DLA
DEFENSE LOGISTICS AGENCY
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The Nation's Combat Logistics Support Agency

Development of a New Radiation Hardened Plastic Encapsulated Microcircuit (PEM) Device Class N and Class P for Military and Space Applications for MIL-PRF-38535

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Agenda

- Background
  - DOD- DSP Program
  - Defense Logistics Agency Land and Maritime (DLA L&M)
    - Document Standardization Division (VA) overview
  - Preparing activity (PA) Document coordination process
- Development of PEM devices for MIL-PRF-38535
  - Market research
  - Coordination support
  - Coordination effort
  - Class P PEM device requirements
  - Challenges
- Impact and Benefit
- Outcome and cost avoidance
- Path forward with Advanced Technology Microcircuits

DOD- DSP Program

- The Defense Standardization Program (DSP) is established by DoD Instruction 4120.24, in pursuant to sections 2451, 2452 and 2457 of title 10, United States Code.

- The Defense Logistics Agency (DLA) goal is to deliver high reliable Microelectronics devices to DLA supply chain for end user application of US military services, other federal agency i.e., NASA and allied nations.

- DLA Land and Maritime is responsible for DOD's Microelectronics devices standardization and qualification program. The benefits of standardization program are:
  - To provide the warfighter with standardization of equipment, parts, and materials that are interoperable, reliable, and technologically superior.
    - Improved operational readiness
    - Reduced ownership costs
    - Reduced cycle time

DLA Land and Maritime Microcircuits program

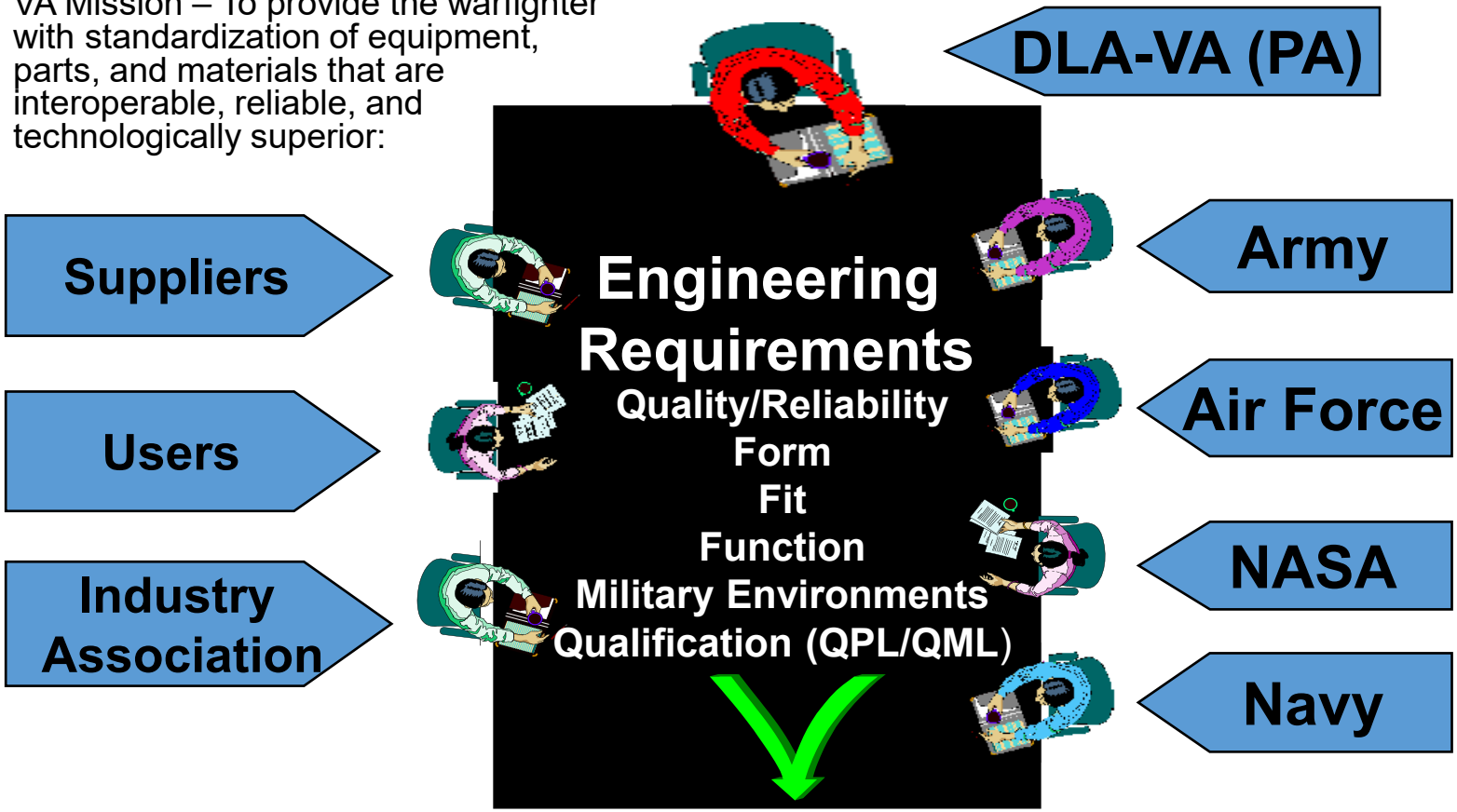
DLA Land and Maritime, Documents Standardization Division manages 17,478+ standardization documents over 70 + Federal Supply Class (FSC) commodities associated with 275,244 + National Stock Number (NSN) parts for supporting warfighter, military terrestrial, avionic, space, satellite communications, and strategic defense applications over 50+ years. For an example:

MIL-PRF-38535 (FSC 5962: Microcircuits device) program supported by 54+ qualified manufacturers, 26+ certified fabrications and 12+ assembly facilities are supplying 28,850+ devices including logic, memory, microcontroller, microprocessor, ASIC FPGA and 10,086+ Radiation Hardness Assurance (RHA) devices for supporting warfighters, DOD weapon systems, and space satellite mission.

Microelectronics parts and specifications are published in the ASSIST website (https://assist.dla.mil/) for Qualified Product List (QPL) or Qualified Manufacturers' List (QML) and DLA Land and Maritime website (https://landandmaritimeapps.dla.mil/) for Standard Microcircuit Drawings (SMD) devices.

DLA Land and Maritime Preparing Activity (PA) Document Coordination Process

- VA Mission – To provide the warfighter with standardization of equipment, parts, and materials that are interoperable, reliable, and technologically superior:



Standardization Document

"Success with Standard"
Development of PEM devices for MIL-PRF-38535

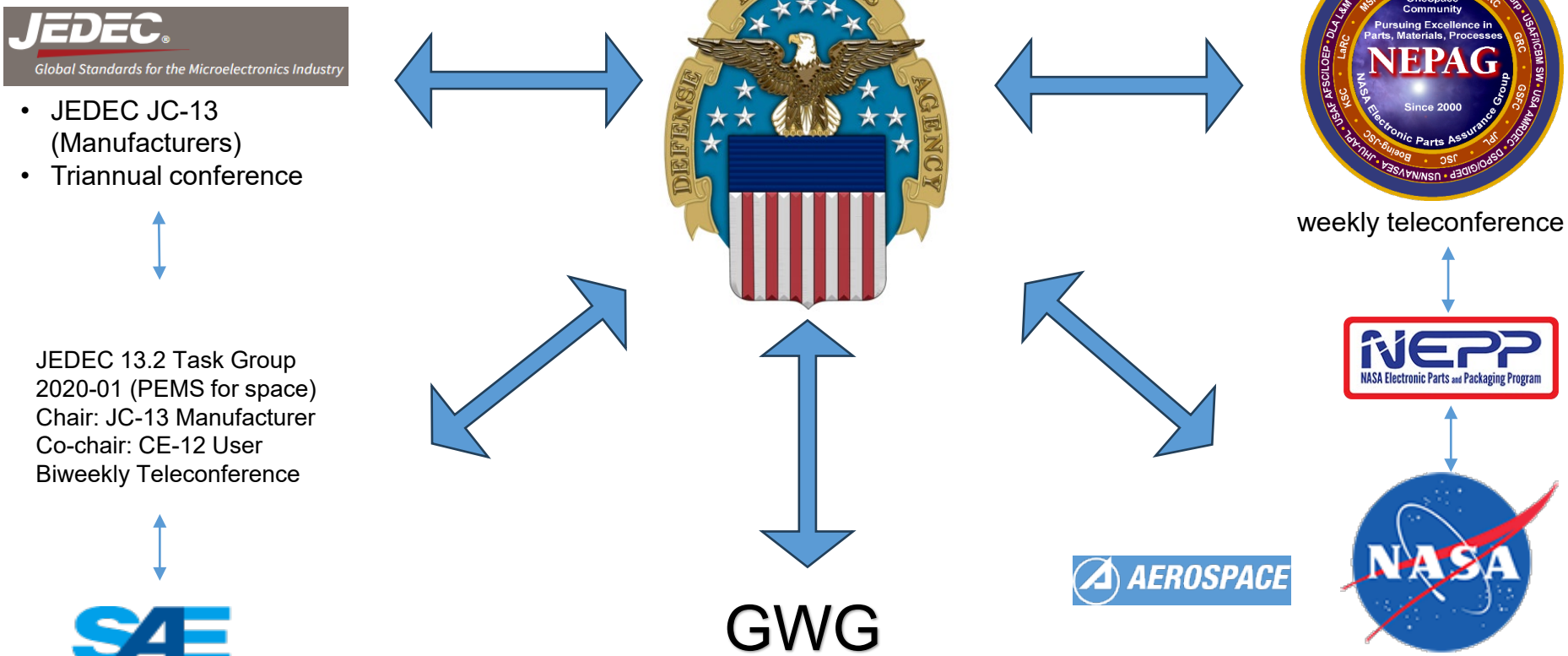
- Background: Design requirements of modern electronics weapon system and satellite/warfare are growing faster and moving forward with advance and complex package technologies. The existing MIL-PRF-38535 specification requirements did not allow for radiation hardness assurance of plastic encapsulated microcircuits for high reliability and space level applications. In September of 2021, the US Military Services, MDA, NRO, OEMs, and NASA approached DLA expressing an idea for new PEM device class levels for military, terrestrial avionics, and space applications with radiation hardness assurance (RHA).

- Rodney Chambers, of DLA Land and Maritime-VAC, conducted an Engineering Practice (EP) study to gather PEM devices requirement information.

- Reviewed requirements of MIL-PRF-38535 existing PEM class N, NASA INST-001, AEC Q100, AS6294/1 and AS6294/2 documents and prepared comparison table for discussion with manufacturers, military services, and User communities.

- The findings of the study were discussed at JEDEC JC-13.2 meetings, and the recommendation was to develop the new Class P devices. Rodney led biweekly working group meetings and progress was presented at JEDEC JC-13.2 meetings. The completed requirements were incorporated into MIL-PRF-38535 for PEM device RHA Class P.

"Success with Standard"
Development of PEM Devices Coordination Support



"Success with Standard"
Development of PEM Devices Coordination Effort

- Mr. Chambers conducted numerous meetings, telephone conferences, emails, etc. with relevant stakeholders of the space community (e.g., NASA Jet Propulsion Laboratory, Aerospace Corporation), device manufacturers, OEM manufacturers, and other government agencies, to discuss issues, necessary changes, and resolve differences in requirements. The major steps were:
- Reviewed EP study findings with MIL-PRF-38535 class N, AEC Q100, NASA INST-001, SAE AS6294/1 and AS6294/2
  - Integrated findings and prepared initial draft for PEM devices requirement that will support:
    - Update to Class N (Military, Terrestrial and Avionics applications)
    - Create new Class P (Space applications)
- JEDEC 13.2 Task group formed TG 2020-01 (PEMS for space) for review draft document:
  - Participants include manufacturers, OEM, NASA, Aerospace, DLA and military services.
  - Task group completed coordination efforts: Final proposal sent to DLA 3/24/22 for formal coordination.
- This multi-year effort concluded in May 2023 with major revision M of MIL-PRF-38535, for the inclusion of plastic encapsulated microcircuit radiation hardness assurance Class P microcircuit devices for military, terrestrial avionics, and space applications.

"Success with Standard"
Development of PEM New Class P Microcircuit

Class P PEM device requirement included to MIL-PRF-38535

- **Screening Table**
  - Wafer lot acceptance test – (discussed QML vs Non-QML) – Consensus for QML approved die
  - Internal Visual – remain with standard TM 2010, condition A
  - Visual inspection - remain with standard 100%
  - X-ray and or Acoustic Microscopy test (Class Y – focus on Acoustic Microscopy inspection) (PEM class focus on just X-ray for 100% screening)
- **QCI Test tables**
  - Group A : (Electrical test) shall be performed for static, dynamic, functional and switching test conditions at room/low/high temperature per MIL-PRF-38535. (sample size 116/0).
  - Group B : (Mechanical and Environmental test) shall be performed on each inspection lot as a condition for lot acceptance for delivery. Group B test shall be performed on each qualified package type and lead finish
  - Group C: (life test) : Burn-in life test shall be performed based on device technology and shall be documented to the QM plan for QA review and approval
  - Group D: (Package related qualification test)
    - D3 (include preconditioning to temp cycling, biased and/or unbiased HAST, acoustic microscopy, external visual, electrical test)
- **QCI Table E - RHA**
  - Radiation Hardness Assurance (RHA) requirements for class P added .
  - Manufacturer performed RHA test for nuclear and space environment applications and documented in devices SMD)
- **Appendix H**
  - Qualifications Table H-IB and H-IIB (updated)
    - 400 hours burn in for class P devices initial qualification
    - Susceptibility to moisture - Which spec is more suitable (JESD22-A113 or J-STD-020) for PEM devices?

Example: Comparison table for Hermetics and non-Hermetics devices package evaluation Group D3 test

TABLE V. Group D tests (Package related test). - Continued.

Subgroups	Test 1/	MIL-STD-883 test method and conditions				
		Hermetic classes		Non-hermetic classes		
		Class Q (class level B)	Class V (class level S)	Class Y (ceramic or organic) (class level S)	Class N (PEM) (class level B)	Class P (PEM) (class level S)
Subgroup 3 sample size 15(0) 6/ 7/ 17/	a. Thermal shock	a. TM 1011 Test condition B, 15 cycles minimum	a. TM 1011 Test condition B, 15 cycles minimum	a. TM 1011 Test condition B, 15 cycles minimum (Ceramic class Y only)	a. 5/	a. 5/
	b. Temperature cycling	b. TM 1010 Test condition C, 100 cycles minimum	b. TM 1010 Test condition C, 100 cycles minimum	b. TM 1010 Test condition C, 100 cycles minimum or condition B 150 cycles	b. i) Acoustic Microscopy 18/ ii) TM1010 Condition B (150 cycles min) iii) Acoustic Microscopy	b. i) Acoustic Microscopy 18/ ii) TM1010 Condition B (150 cycles min) iii) Acoustic Microscopy
	c. Moisture resistance	c. TM 1004 8/	c. TM 1004 8/	c. JESD22-A118 Unbiased HAST condition B	c. JESD22-A118 Unbiased HAST Condition B and/or (JESD22-A110) Biased HAST Condition B 18/	c. JESD22-A118 Unbiased HAST Condition B and/or (JESD22-A110) Biased HAST Condition B 18/
	d. Visual examination	d. In accordance with visual criteria of TM 1004 or TM 1010	d. In accordance with visual criteria of TM 1004 or TM 1010	d. In accordance with visual criteria of TM 1004 or TM 1010	d. In accordance with visual criteria of TM 1004 or TM 1010	d. In accordance with visual criteria of TM 1004 or TM 1010
	e. Seal test 9/ (1) Fine leak (2) Gross leak	e. TM 1014 test condition as applicable	e. TM 1014 test condition as applicable	e. 5/	e. 5/	e. 5/
	f. End-point electrical parameters 10/	f. As specified in the applicable device	f. As specified in the applicable device	f. As specified in the applicable device	f. As specified in applicable device.	f. As specified in applicable device.

- 17/ Preconditioning shall be performed on surface mount devices in accordance with JESD22-A113, prior to subgroup 3 test for non hermetic device classes N, P, and Y with organic substrates. Manufacturer may perform these test sequentially or in parallel (separate samples for 3b and 3c) in accordance to the manufacturers QM plan. Thermal shock is not applicable to class N, P, and organic class Y.

Example of Radiation Hardness Assurance (RHA) features documented in Standard Microcircuit Devices (SMD) :

SMD section 1.5 Radiation features

- **Total Ionizing Dose (TID) test :**
  Maximum total dose available (High dose rate = 50-300 Rad(Si)/s) up to 300 krads(Si)
  Maximum total dose available (Low dose rate ≤10 mrad(Si)/s) upto 100 krads(Si)
- **Heavy ion Single Event Phenomenon (SEP) test perform:**
- **SEL, SEU, SEB, SEGR, SEU test information**
- **Single event upset error rate test for space application**
- **Dose rate survivability test for nuclear environment**
- **Neutron irradiation / displacement damaged test**

- **Challenges of using non-government standards vs MIL-STD-883**

- Non-government standards (NGS) vs Military Standards?

  – Determine when to adopt existing NGS or update the Military standards.
    - Military Standards baseline high reliability military, terrestrial, avionics and space application.
    - NGS – baseline commercial / automotive applications

  – MIL-STD-883 "Test method standard for Microcircuits"
    - Military standards test methods were generated around ceramic hermetic packages.
    - Updates are needed for PEMs and non-hermetic packages.

  For example:
    - Temperature Cycling
      – MIL-STD-883 TM 1010 vs JESD22-A104
        - Should we consider adding condition A to class P (-55°C to 85°C)
    - High temperature storage
      – MIL-STD-883 TM 1008 vs JESD 22 A103
    - Thermal resistance
      – MIL-STD-883 TM 1012 vs ??
    - Use Highly Accelerated Stress Test vs
      Temperature Humidity Bias test method

- **First standardized plastic Class P device with radiation hardened, high reliability for military terrestrial/avionics and space satellite applications.**
  - Non-standard devices often contain pure tin internal and device lead finishes that promote tin whiskers resulting in system failures.
  - Non-standard devices are typically more expensive when qualifying for up-screening to acceptable levels in military programs.
  - Harder to procure because there is no standardization document defining them, are not as reliable due to lack of engineering technical characterization and reliability studies.
  - Become often obsoleted by going out of production much sooner than standard military devices, which leads to Diminishing Manufacturing Sources and Materials Shortages (DMSMS) procurement issues.

"Success with Standard"
Benefits of PEM New Class P Microcircuit Devices

- Non-standard devices also generally have lower operating temperatures (-40C to 70C) and therefore cannot be used in the military temperature range environment (-55C to 125C).
- Will help to meet the current military and space systems longer life cycle needs, will prolong obsolescence, and will deter counterfeit devices from entering the supply chains.
- Cost effective, light weight Class P plastic microcircuit devices will support the warfighter mission.
- Thousands of Class P plastics devices will help strengthen DLA supply chains.
- Current users include MDA, NASA, L3Harris, Raytheon, Lockheed, Northrup Grumman, National Instruments, SEAKR, Boeing, General Dynamics, Indian Space Research Organization, Viasat, Airbus, Honeywell, ExoTerra Resource.

Impact Example New plastic Class P (Space application) devices: MIL-PRF-38535 PEM class P SMD devices released and supplying by TI. Multiple SMDs working in-process. Generally, these class P devices are RHA TID level 50-100 krads (HDR and LDR tested), Heavy ion SEE tested

- Example Standard Microcircuit Drawing (SMD)
  - Half the package size footprint
  - double the power density
  - Weight reduction

	5962R1822001VXC Class V **Hermetic Ceramic** **16-pin CFP**	5962R1822002PYE Class P **PEM** **32-pin HTSSOP**
Dimension (max)	25.142 x 9.6 mm	8.3 x 11.1mm
Height (max)	2.416 mm	1.2 mm
Mass	1.56 g	**0.184 g**

"Success with Standard"
PEM New Class P Microcircuit Manufacturers

New QML Class P for high reliability and Space applications
8 Class P SMD documents approved
15+ in-process new class P SMD
Active sources: **Texas Instruments**
Manufacturers interested to supply or in process qualification : **Texas Instruments** **E2v Teledyne, Renesas, Vorago, Cypress, ADI**

"Success with Standard"
Outcome and cost avoidance of Development of new PEM Class P Microcircuit devices

- Analysis of SD-19, SD-22 and NAS-1524 documents, and manufacturers demand reports result in a conservative estimate that the new class P specification will alleviate a minimum of 125 non-standard parts each year for the next five years.

- The Parts Management Guide (SD-19: pub 2013) states the average total cost of adding a new part into a system is about $27,500. Based on this figure, the new Class P devices will result in a cost avoidance of $3.43 million annually ($17.15 million for five years).

- An added benefit of the new standardized plastic Class P microcircuit devices is that they will be supplied by qualified manufacturers which will result in reliable and qualified supply availability.

- These devices to be listed in the DLA website for government and OEM use, are cost effective, light weight and available for delivery for many years to come.

PATH FORWARD
New Technology Updates

MIL Spec / Class	Description	Current status
MIL-PRF-38535 revision M released: ✓	1. (Pb-Free bump for flip chip devices) 2. (update screening , QCI, PIDTP and qualifications for Flip Chip devices)	1st pb-free bump for flip chip SMD (5962-22210) released September 2023
PEM Class N (military application) ✓	**Plastic Encapsulated Microcircuit class N** New Screening Table, QCI Test tables and Appendix H	199 total legacy class N devices created
PEM Class P (space application) ✓	**Plastic Encapsulated Microcircuit class P** New Screening Table, QCI Test tables and Appendix H	Texas Instruments released PEM class P SMD and 15+ SMD in-process
Non-Hermetic Class Y (space application) ✓	• Non hermetic 2D flip chip device built on organic or ceramic substrate • (lidded device) • Updated PIDTP required • May include (Pb)-free bump	• 3 mfrs. certified for ceramic • 3 mfr. pursuing certification to organic 1st organic class Y device QM plan coordinating with Microsemi/microchip for NASA JPL (HPSC) Project
(New un-released Specification) ← **MIL-PRF-ATM** Class M for (military application) Class S for (space application)	Advanced Technology Microcircuit 2.1D, 2.5D, 3D, System in Package (SIP) and Multi chip module (MCM) type devices	Current JEDEC task group ATM Developing draft MIL-PRF-ATM specification ATM SMD Boilerplate – development in process.
FSC 5962 Vendor Item Drawing (VID)	Procurement vehicle for commercially enhanced product.	Next Generation Enhanced Product (NEP) VID with Pb-Free SAC bump. 1st NEP release V62-23605 (SAC bump)

Contact Information

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