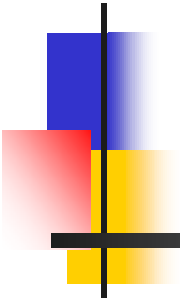


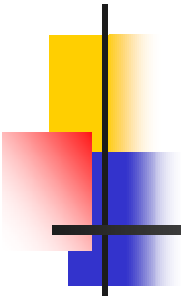
# ASPECTS OF AEROSPACE FLIGHT HARDWARE QA - IN GENERAL -



Design, Production,  
Inspection and Customer  
Acceptance of Satellite and/or  
NASA Parts and Hardware  
Assemblies For Probes -All The  
Way Up To Finished Vehicles  
"It Is Up To The Contract"

Gerry Naugle, QE Starsys Inc.

# CONTRACTS

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- n Bid & Proposal Letter by Contractor
  - n Proposal Acceptance by Customer
    - Contractor Starts a Program Number
  
  - n Main Contract - SOW -SDRLs -QAPs
  - n Maybe PO's with the QAPs re-stated
  - n Amendments to contract done by
    - 'contract letters' or by ammended PO's
    - or by re-negotiating to meet customer changes/adds by the re-baseline of a program after it starts.

**"The Customer is Always Correct"!**

# Design Factors

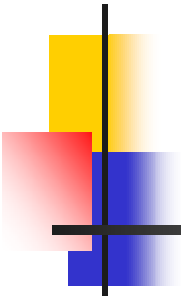


- **Structural Analysis per Axis**
  - Launch Loads: vibration testing: axial and random vibration nodes and includes stage separation loads (esp. 'pyros')
  - Post Boost Flight Loads e.g. spin-ups & de-spins
- **Thermal Analysis** –Heat transfer across the vehicle / solar panels (or) unloading of excess internal sources of heat to space via radiators.
  - Satellites ~55 min of sunlight per 90 min orbit, ~14 hours of sunlight per geosynchronous orbit
  - Probes traveling to Venus or Mercury get vastly increasing heat loading as they approach sun
  - Probes traveling outward from Earth: very warm near Earth, then exterior hardware drops off to near absolute zero temps at outer four planets. Current and future probes use internal heat sources out there to actively warm circuit boards, batteries and keep hydrazine fuel tanks from freezing.

- **FMEAs and Worst Case Analysis on components of critical parts or sub-assemblies, reliability predictors based on RBDs (reliability block diagrams).**

**MIL-HBK217**

**RADC-TR-85-229**

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- n **Radiation Environments: Spaceflight rated electrical and electronic components are normally rated at 75-100 Krad (Si) TAD. Some coils and resistors go to 500 Krad, however, the smaller the components (e.g. 'surface mount' components) the more vulnerable they are to damage from gamma rays, cosmic rays and neutrons [produced when high speed protons hit the outer vehicle hull] and 'spray the inside'.**
  - **Any probe going near Jupiter even for short periods of time must be "radiation hardened".**  
**Galileo Jupiter probe a few years ago took an est 8-10Mrad on some components and they just quit working, it provided good 'endurance' data for some components. Same for long-term geosynchronous Earth satellites from solar activity. Minimum protection in the industry for design is normally .100" of aluminum wall thickness equivalent, often times more.**
  - **Radiation hardening uses extra layers of protective materials as shells and special materials for internal construction of hardware and electronics. e.g fused quartz lenses on probes with special additives for radiation resistance.**

Design cont.

**Materials: Generally no pure silver, cadmium or zinc exposed metals (or) plating anywhere. Absolutely no pure Tin platings (tin can grow whiskers up to .25 inch in vacuum and zero-g's), has caused many shorts. Silver plating over copper (wire ends for example) causes galvanic action in ambient atmospheric humidity with certain wire insulations, leads to 'red plague' in storage or at the sea-side (east or west) at launch sites.**

- n Normally a double redundancy is called for in design aspects of class 1 'critical' components. e.g. fasteners usually have 'head staking' with uralanes or epoxies.**
- n Mechanical press fits of dissimilar metals, e.g. a carbon steel bushing into an Al housing does require two forms of 'mechanical capture' to make sure that the bushing does not come loose upon temp cycling (sun/dark in orbit) or when it gets warmed up by the sun prior to departing Earth orbit.**
- n All human-rated flight hardware in STS and ISS must be triple-redundant design on all class 1 critical components. Certain critical systems can be spec'd (by NASA) to be quadruple redundant.**

# INSPECTION



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## n Inspection Requirements:

- “Flight Certified” means to be: 1) dimensionally and visually checked to print requirements with flagged critical dimensions (or) special notes are 100% checked (*added costs*) and certified by incoming QA. The QAPs from the contractor to suppliers are checked for completeness. e.g. outgassing properties of plastics, lubricants. Complete ‘certs’ paper.
- 2) Where alloy parts or any other parts are deemed to be ‘chem-phys’ means total traceability back to the foundry heat/batch data and can include the ‘actuals’ of metal assays at foundry (*much added costs*).
- 3) Anything built for NASA generally requires screening to “GSFC screening requirements” for fasteners. For most small batches means 3 out of 5 random fasteners get DPA analysis. (*more added costs*)



## PRODUCTION and PACKAGING

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Flight hardware production is done in clean rooms, class 1000 or better. The workers wear ESD rated smocks/garments, beard covers [guys], hair covers, shoe covers and sterile butyl-nitrile gloves. Generally, all assembly is performed at flow benches where the outflow air from the filter banks is class 100. Can be done in visibly clean areas when flight cleaning will follow and no internal cavities exposed. Class 100 means 100 or less of .5 micron particles per cubic foot of air, measured per particle counters (very accurate). See representative workmanship standards for typical satellite and probe parts and assemblies (next slide).

Generally, finished parts and assys are customer source inspected by customer QA or sub-contractor QA reps on site. Their affirmative source reports are authorization to then proceed to packaging & shipping.

# Typical NASA and prime contractor workmanship standards

requirement for flex and microwave products. The appropriate manufacturing standards shall be used as shown in the following list:

- IPC-2223, Sectional Design Standard for Flexible Printed Boards
- IPC-2221, Generic Standard on Printed Board Design
- IPC-2222, Sectional Design Standard for Rigid Organic Printed Boards (Rigid boards shall be the class 3A requirements of IPC-6012 rev B class 3A requirements as mandated by the IPC-6012 performance specification sheet for space and military avionics (PSSMA))

## b) Printed Wiring Board (PWB) Manufacture:

Flight PWBs shall be manufactured to class 3 requirements of the following documents with the exceptions shown for IPC-6012 PWBs: IPC-A-600, Acceptability of Printed Boards

- IPC-6011, Generic Performance Specification for Printed Boards
- IPC-6012, Qualification and Performance Specification for Rigid Printed Boards
- IPC-6013, Qualification and Performance Specification for Flexible Printed Boards
- Hardware PWBs shall comply with class 3/A requirements as mandated by the IPC-6012 performance specification sheet for space and military avionics (PSSMA)

The contractor shall provide PWB coupons to the NASA/GSFC COTR, or to a GSFC approved laboratory for evaluation. PWB coupon approval shall be obtained from NASA/GSFC COTR or a GSFC approved laboratory prior to population of flight PWBs.

## 6.6.5.2 Workmanship Requirements

The following workmanship requirements shall apply:

- Conformal Coating and Staking: NASA-STD-8739.1, Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies;
- Surface Mount Technology (SMT): NASA-8739.2, Workmanship Standard for Surface Mount Technology;
- Hand Soldering Assemblies: NASA-STD-8739.3, Soldered Electrical Connection
- Crimping, Wiring, and Harnessing: NASA-STD-8739.4, Crimping, Interconnecting Cables, Harnesses, and Wiring;
- Fiber Optics: NASA-STD-8739.5, Fiber Optic Terminations, Cable Assemblies, and Installation



# PACKAGING

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- n Finished parts are flight cleaned to customer contract specs. IEST has cleaning standards, e.g. IEST-STD-CC 1246D. The cleaning is verified/audited at customers by std tape-tests and measured under 10X to 20X binocular microscopes w/guaging reticules for counts.
- n Packaged in double walled bagging, custom made by hot sealing to size of part or assy. Special no-dust nylon inner bags or ESD bags w/dessicant pouches and labeling and then in very tough outer poly bags.
- n Normally the boxes have humidity and shock 'tell-tales' with customer specs for that, in double wall shipping boxes, or hard shell gun-cases w/foam inside for smaller items.
- n Sent premium carriers' services, sometimes "hand carried" on extra seat (strapped in) on airlines by customer's staff or bonded couriers, if it is incredibly "high buck" (\$million assys\$) and/or "extremely hot" needed e.g. same day.