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EEE Parts Program Update

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Outline

- ◆ **Commercial Satellite Industry Overview**
- ◆ **EEE Parts Engineering Role**
- ◆ **Proactive Measures — “Over and Above” the Requirements**
- ◆ **On Orbit Results**

Commercial Satellite Industry Overview



Commercial Geostationary Satellite Marketplace

- ◆ The commercial geostationary satellite industry is a mature international industry with over 30 satellite operators and 6 major satellite manufacturers
- ◆ There are over 300 commercial satellites in orbit today
- ◆ 20 to 25 awards are made per year
 - 12 to 16 are replacements
- ◆ A unique combination of technical strategies and business practices has enabled the industry to simultaneously offer
 - Customizable design building blocks
 - Incremental, evolutionary 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
 - Lower program cost than equivalent government procurements

Commercial Satellite Categories and Characteristics

Military + Commercial Communications Satellites



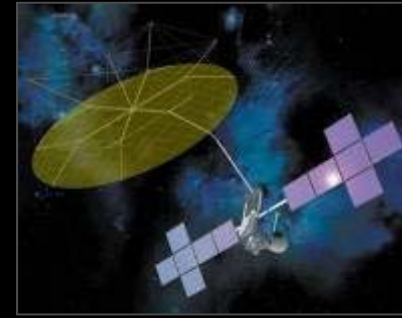
Direct Broadcast Satellites



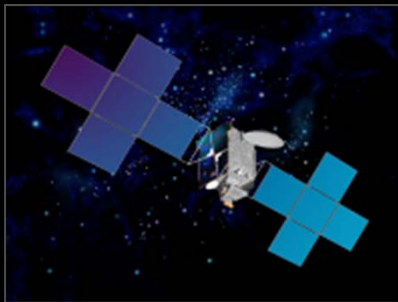
GEO Meteorological and Comm Satellites



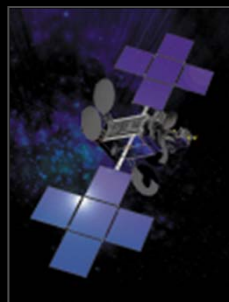
GEO Mobile Communication Satellites



HIEO/GEO Digital Audio Radio Satellites



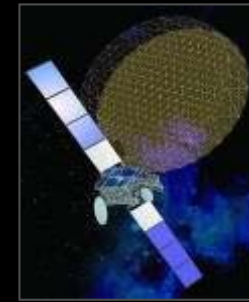
Ku/Ka Spot-Beam Broadband Satellites



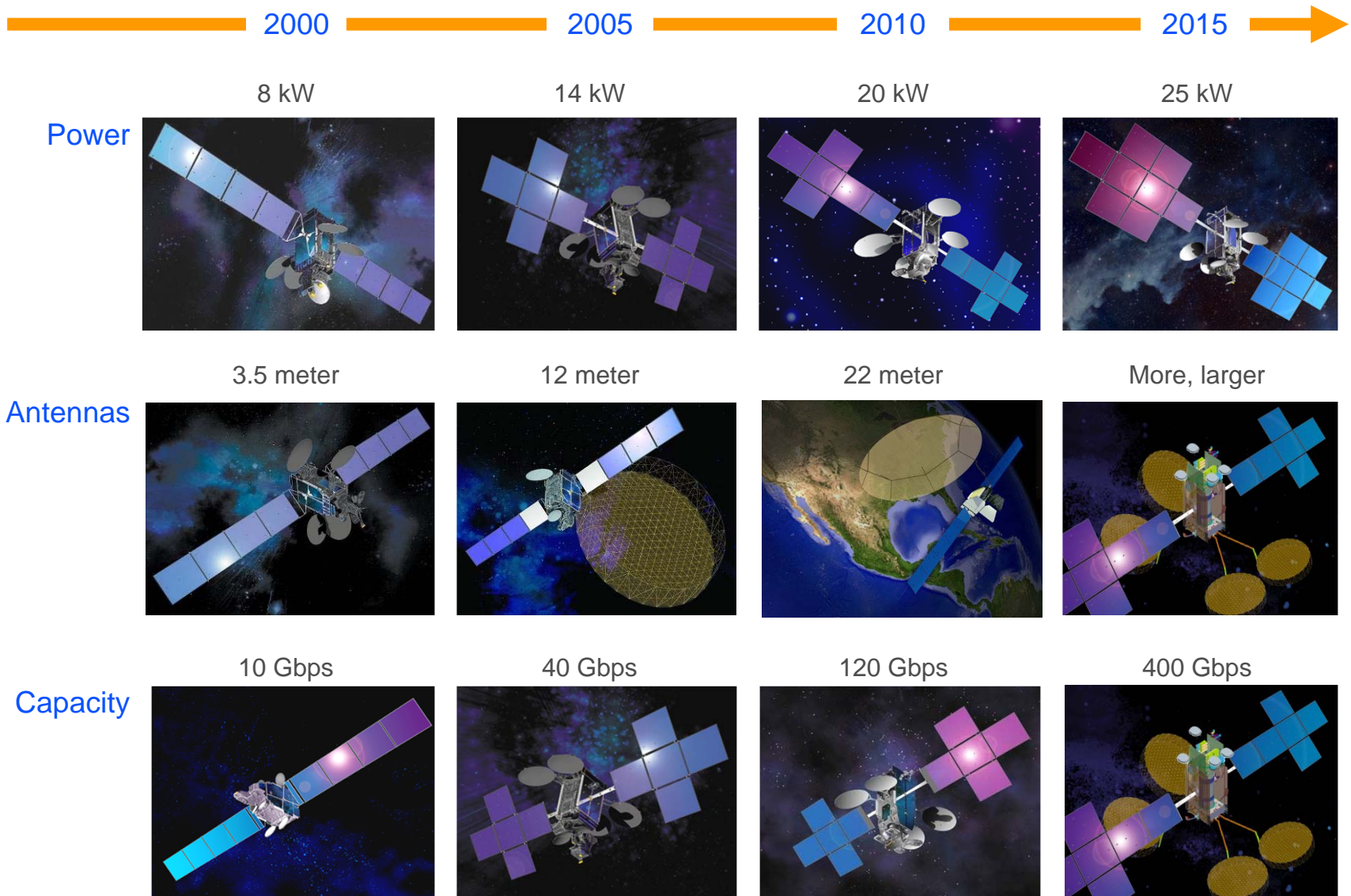
C-Ku-Ka Fixed Service Satellites



GEO Digital Multimedia Broadcast Satellites



Commercial Satellite Capabilities Have Grown Dramatically



Timely, Best Value Options are Key For A Customer's Business

- ◆ Industry drive is to lower CAPEX (cost for capacity) solutions
- ◆ High quality and reliability is the absolute prerequisite to selling satellites — driven by the high cost to launch
- ◆ Schedule assurance is important
 - A high degree of standardization in a factory environment is key
 - Requirements are firm at program start. Changes are rare and unsought
- ◆ Continuously inserting new technology that offers greater communications capability and flexibility is necessary in order to remain competitive
 - Qualification on new technology is done on IR&D before program start
 - Customers typically want proven technologies
 - Will accept some technical/schedule risk for a better business solution
 - Technology approach must be anticipate variations in customer requirements
 - The result: incremental but steady introduction of new technology

Commercial Programs are Process Driven at SSL

- ◆ 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 — continuously updated
- ◆ Standard processes exist for scheduling, planning, and execution

Standardized operations and process stability across programs



Allows focus on program specific differences



Effective program execution

EEE Parts Engineering Role



SSL EEE Parts Mission Statement and Organization

- ◆ **Reliability Mission Statement: Ensure On-time Deliveries with 100% Mission Success**
- ◆ **Organization: EEE Parts / Reliability Department / Engineering, Manufacturing and Test**
 - **EEE Parts Engineering including Parts Specialists**
 - **Relays, Magnetics**
 - **Switches, Thermistors, Pyro Initiators, Shunts, Fuses, Heaters**
 - **Microcircuits, Hybrids**
 - **Crystals, Oscillators, RF Diodes, RF Transistors**
 - **Hybrids**
 - **Connectors, Filters, RF Passives, Cables**
 - **Resistors, Capacitors**
 - **Diodes, Transistors**

SSL Parts Requirements — Standard Parts Are Preferred

- ◆ **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)
 - Space quality ESA parts (e.g., ESCC 5010/Level B microwave semiconductors, 3001/Level C ceramic capacitors)
- ◆ **Parts that are not “MIL” are selected, qualified and screened in the same manner to nearest MIL-Standard to an equivalent Parts and Material Specification**
- ◆ **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**
 - These parts are selected to fulfill the requirements of space
 - Highest reliability
 - Radiation tolerance and single event effect resistance
 - Euro customers are “age” conscious
- ◆ **Subcontractor parts are analyzed to the same standards**

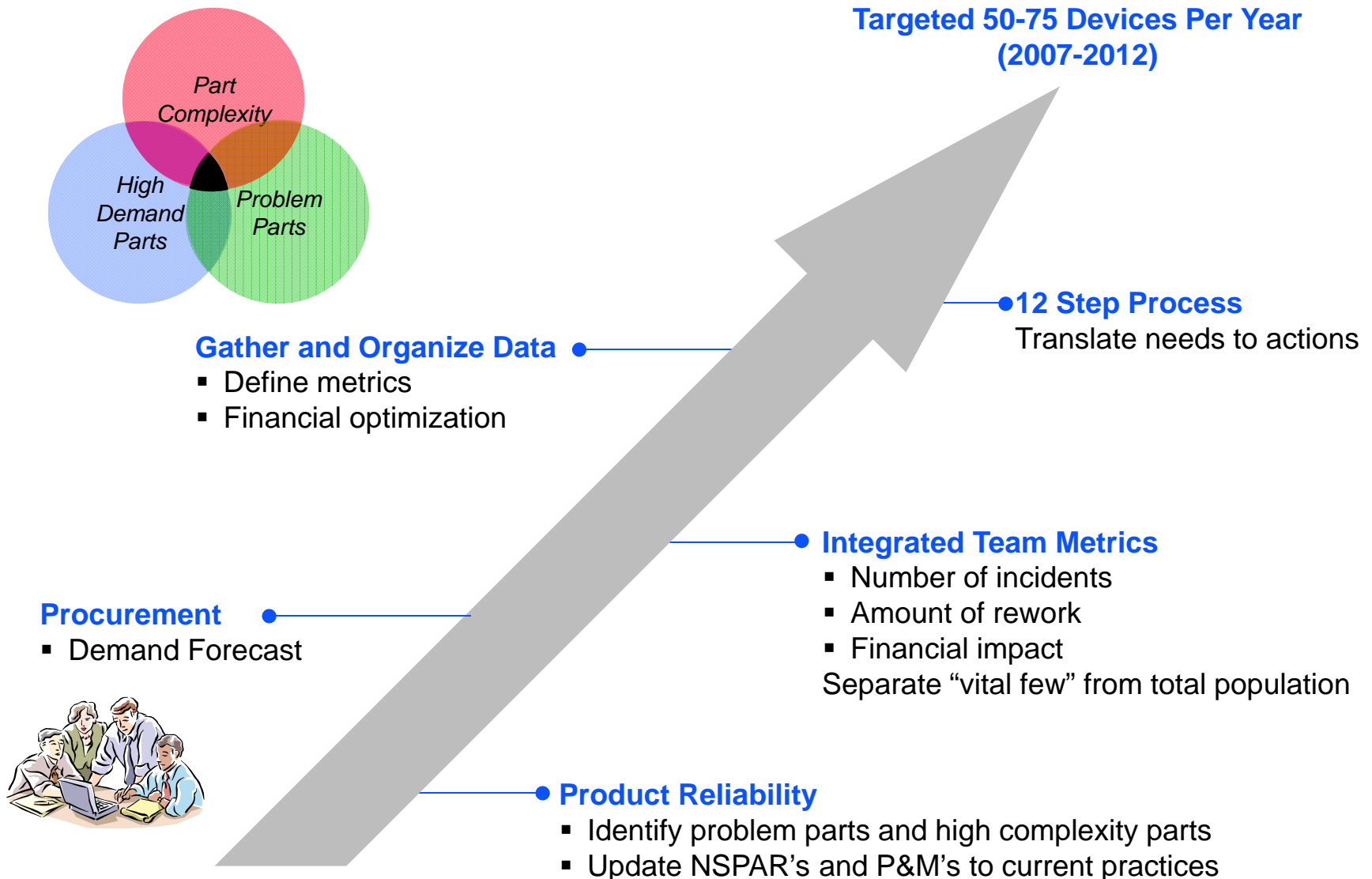
Example of SSL Standard Processes for EEE Parts

- ◆ **EEE Parts Program — Standard Requirements**
 - **SSL Mission Assurance Plan (MAP)**
 - **SSL Subcontractor Mission Assurance Requirements (SMAR)**
- ◆ **Customer specific requirements reflected in addendum**
 - **For example, European Program SMAR Addendum**
- ◆ **Process for adding parts — Request for Engineering Services**
- ◆ **Process for working with vendors on exceptions — Request for Action**
- ◆ **Address new parts and customer unique requirements — Parts Control Board**
- ◆ **Control of parts vendors and subcontractors — Audit Documents**
- ◆ **SSL maintains 36 total “Parts Engineering Instructions” for such activities**

Proactive Measures — “Over and Above” the Requirements

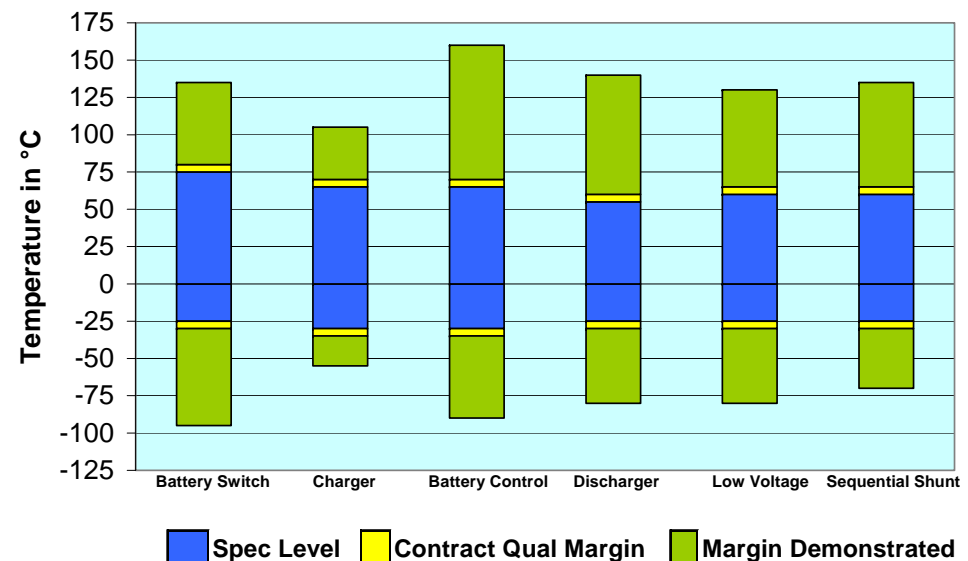
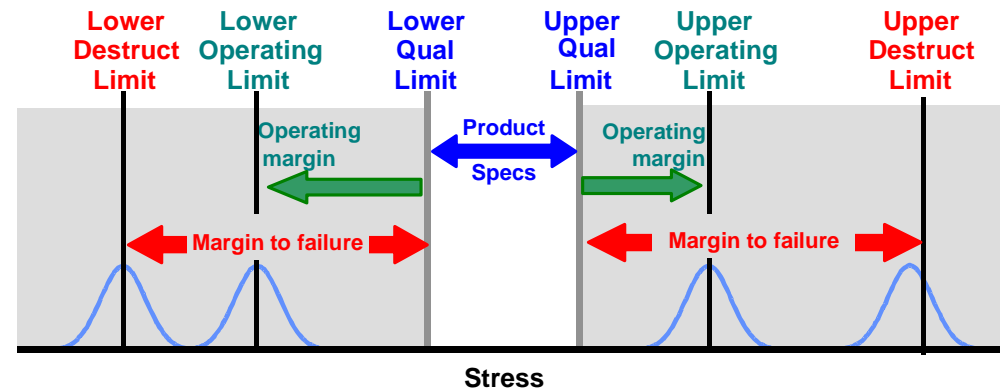


12 Step Process for Top 50 Parts — Ensures SSL Gets the Best Parts



SSL Highly Accelerated Life Test (HALT)

- ◆ SSL goes beyond Mil-Standards for new hardware
- ◆ Highly-Accelerated Life Testing (HALT) determines product performance margin
- ◆ Simultaneous mechanical and thermal stress beyond operating levels reveals weak aspects of the design
- ◆ Analysis of failures may point to straightforward product upgrades that can enhance robustness
- ◆ SSL has successfully used this on new hardware designs to confirm and/or significantly increase margin to failure



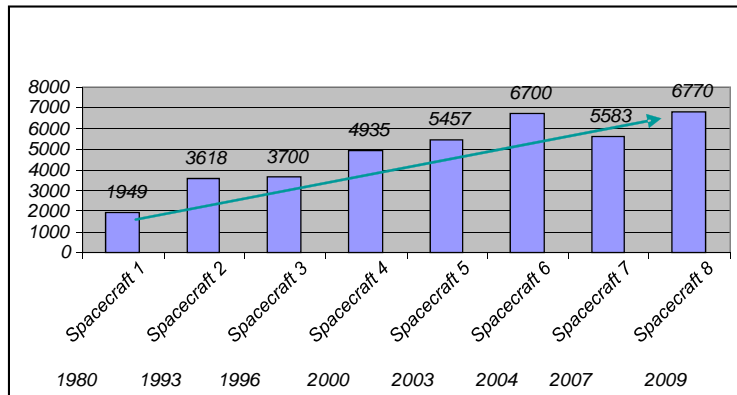
On-Orbit Results



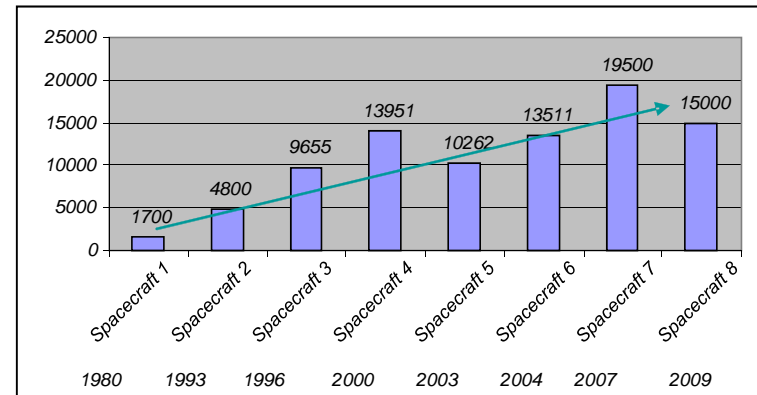
Results — SSL Anomalies are Declining Despite Higher Complexity

- ◆ Due to robust processes, commercial spacecraft show strongly declining anomaly rates in spite of increasing complexity, power, and capacity

Total Mass (kg)



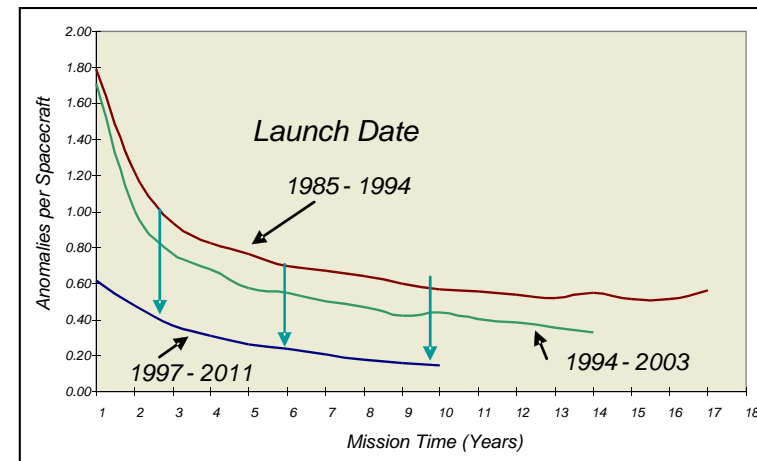
Power End-of-Life (Watts)



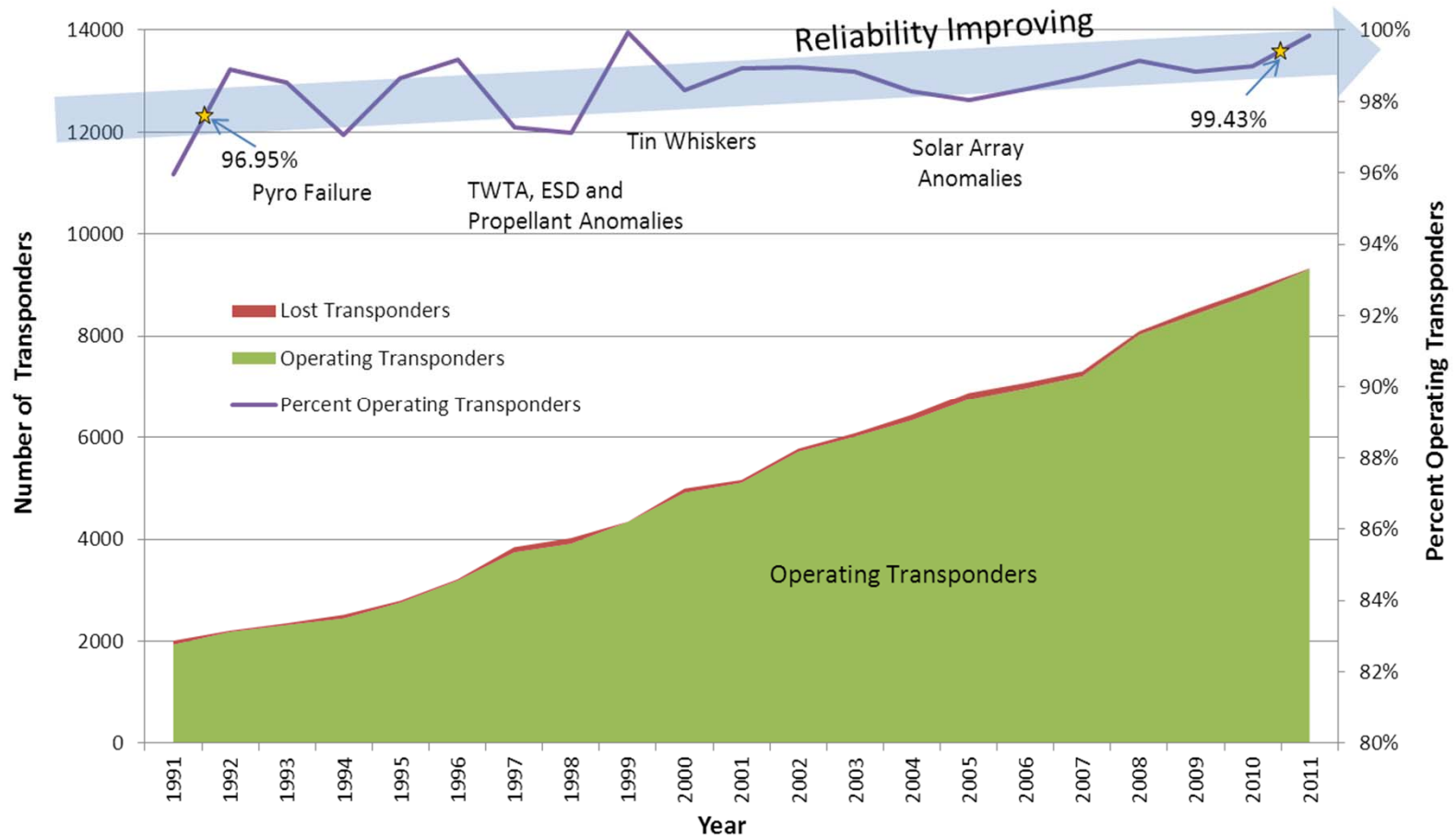
- ◆ Spacecraft mass has tripled
- ◆ Spacecraft power has increased tenfold
- ◆ Additional and upgraded subsystems
- ◆ Significant increase in payload complexity and equipment count
- ◆ 50000 EEE parts per spacecraft
- ◆ Yet, failures per spacecraft have been reduced by more than 50%



Anomalies per Spacecraft per Year



SSL On-Orbit Reliability Continues to Improve



With nearly five times the number of transponders on-orbit, failures have been reduced from 3% to 0.5% over the last 20 years

Summary

- ◆ **The commercial satellite business drives technology improvements that**
 - **Incrementally increases on-orbit performance at low risk**
 - **Reduces cost for capability provided**
 - **Maintains short, assured schedules**
- ◆ **SSL has developed various processes that are paying off in**
 - **Reduced parts anomalies per satellite by 50%**
 - **Driving up on-orbit spacecraft reliability**
 - **Greatly improving the anomaly rate while significantly increasing satellite size and complexity**

Rigorous use of the highest quality available EEE parts supports the commercial space business strategy