National Aeronautics and
Space Administration

MIL-PRF-38535 Standard Microcircuits Hermetic and Non-hermetic

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This artist's concept depicts astronauts and human habitats on Mars. NASA's Mars 2020 rover will carry a number of technologies that could make Mars safer and easier to explore for humans. JPL is building and will manage operations of the Mars 2020 rover for the NASA Science Mission Directorate at the agency's headquarters in Washington.

Image Credit: NASA

Presented at NEPP ETW, 15-18June2020
(Electronic Technology Workshop)

- The mission assurance organizations at NASA have supported many space missions/programs, large and small. Today, that spectrum has got wider, ranging from smallsats/cubesats to flagship missions such as the planned Europa mission. As always, the success of each and every mission counts.
- This presentation is about infusion of new technology into the standards for microcircuits, and the work underway to meet the needs of new missions.

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

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Infusion of the New Class (Y) Technology into the QML System for Space (Status given at JEDEC in January 2020)

Task Group Activities

- ☑ Review M. Sampson Idea
- ☑ Class Y Concept Development
- ☑ EP Study (DLA-VA)
- ☑ Coordination Meeting at DLA Land & Maritime (April 2012)
- ☑ DLA-VA to update 38535 with Class Y requirements and release the draft version (rev. K) for comments
- ☑ DLA-VQ to begin preparation for auditing Class Y suppliers
- ☑ 38535K Coordination Meeting
- ☑ DLA-VA to date 38535K
- DLA-VQ to begin audit of suppliers to Class Y requirements (in progress)
- Manufacturer Cert and Qual to QML-Y (DLA-VQ) (in progress)
- Users to procure QML-Y flight parts from certified/qualified suppliers (in progress)

Task Group Inputs

Government | Manufacturers | Primes | Others

G-12 Class Y Task Group Non-Hermetics in Space

Supplier PIDTP Presentation

- ☑ Aeroflex (October 2011)
- ☑ Xilinx (February 2012)
- ☑ Honeywell (May 2012)
- ☑ BAE (October 2012)
- ☑ e2v (January 2013)

Conference

- ☑ Minnowbrook Conference Oct. 2013, New York
- ☑ CMSE (Feb. 2013), LA

Task groups with Class Y interest formed and closed out.

Status as of January 2020

- Class Y First SMD available
- Qualified Mfr – Honeywell; Cobham (In progress)
- Certified Mfr – e2v Grenoble, Xilinx (Planned), Cypress (Planned)
- Certified Assembly and Test – Kyocera, e2v Grenoble
- Certified Column Attach Manufacturing – Six Sigma, Micross Crewe, Micross AIT, Honeywell, and BAE
- BME IDCs: Slash Sheets available.

Note: Certification = Capability Demo, Qualification = Actually Producing Part

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

Class Y Qualification Status

- Honeywell Aerospace - Plymouth
    - Complete
    - SMD 5962-17B01
    - Title: Microcircuit, Ceramic Non-Hermetic, Flip Chip, Digital, CMOS SOI, Gate Array, HX5000, Radiation Hardened, Monolithic Silicon
- Cobham Colorado Springs
    - In progress
    - SMD 5962-17B02
    - Tentative Title: Microcircuit, Digital, Radiation Hardened, 90nm Standard Cell, Monolithic Silicon, Class Y, Radiation Hardened, Monolithic Silicon
- Teledyne e2V Grenoble France
    - In progress
    - SMD 5962-19205
    - High performance processor, PC8548
- Cypress Semiconductor
    - Planned
    - 144 Mbit QDR IV SRAM

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ClassY Moving Forward

- A Follow-on to Ceramic Substrate Class Y
  - Interest in organic Class Y, and molded plastic parts had been growing.
  - The JC-13.7 created a new task group on organic substrate Class Y (September 2018).
  - Related task groups started as well (next slide)
- Defense Logistics Agency (DLA) conducted an EP (Engineering Practice) study

A test version of Orion

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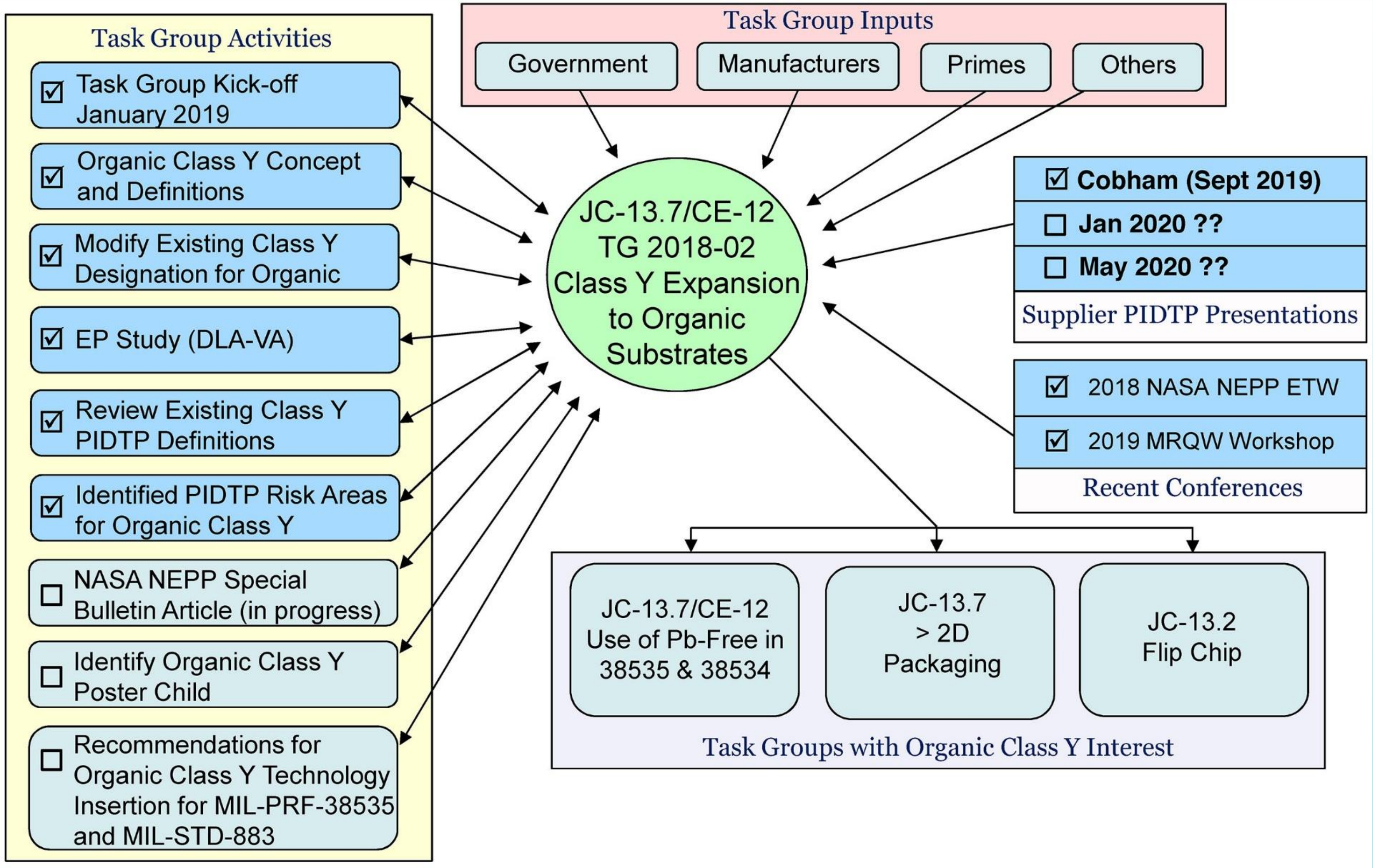
JC-13.7/CE-12 Task Group 2018 – 02

Organic Class Y Status Slide (updated September 2019)



Slide courtesy COBHAM

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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

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Upscreened Zynq Processor as a Poster Child for Organic Class Y Devices

- Xilinx Zynq processor is used at NASA/JPL.
- It is being screened by a third party vendor.
- The Screening Position EEE-INST-002 (Level 2)
- This effort was first reported at the Space Subcommittee meeting in Columbus, 9-18-19.
- The screening/qual information gathered will be shared with the Organic Class Y task group.
- It will serve as the poster child for the TG.
- Jason Heidecker will make a presentation on Thursday.
- FYI, for the space community

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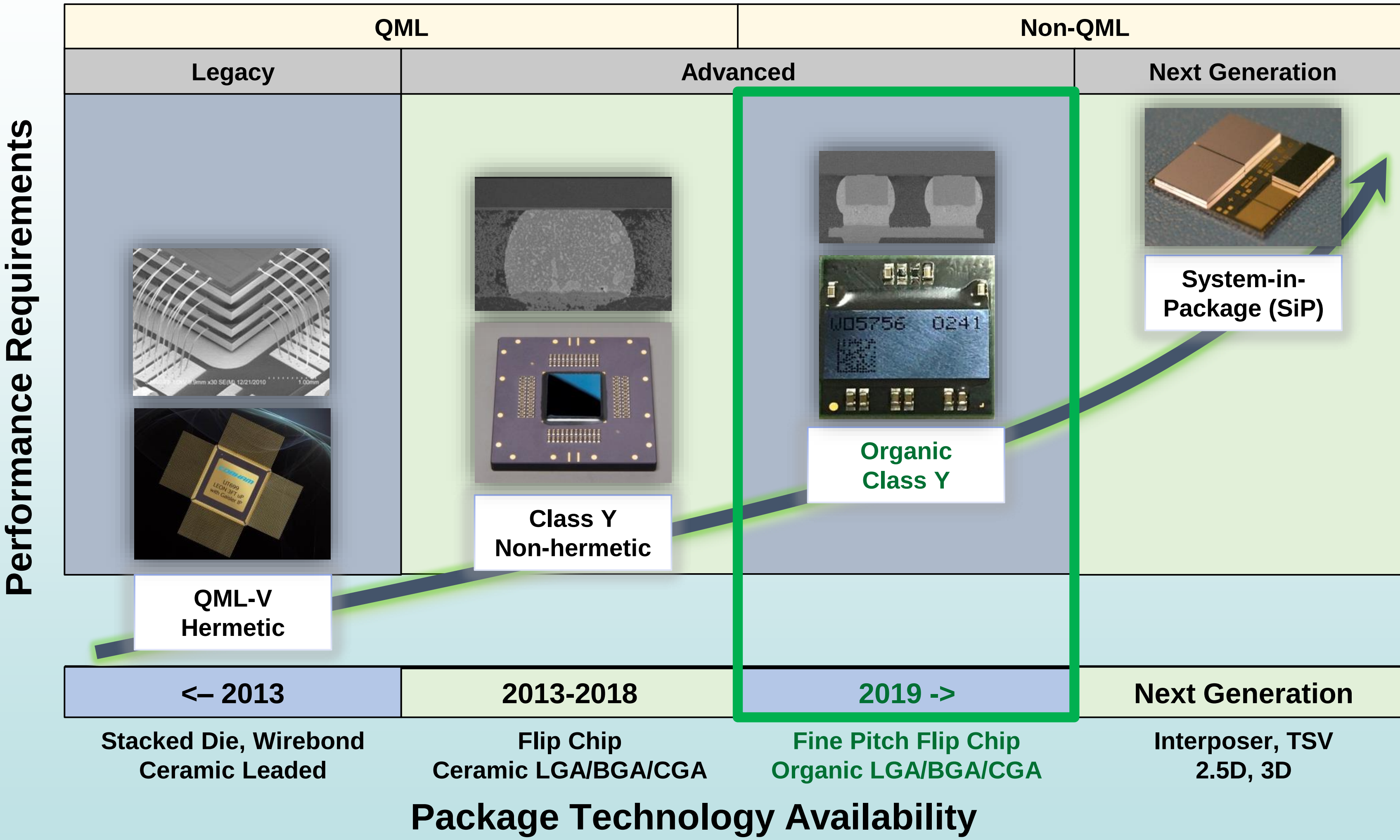
Next Generation Package Technology for Space

Development Roadmap for Space Applications



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

MIL-PRF-ATM
(Advanced Technology Microcircuits)

Presented by : Muhammad Akbar
DLA Land and Maritime -VAC
February, 2020

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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. 2.1D, 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

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MIL-PRF-ATM

- ATM Devices include:
  - Flip-chip 2.1D, 2.5D, 3D
  - System In Package (SIP)
  - Multi Chip Module (MCM)

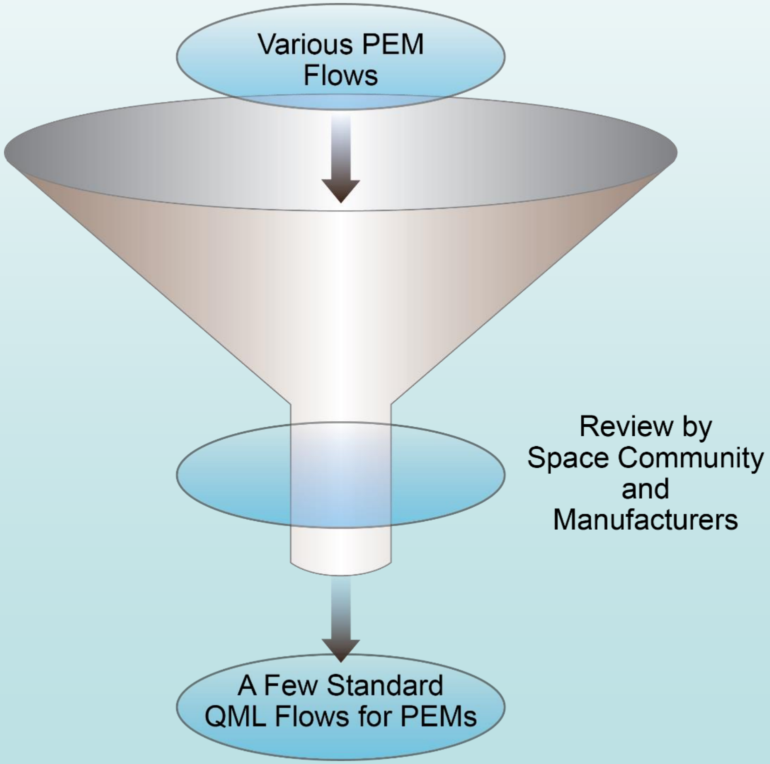
- ATM Devices class and application environment:
  - Class M for military(terrestrial and avionics) application
  - Class S for Space application

Cubesats for Deep Space Exploration

- Growing Use of NASA Cubesats
  - Many new NASA missions are Cubesats and Smallsats. 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, would be a good starting point.



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MarCO and Mars Helicopter

- 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
  - Weighing at less than 4 lbs, the Mars Helicopter will be part of the Mars 2020 Rover mission. Many challenges include withstanding temperatures dipping down to -130F (-90C).

Renesas (Formerly Intersil)

Test	Class V	PEMs Plastic	RT Plastic
Wafer Lot Acceptance	YES	YES	YES
Nondestructive Bond Pull	YES	NO	NO
Visual Inspection and Serialization	YES	YES	NO
Radiography(pre- and post-stress)	YES	YES	NO
Acoustic Microscopy (C-SAM, pre- and post-stress)	NO	YES	NO
Temperature Cycle	YES	YES	NO
PIND	YES	NO	NO
Constant Acceleration	YES	NO	NO
Interim Electrical Test (Pre- and Post-Burn in)	YES	YES	NO
Burn-in (Static and Dynamic)	YES	YES	NO
Final Electrical Test (Tri-temp, -55C, +25C, +125C)	YES	YES	NO
Percent Defective Allowable (PDA) Calculation	YES	YES	NO
External Visual	YES	YES	NO

Figure showing a comparison of Renesas's PEM and RT plastic production flows (www.renesas.com) Source: NASA EEE Parts Bulletin, May 2020,

- Renesas's radiation-tolerant (RT) plastic flow is intended for LEO missions with an expected life cycle of about 5 years or less. Their PEMs flow mimics the SAE AS6294/1. This flow essentially attempts to create a plastic "Class-V"-type flow and is intended for medium–Earth orbit (MEO) or GEO missions with an expected life cycle of over 15 years.

ST Microelectronics (ST)

Step	Description
Specification	TID 50krad(Si) – TIND : tbd SEL free @ 43MeV.cm2/mg + characterization up to 60 MeV.cm2/mg Temperature : -40°C to 125°C No serialization – No Burn in Certificate of Conformance
Die	Front end with ST Process control Electrical Wafer Sort with PAT (1) & GPAT (2) Wafer Lot Acceptance Test : HTOL + Radiation
Package	Assembly lines of AEC-Q100 qualified products Finishing : default Ni/Pd/Au Molding compound characterization (including RML & CVCM) Selected packages : TSSOP20 – PowerSO20; Others under evaluation
Screening	Based on AEC-Q100 : 10 Thermal cycles @ 100% + CSAM by sampling + external visual
Logistic	Packing : Tape & reel MOQ : 1000 pieces typical Max 2 date code per shipment & 1 date code / reel – No additional traceability at order entry Max date code : 5 year

Figure showing STMicroelectronics Rad-Hard LEO product line (plastic packaging) (www.st.com)

Source: NASA EEE Parts Bulletin, May 2020

- STMicroelectronics is working on creating a new product line for LEO applications. These products will be plastic-packaged, with assembly in ST’s high-volume back-end manufacturing sites, on assembly lines used for AEC-Q100-qualified products. The qualification of the LEO product line will be based on AEC-Q100 and will add by default 50 krad(Si) total ionizing dose (TID) and single-event latchup (SEL) immunity up to 43 MeV.cm2/mg, with a characterization up to 60 MeV.cm2/mg.

Texas Instruments Offerings (Source: D. Tanguay/R. Biddle, T.I., 4-3-20)

	Commercial	AEC-Q100	EP	QMLQ	Space EP	QMLV QMLV	QMLV-RHA
Packaging	Plastic	Plastic	Plastic	Ceramic	Plastic	Ceramic	Ceramic
Single Controlled Baseline	No	No	Yes	Yes	Yes	Yes	Yes
Bond Wires	Au/Cu	Au/Cu	Au	Al	Au	Al	Al
Can be Pure Tin (Sn)	Yes	Yes	No	No	No	No	No
Production Burn-in	No	No	No	✓	No	Yes	Yes
Radiation Tested	No	No	No	No	Yes	No	Yes
Radiation Assured	No	No	No	No	Yes	No	Yes
Typical Temperature Range	–40°C - 85°C	–40°C - 125°C	–55°C - 125°C	–55°C - 125°C	–55°C - 125°C	–55°C - 125°C	–55°C - 125°C
Extra Qualification and Process Monitors	None	X-Ray & Reflow, Outlier Control	Extended HAST, X-ray & Reflow, Outlier	MIL-PRF-38535 Group A, B, C, D	MIL-PRF-38535 "like" A, D, E	MIL-PRF-38535 Group A, B, C, D	MIL-PRF-38535 Group A, B, C, D, E
Life Test Per Wafer Lot	No	No	No	No	No	Yes	Yes
Description	Tailored for high-volume commercial applications and flexible supply	High reliability for automotive applications with flexible supply. Packages can use matte Sn and Cu bond wires.	Controlled baseline ensures more homogenous performance across lots. No Sn or Cu bond wire permitted. Uses increased reliabiity material sethomogeneous performance across lots. No Sn or Cu bond wire permitted. Uses increased reliability material set	Ceramic military grade parts released to a MIL spec. Intended for extreme environments and long term dormant storage	Space grade parts meant for low orbit missions. Screening for TID (Radiation Assured) High-reliability material set, similar to EP	Space grade parts release to a MIL spec. Meant for long lifetime, high reliability missions	Same as QMLV but additional lot testing and screening for TID (Radiation Assured)

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Texas Instruments (TI)

Space EP Baseline Controlled Flow

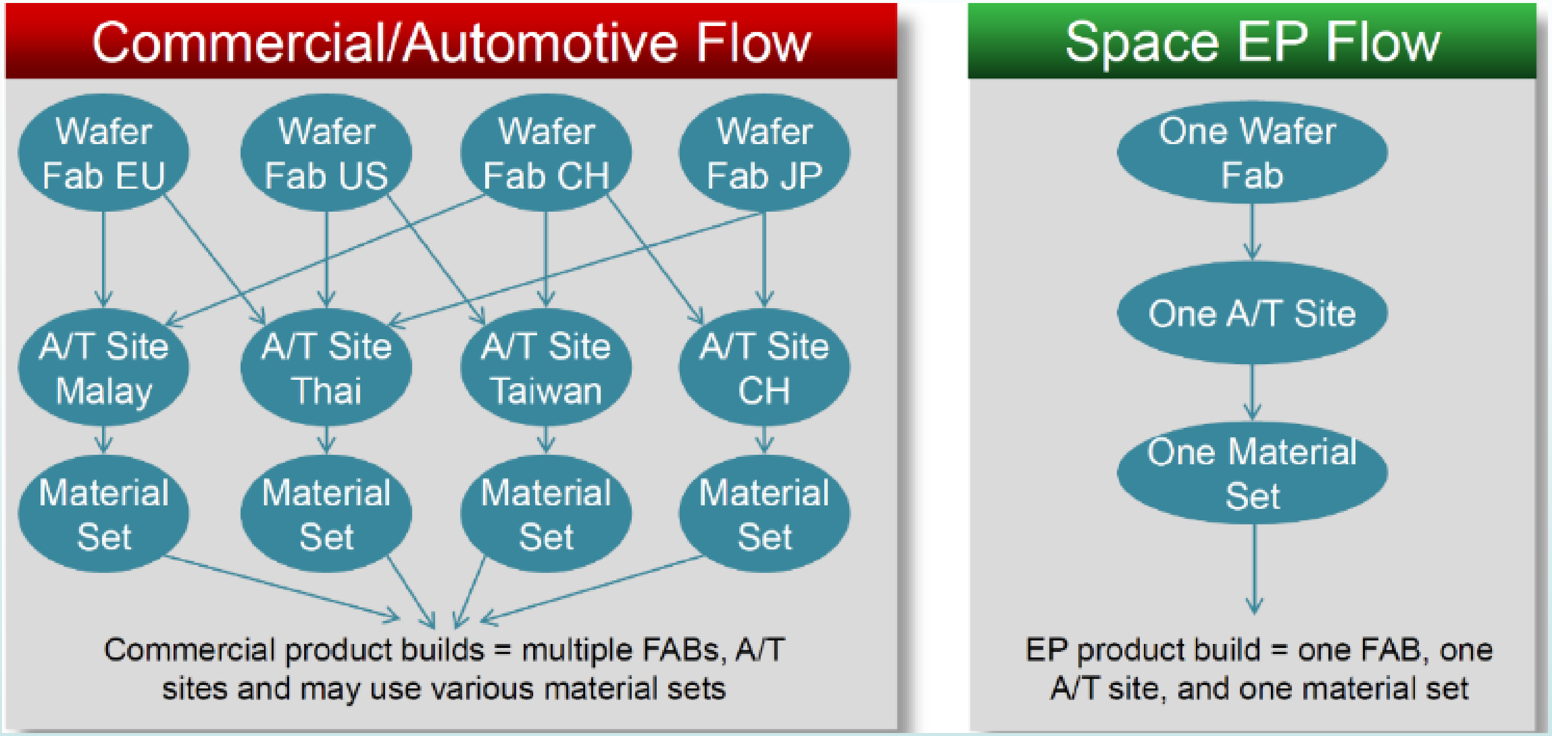

Image Courtesy of Texas Instruments

- The above chart provided by TI shows that their commercial/automotive products maybe built at multiple foundries, assembly/test facilities and may use various material sets.
- Contact manufacturer for a current version of this chart.

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Analog Devices, Inc. (ADI)

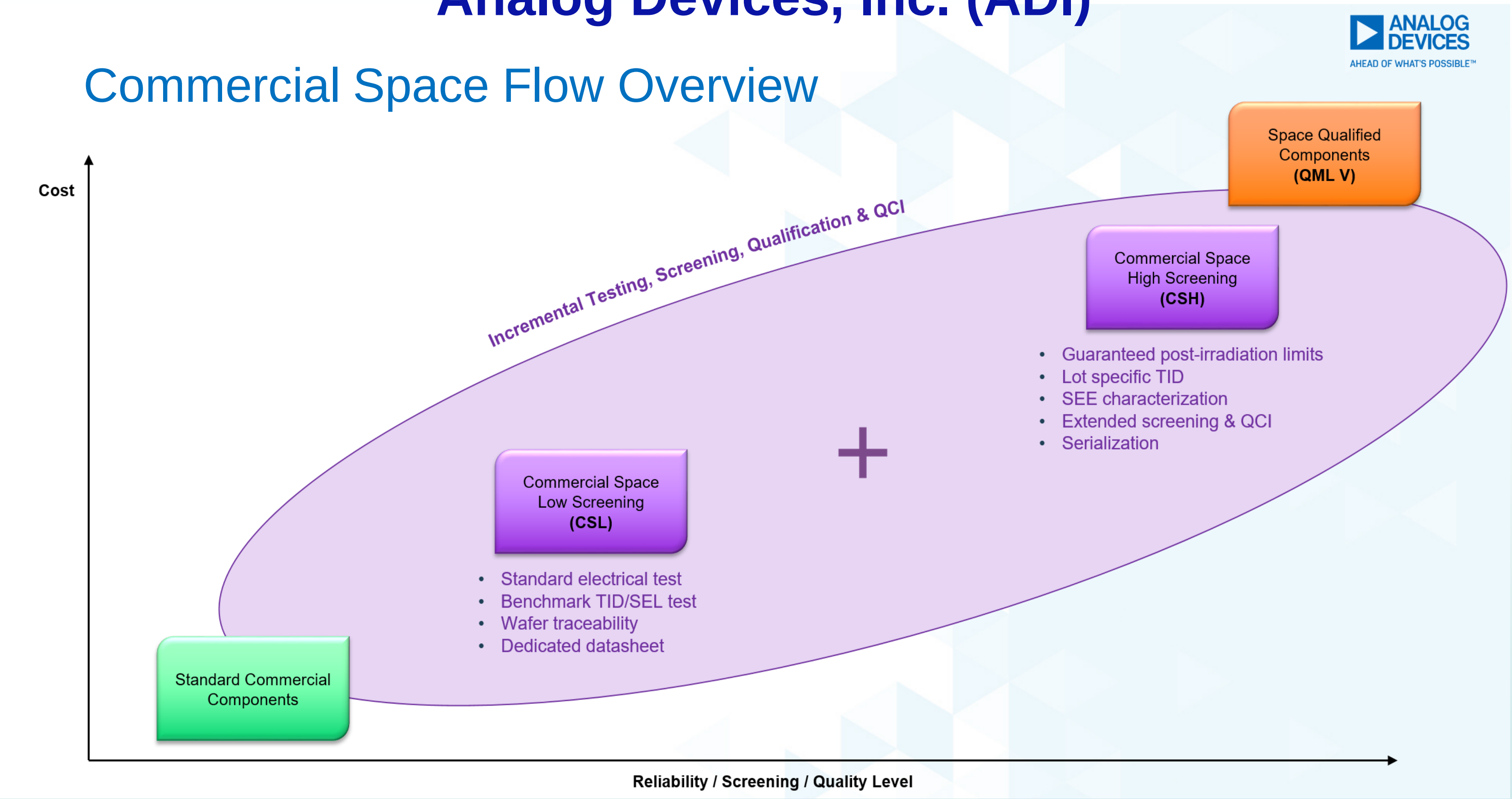

Figure showing Analog Devices commercial space flow grades (www.analog.com).

Source: NASA EEE Parts Bulletin, May 2020

- Analog Devices has established two commercial space product screening and qualification flows, namely Commercial Space Light (CSL), and High (CSH). The CSL flow is for low-cost, high-volume requirements, offering minimal testing and screening for LEO constellations. CSH provides the highest screening and qualification level, including 100% lot burn-in, Wafer Lot Acceptance Tests, burn-in deltas, and lot specific TID, targeted towards applications where no hermetic-package option is available (equivalent to QML V using SAE AS6294 as a guideline)

Cobham AES

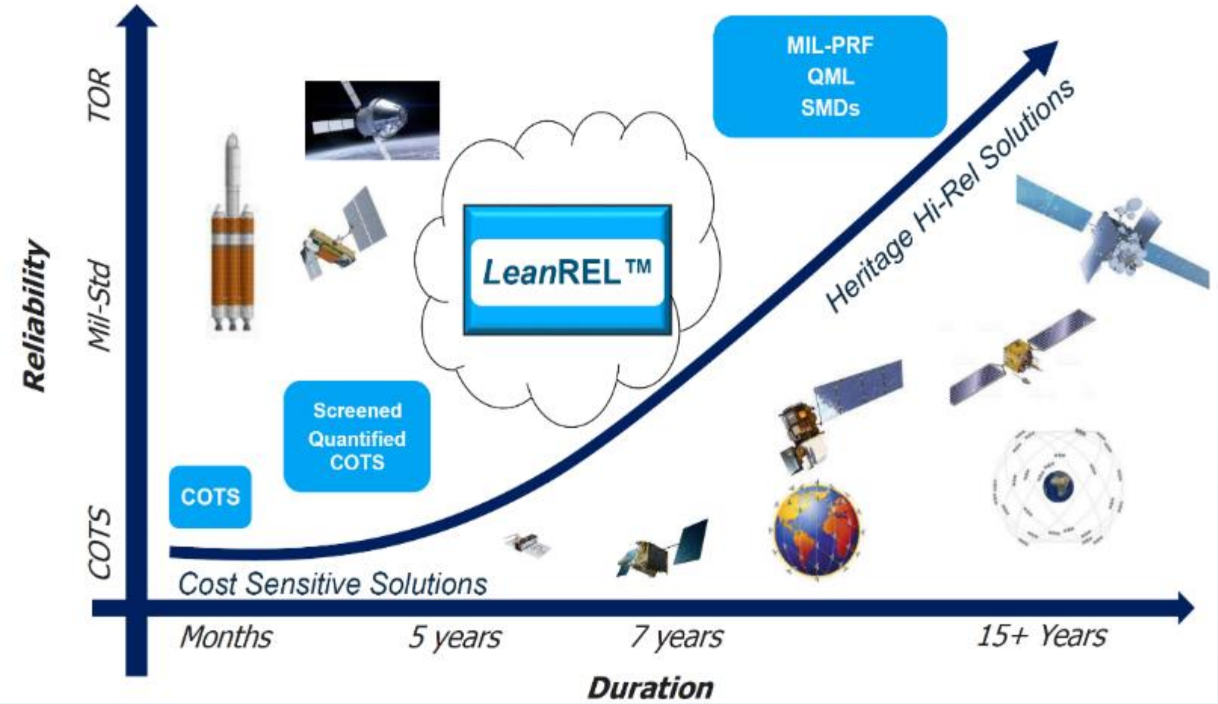

Figure showing Cobham LeanREL product line (www.cobhamaes.com)

Source: NASA EEE Parts Bulletin, May 2020

- Cobham AES is developing a new line of products called LeanREL. LeanREL products will provide an optimized balance for reliability, performance, and affordability and serve satellites with a 3- to 7-year lifetime. These products will provide a QML material pedigree, traceability, optimized test flows, and will be more affordable than QML parts.
- They also have an initiative to merge its quantified COTS (QCOTS) methodology with PEM-INST-001 (EEE-INST-002, Section M4). In an effort to retain some of the valuable features of the QCOTS methodology, such as single homogeneous wafer lots, traceability, restricted wire bonding, SEE and TID characterization per wafer lot, and more expansive electrical testing, Cobham has defined a PEMs+ methodology. Contact Cobham for more details.

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JC-13.7/CE-12

DLA Engineering Practice (EP) Study

EP study on
Update of non-hermetic microcircuits class N (military, terrestrial and avionics application and class Y (Space application) to MIL-PRF-38535.

I. OBJECTIVE: The purpose of this Engineering Practice (EP) Study is to obtain input and justification from the military services, microcircuit manufacturers, and space application user's communities, concerning the update/addition of non-hermetic class N (military, terrestrial and avionics application) and class Y (non-hermetic Space application) microcircuits to MIL-PRF-38535.

II. BACKGROUND: MIL-PRF-38535 offered non-hermetic class N (plastic package) and class Y (ceramic substrate non-hermetic device for space application). In table IB, class N has an inclusive table that comprises screening and QCI tests requirement, which called tests/monitors for plastic package. However, this inclusive table fails to distinguish between screening and QCI test flows that creates confusion with periodic QCI test monitoring issue as well as product reliability.

On the other hand, design requirement of modern electronics satellite/warfare systems are growing faster and moving forward with an advance and complex package technologies. Considering complexity of new technologies and device packaging techniques, JEDEC CE-12 formed a task groups (TG) for exploring the state of the art class Y concept to develop a new organic substrate flip chip devices, and 2D, 2.5D and 3D package technology requirements for qualification and screening of non-hermetic microcircuits packages for space applications.

Accordingly, to bring advancement and adopting new package technologies into QML system to MIL-PRF-38535, DLA Land and Maritime-VAC is conducting an EP study (phase 1) which includes:

(1) Update class N with separating screening and QCI tables to make robust high reliability plastic encapsulated microcircuits(PEM) devices for military, terrestrial and avionics application;

(2) Update/create a new appendix K (Next Gen) with other appendix/sections update for non-hermetic microcircuits devices that includes organic/ceramic substrate flip chip devices, 2D, 2.5D and 3D package technology requirements for space applications.

DLA Land and Maritime-VAC is requesting to review all attachment and send comments and feedback to DLA within the stipulated time for discussion and further development. Survey questionnaire (**see attachment # 1**) to evaluate the industries overall opinion for adding/updating class N and class Y devices package construction technical issues. Proposed non-hermetic class N and class Y devices screening and QCI requirements (**see attachment # 2**). Proposed update Appendix H (new technology qualification including PIDTP update (**see attachment # 3**). Proposed addition of Appendix K (Next Gen) for non-hermetic class Y devices including organic/ceramic substrate flip chip device, 2D, 2.5D and 3D package technology requirements for space applications (**see attachment # 4**).

Evaluating Automotive Parts for Potential NASA Applications

AEC Q specifications are Qualification Requirements Only, Focused on:

- A One-Time INITIAL QUALIFICATION of a Device Family
  - "Device Family" is Common Materials, Processes, Designs, Manufacturing Location, etc.
  - "Generic Data" may be used provided relevance of data can be demonstrated
- Requirements for REQUALIFICATION
  - Provides recommendations as needed
- Requirements for process change notification (PCN) to automotive customers
- THEY DO NOT PROHIBIT PURE TIN

– Whisker mitigation is recommended!

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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 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.
- Contact DLA for updates.

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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 in Space Applications.
- 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, there has been considerable interest at NASA in the use of standard plastic parts in space applications
  - This was discussed on the recent NEPAG (both domestic and international) and GWG telecons
    - We decided to pursue it - basically to see what would it take to make the SAE AS6294 a standard PEMs flow for Space.
  - Some options:
    - DLA to conduct an EP study
      - As shown on their respective charts herein, Renesas and ADI can supply parts built to the AS6294 flow
    - Open a JC13.2 task group, chaired by a major manufacturer

Conclusion

- New technology infusion is an on-going challenge.
- NASA supports a wide spectrum of space missions/programs ranging from smallsats/cubesats to flagship missions such as Juno and the planned Europa mission. The success of each mission is important.
- 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.

Thank you!

BACKUP MATERIAL

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NASA EEE Parts Bulletin, May 15, 2020

National Aeronautics and Space Administration

EEE Parts Bulletin

Electrical, Electronic, and Electromechanical

A periodic newsletter of the NASA Electronic Parts Program / NASA EEE Parts Assurance Group and the Jet Propulsion Laboratory

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Non-Hermetic and Plastic-Encapsulated Microcircuits

The mission assurance organizations at NASA have supported many large and small space missions and programs over the years. Today that spectrum has expanded, ranging from flagship missions such as Mars 2020 with its Perseverance Rover, Europa Clipper, and the proposed Europa Lander, to SmallSats/CubeSats such as the Temporal Experiment for Storms and Tropical Systems—Demonstration (TEMPEST-D) and Mars Cube One (MarCO). Plastic-encapsulated microcircuits (PEMs) have become more attractive since leading-edge alternatives are not available as space-qualified products. PEMs generally have smaller footprints and are lighter than the ceramic packages used in space-qualified products [1]. As the demand and use of non-hermetic and plastic-encapsulated microcircuits for space has increased, the scope of what future missions are capable of has also widened. This changing climate related to EEE parts selection presents new challenges for NASA, which—as always—holds the success of every mission paramount.

Growing Use of NASA SmallSats and CubeSats

Due to the need for low-cost communications satellites and new businesses evolving around Earth-observation services, there's been an increased interest in the use of CubeSats and SmallSats. Many NASA centers have been involved in developing and flying CubeSats and SmallSats, working together with multiple universities and industry partners. These undertakings require new product solutions for smaller, lighter, and lower-cost spacecraft, which cannot be produced using traditional space-qualified electronic parts.

The reliability and radiation requirements for CubeSats and SmallSats are significantly lower than for larger spacecraft because these smaller satellites operate mainly in low Earth or geosynchronous orbits (LEO or GEO, as opposed to deep space) and for relatively short periods. Radiation-hardened, high-reliability, space-grade parts are often too expensive for such missions and do not match well with their requirements.

There are a few notable exceptions to the usual use of CubeSats, particularly MarCO-A and MarCO-B, which were the first CubeSats to fly to deep space, where they successfully supported the Interior Exploration Using Seismic Investigations, Geodesy, and Heat Transport (InSight) mission by relaying data to Earth from Mars during the entry, descent and landing stage (Figure 1). MarCO successfully demonstrated a "bring-your-own" communications-relay option for use by future Mars missions in the critical few minutes between Martian atmospheric entry and touchdown. Further, by verifying that CubeSats are a viable technology for interplanetary missions, and feasible on a short development timeline, this technology demonstration could lead to many other applications to explore and study our solar system.

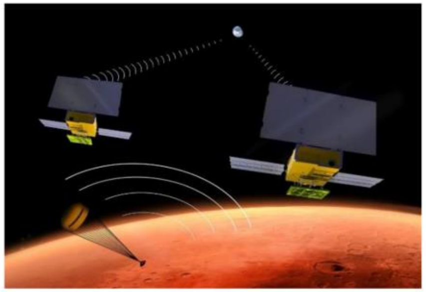

Figure 1. MarCO accompanying the InSight Mars lander and relaying data to Earth as it landed on Mars.

[1] The EEE Parts Bulletin was not published in fiscal year 2019 (FY19). The two issues of Volume 10 were published in FY18.

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Space Parts World

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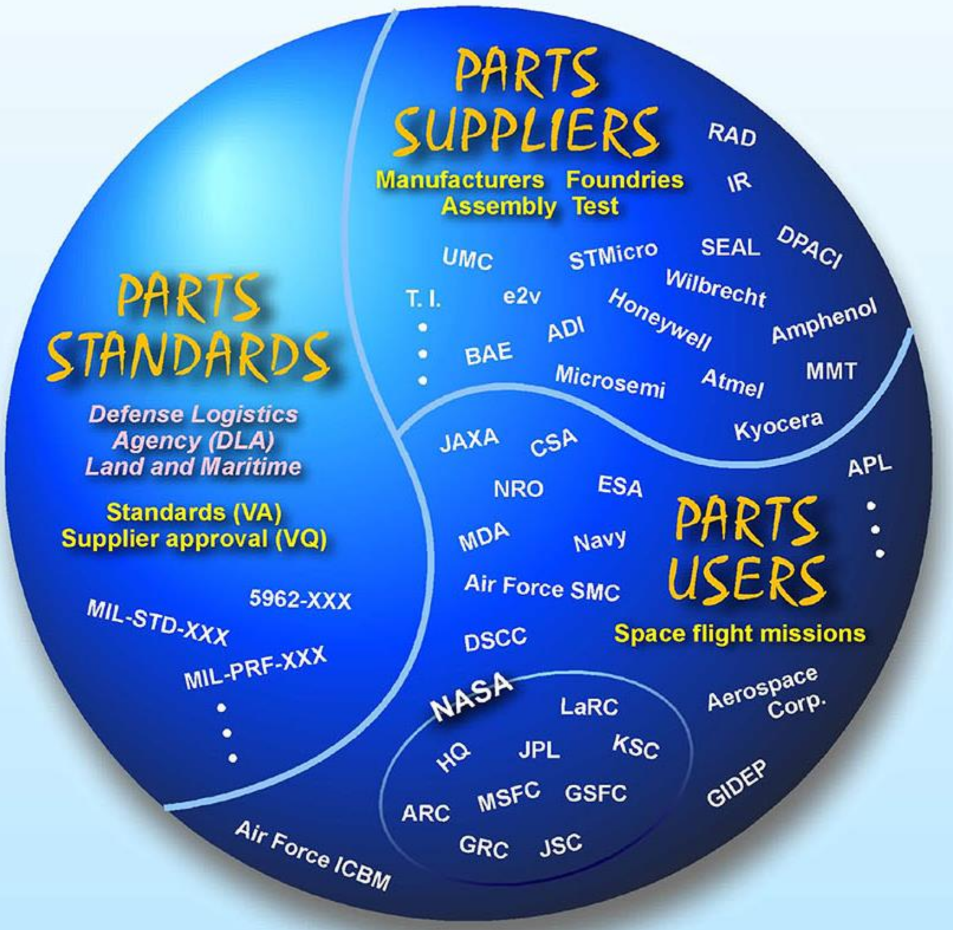

The parts users and standards organizations work with suppliers to ensure availability of standard parts for NASA, DoD, and others. **For Space microcircuits, DLA, NASA/JPL (S. Agarwal*) and the U.S. Air Force / Aerospace Corp. (L. Harzstark) form the Qualifying Activity (QA).**

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

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