Logistics Agency (DLA) audits of supply chain (Audits are currently on hold):**
  - **Wafer foundry**
  - **Wafer bumping**
  - **Assembly and test**
  - **Column attach**
  - **Proper shipping/handling/ESD precautions become important.**
    - **Per unit costs have increased dramatically**
    - **NASA ESD surveys**
      - **NASA *EEE Parts Bulletins***
- **Qualifying Activity (QA) Reviews/Approvals:**
  - **NASA is part of the QA**
  - **Manufacturers to perform qualification as required in MIL-PRF-38535.**
    - **For example, a 4000-hour life test**
  - **DLA and manufacturers to develop standard microcircuit drawing (SMD)**
    - **Update existing boiler plate to accommodate new features**

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. According to one source:
    - 0.3eV is for oxide/dielectric defects, chemical/galvanic/electrolytic corrosion
    - 0.7eV covers electromigration, broken bonds, lifted die
    - 1.0eV is for surface contamination induced shifts, lifted bonds (Au-Al interface)
- 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 of discussion in 12 Aug, 2020 NASA Electronic Parts Assurance Group (NEPAG) telecon.

Some Notes on Fracture Mechanics in Plastic Packages

- PEMs
  - Lots of JC13/CE-12 activity to develop Standards for Microcircuits
    - Heavy discussion on plastic parts in the next 2-3 years (and beyond), on both ends (overmolded and organic)
    - Good time to review the fundamentals of plastic packages – the community is making heavy investment in them to cover expanded application spectrum/ infuse new technology
  - Temp cycling
    - Done per MIL-STD-883, Test Method 1010
      - Condition C: -65C to +150C, used for ceramic parts
      - Condition B: -55C to +125C, being proposed for PEMs for Space
      - Condition A: -55C to +85C
      - How about the ramp rates, dwell times?
  - Glass Transition Temperature
    - No one seems to talk about it any more, it has been a mystery.
      - Always measured lower than specified (JPL experience from several years ago)
  - Packages are getting smaller, thinner.
    - A GaN device that NASA/JPL wants to use comes in a 8mm x 8mm size package.
  - Post Assembly
    - Are any parts issues (e.g., crack propagation) off limits (IPC problem?)
      - CTE mismatches
      - Time dependence
    - Bring parts, IPC, manufacturer communities together
      - Could a QCI type test/set of guidelines be developed at the part level?
      - Look at 38535 and 19500 products
  - What tests do the materials suppliers run to demonstrate quality/reliability?
  - Making improvements to standards, performance specifications
    - Is the potential impact of stress/pressure build up in plastic packages being adequately addressed?
- Is it time to address Fracture Mechanics and Microcircuit Standards?
  - To identify any gaps and assess their impact
  - Plastic encapsulants, dielectric polymers, and underfill materials are subject to delamination and cracking with thermal cycling. Crack propagation during use environment exposure, drives the potential for failure of microelectronic devices and is therefore a necessary focal point in qualification and life testing.
  - Develop methodology for evaluating the time-dependent mechanical failure of semiconductor packages
    - Resulting from combined effect of stress, temperature, moisture absorption and crack like defect

Cubesats for Deep Space Exploration

- **Growing Use of NASA Cubesats**
  - **Many new NASA missions are Cubesats and Smallsats.**

- **Cubesats support to Insight Lander**
  - **Mars Cube One, or MarCO was a Cubesat mission comprising two functionally identical six-unit Cubesats accompanying the Insight Mars Lander.**
    - **By successfully relaying data from another planet, this technology experiment has opened new possibilities for space exploration.**

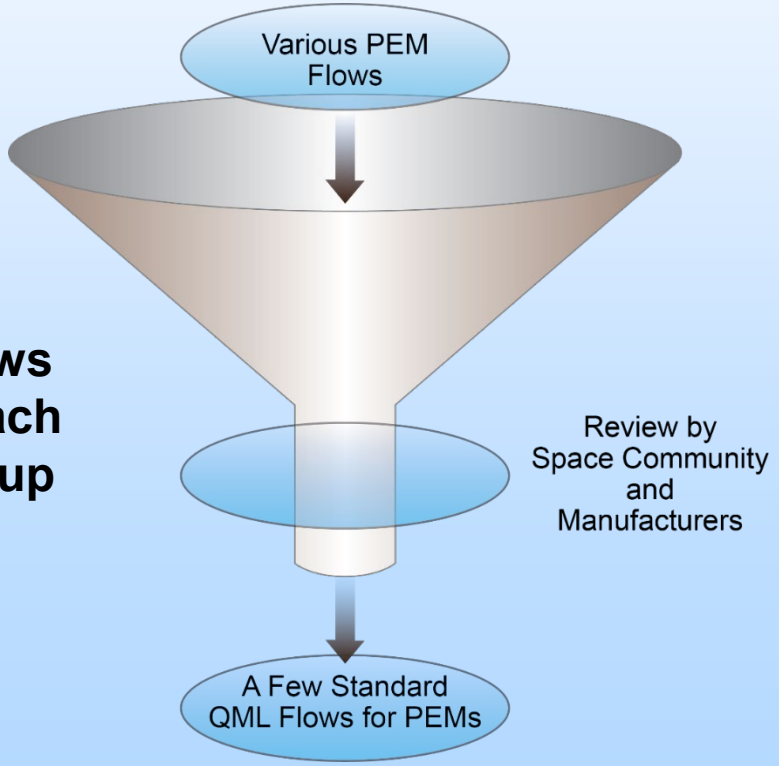
- **The Mars Helicopter for Mars 2020**
  - **The Mars Helicopter is part of the Mars 2020 Rover mission. Weighing at less than 4 lbs, it is made of light weight carbon fiber and other materials like aluminum, silicon and foil. Many challenges include withstanding temperatures dipping down to –130F (–90C).**

Cubesats for Deep Space Exploration

- **Growing Use of NASA Cubesats**
  - **Major suppliers, such as Texas Instruments, Analog Devices, Cobham, and Renesas, offer a range of up to seven solutions depending on quality, reliability, radiation, and cost. (This is not to say that the demand for standard QML products are going away – the manufacturers have reported robust sales of standard microcircuits.)**

- **Newer Applications**
  - **CubeSats**
  - **SmallSats**

- **Standardizing on a few well-defined flows rather than multiple flows defined by each manufacturer or by each standards group (including Automotive and VID parts).**
- **SAE AS6294, developed by CE-12, provided a good starting point.**



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 parts to a flow similar to AS6294/1
  - Actions:
    - JC13.2 voted to open a Task Group (TG)
      - T.I. (Samantha Williams) and Boeing (Rod de Leon) to co-lead
      - This TG has made good progress.

DLA's VID (Vendor Item Drawing) Program

Current Supplier's Program Benefits

1. Single Standardization Document
2. Controlled baseline.
3. Enhanced product change notification of processes, materials, electrical performance, finish, molding compounds and manufacturing locations.
4. Extended temperature performance.
5. Enhanced Pedigree - Reliability and electromigration checks, electrical characterization over temperature and confirmation of package performance over temperature.
6. Enhanced Obsolescence management.
7. No pure tin.
8. No copper wire bonds.

See the attached listing or check our website for an up to date list of product coverage.

DSCC ANNOUNCES THE RELEASE OF A NEW TYPE OF STANDARDIZATION DOCUMENT.

DSCC

DSCC is releasing new Vendor Item Drawings (VIDs) almost daily. These documents have been created to provide a procurement vehicle for enhanced commercial products. Specifically, commercially available microcircuit products are being documented for the first time on a standardization document. Use of these DSCC VIDs will avoid the use of manufacturer generated specification control drawings (SCDs) or manufacturer's VIDs and avoid the potential proliferation of non-standard products. The participating manufacturers have agreed to provide information and services that have not traditionally been associated with commercial products. See our website for a list of documents that are currently available.

All Vendor Item Drawings are ***NOW*** available on the DSCC web site

http://www.dscc.dla.mil/Programs/MilSpec/

- **Analog and digital functions offered**

Evaluating Automotive Parts for Potential NASA Applications

- The main drivers are size, weight, and price of electronic components.
  - Commercial electronic parts usually offer varied functions.
  - How do automotive parts compare to catalog commercial?

- Commercial Parts Options
  - Manufacturers make parts to meet the needs of their chosen market(s).
  - Automotive parts are designed to meet the needs of subsystem suppliers to automobile manufacturers.

- Space
  - Parts from manufacturers that are qualified to the Automotive Electronics Council (AEC) Q specifications seem to offer advantages for the SmallSat users.
  - NASA is continuing with limited evaluations of automotive electronic parts.

Texas Instruments (TI)

Space EP Baseline Controlled Flow

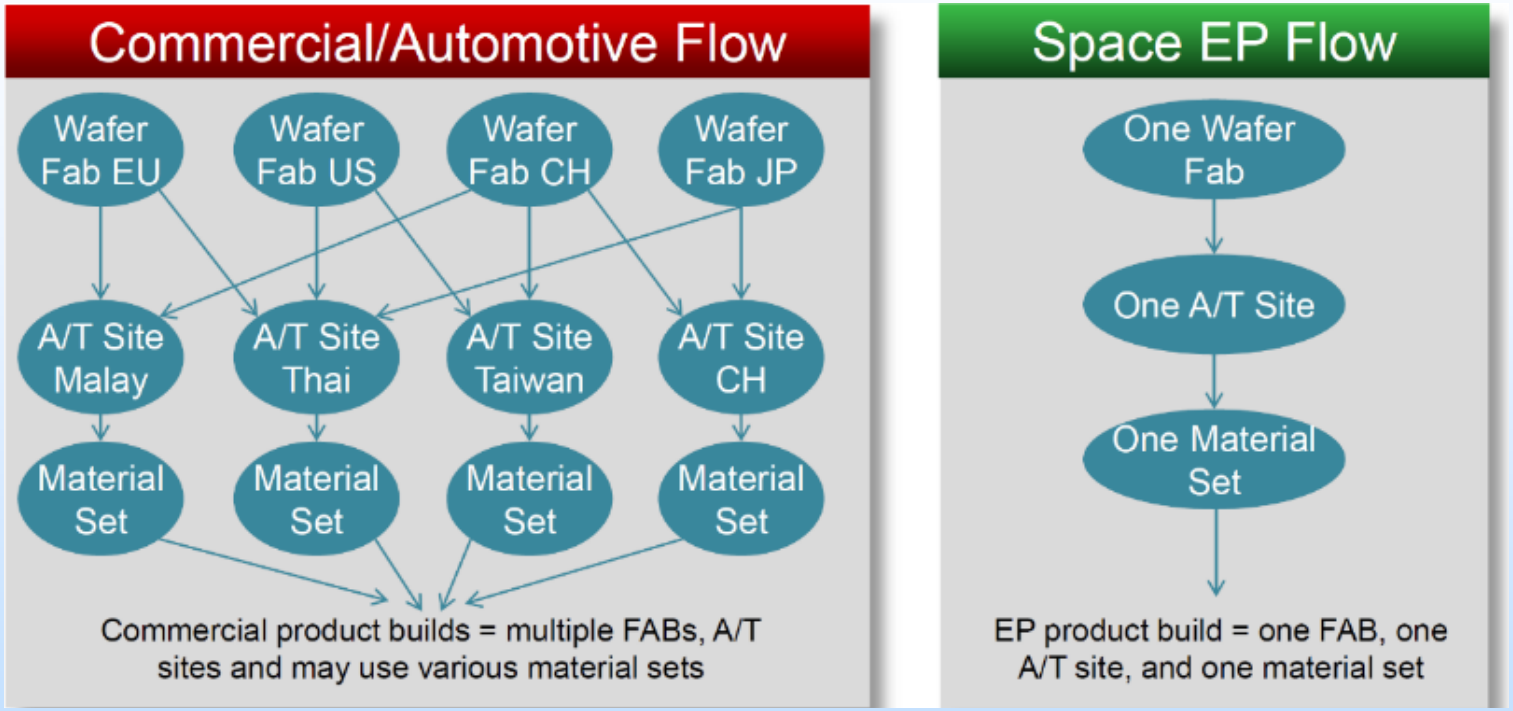


Image Courtesy of Texas Instruments

- **The above chart provided by TI shows that their commercial/automotive products may be built at multiple foundries and multiple assembly/test facilities and may use various material sets.**
- **(Contact TI for most recent version.)**

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.

ATM = Advanced Technology Microcircuits

MIL-PRF-ATM

- **ATM Devices include:**
  - **Flip-chip 2.5D, 3D**
  - **System In Package (SIP)**
  - **Multi Chip Module (MCM)**

- **ATM Devices class and application environment:**
  - **Class M for military(terrestrial and avionics) application**
  - **Class S for Space application**

SpaceX Dragon and Space Station Meet

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

Electronic Parts and Electrostatic Discharge (ESD) – Gaps and Mitigation Strategies

- Gaps have evolved because of new technology and inconsistencies of standards development (e.g., three zaps vs. one zap per pin for testing). Parts have continued shrinking to smaller sizes & growing in complexity. Consequently, they are more susceptible to ESD and require more testing effort.
- Costs cannot be ignored—per unit price for advanced devices is approaching $200k. ESD mitigation costs are minute compared to the device unit costs.
- Mitigation strategies include ESD surveys, observations during audits, standards updates (including harmonization of standards), & outreach to the military & space communities.
- NASA has been supporting Defense Logistics Agency (DLA) audits of the supply chain.
- During the audits, it was observed that the MIL-PRF-38535 requirements were practically nonexistent regarding ESD aspects of electronic parts.
- Microcircuit pin count has increased significantly (e.g., Vertex 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 Comments
ESD Specific

- **Metal vs Cloth Wrist Straps (Apple/Martinez/Gutierrez/Morehart/Dedmon)**
  - **JPL flows down quality clause (QC35d) to suppliers of EEE parts: it forbids the use of cloth wrist straps.**
  - **JPL surveyed 88 suppliers; 13 responded that they were using cloth wrist straps; 3 are not changing.**
  - **Metal wrist straps provide two significant benefits:**
    - **Maintain better contact with wearer's body**
    - **Decrease the risk of FOD (foreign object debris) generation**
  - **Community comments requested on this**

- **MIL-PRF-38535. ESD CDM. NASA and the Aerospace Corporation would like CDM testing made a requirement (rather than a recommendation). No surety which test method is worse, CDM or HBM. Most IC manufacturers perform both tests. For those who don't test for CDM, they could justify it in their QM plan which QA would review on a case-by-case basis.**

- **NASA EEE Parts Bulletins on GaN ESD (Han/Khan/Gallagher)**
  - **Released – Test results comparing HBM and CDM models**
  - **In progress – Compilation of ESDS data on GaN devices**

NASA Electronic Parts and ESD FY22

- **Activities (New issues every year)**
  - **Continue NASA ESD Surveys of Supply Chain – Doe, Nelson, others**
    - Align with DLA audits (At some point have DLA take over, we focus on non-QML/coml)
    - DLA Product Test Center (DLA's request)
    - JPL ASIC and PWM supply chains
    - GaN supplier(s) of interest to NASA (new technology)
    - Others TBD
  - **ESD Test Data (Deliverable: Test Report) – Michael Han, Erick Kim**
    - Limited resources
    - HBM per 883/3015 vs JEDEC 001. Data shows 883 test is worse of the two.
    - CDM per JEDEC 002
  - **ESD Program Implementation – Minh Doe**
    - Review ESD test data and issue internal guidelines
  - **Mil Standards Update – Agarwal (don't know which is worse, HBM or CDM - Technology dependent?**
    - CDM test should be made a requirement for ICs. Package capacitance should be stated.
    - HBM test method should be explicitly stated, whether 883/3015 or JEDEC 001.
    - What about the high speed pins?
    - ESD Latency is another concern.
    - Requirements to be added to 19500 and 38534
  - **Continue to support JC-13 Activity – Ovee, Agarwal**
    - Present at meetings
    - Facilitate Technical Talks on ESD
  - **Bulletins and Guidelines document – Khan, Gallagher, Khandker**
    - Continuing Effort
  - **Questions from Designers – Taylor**
    - Mostly related to overshoot/undershoot, undefined parameters in SMDs

The Last Page

- **Mars Sample Return and other notable projects signal an exciting new decade in space exploration.**
  - ***NASA's Ingenuity Mars Helicopter Successfully Completes First Flight***
  - ***Mars Report: Update on NASA's Perseverance Rover SHERLOC Instrument***

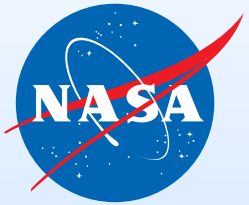
- **The infusion of new technology and the ongoing maintenance of current standards present both unique challenges and the opportunity to reinvent parts engineering.**

- **NASA champions and supports a large array of space missions and programs. Success of each mission is critical.**

- **ESD characteristics should not be neglected.**

- **JAXA MEWS workshops are an invaluable experience, offering participants the chance to work with space organizations around the world. Thank you, JAXA!**

http://nepp.nasa.gov



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