National Aeronautics and Space Administration



# NEPAG Report NASA Electronic Parts Assurance Group

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Mars 2020 Perseverance Rover is exploring surface of Mars. The mission, targeted for launch in July/August 2020, takes the next step by not only seeking signs of habitable conditions on Mars in the ancient past, but also searching for signs of past microbial life itself.

Elements of this image furnished by NASA



## **NEPP – Mission Statement**



Provide NASA's **leadership** for developing and maintaining guidance for the **screening**, **qualification**, **test**, and reliable use of EEE parts by NASA, in **collaboration** with other government agencies and industry.



NASA Electronic Parts Assurance Group (NEPAG) is a core portion of NEPP

## **NASA Electronic Parts Assurance Group (NEPAG)**

- NEPAG is about Standards for electronic parts; finding solutions for NASA flight projects/programs; day-to-day parts issues. We are part of Mission Assurance Standards and Capabilities (MASC) Division.
  - o Maintenance
    - Provide NASA leadership
  - $\circ$  Creation
    - Infuse New Technology, e.g., Class Y for Space
    - Address the advances in packaging technology, e.g., newly started task group (TG) on 2.5D/3D devices
    - Respond to user requests, e.g., a new TG on standard plastic encapsulated microcircuits (PEMs) in Space
    - Relevant TGs: 3 main and 4 support TGs open
  - Related Activities
    - Hold telecons
      - NASA Electronic Parts Assurance Group (NEPAG)
      - Government Working Group (GWG)
      - Hybrid Working Group (HWG)
    - Support Defense Logistics Agency (DLA) audits of supply chain
    - Partnerships: JEDEC, SAE, Domestic and International space organizations, DLA, GIDEP, others
    - Standard microcircuits drawing (SMD) review
    - Outreach (Publish NASA EEE Parts Bulletins; present at meetings)
    - Learn and Lunch Webinars with the supply chain
    - Parts issues resolution at JPL. Booklet in progress.
    - Other as needed

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## Impact of COVID-19

#### Response to COronaVIrus Disease – 2019, COVID-19 (October 2020 onwards)

- Significant Impact
  - DLA Audits and NASA ESD surveys continued to be on hold
  - DLA 19500 manufacturer qualification group set up a process to perform virtual audits. Was supported by MSFC.
- 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
    - SWG 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
  - Learn@Lunch Webinars (changed to virtual only)
  - NASA Parts Bulletins (No impact)
  - SMD reviews (No impact)
  - JEDEC/SAE meetings (changed to virtual only)
  - Electronic Parts and ESD (Some impact)
  - Conferences/Meetings
    - All Virtual ESCCON, SPWG, NEPP ETW (NETW)
    - Mixed format JAXA MEWS
    - NASA Face-to-Screen-to-Face (F2S2F) Parts Meetings
      - Changed to all virtual format

#### Other

 The 8739-11 document was the subject of a NASA Technical Talk at the SAE CE-12 meeting last month. It was led by P. Majewicz, C. Green and N. Siddiqi.



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## **Telecons**

- **NEPAG Telecons** (Core team that sets the weekly agenda: S. Agarwal, B. Brandon, P. Majewicz, J. Pandolf, J. Brusse, K. Laird, L. Harzstark/Aerospace)
  - Held since 2000, these telecons drive the NEPAG program. The weekly cycle is shown below.
  - Typical Telecon Agenda Package contains
    - List of items for discussion
    - DLA audit schedule, SMD review status, Learn@Lunch Webinars, technical meetings, list of items for discussion at next JEDEC/CE-11, CE-12.
  - Return on Investment for NASA flight projects
    - \* Coordination of parts issues with DLA and the aerospace community
  - Q1-Q2 FY21 Status: Had 14 Domestic and 6 International calls.
  - Impact of Coronavirus: None

Wednesday	Thursday	Following Monday	Tuesday	Tuesday	Tuesday	Tuesday
Telecon Day	Send Request for Inputs for Next Telecon	Finalize Agenda with NASA/Ae- rospace team	Update Audit Schedule	Send Last Telecon Minutes	Contact Topic Leads	Publish Agenda Package
	•	Telecon Preparation Activities				

### Weekly Telecon Cycle



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5

## Defense Logistics Agency/Land and Maritime "DLA" Audits

### **DLA Audits**

- NASA supports DLA audits as technical experts. Responsibilities divided as follows:
  - Passives: Brusse; Hybrids: Panashchenko, Pandolf and Majewicz; PWB: Gutierrez; Discretes: Damron; Connectors: Billig; Test Methods: Laird; Microcircuits: Agarwal
- Reports: Verbal reports given on NEPAG telecons. SAS (Supplier Assessment System) report sent to M. O'Bryan at GSFC for posting on database at JSC.
- Return on investment for NASA flight projects
  - **Solution** Ensure that NASA inputs are incorporated into part manufacturers' processes
  - Review and resolve any parts issues with the manufacturers while on audit
  - Develop contacts for future needs (e.g., finding critical parts)
- FY21 Status: NASA participated in 2 virtual audits so far. Due to novel Corona virus crisis, DLA has postponed all travel until further notice.
- Impact of Coronavirus: Yes, major impact.

### **Audit Process**

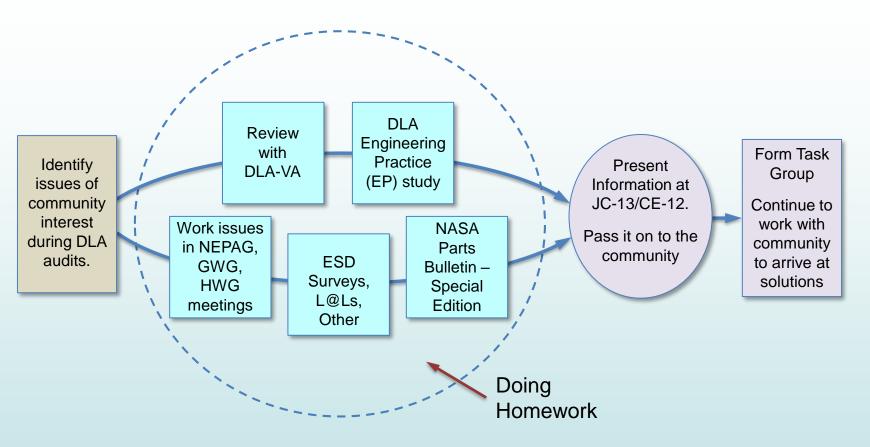
Decision	Pre-Audit	Conduct Audit	Audit Reporting	Post Audit	Going Beyond Audit
Telecon	Preparation for Audit Agenda Development	+ NASA ESD Survey Where Possible	NEPAG Telecon SAS Report	DARs Closure	New NASA Initiative Activity Flowing Out of Audits



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## **Taking Audit Findings a Step Further!**





- Bring general awareness (Via NASA Bulletins, Surveys, Learn and Lunch webinars with supply chain, presentations at meetings)
- Work with DLA to conduct engineering practice (EP) study
- Generate a basic proposal and related information so the potential task group (TG) has a strong starting point.
- This path has **saved time** in working on major issues.

## **Standard Microcircuit Drawings (SMDs) Review**

- SMDs Review/Standards Activity (All centers with NEPAG Partners)
  - NASA Specific Goals
    - Provide comments to DLA-VA on newly drafted SMDs.
      - > 10 day comment period
    - ✤ As part of QA (Qualifying Activity), review qualification data on new microcircuits
      - Several telecons are held with Aerospace, DLA and manufacturer
  - Return on investment for NASA flight projects
    - NASA gets to bring in their perspective on standards issues. JC-13/CE-11/CE-12 represent a big investment on standards activity for NEPAG. NASA works with the community on standards issues.
  - Impact of Coronavirus: No impact. Continued document reviews.

## JEDEC JC-13 / SAE CE-11, CE-12

### Support to JC-13/CE-11/CE-12

- Work with/lead JC-13/CE-11/CE-12 communities to develop/maintain standards
  - ✤ Vice-chair CE-12
  - Member Executive Council
  - Chair CE-11/CE-12 Space Subcommittee
  - Take CE-12 meeting notes
  - Present status update, e.g., Class Y
  - Actively support various task group meetings

#### • The May 2021 meeting was virtual

#### o CE-12 Leadership

- The current Chair will step down after January 2022
- NASA has a big investment in these meetings
- Agencies and the primes have to develop a succession plan
- Return on investment: JC-13/CE-11/CE-12 represent a big investment on standards activity for NEPAG. NASA works with the community on standards issues.

### • Future Meeting

The September 2021 meeting will also be virtual.

## **Electronic Parts and ElectroStatic Discharge (ESD)**

- Electronic Parts and ESD (N. Ovee, M. Doe, M. Nelson, M. Han, E. Kim, S. Agarwal)
  - NASA Specific Goals

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- During the DLA audits of the supply chain, we realized that there were practically no requirements for ESD. Need to update standards.
- Microcircuit pin count has increased significantly (e.g., Vertex FPGAs have 1752 columns). 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.
- Costs can not be ignored per unit price for advanced devices is approaching \$200k.
  ESD mitigation costs are minute compared to the device unit costs.
- ESD surveys/audits of COTS hardware/parts suppliers should be mandatory.
- Mitigation strategies include ESD surveys, observations during audits, standards updates & outreach to the military & space communities. There is always a latency risk from ESD.
- Outreach: NASA has published extensively on this subject (released 4 Parts Bulletins).
  We plan to publish a guideline document, and will continue to report at conferences.
- Return on investment for NASA flight projects
  - NASA initiated and led the Electronic Parts and ESD effort. We provide updates at JC-13 TG, SPWG and ETW meetings.
  - Supply chain is deriving benefits from NASA ESD Surveys.
- FY21 Status Report: Presented at JC-13 TG meeting in January. Conducting limited testing per human body model (HBM). Released NASA Bulletin on ESD testing.
- Impact of Coronavirus: Partial no NASA ESD surveys. Continued testing and meetings.

## **NASA EEE Parts Bulletins**

### • **EEE Parts Bulletins** (All centers with NEPAG Partners)

#### • NASA Specific Goals

- ✤ An outreach activity since 2005
- The EEE Parts Bulletin is a 4-10 page newsletter with articles of interest to the community.
  - Goal is to issue one to four times per year
  - > Distribution is to few thousand individuals in the user/supplier communities
- Return on investment for NASA flight projects. A unique NASA outreach activity which is appreciated by the space community around the world.
- **FY21 Status Report**: Released bulletins on non-hermetics, ESD testing, KGD.
- o Impact of coronavirus: None



## Learn at Lunch (L@L) Webinars with Supply Chain

### NASA L@L Webinars

#### • NASA Specific Goals

- Supply chain is asked to present technical descriptions of existing, new products under development, and their near-term vision. Marketing pitches are kept to a minimum.
- Usually held on Wednesdays at lunch time
- ✤ Audience: All NASA centers and space community. On-site and remote participation.
- Representatives from Standards organizations (e.g., DLA and ESA) have also presented on status/trends of EEE parts specifications.
- ✤ We gather manufacturer data on status of parts functions, e.g., A/D Converters.
- The supply chain likes these meetings because they get to meet their customers (hardware designers, parts engineers), see the campus, etc. Separate meetings are scheduled to review any on-going issues.
- The support is provided by JPL Component Engineering and Assurance Office (CEAO).
  - Management: M. Mojarradi, J. Bonnell, N. Sucher
  - > Organizing Team: B. Brodkin, N. Ovee, S. Agarwal
- *Return on investment for NASA flight projects* 
  - These Webinars give NASA (and other user community) an opportunity to get to know our supply chain.
- FY21 Status: Organized 14 Webinars. All were virtual.
- Impact of coronavirus: Limited supplier are no longer able to come on campus for face-to-face meetings with designers/parts engineers.

## **Partnerships**

	JEDEC JC-13 (Manufacturers)			-	AE CE-11/CE-12 y Users, Primes, Subs)
JC-13	Solid State Devices Government Produc		Joint meetings held	SAE SSTC	Users of Passive Components
JC-13.1	Discrete Semicondu for Government Pro		3 times a year	CE-11 SAE	Users of Solid State
JC-13.2	Microelectronics for Government Produc	ts 🛌		SSTC CE-12	Devices CE-12 Management:
JC-13.4	Radiation Hardness		NRO • USAF/SMC		Chair – A. Touw Vice Chair –
JC-13.5	Hybrids and Multi-c Modules for Govern Products	ment	SS NOA NASA HO The Act		(JPL) S. Agarwal
JC-13.7	New Electronic Dev Insertion for Goverr Products	ce ment	A Community Pursuing Excellence in Parts, Materials, Processes NEEPAG Since 2000	SAE SSTC CE-11 & CE-12	Space Subcommittee Chair – S. Agarwal
			A President Since 2000 S S S S S S S S S S S S S S S S S		
	NASA Centers:				ers from Outside NASA:
	ARC JSC GRC KSC GSFC LaRC JPL MSFC		Weekly NEPAG and Biweekly GWG Telecons (Domestic)	J T L	nestic IHU/APL, Others The Aerospace Corp, J.S. Air Force, U.S. Navy, J.S. Army, MDA, DLA
		•	Monthly Telecons (International and HWG)		mational ESA, JAXA, CSA



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### Space Parts World NEPAG helps to Develop/Maintain Standards for Electronic Parts

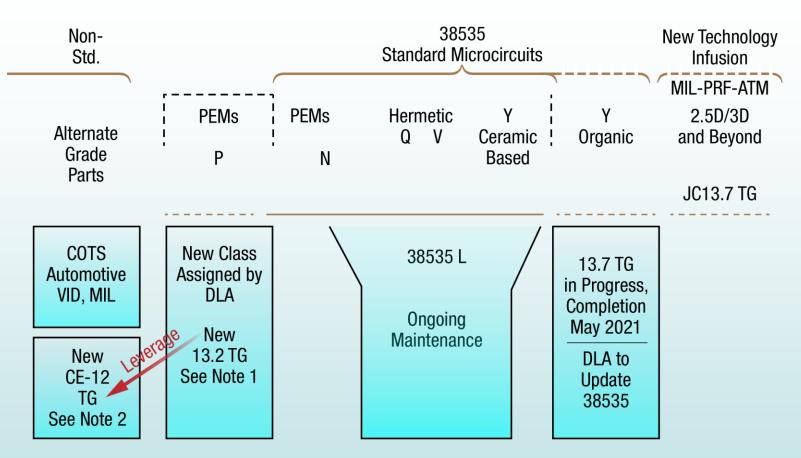




The parts users and standards organizations work with suppliers to ensure availability of standard parts for NASA, DoD, and others. For Space microcircuits, DLA, NASA/JPL (S. Agarwal\*) and the U.S. Air Force / Aerospace Corp. (L. Harzstark) form the Qualifying Activity (QA).

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

## Options for Microcircuits Rev. D, 6-10-21



- 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.

## **NEPAG Activities (Contd.)**

### Other Significant Activities

#### • NASA Parts Management Meetings

Held two times a year. The next meeting is June 21-22, will be virtual. (B. Bodkin, S. Douglas)

#### • Component Engineering and Assurance Office (JPL Office 514)

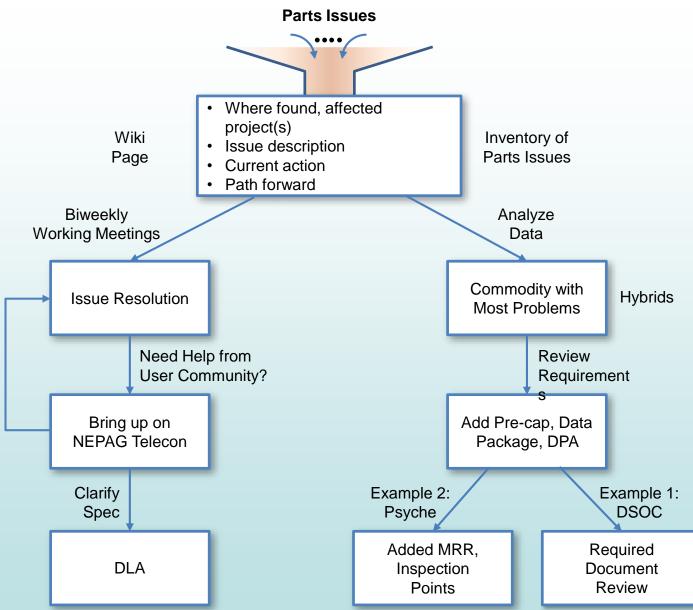
- S. Agarwal Chairs the bi-weekly meetings on path to resolve flight parts issues.
  - > Wiki Page. A wiki page has been created to simplify the effort.
  - Booklet. A booklet summarizing our experiences for the first 10 issues is being compiled. (R. Brandon, C. Marie-Peterson)
  - > **NEPAG Connection.** Used NEPAG, GWG and HWG telecons as a resource.
  - Hybrid DPAs and FAs. Since hybrids had the most problems, created a telework task to review their DPAs and FAs. (S. Gore, T. Apple, J. Martinez, R. Evans)
  - MIL-STD-883/Test Method 2012 Review. There were questions raised on third party disposition of hybrid X-ray results. A telework task was opened to review the radiography test method for any ambiguities. This work was submitted to the HQ. The comments were also passed on to the GWG for further discussion and recommendations. (J. Bescup)

#### Impact of Coronavirus

- DLA Audits and NASA ESD Surveys were postponed
  - A telework task was created to make supply chain assessment. The progress was reported on NEPAG domestic and international telecons. (I. Khan, S. Grover, L. Boyle)



### **Path to Parts Issues Resolution**



DLA: Defense Logistics Agency; DPA: destructive physical analysis; DSOC: Deep Space Operations Center; MRR: Manufacturing Readiness Review.



### Next Step: A "Parts Issues Booklet"

- The wiki page contains over 125 parts issues
  - How to use this data/disseminate this experience base to others while safeguarding information that might be vendor/JPL project- proprietary
  - Concept of a booklet evolved
- Create a booklet that
  - Captures the technical essence (summary) of each parts issue
    - In consultation with parts SMEs
- Share with NASA centers



## **BACK - UP**



19

## **NEPAG Activities in Q1-Q2FY21**



Activity	Q1	Q2	Q3	Q4	Total
*F	Y21				
DLA Audits Supported	**	**			0
NASA ESD Surveys	**	**			0
Standard Microcircuit Drawings (SMDs)	4	2			6
Domestic Telecons (Average Attendance)	7 (42)	7 (39)			14 (41)
International Telecons (Average Attendance)	3 (35)	3 (37)			6 (36)
NASA EEE Parts Bulletins	1	1			2
Learn @ Lunch Webinars	4	5			9
Meetings/Conferences (Agarwal)	1	1			2
JPL Inputs on INST Update		Done 3-29-21			
*Supported by: B. Bodkin, A. Hanelli, S. Khandker, N. Ovee, D. Gallagher, M. Han, R. Swain, K. Munsell, J. Martinez, C. Ashbury, A. Azizi, R. Evans, I. Khan, L. Boyle, S. Grover, M. Do, P. Spence, T. Gutierrez. **Postponed					

### NEPAG Activities in FY19 (No Covid) vs FY20 (Covid)

#### (COVID-19 impacted travel activities, such as Audits/Surveys. Meetings were changed to virtual format)



Activity	Q1	Q2	Q3	Q4	Total		
FY19 (No COVID)							
DLA Audits Supported	5	2	7	12	26		
NASA ESD Surveys	1	1	1		3		
Standard Microcircuit Drawings (SMDs) & Slash Sheets	5	7	2	1	15		
Domestic Telecons (Average Attendance)	6 (30)	10 (32)	5 (33)	8 (32)	29 (32)		
Intl Telecons (Average Attendance)	2 (27)	2 (28)	3 (29)	2 (27)	9 (28)		
EEE Parts Bulletin			1		1		
Learn@Lunch Webinars	2	3	5	4	14		
Meetings/Conferences (Agarwal)	1	1	3	2	7		
FY20 (COVID from Q2 to FY End)							
DLA Audits Supported	5	3	**	**	8		
NASA ESD Surveys	**	**	**	**	**		
Standard Microcircuit Drawings (SMDs) & Slash Sheets	2	5	9	4	20		
Domestic Telecons (Average Attendance)	7 (32)	9 (39)	9 (49)	8 (51)	33 (43)		
Intl Telecons (Average Attendance)	3 (29)	2 (29)	3 (40)	2 (40)	10 (34)		
EEE Parts Bulletin			1	*1	1+*1		
Learn@Lunch Webinars	4	8	2	5	19		
Meetings/Conferences (Agarwal)	4	2***	1***	1***	7		

- \* 1 Bulletin in review by NASA centers.
- \*\* Postponed \*\*\*Virtual

### NASA EEE Parts Bulletin, May 15, 2020



October 2019–March 2020 Volume 11, Issue 1,<sup>1</sup> May 15, 2020 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 space-craft, 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.

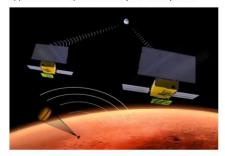


Figure 1. MarCO accompanying the InSight Mars lander and relaying data to Earth as it landed on Mars.

<sup>1</sup> The EEE Parts Bulletin was not published in fiscal year 2019 (FY19). The two issues of Volume 10 were published in FY18.

22



VEPAG

### NASA EEE Parts Bulletin **Special Edition: Non-Hermetic and Plastic-Encapsulated Microcircuits, Part 2** URS296932, CL#20-6169



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-gualified products. PEMs generally have smaller footprints and are lighter than the ceramic packages used in space-gualified products [1]. As the demand for 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 of EEE parts selection presents new challenges for NASA, whichas always-holds the success of every mission paramount. In this second issue devoted to non-hermetic and plasticencapsulated microcircuits, we discuss more manufacturers' PEMs flows, and introduce the AS6294/1 aerospace standard document on "Requirements for Plastic Encapsulated Microcircuits in Space Applications."

#### Aerospace Standard AS6294/1

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

In 2017, a subcommittee of SAE International's Group 12 (G12) was created to standardize a PEMs flow and to address a possible future extension of the Qualified Manufacturer List (QML) system to include PEMs for space. Considerable effort was put into developing a PEMs flow for space applications, documented in SAE Aerospace Standard AS6294/1, issued in November 2017, titled "Requirements for Plastic Encapsulated Microcircuits in Space Applications," The "/1" version was directed at space applications, the "/2" version at

terrestrial applications, SAF AS6294/1 pulled information from many Marshall Space Flight Center (MSFC), Goddard Space Flight Center (GSFC), and SAE standards applicable to NASA-namely, MSFC-STD-3012, GSFC EEE-INST-002, GSFC PEMS-INST-001, and SAE SSB-001-as well as reviews of multiple industry practices.

AS6294/1 defines the requirements for screening, qualification, and lot-acceptance testing for use of PEMs in space flight applications. The level of testing is dependent on the risk approach, the application, and the reliability and radiation requirements of the mission. However, AS6294/1 contains only requirements that meet the highest known reliability for space applications. The document also addresses many concerns associated with PEMs, such as narrower operating temperature ranges and greater susceptibility to infant mortality and moisture absorption than space-grade products have [2]. AS6294/1 starts with device characterization for parts that don't meet space requirements. The characterization step includes the initial investigations needed to understand the details of the technology used in a PEM product [2]. This is crucial when the

1

valuated the of a PEM in a	Non- Std.			385 Standard M			New Technology Infusion
nding on the n the manu- include con- evaluation,	Alternate Grade Parts	PEMs 6294 Based Space N	PEMs N	Hermetic Q V	Y Ceramic Based	Y Organic	ATM 2.5D/3D etc. ATM
s analysis. ortant infor- vorkmanship, ed to a PEM	COTS Automotive VID, MIL	DLA EP New 13.2 TG		38535 L Ongoing Maintenan		13.7 TG in Progress, Completion Jan. 2021	
ata gathered ning and lot- cation steps	New CE-12 TG See Note 2	See Note 1				DLA to Update 38535	

Note 1: Standard PEMs for Space initiative. Supported by NEPAG. Note 2: For alternate grade microcircuits, follow the activity in 13.2 TG d to all flight to avoid any duplication of effort. Will be discussed on the next NEPAG nd inspecting telecon (slated for Sep 30 2020). checks the

Figure 1, Options for standard, nonstandard, and new-technology microcircuits. creening test n AS6294/1

> TG will be heavily leveraged in order to avoid any duplication of effort. See Figure 1 for details on current and future options for nonstandard, standard, and newtechnology microcircuits

#### Manufacturer Solutions for Non-Hermetic and Plastic-Encapsulated Microcircuits

Historically, satellite programs have used space-grade, hermetically sealed, QML-V (space) and QML-Q (military) qualified components for enhanced reliability and radiation hardness. With the emergence of "commercial space," there has been increased interest in using PEMs in space for a variety of reasons. Countering the concerns cited above-narrow operating temperature ranges and susceptibility to infant mortality and moisture absorption [2]-are certain advantages of PEMs over most space-grade hermetically sealed microcircuits: lower cost and weight, more advanced performance, lower power consumption, and smaller overall package size. With this new growing trend in the market, an increasing number of suppliers now offer a wide range of enhanced plastic product solutions depending on quality, reliability, radiation, and cost. Not all of these product lines follow a consolidated test flow, and all depend on the specific tailoring that each manufacturer makes to them. Hopefully, in the near future, the industry will lean

mon flow that will be produced

develops and manufactures s for healthcare, life sciences, fense, security, and industrial ceramic and plastic, hermetic s, tested to various flows, O. OML-Y (non-hermetic for nore. Table 1 shows Teledyne nd qualification flows and the hey use [3].

space applications, sub-QML arrays (FPGAs) aimed at traditional QML components shelf (COTS) components, the radiation or reliability data. For ons and constellations of small tringent cost and schedule PGAs are the optimal solutions, tolerance of OML components flight heritage, which permits

reduced screening requirements, resulting in reduced cost and lead times.

Microchip also provides two space plastic flows: HiRel plastic radiation-tolerant (HP) and 8-lead plastic smalloutline (SN). The HP flow is for low-cost and high-volume requirements, typically meeting low-Earth-orbit (LEO) constellations' needs. The SN flow provides a higher screening level, including wafer lot acceptance, serialization, 100% thermal cycling, 100% burn-in, and PDA. These flows apply to both rad-hard-by-design and rad-tolerant products. Products made to these flows (SN, HP) meet gualification levels compliant with automotive requirements (AEC-Q100), with the SN flow based on AS6294/1. See Table 2 for more details on the screening and gualification flows for Microchip HP and SN devices [4].

Micross offers an extensive array of COTS componentsboth hermetic and plastic-including a wide selection of power modules and small-signal discretes. They also stock a wide range of upscreened plastic products, including an assortment of integrated PEM (iPEM) memory devices that have been tested to selected highreliability performance levels. In their Retail+ products line, Micross provides customers with industry-leading

ence of "commercial	n Benefit		"-Nx" NASA level			Enhanced
terest in using PEMs			Level 1	Level 2	Level 3	-EP
ntering the concerns		Specification reference>>	EEE-INS	T-002 / PEM-II	VST-001	Int. procedure
perature ranges and	ssembly a	and test site, one BOM	4	1	*	*
d moisture absorp-	datalog		1	~	4	
of PEMs over most		Condition/method				
microcircuits: lower performance, lower		MIL-STD-883 TM1010 cond. B (-55/125°C) or C (-65/150°C) MIL-STD-883 TM2012	20 cys - cond. B	20 cys - cond. E	120 cys - cond. E	310 cys - cond.
erall package size.	diate	WIE-51D-665 TWI2012		•	•	
and the second second second	ciace	MIL-STD-883 TM1015 cond. D (125°C)	240 hrs	160 hrs	160 hrs	160 hrs
harket, an increasing	ctricals	MIL-STD-883 TM1015 conds. A. B or C (125°C)		2001113	200103	200 1115
e range of enhanced	(wed)	Ambient temperature post dynamic	5%	10%	10%	5%
nding on quality,	tricals	Per device specification (-55/125°C)	4	1	4	4
all of these product		Per device specification (25°C)				1
, and all depend on	SA)	Condition/method				
ufacturer makes to		TID & SEE	Per rad tests	Per rad tests	Per rad tests	
he industry will lean		PEM-INST-001	22	22		
		Moisture soak/Reflow simulation	32	32	17	
		MIL-STD-883 TM1005 / D / 125*C	1500 hrs / 22	1000 hrs / 22	500 hrs / 10	
	e cycling	MIL-STD-883 TM1010 / 8 + DPA	500 cys / 22	200 cys / 22	100 cys / 10	
		PEM-INST-001	22	22		
Sub-group 1b - DPA/FA		EEE-INST-002 on 5 parts	*	1		
Sub-group 2 - Biased HAS	т	JESD22-A110 96 hrs / 130°C / 85% RH	10			
		JE5D22-A118 / A / 96 hrs / 130°C / 85% RH		10	7	

<sup>1</sup>This issue is a follow-on to Volume 11, Issue 1, released May 15, 2020: "Non-Hermetic and Plastic Encapsulated Microcircuits."

leon of Boeing. e the task group based on JC13.2 completes its work, a new proposed TG will be formed to support alternategrade microcircuits. The work performed by the JC13.2

nd functional tests, a percent

value is calculated with a

rformed on parts that pass

step includes life-testing

temperatures, temperature

I by failure analysis for any

As have met all requirements

ver become a standard QML

mmediately adopted in its

nufacturers, who offer their

that in AS6294/1. With the

the use of standard plastic

ns, the space community

iment and take a renewed

a standard PEMs flow for

scussed in domestic and

nic Parts Assurance Group

open a new task group was

20 JC13.2 session, in which

task group from industry

WG support. The task group

mantha Williams of Texas

Working Group (GWG)

are cleared for flight.

## NASA EEE Parts Bulletin **Special Edition: Comparison of Test Methods for** Human Body Model (HBM) Electrostatic Discharge (ESD) URS296931, CL#20-6000



#### Volume 11, Issue 2, September 27, 2020

#### Special Edition: Comparison of Test Methods for Human Body Model (HBM) Electrostatic Discharge (ESD)

Damage from ESD is a cause of major costs to the microcircuit industry in terms of time, money, and mission risk. The EEE Parts Bulletin has released four special issues on ESD [1]-[4]. The first issue, in 2016, stressed the need to upgrade specifications related to FSD and suggested improved FSD practices wherever parts are manufactured, stored, or prepared for shipment. The second ESD special issue, in 2017, focused on a parts failure investigation that ultimately identified ESD as the most likely cause of the failure. The 2017 special issue also included an important reminder about regular ESD testing. The third issue, in 2018, provided an example demonstrating the importance of maintaining ESD discipline and high-level risk analysis related to ESD. The fourth issue, later in 2018, was a compendium of the previous three special issues and included an overall updated view of the subject matter.

The current special issue focuses on one specific aspect of ESD damage that is caused by the human body during parts handling. The susceptibility of electronic devices to such damage is characterized by the human body model (HBM). For

1

illustration, the magnitude of electrostatic voltage built up on a chip under different handling means and relative humidity (RH) conditions is shown in Table 1 [1]. A microcircuit device exposed to an ESD event induced by contact with a human body can easily experience an electrostatic voltage attack in the kilovolt range. Thus, a better understanding of HBM ESD events is warranted. In this issue of the EEE Parts Bulletin, we report on independent experimental evaluations of two popular HBM-specific test methods: MIL-STD-883 Test Method 3015.7 [5] and JEDEC JS001-2017 [6]. Similar to the latter, the Automotive Electronics Council (AEC) HBM test method is also included for reference. For a fair and straightforward comparison, a chosen microcircuit chip was subjected to HBM zaps under MIL-STD-883 and JEDEC/AEC conditions, respectively,

#### HBM Test Standards

**IEPAG** 

A good overview of HBM test standards was presented in the first EEE Parts Bulletin special issue on ESD [1]. In this special issue, we compare and evaluate three popular HBM test standards:

- 1. MIL-STD-883 Test Method 3015.7 (abbreviated MIL-STD-883) [5]
- 2. JEDEC JS001-2017 (based on JESD22-A114. abbreviated JEDEC-JS001) [6], [7]
- 3. AEC-Q200-002 REV-B (abbreviated AEC-Q200) [8]

Means of Static	Electrostatic Voltages				
Generation	10-20% RH	65-90% RH			
Walking across carpet	35,000	1,500			
Walking over vinyl floor	12,000	250			
Worker at bench	6,000	100			
Vinyl envelopes for work instructions	7,000	600			
Common poly bag picked up from bench	20,000	1,200			
Work chair padded with polyurethane foam	18,000	1,500			

In the following sections, test methods and classifications for these three test standards are extracted from their respective specification documents. The test methods and classifications are summarized and compared in Table 5. There are many similarities between JEDEC-JS001 and AEC-Q200, so the primary focus of the comparison was between MIL-STD-883 and JEDEC-JS001.

#### ulnerable to cumulative 001 are shown in Table 3. eshold classifications for HBM EDEC-JS001. Voltage Threshold 0 to 49 volts 50 to 124 volts

Class 2

Class 3A

Class 3B

#### 125 to 249 volts 250 to 499 volts 500 to 999 volts. 1,000 to 1,999 volts 2,000 to 3,999 volts 4 000 to 7 000 volte 8.000 volts and above

2

#### AEC-0200-002 REV-B

#### Test Method

AEC-Q200 stipulates: Each sample group shall be composed of 15 components (five voltage levels with three parts per voltage level) and tested using a direct contact discharge probe at one voltage level, at steps of 500 V. 1 kV. 2 kV. 4 kV. and 8 kV. or using an air discharge probe at 25 kV. Two discharges shall be applied to each pin under test within a sample group and at each stress voltage level, one with a positive polarity and one with a negative polarity.

#### Classifications

Classifications per AEC-Q200 are shown in Table 4.

base	d on AEC-Q200.
Classification	Voltage Threshold
Class 1A	0 to 500 volts (DC)
Class 1B	500 to 999 volts (DC)
Class 1C	1,000 to 1,999 volts (DC)
Class 2	2,000 to 3,999 volts (DC)
Class 3	4,000 to 5,999 volts (DC)
Class 4	6,000 to 7,999 volts (DC)
Class 5A	8,000 volts (DC) to 11,999 volts (AD
Class 5B	12,000 to 15,999 volts (AD)
Class 5C	16,000 to 24,999 volts (AD)
Class 6	25,000 volts (AD) and above

The main differences among MIL-STD-883, JEDEC-JS001, and AEC-Q200 test methods and classifications are summarized in Table 5.

#### Table 5. Comparison of MIL-STD-883, JEDEC, and AEC test

	methous and	a classifications.	
Item	MIL-STD-883	JEDEC-JS001	AEC-Q2
Sample Size	Not specified	Three	Three
First Pulse	500 V	50 V	500 V
Pulses per Zap	3 +ve pulses followed by 3 -ve pulses	1 +ve pulse followed by 1 -ve pulse	1 +ve pulse followed by 1 -ve pulse
Timing Interval between Pulses (min.)	1 second	0.3 second	Not specifie
Classifications	Three main groups (1,2,3)	Four main groups (0,1,2,3) and three subgroups (OZ/OA/OB, 1A/1B/1C, 3A/3B)	Six main g (1,2,3,4,5,6 and two subgroups (1A/1B/1C 5A/5B/5C)

ications.	t HBM	
C-JS001	AEC-Q200	
	Three	Three pa
	500 V	Two par
ulse d by ulse	1 +ve pulse followed by 1 -ve pulse	One par
		0-883

then o tage st uent za esults TD-883 HBM M3 sho zaps ac

e show Pins 1–9 of the three parts consi HBM zaps.

UT) selected for this digital driver fabricated using a nentary metal-oxideechnology. This is a common al NASA Jet Propulsion All of the DUT parts were ate/lot code and tested by the e same test procedure and was based on a two-terminal terminal was always itching system (VSS) while the ed to the specific test pin of the pins floated, Proper HBM tions were also performed xperiment.

#### TD-883 and JEDEC-JS001

d on this octal driver chip using tep following test procedures d JEDEC-JS001 methods experimental results and as conducted under "stope can conclude that the ed after the 250-V step per S001 classifications. The failure 15% tolerance in measured nd post-zapped two-terminal acterization.

#### trial (250-V pulse step).

Results	19
	20
ts failed after 250 V	SN M3
a failed after 250 V failed after 500 V	Pins
	1
	2
	3
designed with smaller	4
	5
ep of 50 V with 100-V	6
aps: 50 V, 100 V, 200 V.	7
of the second trial-run	8
	9
<ol><li>Two parts (M1 and</li></ol>	11
ESD failures over a	12
owed that it could	13
	14
ross all its pins. Another	15
ed in Table 6 is that	16
istently failed after the	17

M1				
Pins	50V	100V	200V	300V
1	Failed	NA	NA	NA
2	Failed	NA	NA	NA
3	Failed	NA	NA	NA
4	Failed	NA	NA	NA
5	Failed	NA	NA	NA
7	Failed Failed	NA	NA	NA
8		NA	NA	NA
9	Pass	NA	NA	NA
11	Pass	NA	NA	NA
12	Pass	NA	NA	NA
13	Pass	NA	NA	NA
14	Failed	NA	NA	NA
15 16	Pass	NA	NA	NA
10		NA	NA	NA
1/	Dace	NA	NA	NA
19	Pass	NA	NA	NA
20	Failed	NA	NA	NA
M2				
Pins	50V	100V	200V	300V
1	Failed	NA	NA	NA
2	Pass	NA	NA	NA
3	Failed	NA	NA	NA
4	Failed	NA	NA	NA
5	Failed	NA	NA	NA
6	Failed	NA	NA	NA
8	Failed	NA	NA	NA
9	Failed	NA	NA	NA
11	Pass	NA	NA	NA
12	Failed	NA	NA	NA
13	Pass	NA	NA	NA
14	Failed	NA	NA	NA
15	Pass	NA	NA	NA
16	Failed	NA	NA	NA
17	Pass	NA	NA	NA
18 19	Pass	NA NA	NA NA	NA NA
20	Pass	NA	NA	NA
M3	a annea	11/4	104	1975
Pins	50V	100V	200V	300V
1	Pass	Pass	Pass	Failed
2	Pass	Pass	Pass	Pass
3	Pass	Pass	Pass	Failed
4	Pass	Pass	Pass	Failed
5	Pass	Pass	Pass	Failed
6	Pass	Pass	Pass	Failed
7	Pass	Pass	Pass	Failed
8	Pass Pass	Pass Pass	Pass	Failed
11	Pass	Pass	Pass Pass	Pass
12	Pass	Pass	Pass	Pass
13	Pass	Pass	Pass	Pass
14	Pass	Pass	Pass	Pass
15	Pass	Pass	Pass	Pass
16	Pass	Pass	Pass	Pass
17	Pass	Pass	Pass	Pass
18	Pass	Pass	Pass	Pass
19	Pass	Pass	Pass	Pass

0 to 1 999 volts 2.000 to 3,999 volts 4 000 volts and above mple of three devices for haracterized for the device

> 1 kV. 2 kV. 4 kV. and 8 kV s shall be stressed at one tive and one negative pulse seconds between pulses. ed and should be used if the

Method 3015.7

mple of devices shall be

2 kV, and 4 kV, as a

be tested using three

he pulses.

IL-STD-883.

pulses with a minimum of

883 are shown in Table 2.

eshold classifications for HBM

Voltage Threshold

recommended voltage steps

ESD failure threshold using

24



EPAG

### NASA EEE Parts Bulletin Special Edition: Known Good Die

### URS299800, CL#21-2280



#### Known Good Die

There are many use cases for which engineers and designers elect to purchase bare die for their applications. They might integrate the die into a multichip module (MCM), or use it directly as a chip-on-board (COB), in order to meet size, cost, and mass constraints. In some special radio frequency (RF) applications a COB solution might be required to minimize the inductance and capacitance of integrated circuits leads. Furthermore, many manufacturers purchase bare die from other providers and integrate it into their packaged parts. The term "known good die" (KGD) is commonly used when referring to these die purchases; however, it is not well defined and might have different meanings depending on the manufacturer or specific use cases. In this bulletin, we describe what KGD might refer to and some of the detailed flows that KGD go through at different manufacturers.

1

#### "QML Die" in MIL-PRF-38535

Under MIL-PRF-38535, "QML die" can have several different meanings. The first is Qualified Manufacturers List (QML) die that is covered by Appendix A in the Standard Microcircuit Drawing (SMD) of the part that is offered in die form. This is commonly referred to as "SMD die" and is assigned a die code of "9" in the QML part number's case outline position. Figure 1 shows an example of such a part (5962-9663), it is important to note that the manufacturers that offer the SMD die are also expected to offer the fully packaged part (per the SMD) on the QML listing.

A 1 BODRE A 1.1 Second File sequence control control control control control control and the to be supplied upon the Southern Meeting and the Southern and the sequence of the sequence of the sequence of the Southern and the southern and the sequence of t



Figure 1. SMD die example showing the die code.

For QML die products, the minimum screening steps are listed in the SMD (Section A.4.2). Some manufacturers might elect to do more testing than the minimum requirements, shown in Figure 2 (from 5962-96663). Al-2 Allerge register and the state of the first and the first and the state of the first and the state of the first and the first and the state of the first and the state of the first and the f

 100% internet vous impection to the applicable class Q or V ortion defined in ML-872-885, nethod 2010 or the alternativ procedures advand in ML-872-885, nethod 5004.
 Figure 2, SMD die minimum screening required.

The 100% wafer probe includes functional and parametric testing sufficient to make the packaged die capable of meeting the electrical performance requirements listed in the electrical characteristics table of the SMD, which lists parameters throughout the part's rated temperature range. It is important to note that QML die is not required to go through temperature cycling or burn-in at the die level. However, as specified in MIL-PRE-38535 Section 4.2 all OMI integrated circuits shall meet the requirements of the screens specified in Tables 1A and 1B of the specification whether or not the actual testing has been performed. The manufacturer might elect to eliminate or modify a screen based on supporting data that indicates that for the OML technology, the change is justified. For example, many manufacturers have optimized their wafer probe process and in agreement with the Defense Logistics Agency (DLA) perform it only at 25°C. If such a change is

implemented, the manufacturer is still responsible for

ets all of the performance, rements of MIL-PRF-38535. s is performed on packaged µuality level. Furthermore, r devices to be delivered as uples from the wafer lot shall accept level of 10(0).

e is one that comes from a y/line/process that has been vered under a OML-38535 ML die sales are not listed in cate of Conformance (CoC) ved fab would exempt the erforming a site audit of the ype of QML die are: National Texas Instruments (TI), or Jiling their wafer/die from ies/facilities/lines/processes

ove, the term "KGD" is not meanings for different ent products. Currently, fine KGD.

PRF-38534 defines KGD as "a ty and reliability level as an

#### F-19500

ed Products List (OPL), die is , JANHC and JANKC, which of the standard. Military-MIL-PRF-19500 JANHC die, lassified as MIL-PRF-19500 manufactured and sourced acility that has been used to QPL. Manufacturers of QPL can be either in-house or ust be audited and qualified ee Figure 3 for an example 9500 die (JANHCAR2N2857). specifies the screening and r JANHC and JANKC die. The equirements are congruent evaluation requirements.

6.5.2 Un-encapsulated devices. The PINs for un-encap	oulated devices	are co	nstruct	ed using	the
	JANHC.	A	R	211	3
JAN certification mark and quality level (see 1.5.1.2) -					
Disidentifiers for unencapsulated devices (see 1.5.0)					
RHA designator (see 1.5.2)			_		
First number and first latter symbols (see 1.5.3.1				_	
Second number symbols (see 1.5.3.2					

Figure 3. Example specification of a JANHC die.

JANHC and JANKC QPL die are electrically probed for key electrical parameters, and defective die are identified during this process. Wafer screening requirements are specified in Paragraphs G.5.2 through G.5.2.7. Screening consists of 100 percent electrical test, 100 percent visual inspection of die, and then additional screening of sample die assembled into packages. The minimum sample size is 10 die for each JANHC wafer inspection lot and 22 die for each JANKC wafer inspection lot. The QPL sample die will be assembled into the appropriate package by the OPL manufacturer prior to going through the screening process steps 4-7 listed in Appendix G, Table II, of MIL-PRF-19500. These include temperature cycling, mechanical shock or constant acceleration (JANKC die only), electrical test (read/record), hightemperature reverse bias (HTRB) electrical test read/record, burn-in, electrical test read/record, steadystate life (JANKC die only), electrical test read/record, wire-bond evaluation, die-shear evaluation, scanning electron microscope (JANKC die only), and radiationhardness assurance. Appendix G, Paragraph G.5.4 specifies that die shall be stored in dry nitrogen or another inert atmosphere. All MIL-PRF-19500 QPL die are manufactured on a DLA-audited and -certified manufacturer's wafer fabrication processing facility/line. To ensure traceability, the DLA-qualified manufacturer will provide a CoC for the die manufacturer, as required per MIL-PRF-19500, Paragraph 3.7.

MIL-PRF-19500 does not define KGD, nor does it permit non-QPL die to be used in MIL-PRF-19500 qualified products.

#### Manufacturers' Die Offerings

Many manufacturers offer products in die form at various quality levels. For example, the following manufactures offer SMD die per MIL-PR-38535 as described above: Analog Devices, Cobham, Honeywell, Mercury, Microchip, Micross, Renesa, STMicroelectronics (ST), and TI. Some examples of

manufacturers that sell QPL tified wafer foundries/process chip, Semicoa, Sensitron, and section we'll describe a couple vels offered by some MIL-PRFdemonstrate a few available

pace-qualified products in die e products are offered in two g Model (EM), and Flight Model ered in two different flows, the packaged products are ce Components Coordination

e neral manufacturing flow for own in Figure 4. Since Part Average Testing is as of today plasmented for most diodes. For bipdar nestors and MOSTEN, both Part Average bies and Generalization for American plasmented for most diodes. For bipdar the stand Generalization is made your standard standard and standard s

> e radiation test is only performed on wafer lot ed for the manufacturing of RHA guaranteed rts.

#### oelectronics die flow.

the Engineering Model Quality 1), whether they are QML or ie form come from a qualified th a CoC. The EMs are not reening or testing. ST space FM duct's SMD (they are SMD die he FM parts follow the Die lity Specification (TN0873)[1]. sists of a visual die sort that OID Condition A for QML-V die.

Table 1 summarizes the EM

ged parts. It is indeed performed on each

whenever the wafer-to-wafer variations are rginal vs the part-to-part variations.

#### ctronics EM and FM die.



3

such as burn-in or 100% high- and/or low-temperature test at electrical wafer sort (EWS), commonly referred to as KGD. ST's QML-V products are proposed in die form only when it can be agreed with DLA that an EWS at 25°C plus a wafer lot qualification test on 25 pieces at -55°C, +25°C and +125°C is sufficient to make the packaged die capable of meeting the electrical performance requirements of the SMD.

TI offers a wide variety of products in die form. TI defines KGD as "die tested to the same quality and reliability standards as their packaged equivalents" [2]. Figure 5 shows TI's die parts categories.

#### Die Sales

Class Q and Class V Known Good Die - die fabricated, tested, and qualified in compliance with ML-PRF-38535 QML Class Q or Class V and specified in a Standard Microcircuit Drawing (SMD). RNA is available.

Military and Space Grade Tested Die – Tested Die fabricated on a ML-PRF-38535 certified manufacturing line and tested for DC and functional performance only at ambient temporature. Legacy

Known Good Die (KGD) – commercial grade die specified for full performance over a specified temperature range. Commercial Tested Die (TD) – commercial grade die tested for DC and functional

Figure 5. Texas Instruments die categories.

An example flow of a QML-V die is shown in Figure 6.



Figure 6. Texas Instruments example QML-V die flow.

TI's datapack available for QML die includes the data for Group C, wafer lot acceptance (Class V only), and Group E (radiation-hardness-assured only). However, the attributes (yield) and variables (read and record) are not available. TI does not offer catalog burned-in die at this time. TI does perform testing at multiprobe–for example, VBOX, GOI, and IDDQ—to ensure quality of the die. Wafer fabrication includes engineering parametric testing (test structures), wafer-level reliability testing (WLR), and outlier controls. During feasibility studies, a candidate for die sale is evaluated for packaged-device electrical-yield performance and operational life without burn-in. If either is deemed unsuitable, the device will not be released in die sale.

## **Standards Update - Crystal Oscillators**

### • Crystal Oscillators (Martinez, GWG, DLA-VA)

#### • Background

- During the DLA audits of crystal oscillator suppliers, we found that no one was buying QPL Class S oscillators. Instead, the manufacturers were selling catalog parts to their own "Class S-like" flow.
- Simply stated, the specification MIL-PRF-55310 was out of date and needed a lot of work.
- DLA lead auditor at the time made presentation in CE-12 Space Subcommittee meeting chaired by NASA.
- NEPAG GWG group worked with DLA to revise the specification (Y. Afroz of DLA-VA worked very diligently to make it happen)
- Return on investment for NASA flight projects
  - NASA is in a unique position to lead the community in updating requirements for the use of crystal oscillators in space.
- FY19: NASA worked with DLA and other organizations to update MIL-PRF-55310, the current released version is Rev. F.
- **FY20**: Supported the Aerospace proposed amendment. This Amendment has manufacturers buy-in. It has been released.
- Impact of coronavirus: None

## **Analog to Digital Converter BoK**



### A/D BoK (N. Ovee, F. Irom)

#### o Background

- The last NASA A/D selection guide was published by S. Agarwal in 2005
- Many new products have since become available for NASA applications.
- This effort is to update the document.
- Return on investment for NASA flight projects
  - The updated guide would be a resource for NASA designers of Analog-to-Digital converters.
- FY19: We collected information during L@L Webinars but due to resources limitation (flight projects had priority), the guide could not get started.
- FY20 Status: The number of A/D and D/A products has proliferated in the last 15 years, (close to 1000 counting standard and non-standard parts). Therefore, this task was broken down into phases. The first phase was the radiation aspect of standard A/D and D/A devices. This phase was completed and the document delivered to the HQ. This was a NEPAG supported telework task. Rest of the work was put on hold.
- Impact of coronavirus: None.

## Connectors

- Connectors (Billig, Gutierrez as backup)
  - Background
    - Connectors have had many problems
    - ✤ M. Sampson in late 2019 asked that a small task be opened to
      - > Have NASA presence in some of the prime conferences
      - Support DLA audits of widely used connector suppliers
    - JPL Wire, Cable and Connector specialist Ray Billig was asked to provide support. Tony Gutierrez was designated as his back-up.
  - Return on investment for NASA flight projects
    NASA to help provide solutions to the nagging issues with connectors.
  - **FY19:** (a) Participated in a DLA audit.
  - **FY20:** (a) Presented at a conference. (b) supported all NASA meeting on wires and connectors.
  - o FY21: On hold
  - Impact of coronavirus: Yes no audits, no technical meetings.



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