Manufacturer Audits as Key Elements of the Assurance System for Hi-Rel Space Components in the United States

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Downwind Side of 'Namib' Sand Dune on Mars, Stereo
This stereo view from NASA's Curiosity Mars Rover shows the downwind side of a dune about 13 feet high within the Bagnold Dunes on Mars.
Tags: Jet Propulsion Laboratory, Mars, Mars Science Laboratory (Curiosity)

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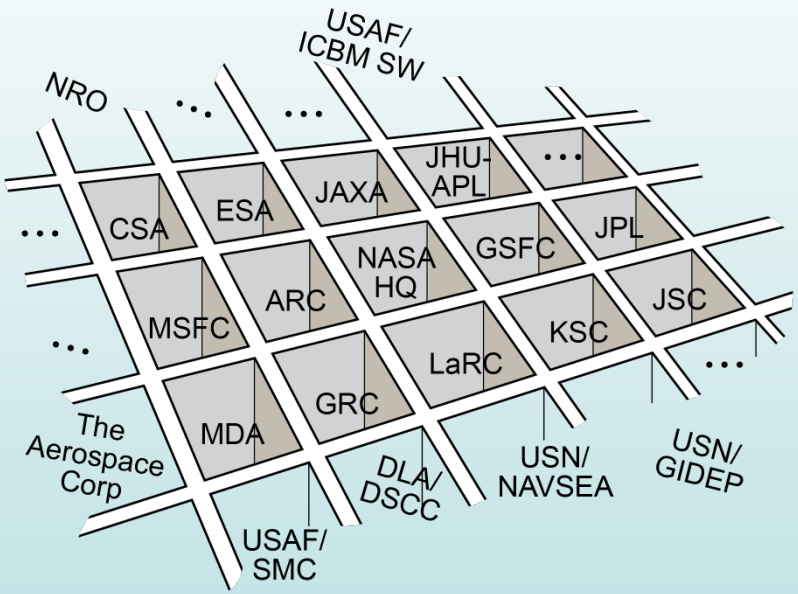
NEPAG Background

World-Wide Space Parts Community Before the Year 2000



Since the Year 2000, Community Pulled Together as NEPAG

NEPAG = NASA Electronic Parts Assurance Group

"Communicate, conserve resources"

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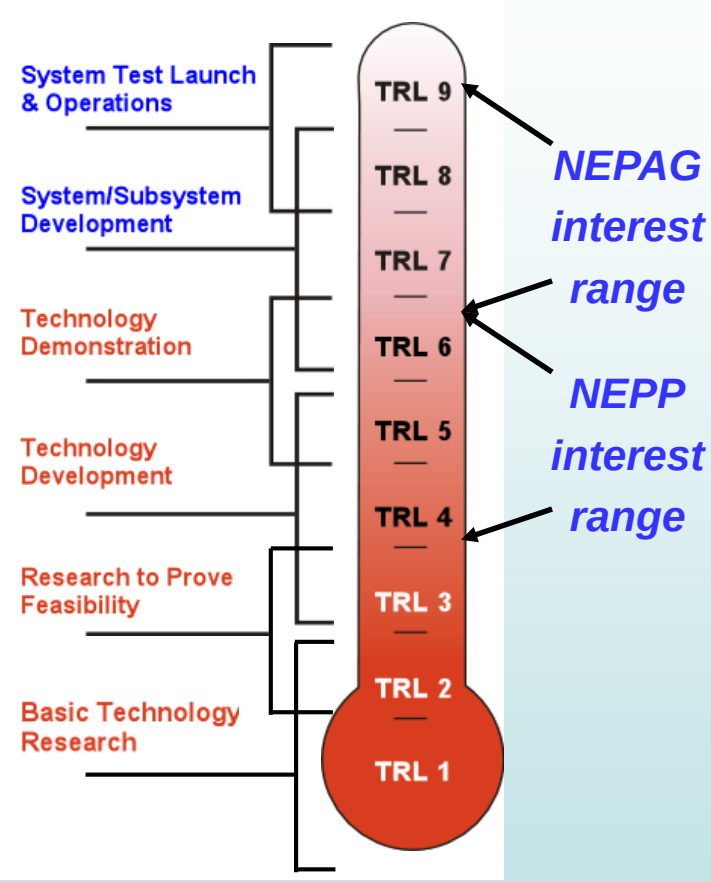
NEPP/NEPAG Focus

- NEPP = NASA Electronic Parts and Packaging Program
- NEPAG = NASA Electronic Parts Assurance Group
- Funded by NASA OSMA
  - ❖ Through JPL 5X ATPO



NASA Technology Readiness Levels (TRLs)

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Partnering with Industry Groups

- **JEDEC JC13 (Manufacturers), and**
- **SAE SSTC G11/G12 (Users)**

JEDEC JC13

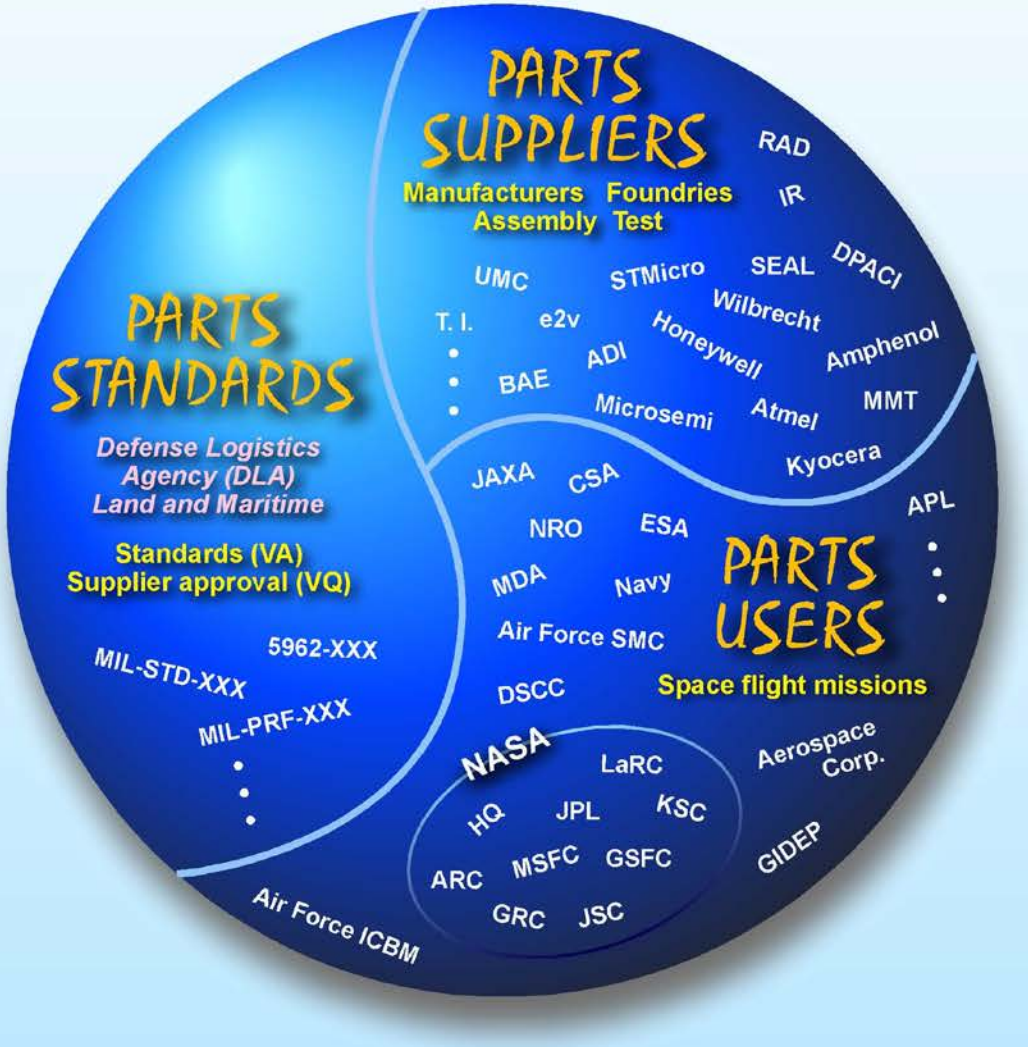
JC-13	Solid State Devices for Government Products
JC-13.1	Discrete Semiconductors for Government Products
JC-13.2	Microelectronics for Government Products
JC-13.4	Radiation Hardness
JC-13.5	Hybrids and MCMs for Government Products
JC-13.7	New Electronic Device Insertion for Government Products

SSTC G11/G12

SAE SSTC G-11	Users of Passive Components
SAE SSTC G-12	Users of Solid State Devices
	G12 Management:
	Chair – A. Touw
	Vice Chair – S. Agarwal

Joint JEDEC and G12 meetings are held 3 time a year. NEPAG is an active participant in those meetings. NEPAG's Shri Agarwal was recently appointed as the vice chair of G12.

Space Parts World
Develop/Maintain Standards for Space 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).**

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NEPAG and DLA Audits

- DLA Audits Support
  - Audit defined (a definition from the internet):
    - An independent review and examination of records and activities to assess the adequacy of system controls, to ensure compliance with established policies and operational procedures, and recommend necessary changes in controls, policies or procedures.
  - Done on a sample basis
  - The DLA audit team works with manufacturer's own/internal audit team
    - The goal is to produce reliable standard products for use on space programs.

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NEPAG and DLA Audits

- DLA Audits Support
  - DLA Land and Maritime (formerly DSCC) is the designated DoD (U. S. Department of Defense) entity that has **authority to approve or disapprove suppliers**. They have a big team of auditors covering all parts commodities. They use certain established methods to conduct these audits. They audit close to 200 domestic and international QML/QPL suppliers every year..
  - What the Agencies like NASA, Air Force, NRO bring to the audits is their **technical expertise**. An MOU (Memo of Understanding) was signed few years back which provides the guidelines for how the audits are to be supported.
  - **The MOU between DLA and space users is very clear on certain things**, e.g. the auditors must be the recognized subject matter experts, they must actively participate in the audit, and stay with the team until the audit has been concluded, etc.
  - Audits to be supported by the space community are **decided on the NEPAG telecons**. Our participation in the audits is therefore customer driven.

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NEPAG and DLA Audits

- DLA Audits Support (contd.)
  - There are two parts to an audit: certification (capability demonstration) and qualification (successfully building product). In most cases we don't visit the supplier facility for qualification approval.
  - The audits of today boil down to the supply chain management, and approval of various entities specializing in the die design, wafer fabrication, assembly, electrical testing, column attach, radiation, etc.
  - These **U. S. government audits** are based on the premise "**trust but verify**". The certification audits can not be done via phone calls or other such means.
  - Many documents are company proprietary and can only be looked at during the audit. They would't send them outside even if there was an NDA.
  - The audit team spends a vast portion of the audit time to go on the production floor, test floor, etc. to talk to the operators, engineers, physically witness the operation or test being performed. It can not be done via the Webex.

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NEPAG and DLA Audits

- DLA Audits Support (contd.)
  - In NASA view the audits are a multi-prong effort: we support them as subject matter experts, gain personal knowledge, make contacts**, resolve any flight project issues with that supplier**.
  - Only a small portion of the audits conducted by DLA are supported by NASA. **In FY15, NASA supported 44 of the 162 DLA domestic and overseas** a**udits combined** (all commodities).
  - The microcircuit QMLV audits are typically scheduled for 3 days. These audits at times get to be intense and grueling.
  - The audit findings are reported on the NEPAG telecons. A high level summary of the audits supported by NASA is entered into the NASA **SAS** (supplier assessment system) database
  - **Changes in the last few years**. It used to be that NASA was outside looking in. But, that's no longer the case.

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- Counterfeit Parts Mitigation
  - At NASA's request, DLA has made discussion on counterfeit parts mitigation a part of all microcircuit audits.
  - The following items are reviewed with suppliers:
    - Any GIDEPs on their product line?
    - How are the rejected wafers /parts stored?
    - Do they de-process wafers/parts to extract gold and other costly metals?
    - How are the rejected wafers/parts dispositioned?
    - Do they support inquiries on counterfeit products?
    - Do they use third party to disposition product?
  - Typical responses received:
    - They have some form of counterfeit mitigation effort in-house.
    - They would support inquiries on a limited basis.
    - They are more active in working with their distributors to mitigate counterfeiting.
    - They list their franchised / authorized distributors on website and keep it current.

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- Overseas Audits
  - Only space level audits are supported.
  - Decision to support an overseas audit is based upon the following selection criteria:
    - NASA wide usage of products made by the particular supplier
    - Problems with supplier
    - When was the last time we were there?
    - Can travel be minimized (cover more than one audits in a single trip)?
    - Can one of the international partners, e.g. ESA or JAXA participate for us?
  - NASA Support to Overseas Audits in FY15 (all commodities):
    - Participated in 8 overseas audits

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- **Findings**
  - From Microcircuit Audits:
    - Mismatches were found between product test and SMD specified test conditions/limits.
    - NASA raised the issue of supply chain management. This would apply to those suppliers who contract out a substantial portion of the fab/assembly/test/screening/qualification work.
    - A new issue came up related to flip-chip devices: MIL-PRF-38535 revision K requires the underfills and thermal interface material (TIM) to meet the requirements specified in MIL-STD-883, Test Method 5011. Some manufacturers have expressed concerns. The issue being resolved in a JEDEC TG.
    - The after-market suppliers, who take over products that have been discontinued by the OEMs, do not seem to perform their own engineering review of the product line documents, including burn-in circuits. This issue is being pursued.
    - There were no requirements for electrical testing after column attach. Some suppliers did not do electrical testing citing concerns for handling and ESD damage. MIL-PRF-38535K requires post column attach room temp electricals.

NEPAG and DLA Audits

- Findings and Action on Burn-in Screening
  - A memory device was being burnt-in with chip in disable (inactive) state. It was a bake rather than a burn-in. DARs were written to fix the problem.
  - Suppliers made claims that only one burn-in circuit was needed to screen out infant mortality (mil specs require two burn-ins).
  - NASA and The Aerospace Corporation requested JC13 to open a Task Group (TG) to review burn-in (BI) of devices:
    - Our audit and specification review work showed that the microcircuits BI screening requirements as stated in MIL-STD-883, Test Method 5004, were **out of date and had multiple interpretations**.
    - Those requirements were developed over 25 years ago
  - The JC13 TG has been meeting for the last several years:
    - Brent Rhoton of Texas Instruments is the Chair
    - A JEDEC document has been published to provide guidelines.
    - Discussion is on-going on some of the newer technology devices, such as the burn-in of hi-speed parts: The current burn-in equipment are set up for a maximum frequency of 6MHz. Is that sufficient to weed out infant mortality of parts that are supposed to work at 200MHz or even in low Gsps range?

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- ESD and Handling:
  - Manufacturer claimed that their wafer fab area was ESD safe. But, we found scotch tapes in that area. They were asked to provide an explanation and take corrective measures.
  - No ESD controls at relay plant. They were asked to stop building affected (transient suppression) relays until the ESD safeguards had been put in place. Another finding for the same relays was inadequate screening and qualification of diodes used in them.
  - It was observed that the wafer fab plants didn't pay attention to card board boxes used for shipping and receiving products. Supplier instructions on boxes of raw material (wafers) were not being followed. There were no precautionary labels (e.g., fragile, this side up, handle with care, ESD sensitive, etc.) on boxes used to ship finished goods (processed wafers). The requirements in MIL-PRF-38535 would have to be tightened.

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- **NASA Electrostatic Discharge (ESD) Surveys of Manufacturers**
  - Microcircuits:
    - Not a part of the DLA audit
    - Candidate companies for NASA ESD survey are identified during the DLA audit
    - The purpose of the survey is to better prepare smaller manufacturers with plans to develop space products
    - The survey is done at no cost to the manufacturer
    - The findings of the survey are non-binding
    - Have had good feedback from those who have gone through it

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A CHANGING LANDSCAPE

A New Trend – Supply Chain Management, an example
(All entities in the supply chain must be certified/approved)

Die design and fabrication	Company A
Fabrication	Company B
Package design and Package manufacturing	Company C
Wafer lap and dice	Company D
Assembly	Company E
CGA column attach, Solderability	Company F
Screening, electrical and package tests	Company G
Complete electricals per SMD	Company H
Internal water vapor content	Company I
Radiation testing	Company J

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- Some Relevant Sections from MIL-PRF-38535, Revision K
  - A quality management (QM) program shall be implemented by the manufacturer. (38535K/3.3)
  - The supplier shall establish a new technology insertion program for the identification, management, and tracking of technology. (38535K/3.4.1.1.1)
  - Deficiencies and concerns shall be noted during exit critique and followed up with a written report (38535K/3.4.1.7). The reports are considered manufacturer proprietary.
  - The interval between on-site revalidation reviews shall normally not exceed two years but can be adjusted by QA. (38535K/3.4.7)
  - The space audit teams are headed by DLA with members from the space community, other interested services, and the customer as necessary. (38535K/B.3.3)

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- Some other Facts
  - NDAs (non-disclosure agreements) may be required as necessary.
  - NASA doesn't support OCONUS (Outside Continental U. S.) audits that are unsafe for its auditors.
  - Urgency of audits for new product introduction. Very common. One major supplier made an urgent request for the audit of their foundry overseas. They have since introduced several new rad hard space products, providing additional options for the designers of space flight hardware.
  - No money changes hands; each auditing organization pays for its own expenses.
  - Some organizations opt to carry more than one certifications, e.g. 38535 and 38534.
  - A balance is kept between meeting room documentation check and shop floor inspections. For example, if the test data shows some kind of an anomaly, we would go to the test floor and retest the part.

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- Facts (Contd.)
  - Mergers and acquisition activity is monitored by DLA. However, there have been times when we don't find out about it until after we get to the company for audit.
  - Multi-product wafer (MPW) section 6.4.47 in 38535K needs to be clarified. There are suppliers building MPW products.
  - Lab suitability is done to ensure the facility can perform the applicable tests called out in MIL-STD-883.
  - Due to budget constraints more and more customers are accepting DLA audits, thus reducing the number of audits of the manufacturers.
  - Test optimization. We do get requests for it. Per 38535K/J.3.12, all applicable JEP121 process elements are required to be addressed for test optimization. One supplier of legacy memory products wanted to optimize out dynamic burn-in in favor of static. NASA worked with them and showed that there was a plenty of margin with dynamic burn-in.

NEPAG and DLA Audits

- Further Comments
  - The business of audit is about common sense.
  - It is important to be patient with people, especially when asking questions of operators. The word “audit” has some kind of a stigma attached to it that makes people nervous.
  - In order for an audit to be successful, we have to work hand-in-hand with manufacturer’s own team.
  - Due to budget constraints and lack of resources, we are able to do only a limited number of audits. It seems there is never enough time during an audit.
  - Travel requires special attention. One should plan for flight delays/cancellations, weather related preparations, remember to keep chargers for electronic equipment, etc.
  - If possible, publish report soon after the audit is done (while it’s fresh in memory).

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Concluding Remarks

- DLA Audits Support
  - DLA audits are a key element of the assurance system for hi-rel space components in the United States
  - DLA Audit teams should be looked upon as an extension of manufacturers' own audit teams
  - The requirements we audit to are not always clear. NASA in co-operation with DLA, Aerospace Corporation and the manufacturers, is addressing this issue.
  - NASA will recommend to DLA that the following item be added to the audit agenda: Handling, shipping/receiving and ESDS (electrostatic discharge sensitivity).
  - And last but not the least, I would like to thank our friends at ESA for their invitation. ESA has been a valued NEPAG partner for over 15 years and we appreciate working with them.

Thank you!

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http://nepp.nasa.gov

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