

Commercial Satellite Perspective on EEE Parts

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Outline

- ◆ **Commercial Satellite Industry Overview**
- ◆ **Parts Requirements and Testing**
- ◆ **System Level Impacts**
- ◆ **Cross Program Issues**
- ◆ **Lessons Learned by Commodity Type**

Commercial Satellite Marketplace

- ◆ **The commercial satellite industry is robustly competitive on a global scale**
- ◆ **There are approximately 15 to 25 satellite awards per year**
- ◆ **Competition is keen, and plays a crucial role in driving product innovation, robust quality, high reliability and low cost**
- ◆ **A unique combination of technical strategies and business practices has enabled the industry to simultaneously offer**
 - **New communications and imagery capabilities due to steady and incremental insertion of new technology**
 - **Exceptional long-term product performance and reliability: up to 18 year life requirement on orbit**
 - **Short delivery schedules: nominally 24 to 36 months**

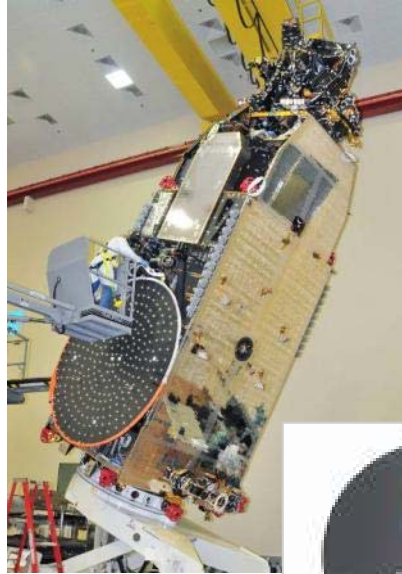
Commercial Satellites Help Shape Today's World

Direct Broadcast Satellites



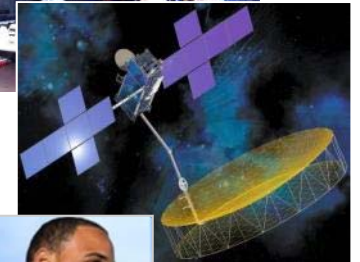
Entertainment

Two-Way Broadband Satellites



Internet Access

Mobile Comm. Satellites



Emergency and Disaster Response

Remote and Global Access

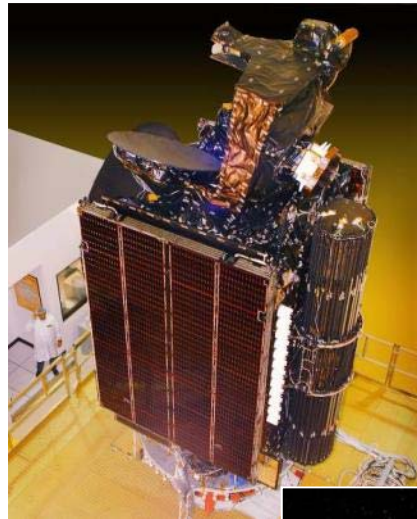
Commercial Satellites Help Shape Today's World (Cont'd)

Digital Audio Radio Satellites



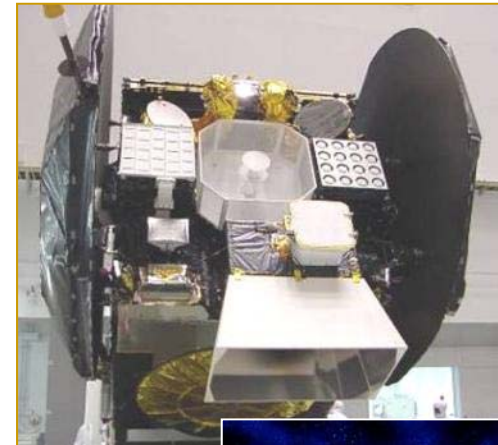
Mobile Audio and Data

Digital Multimedia Satellites



Mobile Entertainment

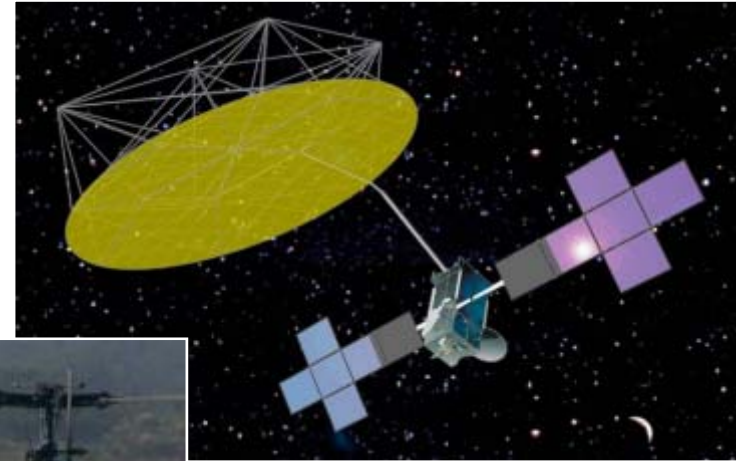
Meteorological Satellites



Weather

Commercial Satellite's Contribution to a Better World

- ◆ Emergency services
- ◆ Search and rescue
- ◆ Telemedicine
- ◆ Distance learning
- ◆ Weather monitoring
- ◆ Economic opportunities in remote regions
- ◆ Infrastructure around the world

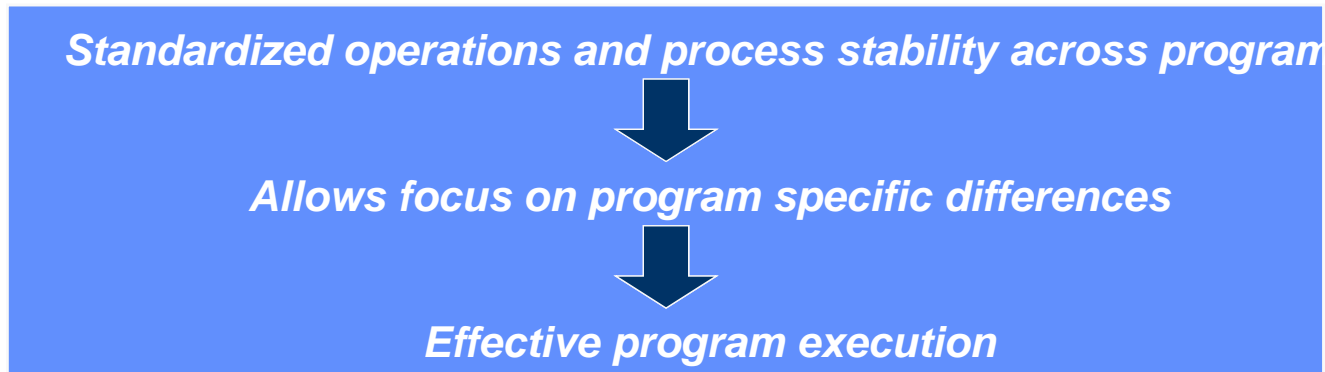


Beams on T-1 were reconfigured to provide emergency services for Hurricane Irene



Commercial programs are process driven

- ◆ **Program execution is controlled by an extensive set of standard processes, design guidelines and work instructions**
 - **Validated and refined over many on-orbit programs**
 - **Current version maintained on internal web site (accessible to customers)**
 - **Includes Mission Assurance plan enveloping requirements from all customers**
- ◆ **Most commercial processes evolved from MIL-STDs and have been strengthened and tailored to support our specific products — including EEE parts**
- ◆ **Standard processes exist for scheduling, planning, and execution**



Parts requirements and testing- Proactive Measures

- **Standard parts include**
 - **MIL-PRF-38535 level-V microcircuits**
 - **MIL-PRF-38534 class-K hybrids**
 - **JANS semiconductors**
 - **Established reliability passive devices (R/S; and “T” grade when available)**
 - **Highest quality ESA parts**

- **Parts that are not “standard” are screened and qualified to be equivalent to the nearest Mil standard using a Parts and Material Specification.**

- **SSL’s “12 Step process” was used to identify additional screens “above and beyond” the minimum requirements on ~350 non-standard part types to ensure the highest reliability**

- **An inventory of parts required to construct all recurring satellite units is maintained. Parts may be drawn from lots used on previous programs.**
 - **Most programs have the same requirements, the parts are interchangeable**

- **New parts are sometimes required due to part obsolescence or new applications**
 - **Highest reliability**
 - **Radiation tolerance & single event effect resistance**

- **Subcontractor parts are analyzed to the same standards**

Cross Program Issues

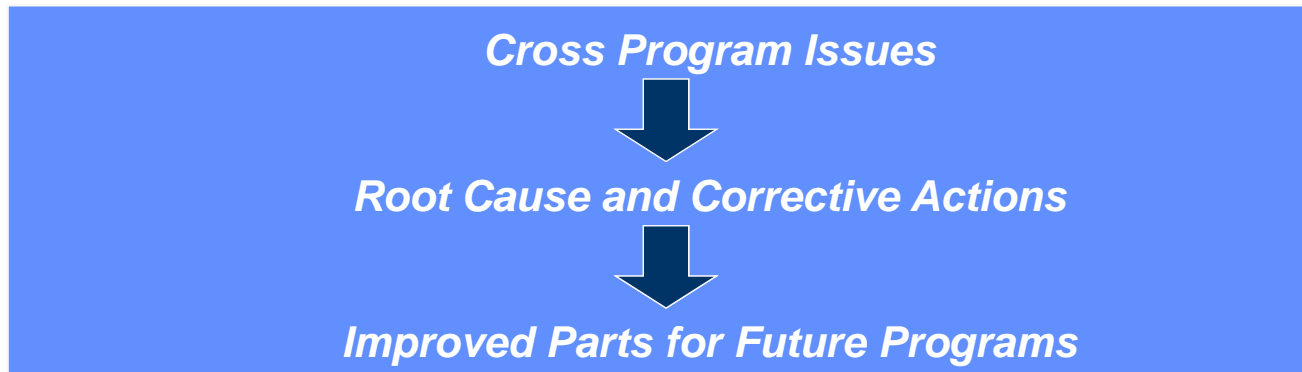
- ◆ **What is a “Parts Engineering” Reliability Cross Program issue?**
 - Issues where the root cause and corrective actions are uncertain
 - Issues that potentially have a wide impact on other trays, units and/or spacecraft
 - Issues that potentially can result in program schedule impact
 - Generally a single installed part failure will not be a cross program issue, but repeated failures of the same part type will become one

- ◆ **Any spacecraft or unit level unit acceptance test, PFM or qualification failures can become a cross program issue and are monitored weekly by FRACAS and Parts Engineering to determine if they meet the criteria**

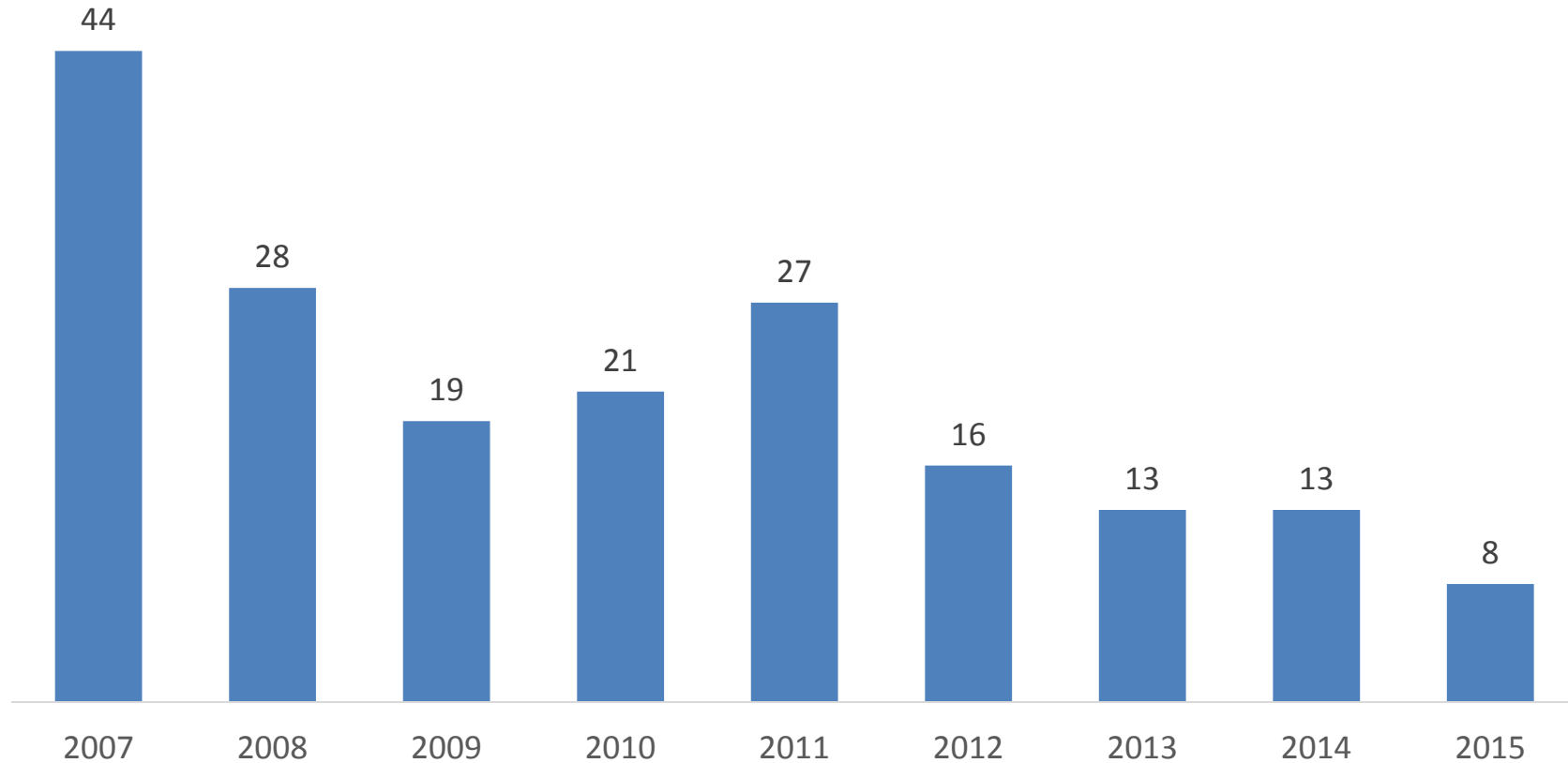
- ◆ **While the trend of unit failures is much improved, any issue can become significant. The following charts highlight 9 years of experience on EEE Parts reliability performance on some 50 spacecraft**

Cross Program Issues

- ◆ First opened for a ceramic 1.0 uF ceramic capacitor issue in late 2006
- ◆ The particular issue led to a large scale rework at unit level and millions of dollars of cost. As a result, the 12 step process program was instituted.
- ◆ SSL has had 194 cross program issues up through 2015. Impact ranges from significant to items that are contained without any impact.
- ◆ Cross program issues are reactive but will lead to better parts



Cross Program Issues By Year



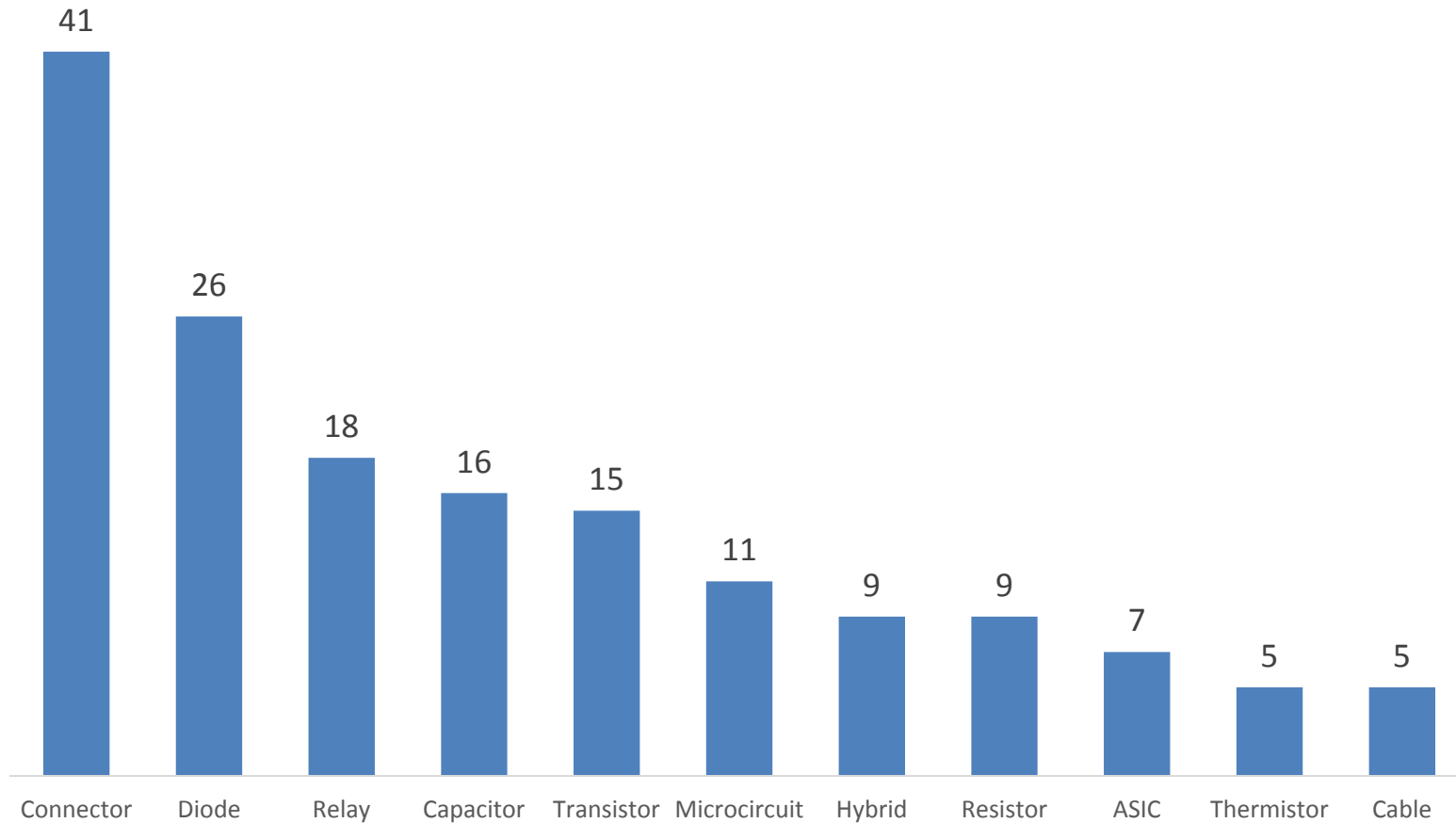
The number of Spacecraft launched has been steady at 7 +/-2 per year

Rigorous use of the highest quality available EEE parts has reduced but not eliminated the number of issues

Cross Program Issues in 2015

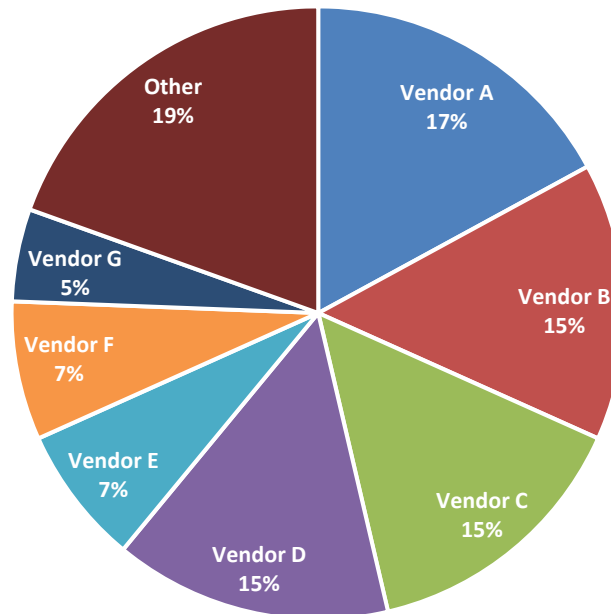
PE#	Part Type	Summary
PE188	Hybrid	The zener zapping process to program the output characteristics of an integrated circuit is not being enabled at cold turn-on.
PE189	Hybrid	A Tungsten tool was used to remove silver epoxy squeeze-out
PE190	Diode	Diode cracking due to a thicker preform being used instead of the proper thinner preform
PE191	ASIC	Solder ball particle FOD
PE192	Pyro Initiator	Initiator fired in a test when the expected result was a no-fire
PE193	Connector	Leak test failures were experienced on hermetic RF modules due to connectors
PE194	Resistor	Fusing resistor opened at cold due to current in test

Cross Program Issues By Part Type



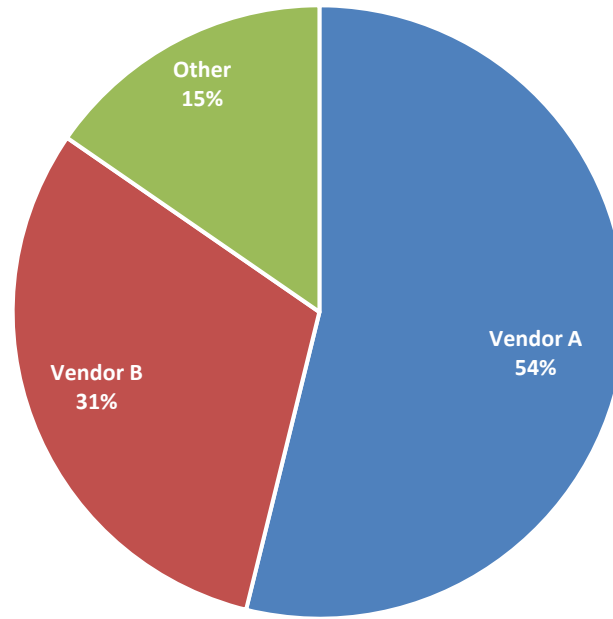
Not all types of EEE parts are equivalent regarding the number of issues

Cross Program Issues By Part Type - Connector



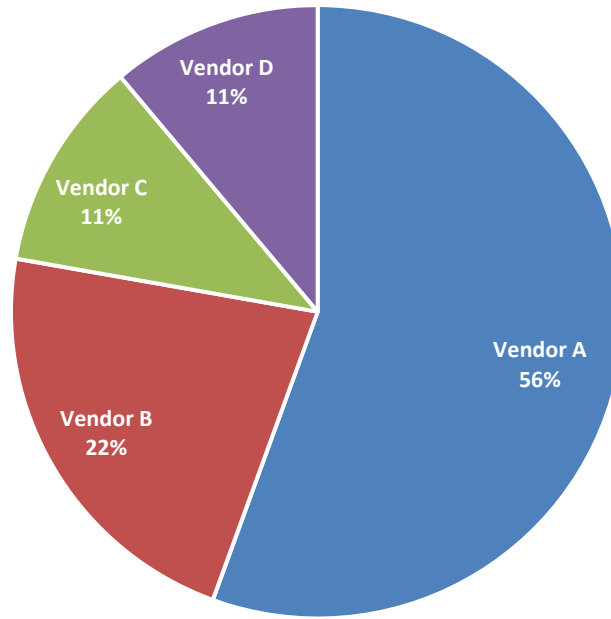
Numerous connector issues
Issues related to contact resistance, contamination, corrosion, hermeticity
Still need better screening & specifications at part level

Cross Program Issues By Part Type - Diode



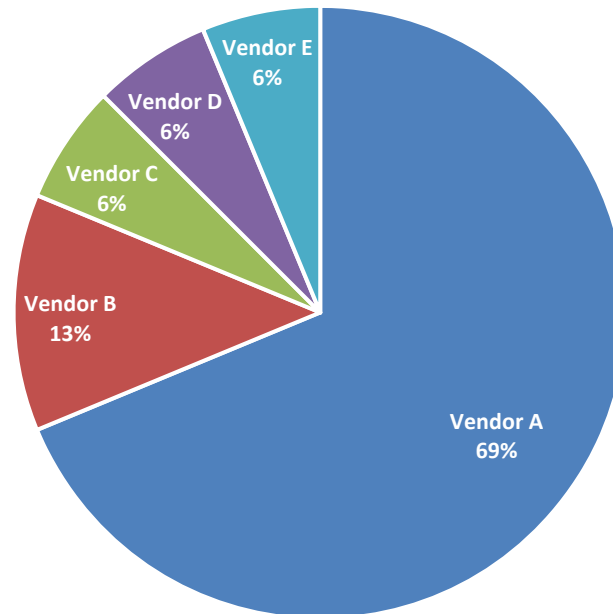
*Too many diode issues considering the complexity of the part
Vendors are responsive when there is an issue
Diodes with similar part numbers, form, fit and function
may not be equivalent in terms of reliability*

Cross Program Issues By Part Type - Relay



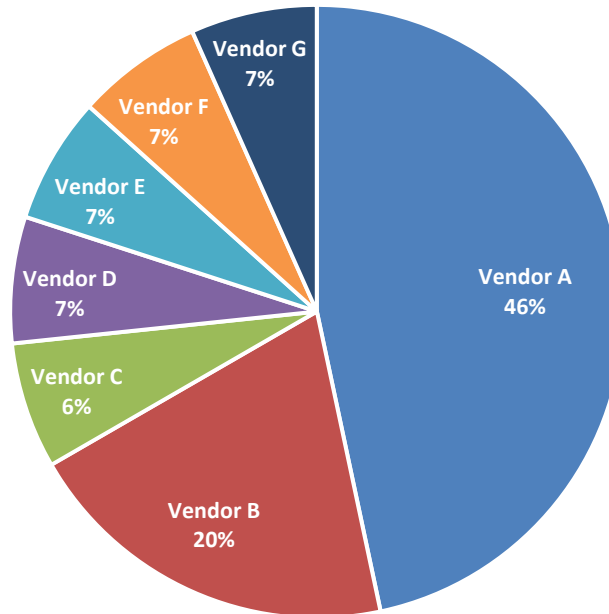
*SSL has never experienced an on-orbit “stuck” relay
We have seen shifts in switching voltage within spec
Increased screening to ensure stability
+ unit level “Rapid Thermal Cycling”*

Cross Program Issues By Part Type - Capacitor



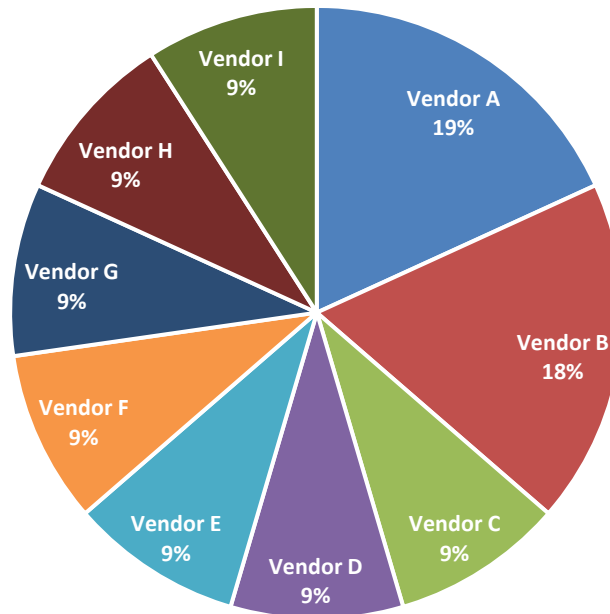
*Implemented better screening /specifications at part level
Extra care in assembly areas
Improved surge testing on Ta caps, one issue recently
Continuing issues with ceramic caps
T- grade caps used where available but R/S are acceptable*

Cross Program Issues By Part Type - Transistor



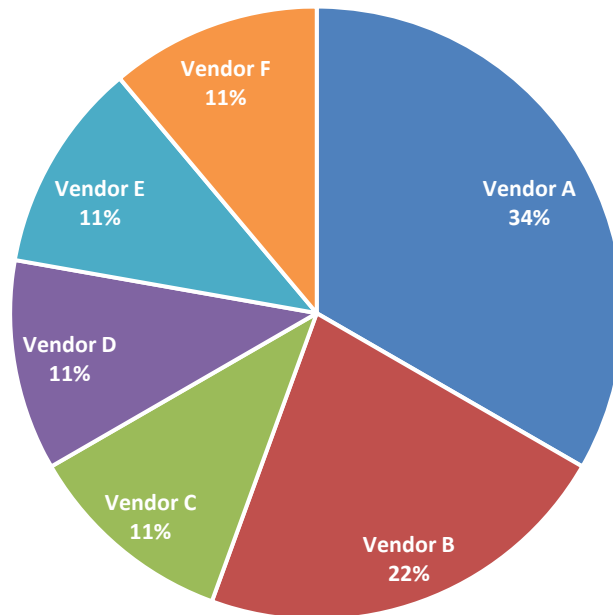
*MOSFET's comprise majority of issues
Bipolar transistors generally have very few repeat issues, except
for moisture problems at one vendor*

Cross Program Issues By Part Type - Microcircuit



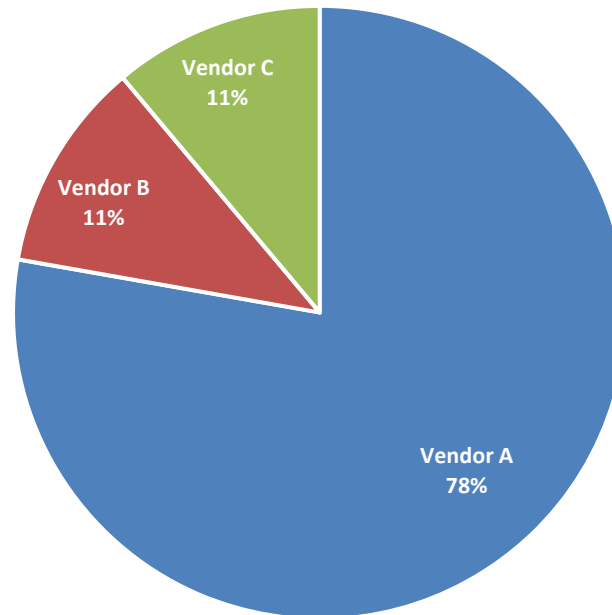
*Generally Microcircuit reliability is excellent.
Surprisingly few issues compared to device complexity.
A few vendors have more problems than others but
all are highly responsive on issues*

Cross Program Issues By Part Type - Hybrid



*Hybrids are low volume parts
More issues than expected based on volume
Moisture, ESD, bond wire & hermeticity related issues*

Cross Program Issues By Part Type - Resistor



*Generally resistor reliability is excellent considering 10's of thousands are used per spacecraft
Both major vendors have been responsive on issues
Experimented with T grade but found no advantage over R&S*

Summary

- ◆ **The commercial satellite business model results in highly reliable spacecraft in a very competitive environment**
 - **Competition drives technical innovation**
 - **Competition demands high quality and reliability**
 - **Expanded capability bid only after qualification on IR&D**
 - **Reduced time to market**
 - **The commercial satellite business is self regulating – sub par performance is punished**

- ◆ **Steady insurance rates for satellites underscore the reliability of commercial satellites**

- ◆ **Challenges still abound in the EEE Parts for Space World**
 - **Even with highest quality parts available, we still have issues**
 - **New technology parts are becoming “standard” without flight heritage**
 - **Strong pressures to lower costs using COTS**

***Rigorous Use of the Highest Quality Available EEE parts
Supports the Commercial Space Business Strategy***