European Space Components Conference (ESCCON)
March 7-9, 2023

National Aeronautics and Space Administration

NASA Presentation

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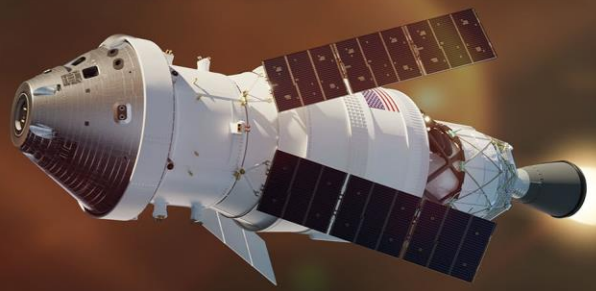


Spaceship Orion on low-orbit of Earth.
Artemis space program.

Elements of this image furnished by NASA.

http://nepp.nasa.gov

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

- **It's a distinct honor to present in-person at this year's ESCCON!**
- **The European Space Agency is a valued partner in NASA Electronic Parts Assurance Group (NEPAG) activities for over 22 years!**

2

NEPAG Leadership Transition

- **NASA Electronic Parts Assurance Group (NEPAG)**
  - Shri Agarwal is the new NEPAG Coordinator for the Agency

- **NEPP/NEPAG Leadership**
  - Pete Majewicz – NEPP Manager
  - Susana Douglas – NEPP Deputy Manager. Also, Acting NASA Parts Manager.
  - Shri Agarwal – NEPAG Coordinator
- **Websites**
  - NEPP: https://nepp.nasa.gov
  - NASA Office of Safety and Mission Assurance (SMA) Parts Website: https://sma.nasa.gov/sma-disciplines/eee-parts

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

Image Credit: NASA

ARTEMIS

Image Credit: NASA

NEPAG

NASA News

- **NEPP Electronics Technology Workshop (NETW)**
  - NETW is held in June every year.
  - Venue: Goddard Space Flight Center, Greenbelt, MD
  - Past papers posted on NEPP Website: nepp.nasa.gov
  - .
- **NASA INST Document**
  - Widely used in the United States
  - It has undergone major changes.
  - The goal is to have a much leaner and up-to-date document.
  - The document will be renamed 8739.11.
  - Planned release in 2023
- **Released Documents**
  - NASA EEE Parts Bulletin on Parts Supply Chain: Instability in the Pandemic Global Space Parts Industry (Khandker, Tiu, Douglas)
  - GaN Body of Knowledge document (GRC)
  - Recommendations on use of COTS EEE parts for NASA missions, Phase 1 (NESC)
    - Phase 2 – released
    - Tech Talk by P. Majewicz
  - Avionics radiation hardness assurance best practices (Pellish)
  - JPL's experience with EEE parts supply chain challenges (subject of a paper by J. Bonnell at ESCCON 2023)

NASA Comments

- We are part of Mission Assurance Standards and Capabilities Division
  - Developing/maintaining standards is our responsibility
- NASA Mission Assurance strives to find solutions for a wide spectrum of applications, from Cubesats to Europa Clipper
  - Success of each of these missions, whether large or small, is important
  - We count on this community to make that happen
- Learn and Lunch (L@L) Webinars with the supply chain
  - Bringing the supply chain and users together
  - Did 12 L@Ls so far in FY23
  - The new Class P was developed as a result of these meetings.
- EEE Parts Training Course 101
  - Held at MSFC
  - Workforce development is a big challenge
- DLA has resumed in-person audits
  - NASA is providing support
  - 7 audits supported so far this FY

NASA Electronic Parts Assurance Group (NEPAG)

- **NEPAG is about Standards for electronic parts, finding solutions for NASA flight projects/programs, and day-to-day parts issues. We are part of NASA SMA's Mission Assurance Standards and Capabilities (MASC) Division.**
  - Maintenance
    - ❖ Provide NASA leadership
  - Creation
    - ❖ Infuse New Technology, e.g., Class Y for Space
    - ❖ Address the advances in packaging technology, e.g., a newly started task group (TG) on 2.5D/3D devices
    - ❖ Respond to user requests, e.g., creation of a new TG that developed requirements for Class P, standard plastic encapsulated microcircuits (PEMs) in Space
  - Related Activities
    - ❖ Hold telecons
      - ➢ NASA Electronic Parts Assurance Group (NEPAG)
        - ▪ Weekly Domestic and monthly International
      - ➢ Government Working Group (GWG)
        - ▪ Detailed discussion of topics, build community consensus
      - ➢ 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

Hybrid Working Group (HWG) Meeting

- **HWG**
  - Meets monthly
  - Chaired by J. Pandolf, NASA/Langley
  - Recently discussed topics
    - ❖ Upcoming DLA audits of hybrid suppliers
    - ❖ Definition of a hybrid microcircuit
    - ❖ Corporate acquisitions in the news
    - ❖ Review & Discussion on the Challenges Facing the Selection, Review, Approval of Hybrid MIL-PRF-38534 Device
    - ❖ Follow up on issues with U. S. suppliers as reported by International partners

Government Working Group (GWG) Meeting

- **GWG**
  - Meetings held bi-weekly
  - Chaired by C. Schuler, Navy Crane
  - NASA representative: B. Damron
  - GWG forms the space community position on various technical issues
  - Recently discussed topics
    - ❖ Review of NEPAG agenda for that week
    - ❖ DLA documents in review
    - ❖ ESDS test requirement in MIL-PRF-38535
    - ❖ Specification issues with diodes
    - ❖ CSAM test method review

February 14, 2023 Draft Document Review Table: Requirements, Guidelines, and EP Studies

Item	Released	Comments Due (Including Extensions)	Specifics
MIL-PRF-19500/578R w/Amendment 2 (Initial Draft) **Semiconductor Device, Diode, Silicon, Switching, Types 1N6638, 1N6642, 1N6643, Quality Levels JAN, JANTX, JANTXV, JANS, JANHC, and JANKC** **FSC: 5961 Dated: 14 February 2023** **File name: idprf19500ss578.pdf, File Size: 935 kb** **Parent Document: MIL-PRF-19500**	02/14/2023	03/16/2023	**Draft proposal generated to remove note 2, for the A version die, change the Al and gold thickness for the C version die, and add a new F version die, the AMSE 14.5 figure references are being removed, and update to latest MIL-STD-961, and section 508 standards.** **POC: Greg Cooley** **Gregory.Cooley@dla.mil**
MIL-PRF-39016/21K (Initial Draft) **Relays, Electromagnetic, Established Reliability, DPDT, Low Level to 1.0 Ampere (Sensitive, 60 Milliwatts) with Internal Diodes for Coil Transient Suppression and Polarity Reversal Protection** **FSC: 5945 Dated: 13 February 2023** **File name: idprf39016ss21.pdf, File Size: 300 kb** **Parent Document: MIL-PRF-39016**	02/13/2023	03/15/2023	**Draft generated to implement MIL-STD-961 boilerplate updates, and incorporate 508 compliance.** **POC: Erika Baker** **erika.baker@dla.mil**

Example of Parts Needed Bulletin

Coordinator: Jay Brusse, NASA GSFC

NEPAG EEE Parts Needed Bulletin # 2023-003 **February 19, 2023**
(Note: Email Distribution List has been suppressed)
Purpose:
The NASA EEE Parts Assurance Group (NEPAG) is contacting you on behalf of a Project that is in need of the following EEE parts. NEPAG requests that you review inventories of EEE parts accessible to you and your organization to see if you have the ability to help out the Project noted below. Please direct your responses to this request DIRECTLY to the Project point of contact listed below:

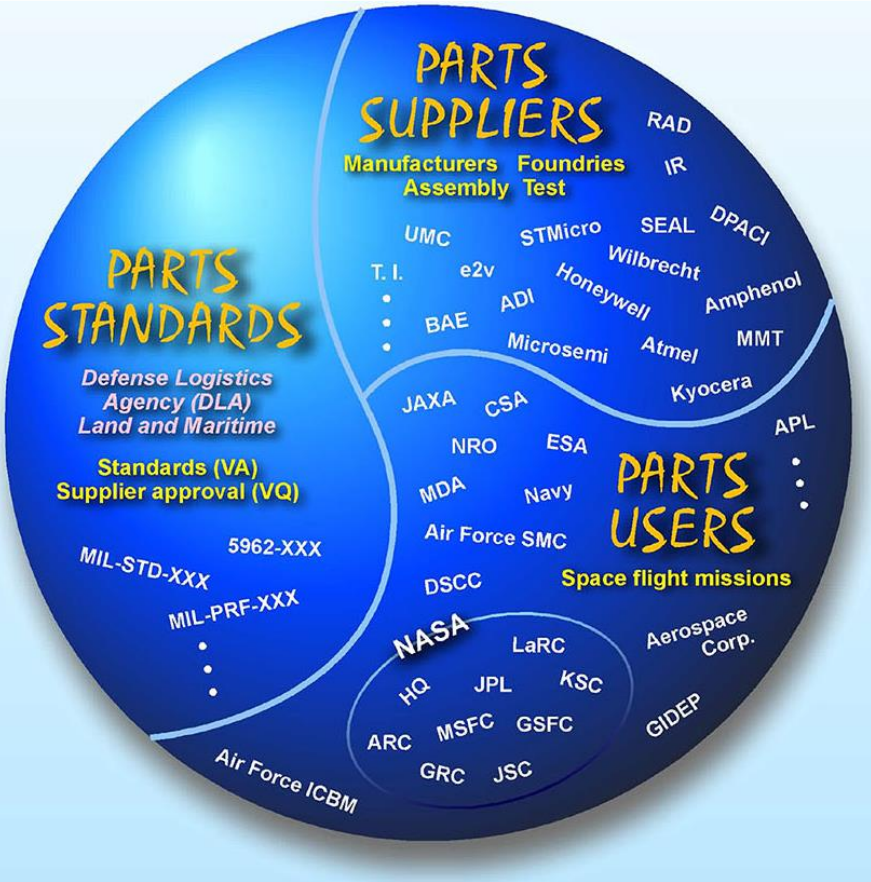
Name:
NASA Center
Phone
email

Part #:	K-J1A, K-J1A-254, K-J2A, K-J1A-254 or similar variations.
Generic:	K-J1A
Description:	K SERIES RELAY, Non-Latching, 4PDT, 12A
Mfgr:	Leach
Quantity needed:	Any quantity

NEPAG thanks you in advance for your assistance

Space Parts World

Developing/Maintaining 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 SAE CE-12 Co-Chair.

Partnerships (NEPAG is about collaboration)

JEDEC JC-13 (Manufacturers)

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

Joint meetings held 3 times a year

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

SAE SSTC CE-11	Users of Passive Components
SAE SSTC CE-12	Users of Solid State Devices
	CE-12 Management:
	Co-Chairs: S. Agarwal (NASA) and A. Touw (Boeing)
SAE SSTC CE-11 & CE-12	Space Subcommittee Chair: P. Majewicz (NASA)

NASA Centers:

ARC	JSC
GRC	KSC
GSFC	LaRC
JPL	MSFC

Weekly NEPAG and Biweekly GWG Telecons (Domestic)

Monthly Telecons (International and HWG)

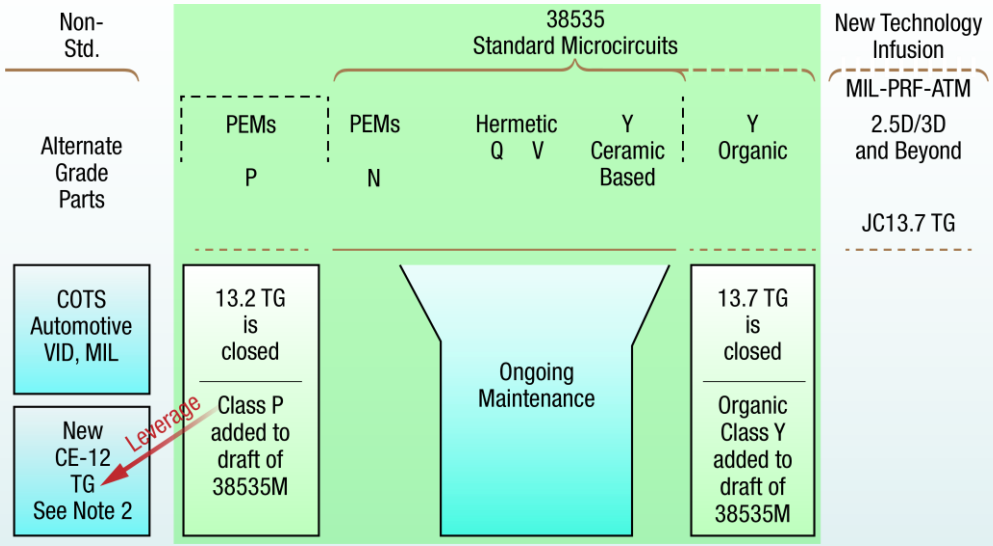
Partners from Outside NASA:

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

International
- ESA, JAXA, CSA

NEPAG

Microcircuit Standards Development



- 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—a future outreach activity.***

The much awaited revision M of microcircuits specification, MIL-PRF-38535, has been officially released. It introduces two new classes of standard parts for space missions:

(a) Organic Class Y which has been baselined for NASA's high-performance spaceflight computing (HPSC) processor to be developed by Microchip Corporation, and

(b) Class P, Radiation Hardened/Tolerant Plastic Encapsulated Microcircuits (PEMs) for Space. The flight projects can realize substantial cost/schedule savings by procuring standard Class P parts (rather than buying commercial-off-the-shelf (COTS) PEM devices and getting them upscreened).

(i) TI's first Class P product: LMX1906 a Low-Noise, High-Frequency Buffer/Multiplier/Divider (300-MHz to 12.8-GHz output frequency). SMD 5962-23202, Availability Dec 2023.

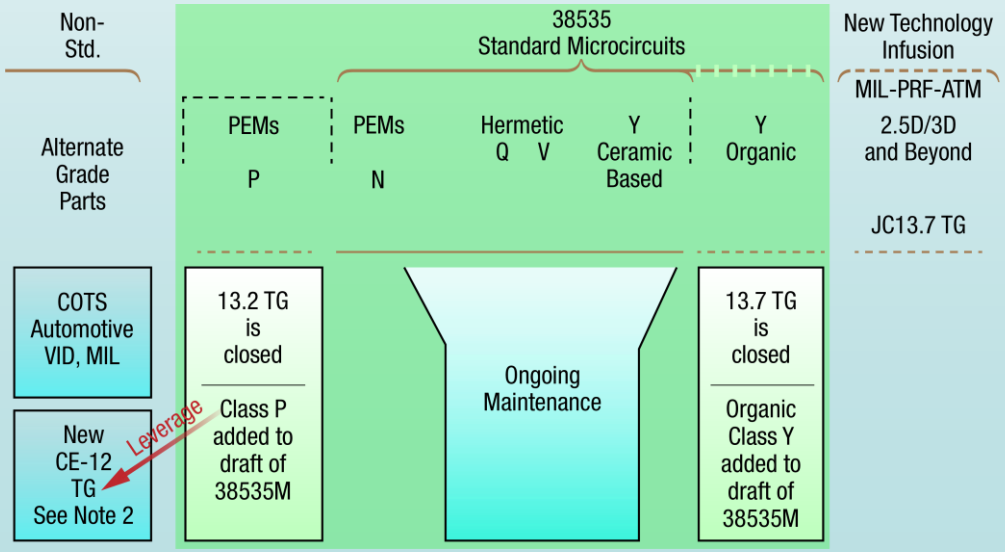
The green area shows current standards coverage. This pretty much completes the standards coverage for 38535 devices.

MIL-PRF-38535, Rev. M

MIL-PRF-38535M

TABLE IA. Screening procedure for hermetic classes Q, V and non-hermetic classes N, P, Y microcircuits. - Continued.

Screening Tests	MIL-STD-883, test method (TM) 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)
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		
6. Visual inspection 6/	100%	100%	100%	100%	100%
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		
8. Serialization 9/	In accordance with device specification (100%)	In accordance with device specification (100%)	In accordance with device specification (100%)	In accordance with device specification (100%)	In accordance with device specification (100%)
9. Pre burn-in (Interim) electrical parameters test 10/	In accordance with device specification 11/	In accordance with device specification 12/ 25/	In accordance with device specification 12/ 25/	In accordance with device specification. 11/	In accordance with device specification 12/ 25/
10. Burn-in test: 10/ 13/ 14/	TM 1015 160 hours at +125°C minimum	TM 1015 240 hours at 125°C, condition D 15/	TM 1015 240 hours at 125°C , condition D 15/	TM 1015 160 hours at 125°C ,	TM 1015 240 hours at 125°C , condition D 15/
11. Post burn-in (Interim) electrical parameters test 10/		In accordance with device specification 12/ 25/	In accordance with device specification 12/ 25/		In accordance with device specification 12/ 25/



Other Standards Development Activities

- **Outside of 38535 Microcircuits**
- **GaN on Si**
  - Used on a couple of NASA projects
  - Joint SAE/JEDEC GaN and SiC Working group task team to start the development of a standardized Screening and Qualification requirements for Power GaN devices using MIL-PRF-19500 as base line
  - DLA has started auditing the companies
  - NEPAG is scheduling L@Ls with GaN suppliers
    - ❖ EPC-Space (March 15)

- **Integrated Photonics**
  - **NASA SME to give a Tech Talk at May JEDEC**
  - **Next step: Develop standards (identify existing specs that can be baselined)**

- **Extreme Environments**
  - **M. Mojarradi of NASA/JPL to give a Tech Talk at JEDEC meeting in September 2023**

Photonic Integrated Circuits (PIC) - Motivation and Recommendation

- Integrated photonics is expected to disrupt satellite technology in the same way discrete fiber optic systems revolutionized commercial terrestrial networks. •
- Currently no defined path to space qualification for PICs. Industry standards for optics and photonics (Telcordia) are only suitable for commercial applications.
- NASA and industry partners are working on raising the TRL of emerging photonic technologies as well as developing novel space qualification methodss (includes development of integrated photonics radiation and reliability database). .
- Current state-of-the-art PICs designed and qualified for terrestrial communication systems in commercial applications as well as academia. Risks associated with reliability of PICs in space environment not well understood.
- Solution: • Develop and validate novel mission assurance methodologies for screening and qualifying state-of-the-art commercial integrated photonics technologies for reliable operation in space applications

NASA's Involvement in Developing New Space Hermetic Products

- **With the Defense Logistics Agency (DLA) and the Aerospace Corporation, NASA participates in the review and approval of new space products:**
  - Standard Microcircuit Drawings (SMDs)
  - Characterization and qualification data per Appendix H of MIL-PRF-38535 (for the monolithics)
- **In FY22, a total of 13 microcircuit SMDs were approved for release. The mix of new product types included:**
  - DC/DC Converters
  - Analog to Digital Converters
  - Digital to Analog Converters (D/As)
  - Operational Amplifiers
  - Others

- **Per manufacturers, there is a continuing strong demand for standard space hermetic products**

NASA EEE Parts Bulletin
EEE Parts Supply Chain: Instability in the Pandemic Global Space Parts Industry

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

Volume 14, Issue 1, November 22, 2022

EEE Parts Supply Chain: Instability in the Pandemic Global Space Parts Industry

With the introduction of COVID-19, the EEE space component industry has seen consequential changes to its supply chain, including its labor workforce, labor practices, shipping, distribution, and sourcing of raw materials. The safety limitations of in-person work have led to a labor shortage in manufacturing facilities, as well as a shortage of on-the-job training, resulting in a deficit of trained personnel and a trend of factories shutting down. Safety limitations have also saturated and deferred the existing distribution channels, affecting electronics suppliers and their inventory storages. Additionally, global political and economic conflicts have added obstacles to the sourcing of raw materials. These changes, along with the introduction of new technologies, have introduced a need for new approaches towards supply chain reliability and scheduling assessment. In this bulletin we will explore the results of these current industry changes on the EEE space component supply chain, through assessing and comparing the lead times of commonly purchased components in the space electronics industry. We will also identify risk reduction methods to ensure a stable EEE component supply chain.

Covid-19 Supply Chain Impact Analysis

In our analysis we define "supply chain delay" as EEE parts that were received past the originally set lead time defined in the parts' purchase orders. We define "supply chain long lead time" as a lead time that is quoted to be longer than the average lead time of the part in the pre-pandemic fiscal years.

The Defense Logistics Agency (DLA) conducted a survey questionnaire of microcircuit manufacturers, asking them how the COVID-19 pandemic affected their microcircuit/semiconductor production and supply chain [1]. The results, as of September 2022, found that due to the strong DoD/Government and industrial partnership efforts of the QML/QPL program, the COVID-19 pandemic had less of an effect on the availability of QML microcircuits than it did on the commercial and automotive sectors of the EEE parts industry [1].

The lead time and delay of components varies by supplier part type [1]. For microcircuits, the overall lead time increased in some areas due to the supply delay of package elements, e.g. ceramic packages. For some manufacturers the package element delay added about 10-20 additional weeks of lead time for their product line [1].

The DLA also reported that some chemical and material shortages impacted the QML and non-QML hermetic product lines as well as hybrid piece parts. Chemical and material shortages include:

- A shortage in liquid hydrogen.
- A shortage in palladium, used for PME capacitors.
- Longer lead time in wafer fabrication equipment.

This shortage increased lead times on MOSFETs, diodes, wafers, epoxies, and other materials [1]. The material and chemical shortage impact added an additional 20-30 weeks on top of normal lead times on lids, base packages, substrates, etc. This also impacted tools, e.g., forming tools, bond wire capillaries, solder dip fixtures, NDBP fixtures, etc. [1]. Recent Arathane 5750 shortages have also been reported, impacting board-level assembly at various assembly facilities.

Figure 1 depicts the trend of semiconductor device lead time increasing over pandemic fiscal quarters. [2]

he increasing over pandemic
suppliers of semiconductor

ering and Assurance Office
Group led an assessment on
heir lead times. Their data
e periods: the pre-pandemic
2019, and the pandemic
2022 [3]. Part types were
hen, the increase in purchase
lated for each part type.

tudy found that
FPGAs, and voltage
cluding resistors and
lead time increases.

es, the lead time increased
almost a year, from pre-
l years [3]. The highest
ingle microcircuit was 51
te regulator that had a 59-
comparison to its 8-week
er outlier quote was for a
86-week delivery in FY22
coupler series from a leading
quoted with no definitive

he lead time increased an
re-pandemic to pandemic
increase in lead time for an
d at 42 weeks, for a surface
hip capacitor. This capacitor
FY20, in comparison to a 3-
Additional outlier long lead
hin film resistor, which had a
nber 2021, and a M55342
resistor, which had a 90-week lead time for 100 pieces [3].

PART DESCRIPTION	PART TYPE	FY	NUMBER OF WEEKS FOR DELIVERY	LEAD TIME INCREASE PER PART NUMBER
Resistor, Bulk Metal, 10mOhm, 0.5%, 3W, 20ppm/C	Resistor	2020	59	17
Resistor, Bulk Metal, 10mOhm, 0.5%, 3W, 20ppm/C	Resistor	2017	42	
Capacitor, Solid Tantalum, 330uF, 10%, 10V	Capacitor	2019	53	34
Capacitor, Solid Tantalum, 330uF, 10%, 10V	Capacitor	2017	19	
Inductor, Power, 10uH, 20%, 28.0 ADC, 4.14 mOhm	Inductor	2020	55	25
Inductor, Power, 10uH, 20%, 28.0 ADC, 4.14 mOhm	Inductor	2019	30	
Diode, Schottky Rectifier, 45Vrrm, 1A	Diode	2020	55	54
Diode, Schottky Rectifier, 45Vrrm, 1A	Diode	2017	1	
Voltage Regulator, 2.5 Amp, Positive Low Dropout (LDO), Adjustable	Voltage Regulator	2020	59	51
Voltage Regulator, 2.5 Amp, Positive Low Dropout (LDO), Adjustable	Voltage Regulator	2018	8	

PANDEMIC
PRE-PANDEMIC

Figure 2. A Comparison of Lead Times of Commonly Purchased Part Types at JPL in the Pre-Pandemic and Pandemic Period [3].

Figure 2 compares the lead times of commonly purchased parts at JPL, quoted in both the pre-pandemic and pandemic fiscal year period. In the pandemic period, all part types were quoted with a lead time of over a year [3].

Discussions on Supply Chain Impact

The outcome of these studies resulted in conversations, led by Goddard Space Flight Center, with affected manufacturers and suppliers about the causes of their long lead times and delays, and their methods to mitigate COVID-19 related obstructions. One industry leading FPGA manufacturer discussed their main issue to be longer lead times in the sourcing of their raw materials and components; they face similar long lead times in their supply chain as well. To mitigate the buyer's scheduling issues, the FPGA manufacturer expressed a desire to know the buyer's project procurement needs earlier in the buyer's project lifecycle, to prepare ahead of time for the longer lead times. The manufacturer is also building more units than their backlogged amount, in anticipation of orders being placed. They suggested consolidating all of NASA's FPGA orders together and providing that visibility to them during the quoting and purchasing process.

A similar discussion was held with a major MOSFET and DC-DC converter manufacturer, whose purchase orders were delayed within the past two months. This

v factory, but assured us that
ot the cause of their issue. Their
used by issues in the product's
nctional parameters did not
wafer level. The affected
ingredient in the makeup of
at NASA, resulting in an
n of the devices and projects
nverters of this manufacturer
rent reason than the MOSFET's
ter delay was caused by a
and by a high employee
19 [5].
facturers expressed challenges
ty, GIDEP stop-ship on various
tages, increased lead time in
nd supply chain uncertainty [5].
rers in this study had long lead
-19 impact. However, some of
major COTS suppliers, did have
ese were caused by the
shipping, and distribution due to
nufacturer delays to their

isk Reduction

fies on COVID-19 Impact to EEE
introduced a need for new
pply chain risk reduction. Listed
take to reduce EEE part supply

rement in the early phase of
—alongside the design process.
parts lists through different
evisions and identify long lead
commonly used parts that can
red and purchased early in the
schedule.
additional funding for parts
earlier in the design phase that
be used in the final design.
sparing policy to the extent the
is capable, for reducing risk of
rtages due to mishaps at
y, changes to the design that
higher need quantities, or
unplanned obsolescence.

2. Prepare for delays and have alternates in place.
    a. Check with other NASA centers, projects, and industry partners to see if there is any excess inventory left over that can be purchased, transferred and used, or borrowed and replaced.
3. Get the Parts List or Bill of Materials quoted before the Design Review.
    a. This will help designers and management understand the cost and lead time.
    b. Budget accordingly with the increase in industry prices.
4. For commonly purchased parts within the organization, organize a common buy or common stock to eliminate lead time and to secure bulk stock early.
    a. Figure 3 highlights examples of microcircuits, discrete semiconductors, and other parts which can be purchased in a common stock [4].
    b. There is a significant cost increase when parts are procured in small quantities, and these parts can provide a long lead time for a new build.
    c. Obtain buy-in from distributors to stock parts with the greatest impact. These will be long lead parts in high demand.
    d. Target your supply chain's problematic vendors and parts for additional stock program strategies, based on recent procurement data [4].
    e. Build a harness stock initiative.
    f. Parts with a high risk for contamination if procured with incorrect requirements or from the wrong vendor include [4]:
        i. Wire braid and anti-abrasion braid sleeves
        ii. Shrink tubing
        iii. Lacing cord

Some Notes on Fracture Mechanics in Plastic Packages

- **PEMs**
  - **Lots of JC13/CE-12 activity to develop Standards for Microcircuits**
    - **Heavy discussion on plastic parts in the next 2-3 years (and beyond)**
    - **Both ends of the spectrum: overmolded, and organic**
    - **Now is a good time to review the fundamentals of plastic packages – the community is making heavy investment in them to cover expanded application spectrum/ infuse new technology**
  - **Temp cycling**
    - **Done per MIL-STD-883, Test Method 1010**
      - **Condition C: -65C to +150C, used for ceramic parts**
      - **Condition B: -55C to +125C, being proposed for PEMs for Space**
      - **Condition A: -55C to +85C**
      - **How about the ramp rates, dwell times?**
  - **Glass Transition Temperature**
    - **Wait for 19500 to complete their investigation**
  - **Packages are getting smaller, thinner**
    - **A GaN device that NASA/JPL wants to use, comes in a 8mm x 8mm size package**
  - **Post Assembly**
    - **Are any parts issues (e.g., crack propagation) off limits (IPC problem?)**
      - **CTE mismatches**
      - **Time dependence**
    - **Bring parts, IPC, manufacturer communities together**
      - **Could a QCI type test/set of guidelines be developed at the part level?**
      - **Look at 38535 and 19500 products**
  - **What tests do the materials suppliers run to demonstrate quality/reliability?**
  - **Making improvements to standards, performance specifications**
    - **Is the potential impact of stress/pressure build up in plastic packages being adequately addressed?**
- **Is it time to address Fracture Mechanics and Microcircuit Standards?**
  - To identify any gaps and assess their impact
  - Plastic encapsulants, dielectric polymers, and underfill materials are subject to delamination and cracking with thermal cycling. Crack propagation during use environment exposure, drives the potential for failure of microelectronic devices and is therefore a necessary focal point in qualification and life testing.
  - Develop methodology for evaluating the time-dependent mechanical failure of semiconductor packages
    - Resulting from combined effect of stress, temperature, moisture absorption and crack like defect
- **Moving Forward**
  - NASA is working with industry to collect limited test data
  - We encourage manufacturers/users to share their failure experiences
  - A Workshop is planned this FY.

Burn-in, and Life Test
Comments from NASA

- 1. The regression tables need a fresher look
  - NASA computations show a large variation in the activation energies (Ea). See summary below
- 1a. Regression Table in MIL-STD-883, Test Method 1005
  - For Class B, Ea range = 0.971eV to 0.986eV
  - For Class S, Ea = 0.292eV to 0.403eV
  - Considerable variation in Ea values
  - For currently quoted Ea of 0.7eV
    - Class B is less conservative
    - Class S is more conservative
- 1b. Regression Table in MIL-STD-883, Test Method 1015
  - For Class B, Ea = 0.397eV to 0.409eV
  - For Class S, Ea = 0.383eV to 0.403eV
  - Considerable variation in Ea values
  - For currently cited Ea of 0.7eV
    - Both Class B and Class S are more conservative
- 1c. What is the correct Ea going forward?
  - Different sources list different values. According to one source:
    - 0.3eV is for oxide/dielectric defects, chemical/galvanic/electrolytic corrosion
    - 0.7eV covers electromigration, broken bonds, lifted die
    - 1.0eV is for surface contamination induced shifts, lifted bonds (Au-Al interface)
- 2. For accelerated temperature burn-in, and life test
    - Are the parts characterized for safe operation before they are subjected to elevated temperatures?
    - Recommend making it a requirement
- 3. JEP 163 Document
    - Is there a plan to update this document?

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

Counterfeit Parts

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

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

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

Need to update standards

ESD Outreach by NASA

- **NASA is Highlighting ESD in our *EEE Parts Bulletins***
  - Released five special editions on ESD.
  - The first dealt with the need to upgrade specifications related to ESD and suggestions for better ESD practices wherever parts are manufactured, stored, or prepared for shipment.
  - The second ESD special issue focused on a parts failure investigation that ultimately concluded that ESD was the most likely cause of the failure. The second issue also included an important reminder about regular ESD testing.
  - The third issue provided an example demonstrating the importance of maintaining ESD discipline and a high-level risk analysis related to electrostatic discharge.
  - The fourth issue was a Compendium.
  - The fifth issue was on ESD testing
  - A guidelines document is planned next.

- **Invited ESD Talks**
  - NASA has been instrumental in arranging invited talks at JC-13/CE-12 meetings.

NASA Comments
ESD Specific

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

- Being reviewed by GWG.

- Very little information available on ESDS of non-standard (COTS, Automotive) parts (Concern)
  - With the exception of VID parts

MIL-PRF-38535, Para 4.2.3 **Electrostatic discharge (ESD) sensitivity**. ESD sensitivity testing shall be performed in accordance with TM 3015 of MIL-STD-883 and the device specification. The testing procedure defined within ANSI/ESDA/JEDEC JS-001 for Human Body Model (HBM) and ANSI/ESDA/JEDEC JS-002 for Charge Device Model (CDM) may be used as an option in lieu of TM 3015 for applicable devices (e.g. high pin count devices wherein parasitic charge may effect ESD failures). However, manufacturers shall document such ESD testing procedure in the QM plan that require QA approval. The reported ESD sensitivity classification levels shall be documented in the device specification (see 3.6.7.2). In addition, unless otherwise specified, Human Body Model (HBM) and Charge Device Model (CDM) tests shall be performed for initial qualification and product redesign as applicable. If manufacturer is using the HBM or CDM or both method for ESD classification, it shall be reported in the device specification or standard microcircuit drawing (SMD) devices certificate of compliance (CofC).

NASA ESD Mitigation Going Forward

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

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

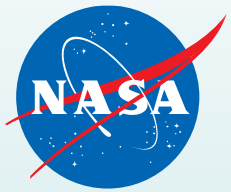
Note: NASA Is Part of the Qualifying Activity (QA) for Space microcircuits.

The Last Page

- **NASA supports a wide spectrum of space missions. The success of each of each of them counts.**
- **NASA is working with the space community to help infuse new technologies into the military standards. ESD aspects should not be ignored.**
- **We encourage the world wide space community to get/stay involved in developing/updating standards.**
- **Development of workforce is an immense challenge.**
- **ESCCON offers an excellent opportunity to work with space organizations around the globe. Thank you, ESA!**

Thank you!

http://nepp.nasa.gov



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BACK - UP

DLA's VID (Vendor Item Drawing) Program

Current Supplier's Program Benefits

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

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

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

DSCC

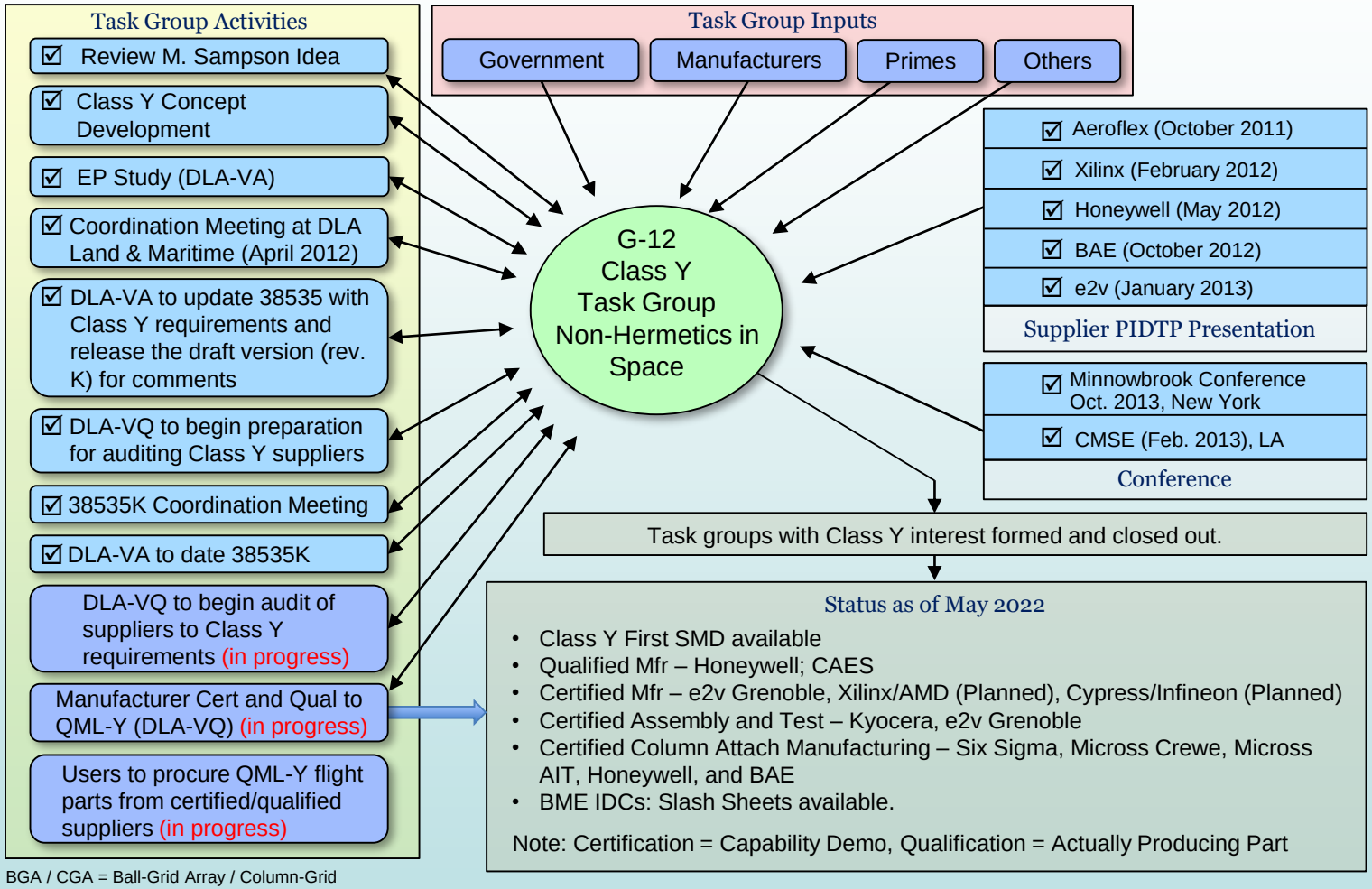
DSCC is releasing new Vendor Item Drawings (VIDs) almost daily. These documents have been created to provide a procurement vehicle for enhanced commercial products. Specifically, commercially available microcircuit products are being documented for the first time on a standardization document. Use of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

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

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

- Analog and digital functions offered.

Infusion of the New Class (Y) Technology into the QML System for Space (Status given at JEDEC in January 2023)



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

Courtesy of Texas Instruments (TI)

Space EP Baseline Controlled Flow

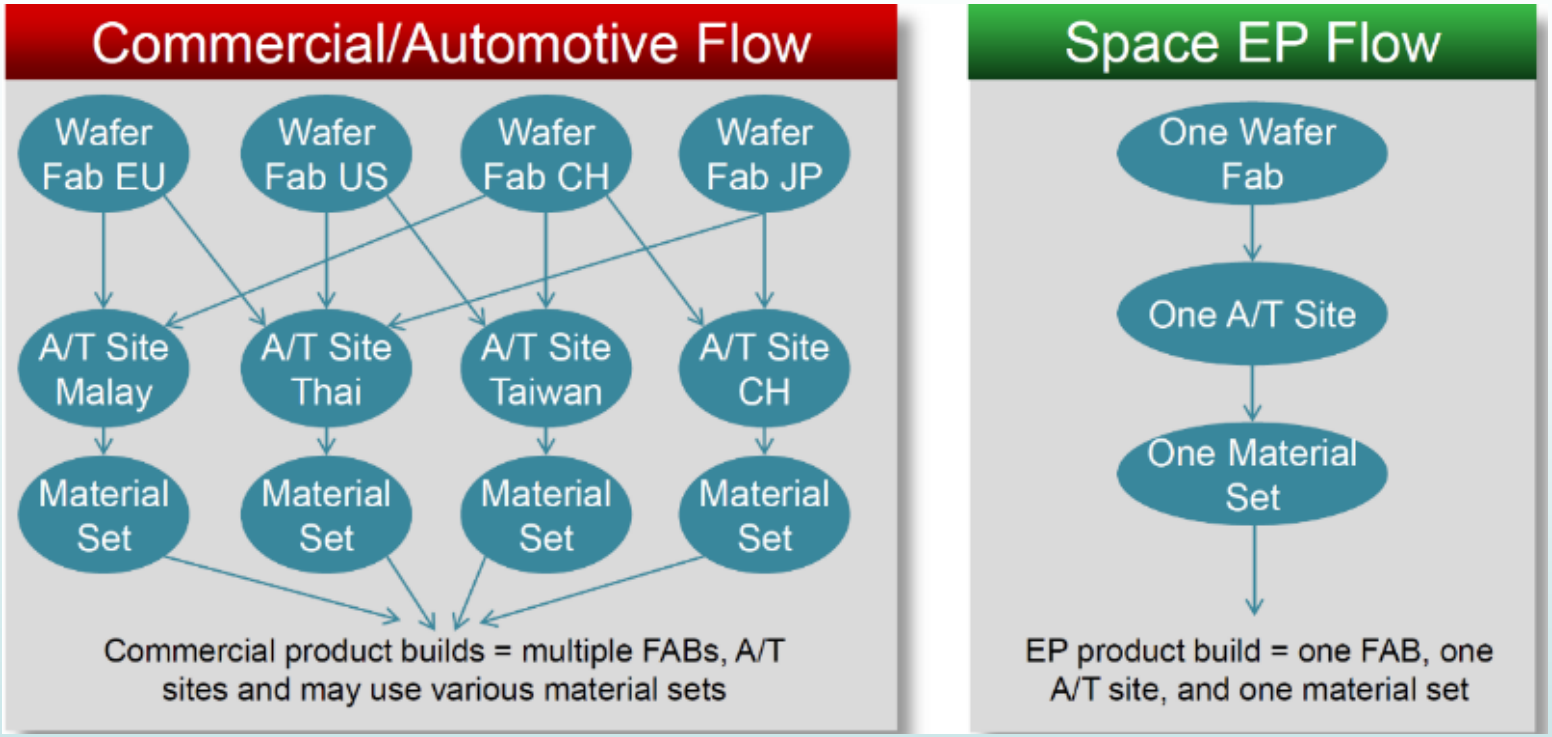


Image Courtesy of Texas Instruments

- 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.

A Changing Landscape (Shipping/Handling/ESD Challenge)

A New Trend – Supply Chain Management
Ensuring gap-free alignment for each qualified product
(All entities in the supply chain must be certified/approved)

Manufacturer A	Die design
Manufacturer B	Fabrication
Manufacturer C	Wafer bumping
Manufacturer D	Package design and package manufacturing
Manufacturer E	Assembly
Manufacturer F	Column attach and solderability
Manufacturer G	Screening, electrical and package tests
Manufacturer H	Radiation testing

More Stops — More Places with ESD Risk

NASA ESD Surveys of Microcircuit Supply Chain

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

NASA ESD Surveys are Meeting Greater ESD Challenges for Electronic Parts

New Technology Evaluation
A Multi-pronged Effort

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