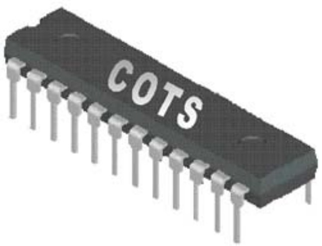
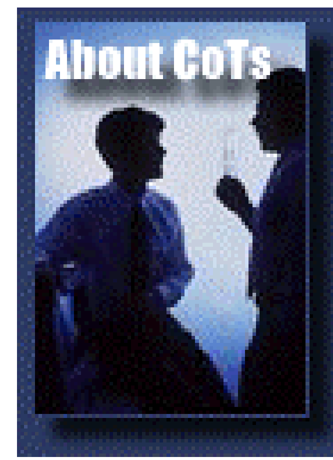
EEE Parts Microelectronics Reliability and Qualification Workshop

1998

Commercial Off-The-Shelf (COTS)

Reliability Concerns for COTS Microelectronics in Space & Military Applications





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&
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Agenda

- Introduction to COTS
- Prevalent COTS Concerns -Space vs Military
- Examples/Data
- Summary

JPL COTS Program Objective:

- Infusion of state-of-the-art COTS parts into JPL flight hardware & systems that meet the requirements of the mission they are used in

JPL COTS Infusion Process:

- Developing new methodologies, performing evaluations, making risk assessments, and implementing tailored mitigation measures to insure reliable parts

Scope of COTS Microelectronics:

- PEMs, KGD, Low Power/Temp., Advanced Microcircuits, FPGAs, ASICs, A/D, Memories, Microprocessors, Mixed Signal, among others

Reasons for Using COTS in Space:

1. The availability of COTS parts is proliferating.

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

3. A new generation of leading COTS IC technologies is introduced every 3 years.

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

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

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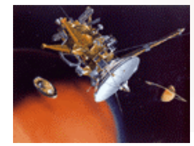
COTS Concerns







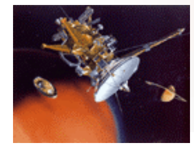
Concern	Military	Space	Why?
1. Very long term storage in a harsh environment (moisture sensitivity).	High risk	Low risk	Typical Storage <1-2 years (can be controlled)
2. Cannot upgrade to military temperature range.	High risk	Moderate risk	Can tailor screens to mission profile
3. Supplier selection is critical to achieving low risk.	High risk	High risk	Suppliers vary considerably
4. Acquisition costs do not reflect total cost of ownership.	High risk	High risk	Depends highly on risk mitigation steps taken
5. Lack of high reliability	High risk	Moderate risk	Apply risk assessment/methodology to meet mission requirements

High risk | Moderate risk | Low risk

COTS Concerns continued



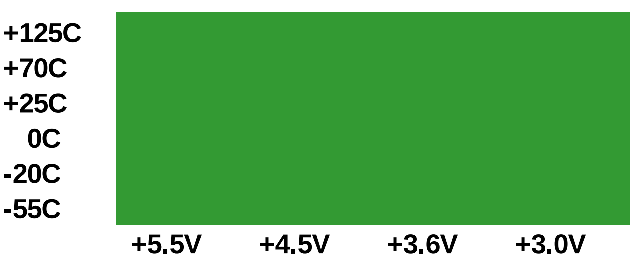




Concern	Military	Space	Why?
6. Lack of data	Red	Yellow	Rely on vendor's data or generate as needed
7. Radiation sensitivity	Yellow	Red	Harsher/more variable radiation requirements
8. Obsolescence	Red	Green	Short design cycles
9. Stockpile reliability	Red	Green	Relatively short shelf life
10. Human life jeopardy	Red	Green	Unmanned missions for planetary exploration
11. Life cycle cost	Red	Green	Reparability is non-issue; one time use only!

Concern #2- Cannot Upgrade to Military Temperature Range

COTS SRAMS have been evaluated by JPL at military temperature range:



Sony CXK584000TM Pass

SS = 6/6

Motorola MCM6246 Pass

SS = 6/6

Hitachi HM628512 Pass

SS = 6/6

Results:

Three different parts from three different vendors passed.

Lesson : Some parts can be upscreened under careful evaluation.

Concern #3- Supplier Selection is Critical to Achieving Low Risk

JPL Experience:

Mars Pathfinder used a COTS hybrid converter because of cost & schedule constraints. They ordered to a military temperature range from a non-QML supplier. Early samples showed problems which were aggressively worked with the vendor. New builds were better and performed well.

Some subsequent JPL projects ordered converters from the same vendor without the same rigorous follow-up, we found:

- Corrective actions from Mars Pathfinder did not persist
- 11/13 DPA samples from different lots were rejected
- JPL source inspection led to many rejects (19/20 lots)
- 8 operational failures in hardware
- Extensive effort required to solve the problems proved very expensive

Lesson : Successful COTS infusion requires careful selection of suppliers.

Concern #4- Acquisition Costs do not Reflect Total Cost of Ownership

Total Cost of Ownership (TCO)= Acquisition + Inventory + Evaluation + Replacement

where Evaluation varies considerably for COTS based on risk mitigation taken.

Case Example for COTS Transistor Evaluation:

a. Upscreen per SCD spec - $4,600

a. Special electrical test with R/R at specified temperature range including Burn-in - $5,600

b. Life test on samples - $3,400

c. Destructive physical analysis/RGA - $400

d. SCD, Engineering Review, CSI, Acceptance - $10,000

e. Replacement - $0

f. Radiation testing not required - $0

COTS Acquisition cost was ~ $600; TCO ~ 40X (can vary to 50X)

COTS Yield = 58% (met our minimum Space reliability requirements & quantity needs).

Concern #5- Lack of High Reliability:

JPL Applied Methodology for Selection of COTS is focused on:

- Detection, recognition, and elimination of potentially critical part problems that could lead to catastrophic mission failure.
- Performing risk assessment and risk mitigation for those parts that may seriously limit or compromise mission objectives.
- Establishing parts criteria that systematically generates data and requires critical decision making even when data/information gaps occur.

Lesson : High reliability is achieved by using incremental decision making.

Concern #7- Radiation Sensitivity:

JPL A/D COTS Radiation Data

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

Lesson: Each part must be evaluated on its own merit & per mission requirements before acceptance

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Radiation Data of PEMs

Moisture Absorption / Bake for Intel DA28F016SV in Plastic Package

(0.6 µm ETOX IV Process Technology)

Conditions: Test Temperature = 25°C, Vdd = 5.0V, Vpp = 5.0V

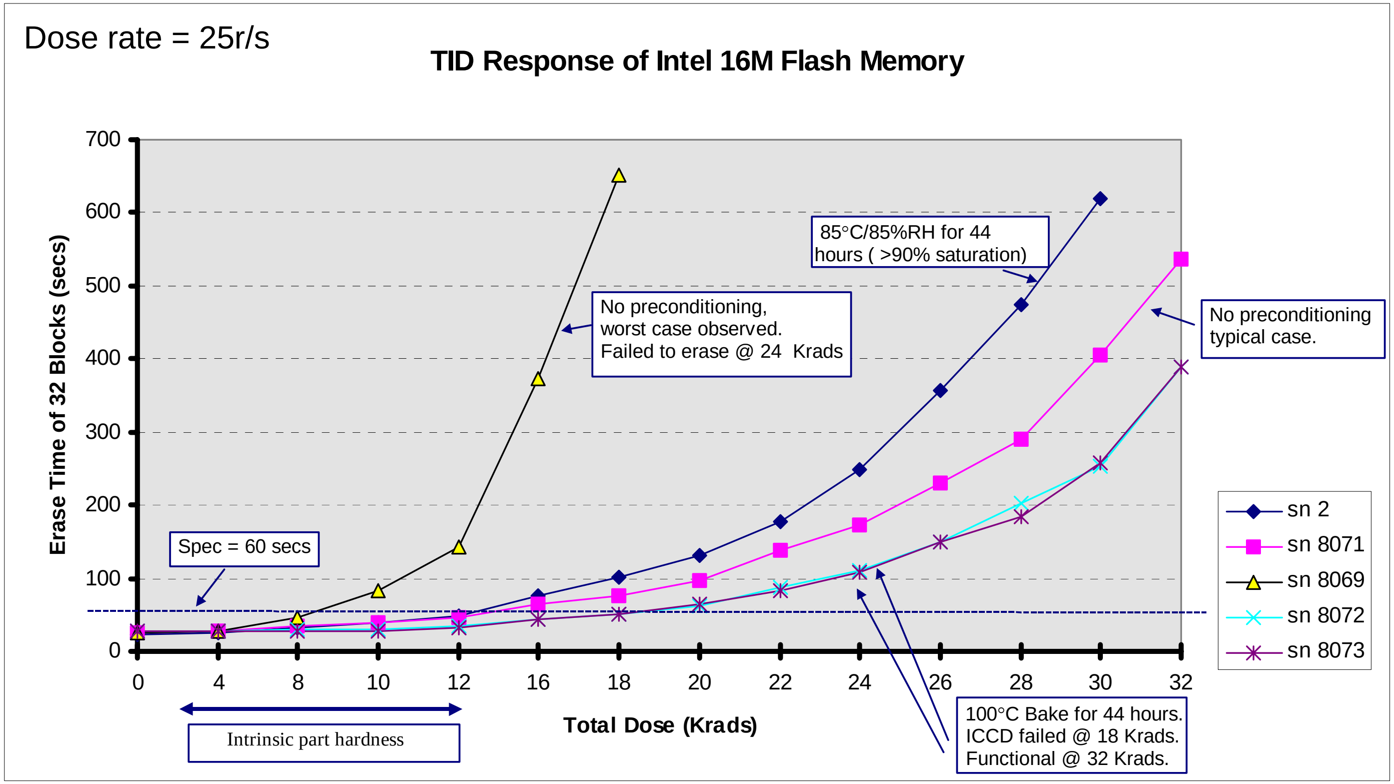

Figure 1
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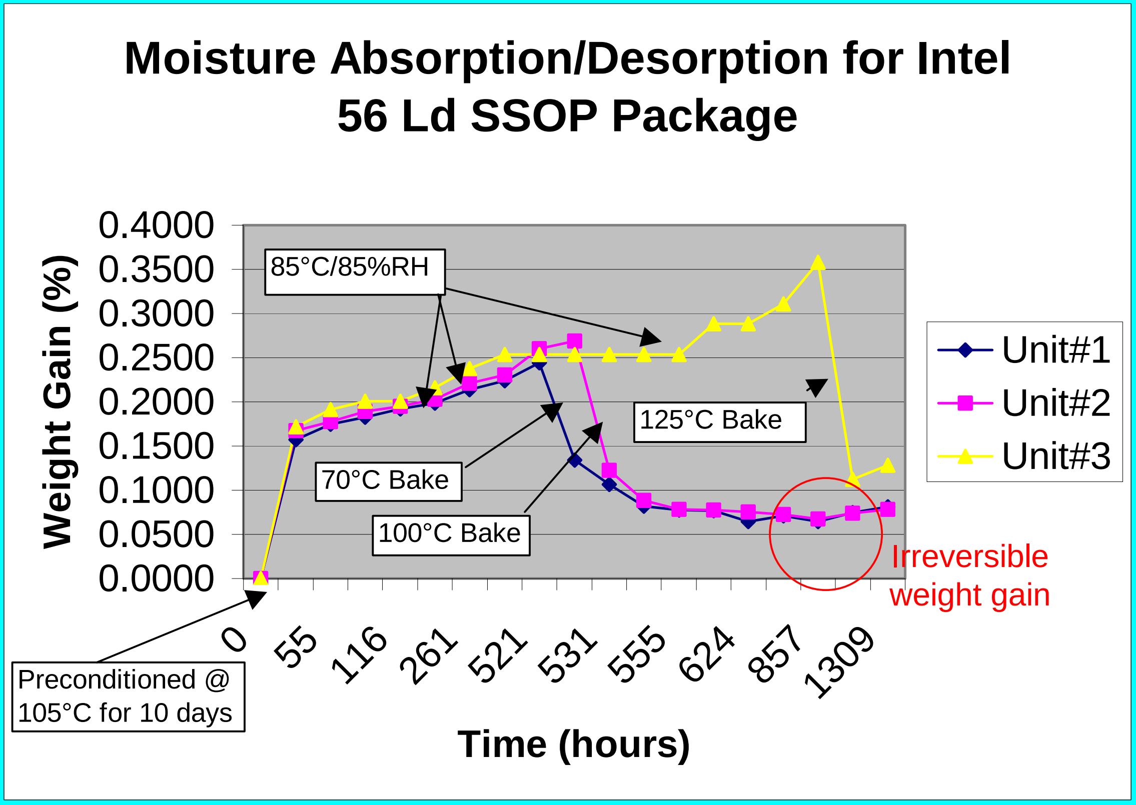
Data on PEMs



Note: Weight Gain (%) = (Wt-Wi)/Wi*100
Weight Loss (%) = (Wtd-Wi)/(Wf-Wi)*100

No evidence of corrosion found on units 1 & 2. Miniscule evidence found on one lead for unit 3.

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Sample COTS Parts Evaluation Data
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Part No.	Mfg.	Process	Function	CA	SEL	SEU	TID	LP	LT	Mrad	OG	MS	Dlam	BI	Proj	Lev	C.F.	Comments
UT54ACS04	UTMC	RH 1.2u	Inverter				x	x							New	x		Report Available
UT54ACS163	UTMC	RH 1.2u	Counter				x	x							New	x		Report Available
UT54ACS273	UTMC	RH 1.2u	Flip-Flop				x	x							New	x		Report Available
DA28F016SV	Intel	ETOX III	Flash M.	x			x				x	x	x	x	Mars	x	x	Report Available
LT1114	Linear T		IC									x	x					Report Available
MCR265	Mot		SCR								x	x	x					Report Available
AM28F020	AMD		Flash M.								x	x	x					Report Available
CAT28F020	Catalyst		Flash M.								x	x	x					Report Available
ADS937	Datel	Hybrid	A/D	x	x		x								New	x		Report Available
LMX23XX	NSC	BiCMOS	PLL	x	x	x	x								MLS	x		
TBD	Qtech	SOI ASIC	Osc					x	x	x					X2000	x		In process,tiny package

All information and data is available at the JPL COTS Web Site

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NEWS

Internet Web Site is Developed at JPL for COTS

http://cots.jpl.nasa.gov/

- Repository
- Disseminate
- Exchange
- Help
- Latest

Technical Solutions to Using COTS in Space:

- ★ Ruggedize the compartment or enclosure if cost effective
- ★★ Upscreen using multiple qualified third parties
- Upscreen using the OEM
- Use cooling fluids to meet military temperature range
- ★ Buy ruggedized COTS if available
- ★★★ Characterize for the application each & every time
- Stay within the manufacture's ratings

Conclusions:

The risks that must be ascertained when using COTS in Space must include

1. Supplier selection to insure good product quality and reliability
2. Total Cost of Ownership including any upgrade screens/qualification
3. Radiation Sensitivity

To successfully infuse COTS in Space applications a complete characterization over the full environment intended is required.