Compliance Issues with Microcircuits Burn-in Screening

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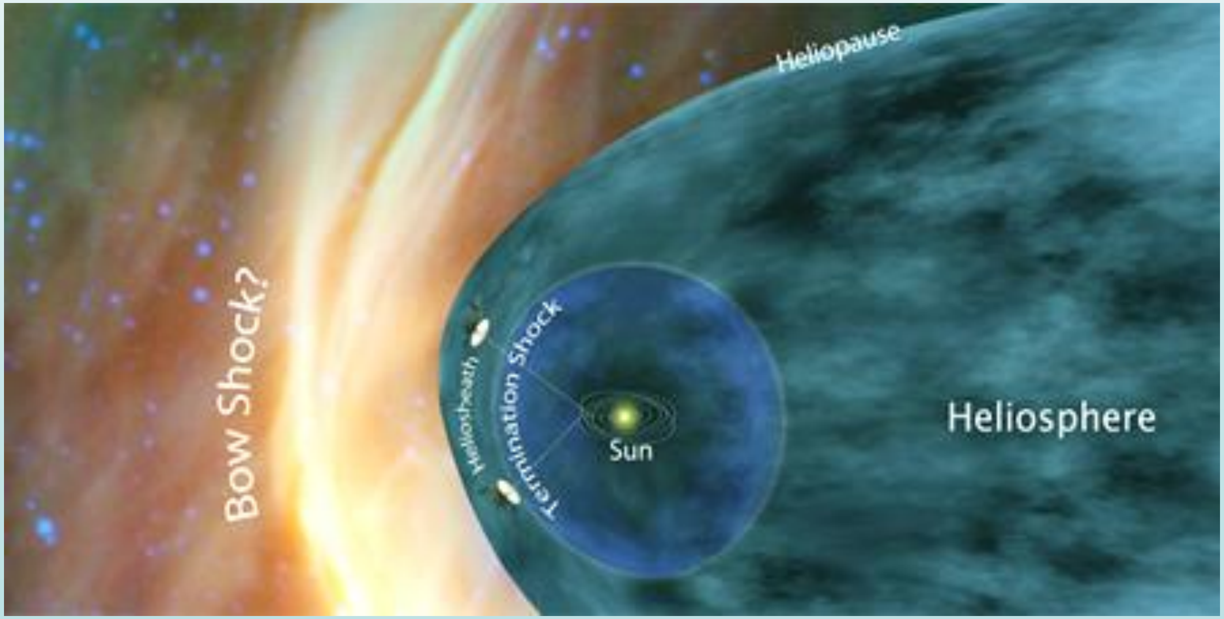
Mars Science Laboratory image of “Sheepbed” outcrop showing veins of salt deposits formed by water flowing through fractured rocks.

- Thanks to Mr. Ralf deMarino, the program committee, and the European Space Agency (ESA) for their invitation. It’s always a pleasure to visit ESA/ESTEC in the beautiful city of Noordwijk.
- Our congratulations to ESA on the ESCCON Conference!
- ESA is our valued partner, and we appreciate their participation in NASA EEE Parts Assurance Group (NEPAG) activities.

Introduction

- In this talk we report on some **serious interpretation/compliance issues with microcircuit screening requirements.**
- **The talk is divided into the following sections**
  - A review of present requirements
  - Supplier Audits – A Major NEPAG Activity
  - Findings from audits
  - NASA Inputs to Burn-in (BI) Task Group



The twin Voyager 1 and 2 spacecraft continue exploring where nothing from Earth has flown before. Flying since 1977, they are now in the "Heliosheath" - the outermost heliosphere layer where the solar wind is slowed by interstellar gas pressure.

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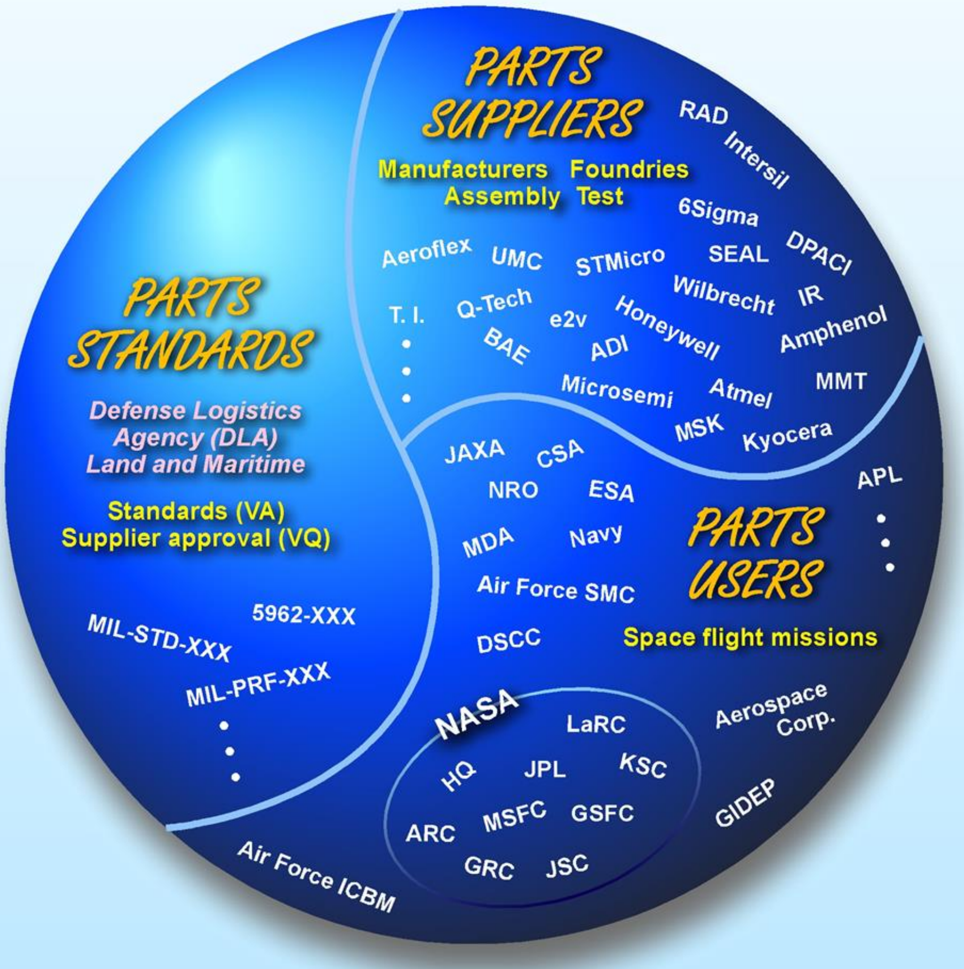
Space Parts World

A Small, Vanishing Part of the Commercial Parts World



NEPAG is actively involved with the procurement process - parts users and standards organizations join hands to ensure timely delivery of reliable parts from suppliers.

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Microcircuits Burn-in (BI) Screening Requirements Are out of Date and Have Multiple Interpretations

- **BI is the key screening step** – considered essential to weed out product infant mortality.
- Our recent audit and specification review work has shown that the microcircuits BI screening requirements as stated in MIL-STD-883, Test Method 5004, are **out of date and have multiple interpretations**.

- **Why are they out of date?**
  - Were developed more than 25 years ago
  - Then: were at 5-micron technology node
  - Now: 45-nm space products in development, on their way to QMLV certification. Made possible by
    - Dual use technology
    - Advances in packaging technology
    - Availability of system-on-a-chip (SOC) products, which could be easily called assemblies
  - With column grid arrays (CGAs), reached limitation for complete screening
  - Changing business landscape

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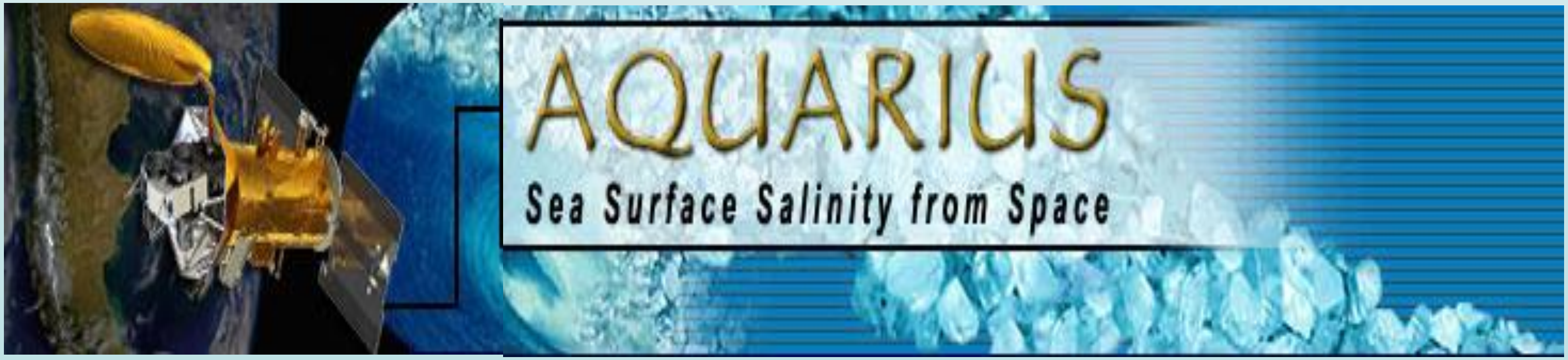
Microcircuits Burn-in (BI) Screening Requirements Are out of Date and Have Multiple Interpretations (Cont'd)

- **No clear interpretation** any longer
  - Varied implementation
- **Periodic, frequent updates are needed!**

- **Recent Activities**
  - At the request of NASA and others, a new JC13 Task Group was formed to provide guidance.
  - More rigorous reviews done during audits and specification reviews



Launched June 10, 2011, the Aquarius/SAC-D mission is a partnership between NASA and Argentina's space agency (CONAE) using advanced technologies to make global space-based measurements of ocean salinity.

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NEPAG Supplier Audits

- **DLA Audits Support**
  - DLA Land and Maritime-VQ (formerly DSCC) is the designated Department of Defense entity that has **authority to approve or disapprove suppliers**. There are two parts to an audit: certification (capability demonstration) and qualification (successfully building product).
  - Agencies such as NASA and the Air Force bring **technical expertise** to audits.
  - Audits to be supported by space community are **chosen during the NEPAG telecons**. We support audits as subject matter experts, gain personal knowledge, make contacts, and **resolve flight-project issues.**
  - Audit teams spend most of audit time on production floor, test floor, and other work areas talking to operators and engineers, and they witness operations and tests being performed. They review supplier chain management, counterfeit parts mitigation, and varied other items.
  - Audit findings are reported on NEPAG telecons. High-level summary of audits supported by NASA are entered into the NASA **SAS** (Supplier Assessment System) database.

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Recent Findings from Microcircuit Audits & New Technology Data Reviews

- **Disabled Chip Burn-ins.** Recent audit for QML device discovered that a chip was disabled during static burn-in; thus, it was not drawing any current.
  Recommendation: For new SMDs, add a statement within burn-in paragraphs stating that parts shall be kept in their enabled state during burn-in.
- **Class Q 160-hr/125ºC Burn-in.** Interpreted as static burn-in (even for CMOS technology).
  Recommendation: Provide specific guidelines in MIL-STD-883, Test Method 5004.
- **At Frequency (Dynamic) Burn-ins.** Test equipment limitation cited for not doing burn-ins at application frequency.
  Recommendation: Burn-in task group to discuss and provide guidance. When SMD says that a part can be used at 200 MHz, doing burn-in at 6 MHz (cited as “burn-in equipment limitation frequency”) is not meaningful!
- **Two Static Burn-ins.** Some manufacturers do electrical testing between two static burn-ins, whereas others do electricals after completing both static burn-ins.
  Recommendation: Provide specific guidelines in MIL-STD-883, Test Method 5004.
- **Thermal Imaging.** For a device with hot spots, thermal resistance, junction-to-case would be much higher than guidelines given in MIL-STD-1835. One supplier used thermal imaging to find hot spots on the die.
  Recommendation: Assign a task group to evaluate effectiveness of thermal imaging at product development stage.

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NASA Inputs to BI Task Group

1. **Clarify burn-in requirements** for space products in Table I of Method 5004: specifically, screening steps 3.1.10, 3.1.12, footnote 9/, and footnote 10/. As written, it implies that dynamic burn-in is a requirement. However, this is not always done. Moreover, for certain functions, such as a precision voltage reference, how would you design a dynamic burn-in? Requirements need to be reviewed and updated.

2. **High-Temperature Reverse Bias (HTRB) vs. Static Burn-in**. No mention of static burn-in in Table I of Method 5004. We all know that digital products are subjected to static burn-ins, often two: one for low condition (Static I) and the other for high condition (Static II). Add reference to static burn-in(s) as appropriate.

3. **How are burn-in voltage, frequency, etc. supposed to be determined?**

4. **Are any manufacturers using low temperature burn-in?** If yes, a low-temp burn-in option should be included in the screening spec.

5. **What activation energy (Ea) should be used for new technology?**
   Some manufacturers are using a fixed Ea of 0.7 eV.

6. **Time-temperature regression tables (e.g., Table I in Method 1015) should be reviewed.**
   What Ea are they based on? Is that Ea still valid?

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NASA Inputs to BI Task Group (Cont’d)

7. Limited-temperature parts:

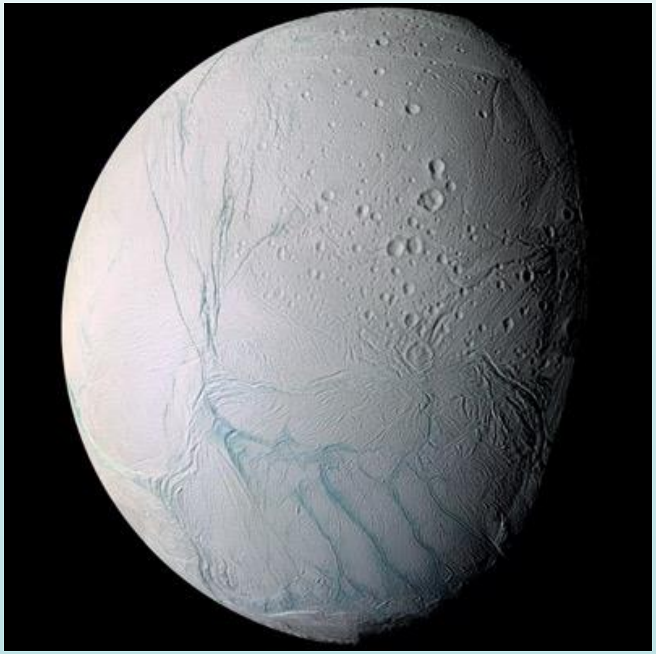
- Anything not meeting full MIL temperature range (–55 ºC to +125 ºC)
- If the part rating has a maximum temperature less than +125 ºC, what is the temperature and duration of the burn-in?

8. Dynamic burn-in for high-speed devices.

- What frequency should be used?

The NASA/ESA/ASI Cassini-Huygens mission has directly sampled the water plumes jetting into space from Saturn’s moon Enceladus. The findings from these fly-throughs are the strongest evidence yet for the existence of large-scale saltwater reservoirs beneath the moon’s icy crust.*

**U.S. National Aeronautics and Space Administration / European Space Agency / Agenzia Spaziale Italiana*



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Additional NASA Inputs to JC13 Task Group
Static Burn-in Circuits

- **Considerable variation on how they are implemented.**
  - **Single circuit used with half of the inputs biased low and the other half biased high**
    - Post static burn-in electricals done.
  - **Two Circuits used.**
    - All inputs low (Static I)
    - All inputs high (Static II)
    - Post static burn-in electricals done **after completion of both** (Static I and Static II) burn-ins.
  - **Two circuits used.**
    - All inputs low (Static I)
    - All inputs high (Static II)
    - Post static burn-in electricals done **after completion of each** static burn-in.

  - **Task Group review and guidance requested. Also, clarify which inputs are being used and their settings: data, control, address, clock,…?**

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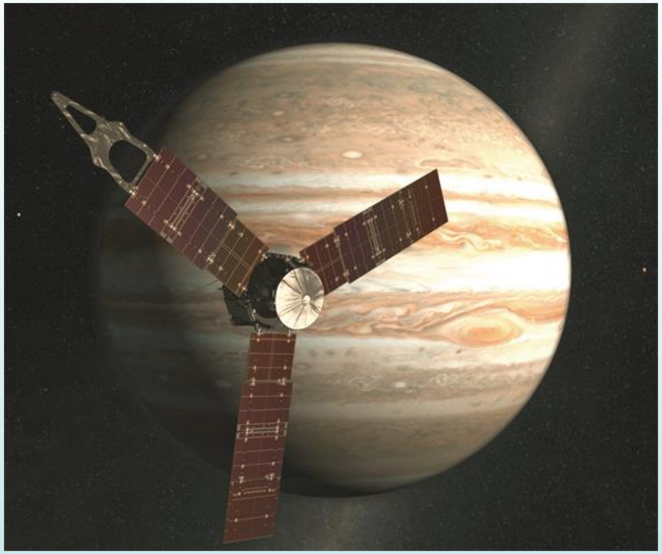
Task Group – 2011-01
SMD Electrical and Burn-in Guidelines

- Charter for Task Group. Develop JEDEC document for guidance to suppliers and users that includes recommendations on Deltas, SMD electrical parameters, and Burn-in. Also, provide recommendations for any needed changes to MIL-STD-883.

1. Burn-In
   a. types required - dynamic and static/high-temperature reverse-bias burn-in (HTRB)
   b. burn-in specified by technology or product type
   c. junction temperatures to be achieved
   d. burn-in conditions - voltages, frequency, etc.

2. Delta Requirements
   a. definition - critical parameters selected to provide a measure of product and process stability
   b. selection of delta parameters

3. Electrical Measurements
   a. parametrics
   b. functional
   c. selection of limits based on what?
   d. parameters guaranteed
      1) but not tested
      2) by design
      3) by characterization data
      4) data required to validate guaranteed position



Launched in August 2011, the solar-powered Juno spacecraft will enter a low, elliptical orbit circling Jupiter from pole to pole to investigate secrets hidden beneath the planet's thick, colorful clouds. The innovative orbit will avoid lethal belts of charged particles surrounding Jupiter like the less dense Van Allen belts encircling Earth.

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Changing Landscape
A New Trend – Supply Chain Management

When auditing your suppliers, should you be auditing your suppliers' suppliers?

Your purchase order to a manufacturer provides a part that may have required careful handling from all the companies in the fictitious but typical supply chain below (and they all will need DLA approval).

Die design	Part Manufacturer
Fabrication	Operation A (could be performed by the manufacturer or Company A)
Package design Package manufacturing	Operation B
Wafer lap and dice	Operation C
Assembly	Operation D
CGA column attach Solderability	Operation E
Screening/electrical/package Tests	Operation F
Complete electricals per SMD	Operation G
Internal water vapor content	Operation H
Radiation testing	Operation I
And so on………	

The Hubble Space Telescope (HST) is a 2.4-m (7.9-ft) aperture space telescope. It was carried into low Earth orbit by a Space Shuttle in 1990, and it remains in operation.

Changing Landscape for Operating Temperature Range:

Use Caution, Many Newer Parts Are No Longer Guaranteed over The MIL Temperature Range

Example: DLA SMD 5962-99607

Device Type	Generic No.	Circuit Function	Access Time
01	8Q512	512K X 8-bit rad-hard low voltage SRAM (MIL Temp)	25 ns
02	8Q512	512K X 8-bit rad-hard low voltage SRAM (Extended Temp)	25 ns
03	8Q512	512K X 8-bit rad-hard low voltage SRAM (MIL Temp)	20 ns
04	8Q512	512K X 8-bit rad-hard low voltage SRAM (Extended Temp)	20 ns
05	8Q512E	512K X 8-bit rad-hard low voltage SRAM (MIL Temp)	20 ns
06	8Q512E	512K X 8-bit rad-hard low voltage SRAM (Extended Temp)	20 ns

Operating case temperature, (T_C) (Device 01, 03, and 05) .... –55 ºC to +125 ºC
Operating case temperature, (T_C) (Device 02, 04, and 06) .... –40 ºC to +125 ºC

This SMD implies that there may be a performance issue at low temperatures.
Use caution for operation at low temperatures. Work with the manufacturer; get product test/characterization data.

Some other Memories (e.g., 5962-01533 and 5962-01511) are specified as follows:

- Device type 01, –40 ºC to +125 ºC;
- Device types 02 and 03, –40ºC to +105 ºC.

These may have performance problems at both low and high ends.

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Issues Going Forward

- **Perhaps, now is the time to review the role and fundamentals of BI.**
- **Is the HTRB still meaningful?**
- **Static BI**
  - How many needed
  - Biasing of each circuit
  - Electrical measurements when
  - Changing business landscape
  - Meaningful readings
- **Dynamic BI**
  - Voltage
  - Frequency
  - Output loading
  - Ensuring proper BI of high speed devices
- **Parametric Deltas**
  - Which parameters.
  - Limits
  - Ensure the readings are meaningful

This image of an outcrop at the "sheepbed" locality, taken by NASA's Curiosity Mars rover, shows well-defined veins filled with whitish minerals, interpreted as calcium sulfate. These veins form when water circulate through fractures, depositing minerals along the sides of the fracture. These veins are Curiosity's first look at minerals that formed within water that percolated within a subsurface environment. The vein-fills are similar in appearance to the Sheepbed rock unit in the Yellowknife Bay area of Northwest Canada.

Issues Going Forward (Cont'd)

- **Junction temperature**
  - How to achieve maximum allowable junction temperature
- **Limited-temperature (restricted-temperature) range parts**
  - BI temperature
  - BI duration – time/temp table in TM 1015, applies to hybrids but is not applicable to microcircuits
  - What temp range to do final (post BI) electricals
- **New technology - CGAs**
  - Suppliers don't recommend post-CGA BI
  - How to ensure infant mortality removal after installation of columns
- **Supply chain management**
  - Additional BI to catch parts potentially damaged by extra handling?
- **Hybrids parts**
  - BI temperature, time, voltage
  - Element evaluation burn-in
- **Hybrid crystal oscillators**
  - BI temperature, time, voltage

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Issues Going Forward (Cont'd)

- **Signal integrity capacitors used in microcircuits**
  - MIL-PRF-38535, Para 3.15.1 specifies screening requirements
  - Base metal electrode (BME) capacitors used with low-voltage high speed microcircuits do not meet Para 3.15.1
    - BMEs were meant to be used in commercial applications
    - However, the upscreened versions of the BMEs have also found their way into microcircuits and hybrids of interest to the space community
    - The suitability of BMEs for use in space applications is being evaluated by
      - JEDEC, NASA, ESA, and JAXA
    - The goal is to have an acceptable screening flow this fiscal year.
    - It should be noted that these screened BME capacitors would see additional screening including the burn-in(s) at the unit level.

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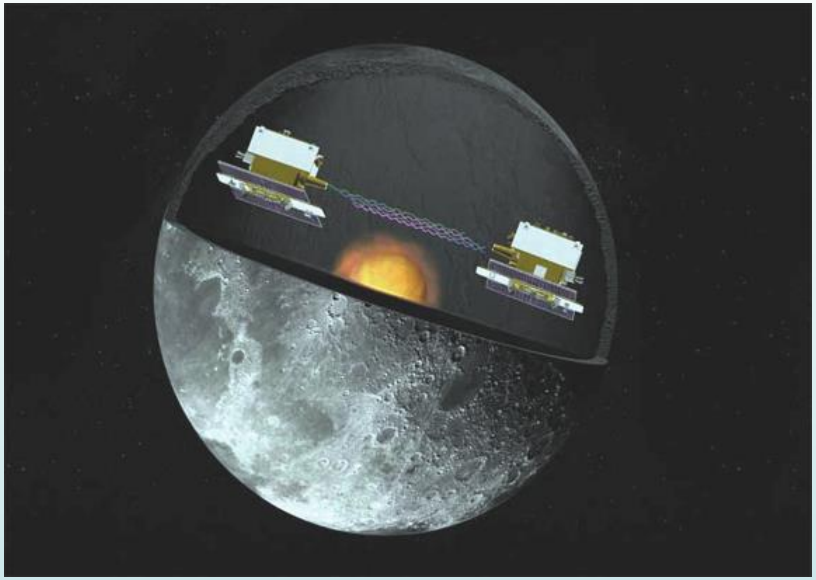
Conclusion

- **BI is the backbone of parts screening—the major vehicle to improve product quality.**
- **A long term BI (life test) is used to assess product reliability.**
- **Needs revisiting**
  - Clarify requirements
  - Ensure implementation
- **Resources**
  - ESCCON (ESA)
  - ETW (NASA)
  - MEWS (JAXA)
  - SPWG (Aerospace Corp.)
  - NEPAG (Space community)
  - Part Manufacturers
  - JEDEC Task Group
  - DLA (VA and VQ)
  - Other
- **Flexibility needed**
  - Especially when it comes to adapting new technology



Gravity Recovery and Interior Laboratory (GRAIL) mission, used twin spacecraft flying in formation to investigate the moon's gravity field, a possible inner core and how Earth and other rocky planets formed. The probes were launched September 2011, arrived with the New Year, and operated until December 17, 2012.

Thank you!

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Thanks to everyone who contributed to the successful landing and operation of the Curiosity Rover!

NASA's Mars Science Laboratory (Curiosity rover)

Launched: Nov. 26, 2011
Landed : Aug. 5, 2012

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http://nepp.nasa.gov

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