National Aeronautics and Space Administration

NASA/JPL's Approach to Selection/Qualification of A/D Converters For Space Applications

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Agenda

- The Space Business
- NASA/JPL
- A/D Selection/Qualification
- Supplier Selection
- NEPAG
- Summary

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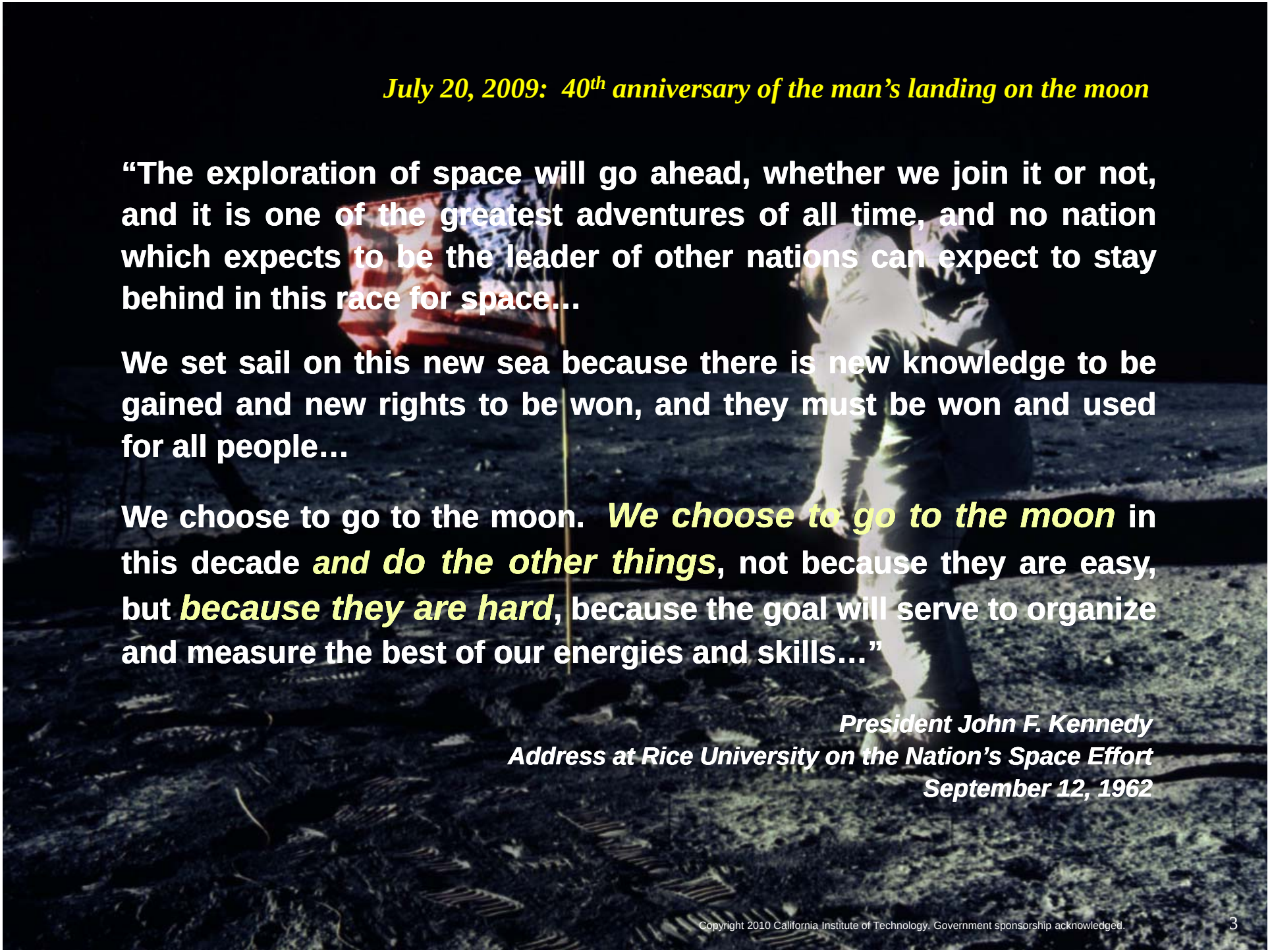

July 20, 2009: 40th anniversary of the man's landing on the moon

"The exploration of space will go ahead, whether we join it or not, and it is one of the greatest adventures of all time, and no nation which expects to be the leader of other nations can expect to stay behind in this race for space…

We set sail on this new sea because there is new knowledge to be gained and new rights to be won, and they must be won and used for all people…

We choose to go to the moon. *We choose to go to the moon* in this decade *and do the other things*, not because they are easy, but *because they are hard*, because the goal will serve to organize and measure the best of our energies and skills…"

President John F. Kennedy
Address at Rice University on the Nation's Space Effort
September 12, 1962

We choose to go to the moon and do other things because they are hard…

- At the outset, our leaders knew that the Space exploration would be hard, requiring individuals with special skills
- Space presents an unforgiving, harsh environment
- The deep space missions NASA /JPL develops are simply non-repairable; can't send a repairman up there
- MARS at night gets very cold
- Above all, there is never enough money to do everything science would like
- In spite of these challenges, the global space community has had notable successes
- As an example of how we assemble a spacecraft from a mission assurance perspective, this talk will address the selection and qualification of analog-to-digital converter devices (A/Ds). General information on NASA EEE Parts Assurance Group (NEPAG) will be provided as well.

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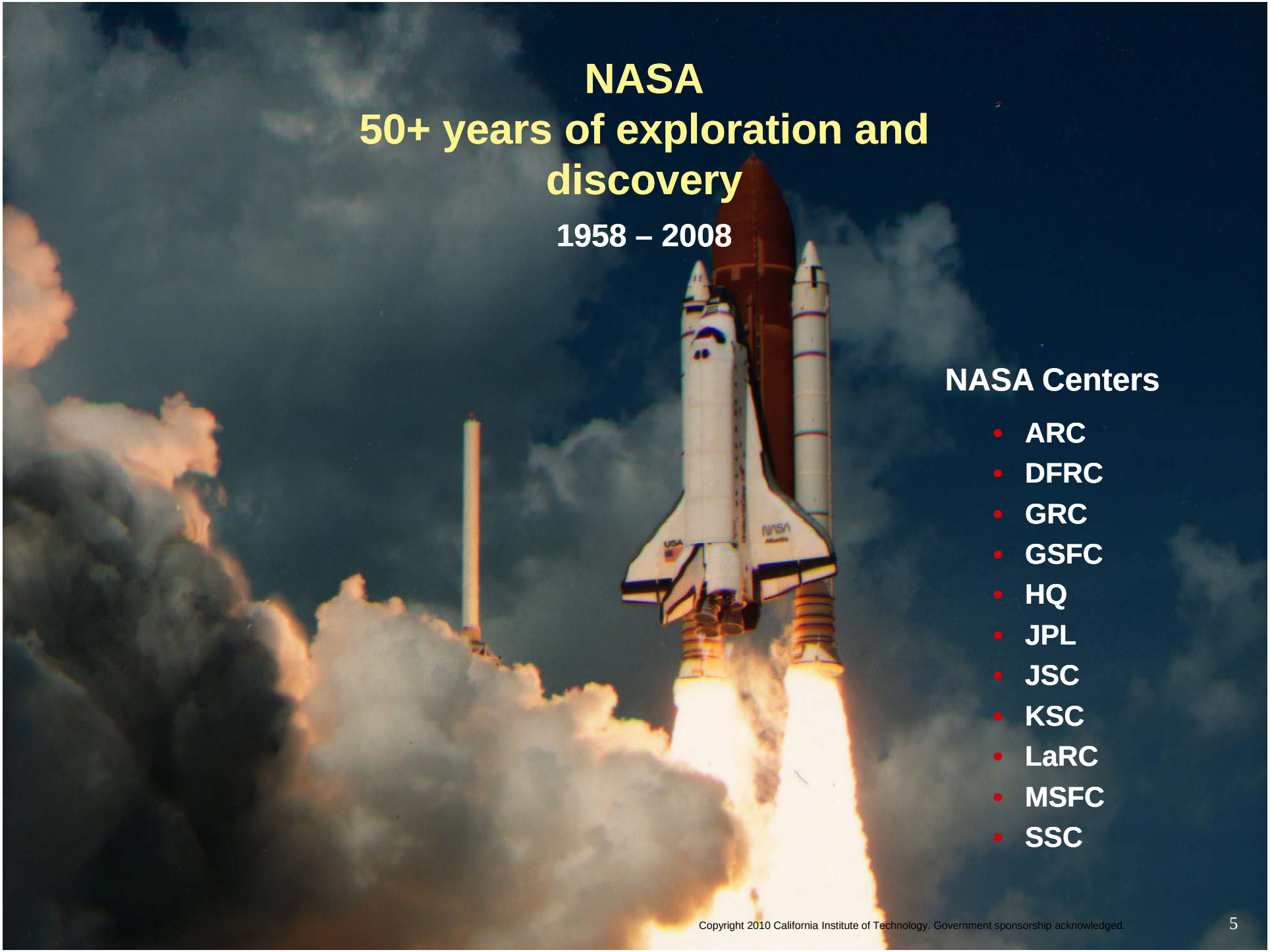

NASA
50+ years of exploration and discovery

1958 – 2008

NASA Centers

- ARC
- DFRC
- GRC
- GSFC
- HQ
- JPL
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- LaRC
- MSFC
- SSC

Jet Propulsion Laboratory (JPL)
www.jpl.nasa.gov

- **Government (mainly NASA)-funded unit of the California Institute of Technology (www.caltech.edu)**
- **Charter: Un-manned (robotic) missions**

NASA/JPL Mission – Mars Rovers

Roving Mars surface

January 2010: 6th Anniversary – Twin rovers land on Mars and continue to return major science

A/Ds Selection/Qualification

- A/Ds are one of the critical components engineers seek when designing electronic hardware for space flight projects. Their performance requirements cover a wide spectrum.
  - The three main features are bit resolution, power and speed. In addition, each project levies radiation and reliability requirements the selected A/D must meet.
  - The number of flight worthy suppliers is dwindling
  - Investigate investigate commercial-off-the-shelf products
- "Selection and qualification" as applied here means the process of considering the requirements from the design group and delivering a space flight worthy product.
  - Standard parts - product that meets the required specifications regarding radiation, temperature and life.
  - Non-standard parts – product that require additional testing to become flight worthy. A worse-case situation could be working with a manufacturer to develop a brand new product that can not only be used on our project but also marketed by the manufacturer to others.
  - Both standard and non-standard parts undergo "selection and qualification":

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Standard and Non-standard A/Ds

- **Standard parts** are sold by manufacturers as space quality with specified radiation characteristics for single event latch up (SEL) and total dose hardness. Examples of standard A/Ds include: Analog Devices 12-bit AD9042, National Semiconductor 8-bit ADC08D1520, Honeywell 12-bit RH9225, ST Micro 12 bit RHF1201, e2v (formerly Atmel) 8-bit TS8388.

- **Non-standard Parts** require additional reliability and/or radiation testing. Below are several examples of non-standard A/Ds that required additional work to become flight worthy:
  - The Cassini Project needed a 12-bit low power A/D. Tested several parts and found Maxim MX7672 was a potential candidate as it had acceptable single event latch up characteristics. However, it showed poor total dose hardness. NASA/JPL learned that a new start up company, Space Electronics, Inc. (SEI), which was an off shoot of SAIC (Science Applications International Corporation), had patented a package shielding technique, RADPAK, that increases total dose radiation hardness for electronic parts. NASA/JPL worked with SEI to develop a space level 7672RP that had Maxim die packaged in a RADPAK flat-pack package.

Non-standard A/Ds (Contd.)

- **Non-standard A/Ds** (contd.):
  - TES project needed a 16-bit low power A/D converter. The Burr-Brown (now TI) 7809 met performance requirements, but it was a commercial part with low total-dose radiation levels. Fortunately, it exhibited non-destructive single event latch-up. Under a research program, SEI developed a reset circuit to provide protection against single event latch up. The discrete version of the circuit was then built as an ASIC providing a two-die solution for parts like the 7809 (7809 die and the LPT ASIC die). LPT = Latch-up Protection Technology. In order to enhance total-dose performance, the 7809 and the LPT ASIC dies were packaged in a RADPAK package.
  - OCO needed a 16-bit serial low power A/D converter. Analog Devices AD977A met the performance criteria, was tested for radiation and found to have acceptable latch-up and total-dose characteristics, but required up-screening to meet the project's reliability requirements.

Non-standard A/Ds (Contd.)

- **Non-standard A/Ds** (contd.):
  - GALEX, CloudSat and other projects needed a 14-bit low power A/D converter. Linear Technology LTC1419A met the performance criteria with acceptable single-event and total-dose characteristics. But, the part was available only as commercial in a plastic package (PEM). Because it is risky to use PEMs on a non-repairable space mission, an up-screen flow developed for PEMs must identify and mitigate those risks. Testing may include the following:
    - Measure glass transition temperature Tg, the temperature at which a substance changes from a hard, glassy material to a softer rubbery one. A margin should be allowed for measuring Tg and the resultant temperature should not be exceeded during screening or flight operation.
    - X-rays looking for any bond wire related issues, such as wire sweep, crossing wires, etc.
    - CSAM screen for delamination.
    - Electrical tests ensure parts work over the intended temperature range. Read and record data.
    - Burn-in temperature and time should be adjusted based on the glass temperature measurement.
    - Qualification tests including life-test, temperature cycling and others to satisfy mission requirements.

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Non-standard A/Ds (Contd.)

- **Non-standard A/Ds** (contd.):
  - MRO, SDO and other NASA projects needed a 16-bit low power A/D. The Linear Tech LTC1604A met the performance requirement had acceptable single event latch up and total dose characteristics and was tested for radiation, but it was available only in a plastic package. It required up-screening to meet project reliability requirements. In this particular case, Linear Tech up-screened the parts to a flow jointly developed with them.

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Example of Standard A/Ds

Table I. Example of Standard A/D Converters

Part Information	**Manufacturer**	**ADI**	**Honeywell**	**e2v**	**National**	**ST Micro**
	Part No.	9042	RH9225	TS8388	ADC08D1520	RHF1201
	Process	Bipolar/SOI	CMOS/SOI	Bipolar	CMOS	CMOS
	Power Supply	+5V	+5V	+5V, -5V	+2V	2.5V
	Power Dissipation	595mW	240mW	3.4W	2W	100mW
	Analog Input Voltage	2.4V	4v p-p	500mV diff/single	2V	2v p-p
	Digital Interface	Parallel	Parallel	Parallel	Parallel	Parallel
	Conversion rate/time	41Msps	20Msps	1Gsps	1.5Gsps	50Msps
	NASA/JPL Usage	Yes	Yes	Yes	Std Part	Yes
	Availability	Yes	Yes	Yes	Yes	Yes
Test Results	**Construction Analysis / DPA**	Acceptable	Acceptable	Acceptable	-	Acceptable
	Single Event Latchup	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable
	Total Ionizing Dose	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable
	Reliability	QMLV	QMLV	Space flow	QMLV	QMLV
	Other	Flatpack	Flatpack	Flatpack	Flatpack	Flatpack

Example of Non-standard A/Ds

Table II. Example of Non-standard A/D Converters

Part Information	**Manufacturer**	**Linear Tech**	**ADI**	**(SEI) Maxwell**	**Linear Tech**	**SEI (Maxwell)**
	Part No.	LTC1419/A	AD977A	7672RP	LTC1604A	7809LPTRP
	Process	CMOS	BiCMOS	CMOS	CMOS	CMOS[1]
	Power Supply	+5V, -5V	+5V	+5V, -12V	+5V, -5V	+5V
	Power Dissipation	150mW	100mW	110 mW	220mW	150mW
	Analog Input Voltage	+/- 2.5V	several	+5V, +10V, +/-5V	+/-2.5V	Several
	Digital Interface	Parallel	Serial	Parallel	Parallel	Serial
	Conversion rate/time	800 ksps	200ksps	5 us	333ksps	100ksps
	NASA/JPL Usage	Yes	Yes	Yes	Yes	Yes
	Availability	Yes	Yes	Yes	Yes	Yes
Test Results	**Construction Analysis / DPA**	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable
	Single Event Latchup	Acceptable	Acceptable	Acceptable	Acceptable	LPT
	Total Ionizing Dose	Acceptable	Acceptable	RADPAK	Acceptable	RADPAK
	Reliability	Upscreen	Upscreen	Space flow	Screened by Manufacturer	Space flow
	Other	PEM	Ceramic	Maxim die, flatpack	PEM	TI (BB) die, LPT ASIC die

Supplier Selection

- Space missions are global in nature
- So are the parts: fabricated in Taiwan; assembled in Thailand; tested in Singapore; sent to the USA for sale
- Supplier selection for space flight programs
  - QML suppliers are preferred
  - Country of origin is not a barrier
- Some Examples
  - Began about 25 years ago, what was then known as Marconi (located in Lincoln, England) was listed as a source for HCS logic used on Cassini project.
  - Currently we are evaluating 24 bit A/Ds from three suppliers, one of them is a European manufacturer.

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What is NEPAG?

- NEPAG is the acronym for NASA EEE (Electrical, Electronic, Electro-mechanical) Parts Assurance Group.
- It is a forum for the exchange of information on EEE parts across NASA (OneNASA) and the world-wide space community (OneSpace).
- Our Charter is to exchange EEE Parts information of mutual interest on the subjects of quality, reliability, radiation, availability, and technology used in space flight. We also, through consensus, control the necessary industry specifications, coordinate Military Specifications, mitigate vendor issues, resolve on-going problems, and support DLA Land and Maritime (formerly DSCC) audits to ensure reliable hardware.

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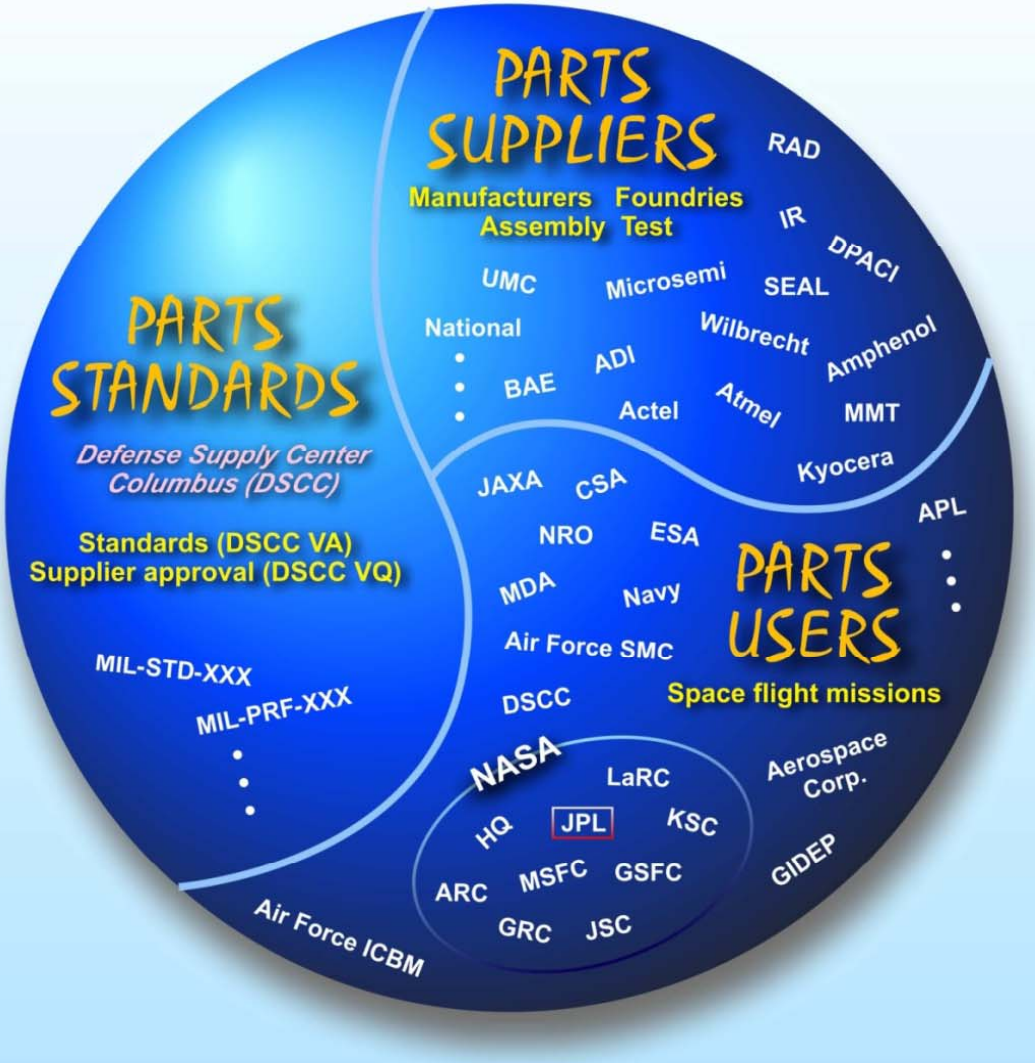
Space Parts World

A Vanishingly Small 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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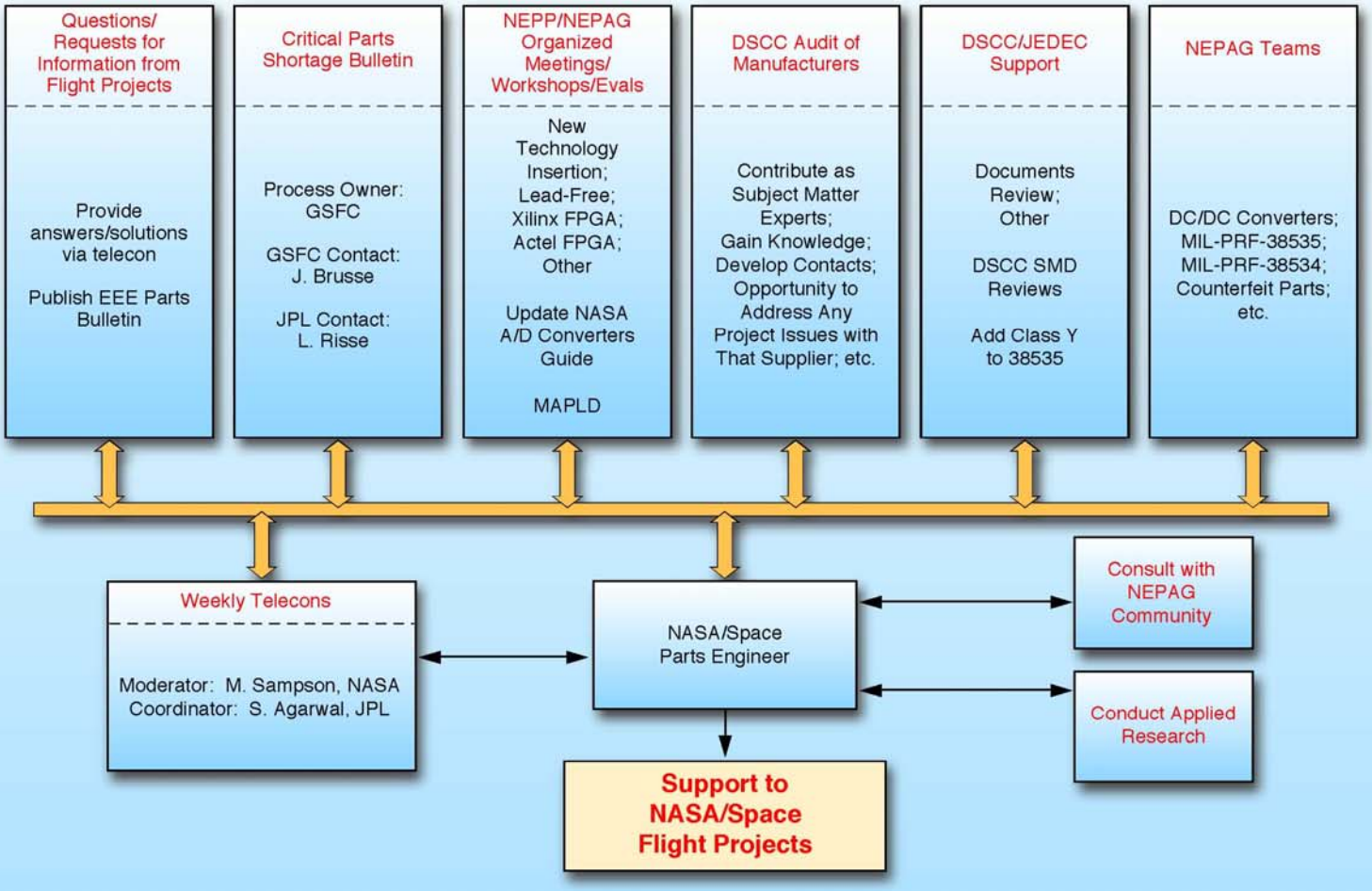
NASA/JPL NEPAG Activities



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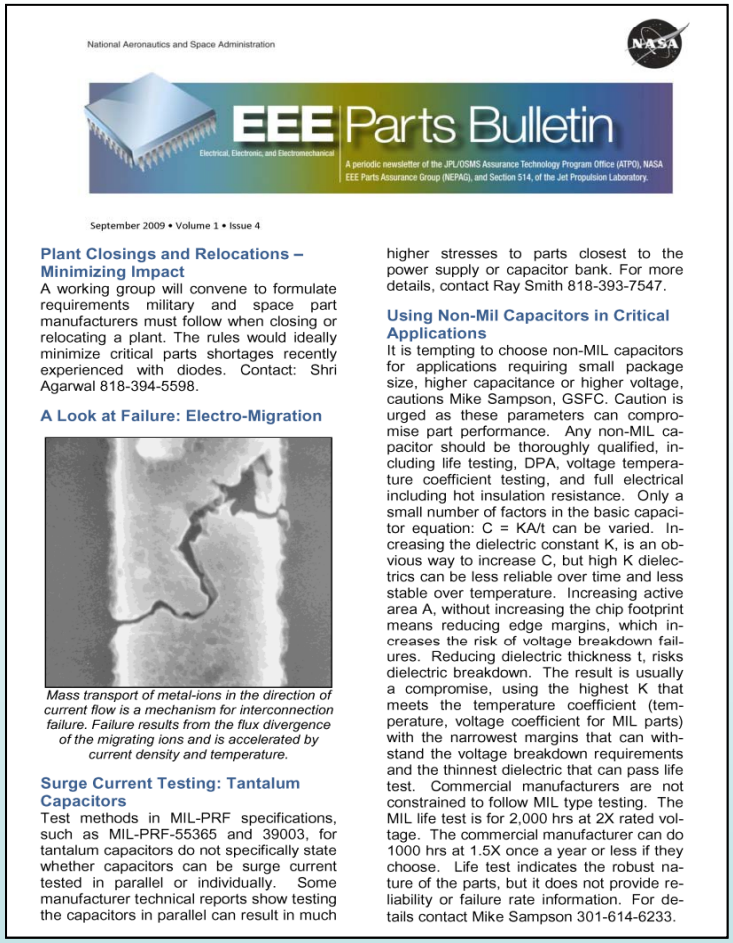
EEE Parts Bulletins



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EEE Parts Bulletin

Electrical, Electronic, and Electromechanical

A periodic newsletter of the JPL/OSMS Assurance Technology Program Office (ATPO), NASA EEE Parts Assurance Group (NEPAG), and Section 514, of the Jet Propulsion Laboratory.

September 2009 • Volume 1 • Issue 4

Plant Closings and Relocations – Minimizing Impact

A working group will convene to formulate requirements military and space part manufacturers must follow when closing or relocating a plant. The rules would ideally minimize critical parts shortages recently experienced with diodes. Contact: Shri Agarwal 818-394-5598.

A Look at Failure: Electro-Migration

Mass transport of metal-ions in the direction of current flow is a mechanism for interconnection failure. Failure results from the flux divergence of the migrating ions and is accelerated by current density and temperature.

Surge Current Testing: Tantalum Capacitors

Test methods in MIL-PRF specifications, such as MIL-PRF-55365 and 39003, for tantalum capacitors do not specifically state whether capacitors can be surge current tested in parallel or individually. Some manufacturer technical reports show testing the capacitors in parallel can result in much higher stresses to parts closest to the power supply or capacitor bank. For more details, contact Ray Smith 818-393-7547.

Using Non-Mil Capacitors in Critical Applications

It is tempting to choose non-MIL capacitors for applications requiring small package size, higher capacitance or higher voltage, cautions Mike Sampson, GSFC. Caution is urged as these parameters can compromise part performance. Any non-MIL capacitor should be thoroughly qualified, including life testing, DPA, voltage temperature coefficient testing, and full electrical including hot insulation resistance. Only a small number of factors in the basic capacitor equation: C = KA/t can be varied. Increasing the dielectric constant K, is an obvious way to increase C, but high K dielectrics can be less reliable over time and less stable over temperature. Increasing active area A, without increasing the chip footprint means reducing edge margins, which increases the risk of voltage breakdown failures. Reducing dielectric thickness t, risks dielectric breakdown. The result is usually a compromise, using the highest K that meets the temperature coefficient (temperature, voltage coefficient for MIL parts) with the narrowest margins that can withstand the voltage breakdown requirements and the thinnest dielectric that can pass life test. Commercial manufacturers are not constrained to follow MIL type testing. The MIL life test is for 2,000 hrs at 2X rated voltage. The commercial manufacturer can do 1000 hrs at 1.5X once a year or less if they choose. Life test indicates the robust nature of the parts, but it does not provide reliability or failure rate information. For details contact Mike Sampson 301-614-6233.

Test Data on JANS Parts

Thermal impedance data for JANS diodes may not be included in data packs unless specifically requested on the purchase order to the manufacturer. For details contact Ed Powell 818-354-3188.

Counterfeit Parts – New Blacktopping Material in Use

A semiconductor distributor recently found two instances of suspect counterfeit parts that use a new blacktopping material designed to evade detection. The substance passes visual inspection and is immune to acetone—so many quality control technicians might not suspect the part is counterfeit. Parts were bought from brokers. A GIDEP advisory will be issued. Contact Phil Zulueta 818-354-1566.

Remarking of Parts

A recent procurement of a commercial microcircuit by a broker from an authorized distributor revealed the parts were remarked by the manufacturer to a lower grade part number. The manufacturer acknowledged that this is their practice when a part fails a higher specification but still meets a lower level spec. Notification would be helpful when parts are remarked. Military/Aerospace QML microcircuits may be remarked when properly documented and MIL-PRF-38535, para. A.3.6.13, requirements are met. Remarking semiconductors is also permitted and must meet MIL-PRF-19500 requirements when a higher-product-assurance-level part is substituted for a lower-assurance-level part (see para. 1.3.8). There are no regulations for remarking commercial microcircuits. Contact Lori Risse 818-354-5131.

Recent DSCC Audits supported for NASA by JPL Specialists

BAE Systems; Pacific Aerospace & Electronics; International Rectifier (Santa Clara); and Kyocera America Inc.

GIDEP 6E-P-09-01 Suspect Counterfeit: Leaded Small Signal Transistor

Parts marked JANTX2N2920 with date code 0309 purchased from an unauthorized source are suspected to be counterfeit. Contact: Ed Powell 818-354-3188.

GIDEP C7E-A-09-01 Suspect Counterfeit: Microcircuit, 32Kx8 nvSRAM

Parts marked STK14C88-N351 date code 0307 purchased from an unauthorized source are suspected to be counterfeit. Contact: Ramin Roosta 818-354-7385.

Upcoming Meetings:

- Military and Aerospace Programmable Logic Devices Aug. 31-Sept. 3 http://nepp.nasa.gov/mapld_2009
- JEDEC Joint Electron Devices Engineering Council JC-13 Meeting, Columbus, OH Sept. 21 - 24 http://www.jedec.org/default.cfm

Contacts

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Previous Issues:
http://atpo/nepag/index.html

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Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

A project engineer wrote, “Thanks, important EEE parts issues in a Bulletin format is a wonderful sight to see. Great information!”

B. Hughitt wrote that the JPL/NEPAG EEE Parts bulletins are outstanding. He asked that they be distributed to all QLF (Quality Leadership Forum) members.

NEPAG – OneSpace Community

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Summary

- NASA/JPL's approach to select and qualify Analog-to-Digital converter parts for space flight application was presented from a product assurance perspective.

- An overview of NEPAG was provided. It is like a big component engineering group representing the world wide space community. Together, we are working to improve the quality of EEE parts, including the A/D converters, used on space flight hardware. ESA is a valued partner of NEPAG.

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ACKNOWLEDGEMENT

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