Technology Management Symposium and Expo

1997

Commercial Off-The-Shelf (COTS)

Search for Low Power Space Electronic Parts (LPSEP) - COTS Parts Evaluation Results

Shri Agarwal & Mike Sandor

Organization

- Office 507 – Electronic Parts Engineering – Kevin P. Clark, Mgr.
  - Administrative Staff
  - Electronic Parts Information Management System (EPINS)
  - Parts Support – Ed Svendsen, Group Superv.
  - Radiation Effects & FA – Chuck Barnes, Group Superv.

Agenda

- Low Power (LP) Parts in Space
- Achieving Low Power
- Parts Evaluation Results
- Summary

The Meaning of COTS Varies by User

- "Buy and Fly"
- "Procuring via catalog part number to QML-V standards"
- "Procurement is performed without formal specification"
- "The product is not developed using government funds or is currently no longer subsidized by any government funds"

Our Interpretation:

COTS are parts whose specification is ***manufacturer-controlled*** as opposed to traditional "Hi-Rel"parts whose specification was ***Government or customer-controlled***

Why Put COTS Low Power (LP) in Space ?

1. The availability of COTS LP parts is proliferating.

2. COTS LP parts performance capabilities continue to increase (e.g. processing power & high density memories).

3. A new generation of leading COTS LP IC technologies is forthcoming:Bulk CMOS/RH & Silicon-On-Insulator (SOI).

4. COTS LP parts typically cost much less than radiation hardened counterparts; by using radiation tolerant parts the cost advantage can be preserved.

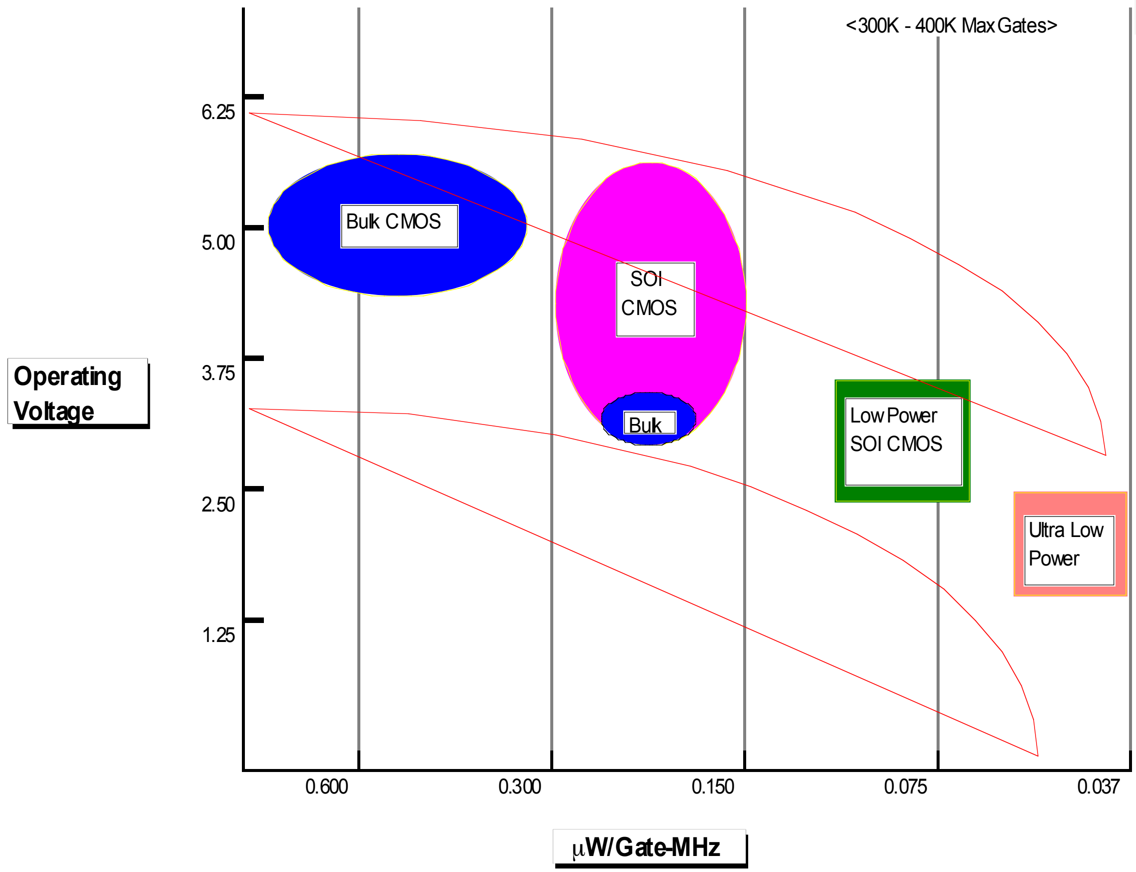
5. Some COTS LP parts (plastic only) have been reported to demonstrate good to excellent reliability.

Spacecraft Power Migration:

	Cassini	Galileo	X2000	Mars Pathfinder
Power Source	3 RTGs	2 RTGs	ARPS	Solar/Battery
SC Power Usage/ Requirements	900 Watts	600 Watts	150 Watts	3-12* Watts (Rover)

Notes:
RTG: Radioisotope Thermoelectric Generator
ARPS: Advanced Radioisotope Power Source
SC: Spacecraft
* Dependent on the operational mode

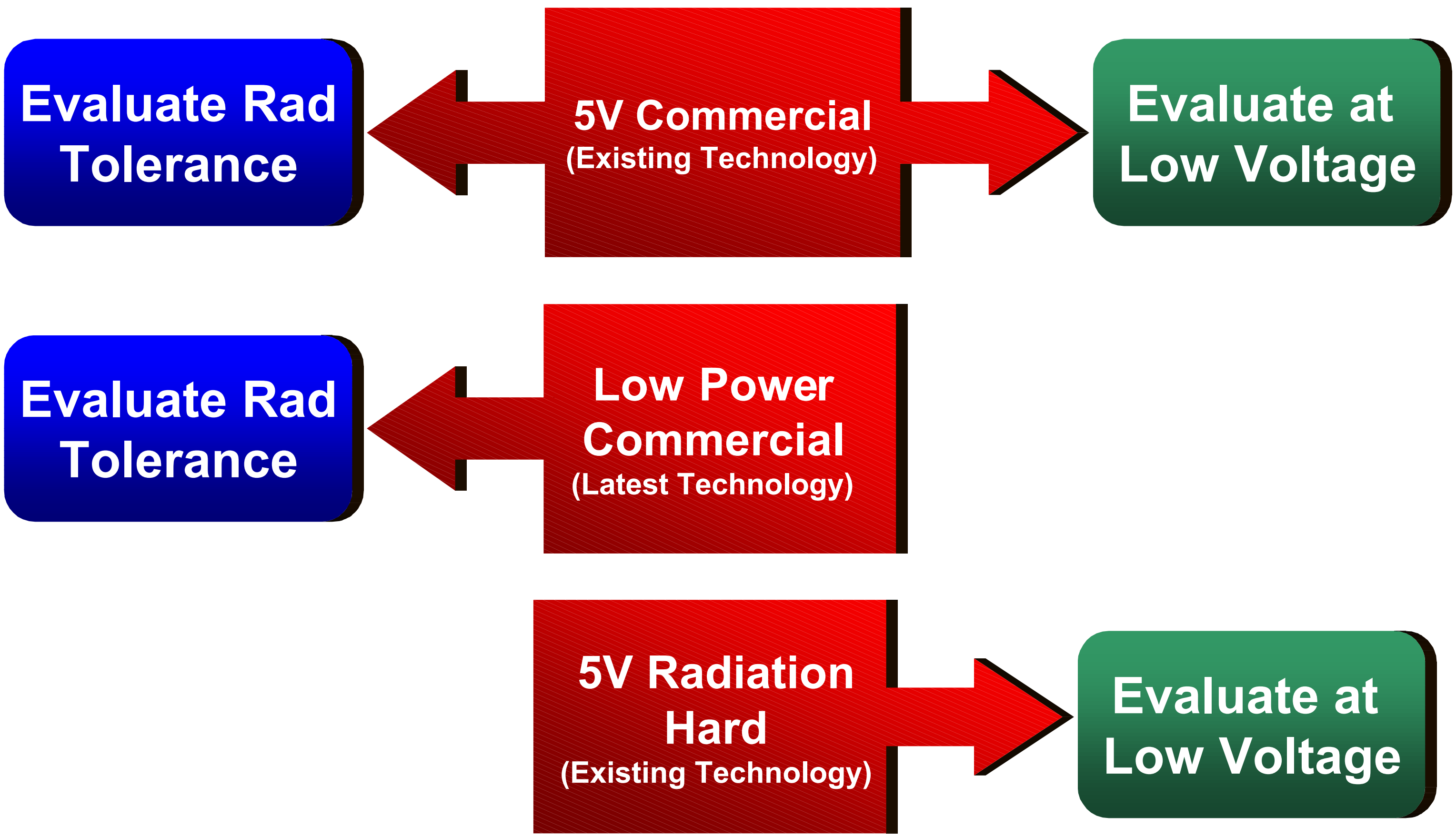
Low Power Parts Migration Path



Approaches:

1. Further Scaling of Structures for Conventional Bulk/RH
2. Thinner Si Active Regions for Silicon-On-Insulator
3. Ultra Thin Gate Dielectrics for Silicon-On-Insulator

Methods to Achieve Low Power Parts:



Reducing CMOS Device Power Dissipation:

{------------------------Dynamic Switching--------------------} {Short Circuit} {----dc Static----}

Power Equation: $P_T = n_p C_{load} V_{out} V_{dd} f_{clock} + Q_{SC} V_{dd} f + I_{leakage} V_{dd}$

n_p = activity factor determined by power management schemes

Qsc = short circuit charge during switching transient

Ileakage = dc static current (junction leakage)

Dominant Power Dissipation Factor: Dynamic Switching

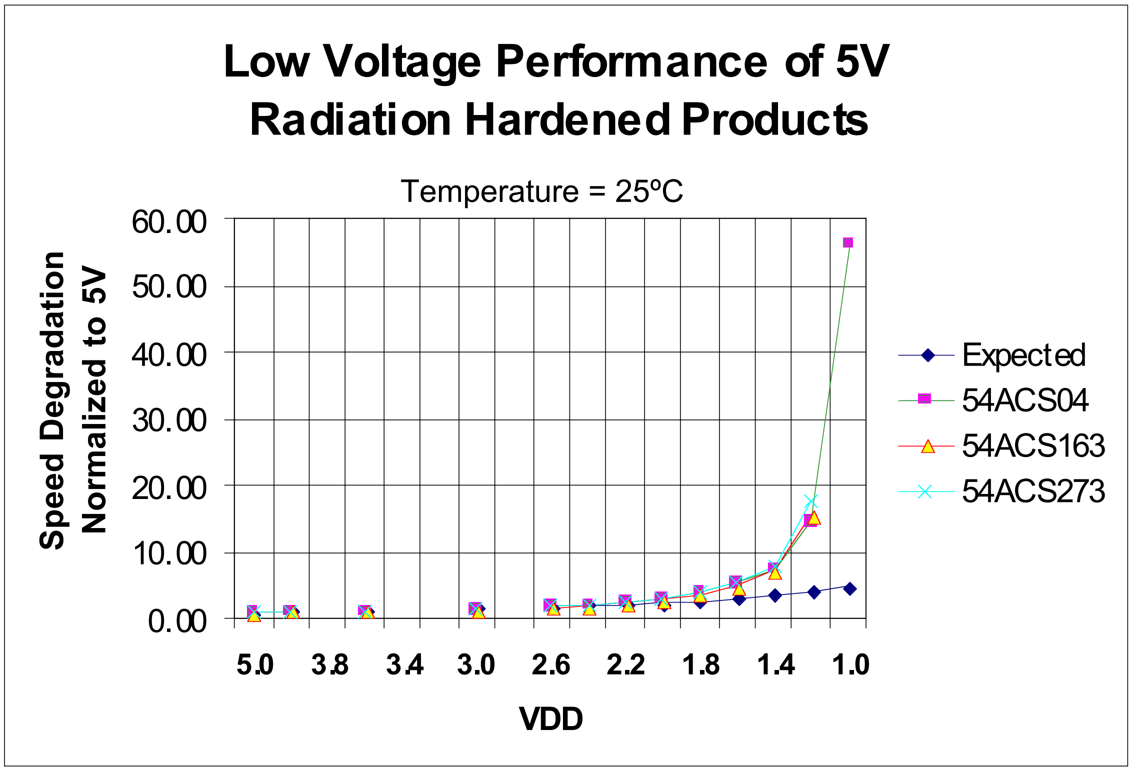
Dominant Power Reduction Controls for User:

1. **Vdd (supply voltage)**
2. **f (clock frequency & clock cycle)**

Issues To Consider When Using Low Voltage (Vdd) Parts:

- Speed degradation
- Realized power savings vs theoretical
- Performance over temperature
- Radiation effects
- Decreased signal to noise ratio
- Inadequate burn-in voltage and time
- Efficacy of applying derating factors

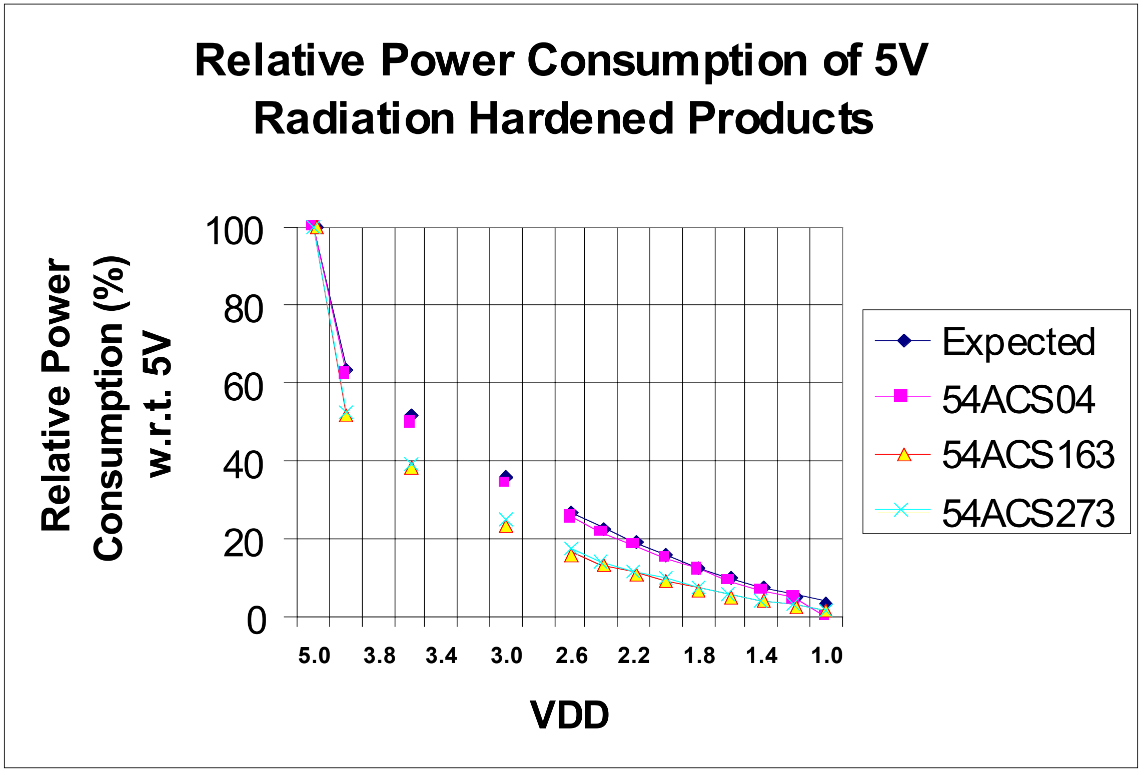
Speed Degradation Results:



Notes:

1. 54ACS163 and 54ACS273 failed functional test at VDD = 1.0V.
2. Below VDD = 2.5V there is a speed penalty over and above the expected degradation.

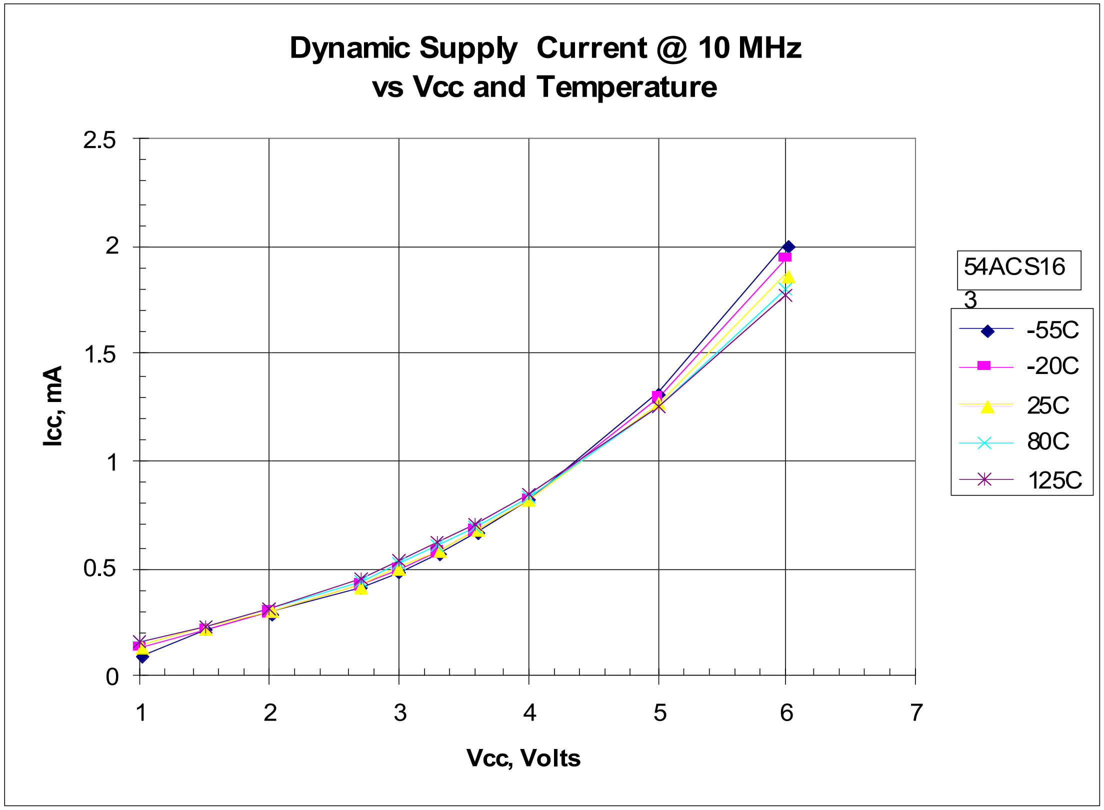
Realized Power Savings vs Theoretical Results:



Notes:

1. 54ACS163 and 54ACS273 are better than predicted.
2. 54ACS04 follows the prediction.
3. Power is calculated for each part using its dynamic current. The quiescent current contributions are negligible.

Temperature Compensation Results for 5V Radiation Hardened Products:



Notes:

1. All 3 parts showed excellent temperature compensation for dynamic current in the low Vcc range
2. At 6.0V, 15% w.c. divergence is observed for 54ACS163.

A/D Low Power COTS Radiation Results:

P/N	Resolution	Process	VDD	Power	Speed	Total Dose	SEL
LTC1419	14-Bit	CMOS	+/- 5V	150 mW	800 Ksps	TBD	None, LET>100 MeV/mg/cm2
SPT7725	8-Bit	Bipolar	- 5.2V	2.2 W	300 Msps	>100 Krad (Si)	None, LET>100 MeV/mg/cm2
HI1276	8-Bit	Bipolar	- 5.2V	2.8 W	500 Msps	TBD	None, LET>100 Mev/mg/cm2
AD7714-3	24-Bit	CMOS	+ 3V	2.6 mW	See data sheet	TBD	LET = 55 Mev/mg/cm2
ADS7809	16-Bit	CMOS	+ 5V	100 mW	100 Ksps	10 Krad (Si)	LET = 19.9 MeV/mg/cm2

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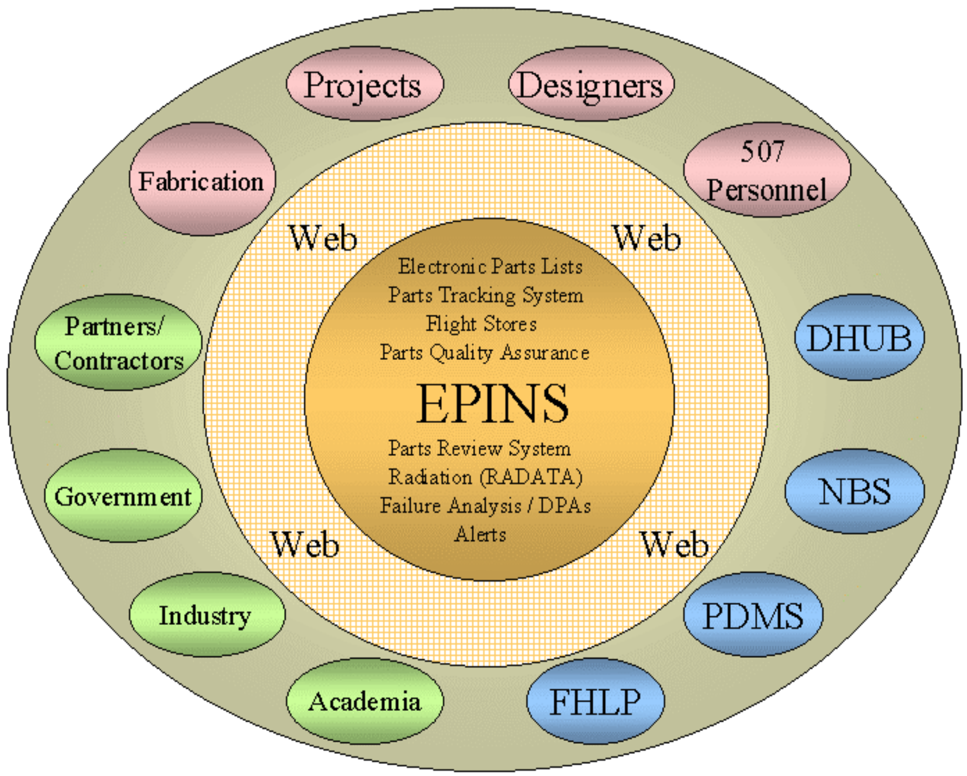
http://parts.jpl.nasa.gov



Electronic Parts Information Network System

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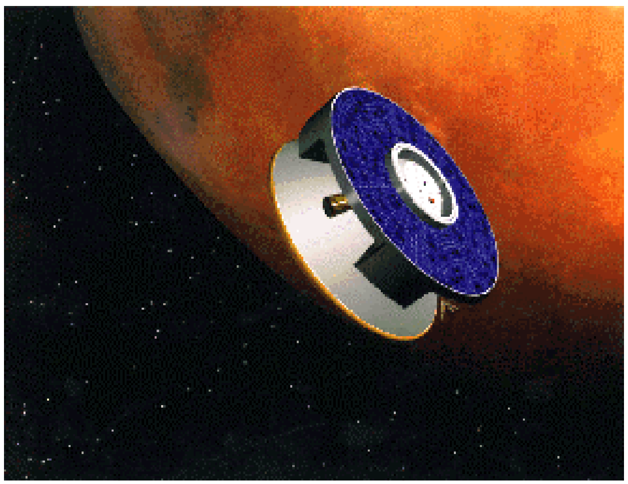
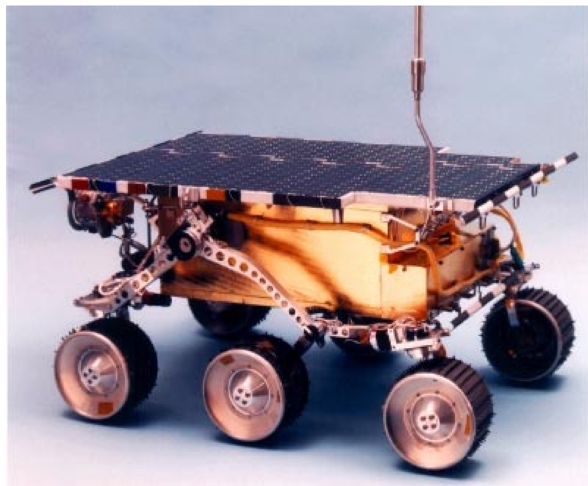
Plastic Parts Successfully Used For Mars Pathfinder:

16 Mbit DRAM Used in Pathfinder Flight Computer



FETs ; ASIC & Microcontroller Used in Modem for Lander and Rover



Passed 1000 Hours Life Test on Mars !

Conclusion:

More power constraints in future Space designs will necessitate using all available methods to reduce power consumption & improve performance via-

	Examples
1. Part selection	Lower voltage and power
2. Circuit design	Encoding of data or states
3. Architecture trade-off	Multi-level bus architectures
4. Power Management	Powering off selected bus nodes
5. Radiation Performance	Infusion of SOI technology

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EPE 507

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Risk Management Implementation for Low Power Electronic Parts in Space

QUALITY

	Weight	Problem Found		Risk Mitigation Solution			Risk Usage Assigned		
	Assigned	Yes	No	Yes	None	Unknown	Low	Medium	High
Construction Analysis:	M		X				L		
External Examination			x						
Internal Examination			x						
Die Cross Section			x						
Wire Bond (X-Ray)			x						

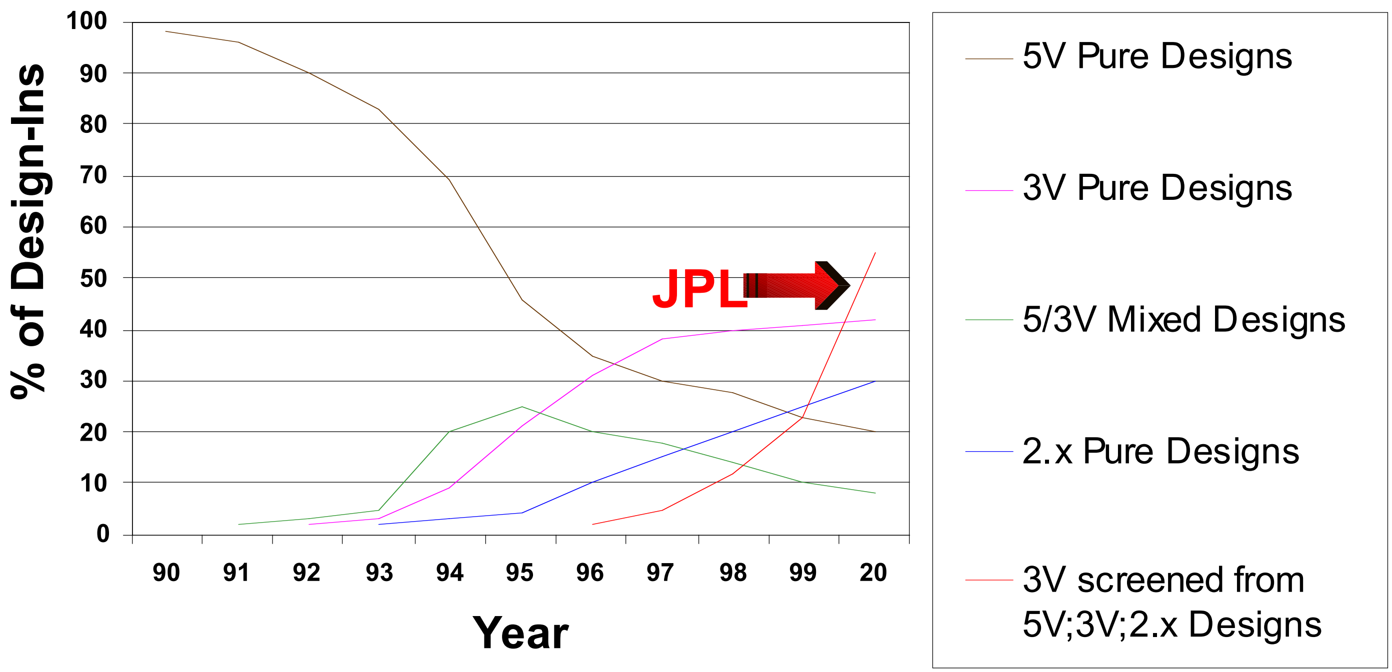
RELIABILITY

	Weight	Problem Found		Risk Mitigation Solution			Risk Usage Assigned		
	Assigned	Yes	No	Yes	None	Unknown	Low	Medium	High
Failure Rate Analysis:	H	X				X		M	
FIT Projection			x						
Test Coverage @ Temp		x		x					
Electrical Characterization		x				x		x	
Reported Failures			x						

RADIATION

	Weight	Problem Found		Risk Mitigation Solution			Risk Usage Assigned		
	Assigned	Yes	No	Yes	None	Unknown	Low	Medium	High
Radiation Performance:	H	X			X				H
Total Ionizing Dose			x						
SEU			x						
LET Latchup		x			x				x
Low Dose Rate Sensitivity			x						

Forcasted Migration of Low Power Designs - JPL vs Industry



Industry Data Source: ICE 1996