Spacecraft Manufacture and Test

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Lesson Objective

- To introduce and discuss manufacturing and test processes and philosophies

Uniqueness of Satellite Manufacture

- Small production runs
- Extreme operational environments
- Limited repair/replace options after launch
- High product cost and importance
- High cost test environment
- Highly coupled designs minimize weight and maximize performance but yield high complexity

Overall Manufacturing Process

- Prepare engineering data
  - Drawings, specifications, and processes
- Manufacture component
- Qualify the component
- Integrate and test
- Repeat for other components and at higher levels of assembly

Classic Manufacturing Processes

- Raw materials ordered from certified vendors
- High reliability (S-level) electronic piece parts
  - Group A, B, and C testing to ensure part quality
- Project approved parts and materials lists
- Clean rooms for critical assemblies

Clean Rooms

Facility/Operation	**Cleanliness**
Mechanical Manufacturing	Not controlled
Electronic assembly	Class 10,000
Electromechanical assembly	Class 100
Inertial instruments	Class 100
Optical Assembly	Class 100
Spacecraft Assembly and Test	Class 100,000

Classical Quality Assurance

- Identify points in process flow where we can make sure the hardware construction complies with engineering data before the next steps prevent inspection
- Test surveillance certifies test equipment and processes
- Quality assurance records all failures and anomalies

Qualification Test

- Establishes that the design has suitable
  - Performance
  - Capacity to survive the operating environment
- Includes vibration, shock, launch acoustics and the temperature extremes of space
- Unique functional performance tests in each environment

Designing for Manufacturability

- Traditional approach to quality (test/retest) is high cost and takes a long time
- New approaches use concurrent engineering and lean manufacturing processes to reduce cost and ensure quality

Lean Manufacturing

- Establishes and implements quality goals in the design phase
- Focuses on the processes
- Minimizes wasted time and effort
- Involves manufacturing personnel in the design effort
- Minimizes work in progress

Test Philosophies

- Design verification establishes the performance of the design in functional test, vibration, shock, and space environments
  - Moving toward limiting verification to initial system
- Process verification establishes the performance of the production system
  - The focus of lean manufacturing

Part Selection Criteria

- Cost - S-level parts are not always required
- Interchangeability - Ease of remove/replace
- Simplicity - Cheaper, fewer installation issues, higher reliability
- Availability - Just In Time delivery minimizes inventory
  - Reduces part cost, handling, waste due to obsolescence and redesign

Concurrent Engineering

- Involves manufacturing and test personnel in the design team
- Refines the design while changes are relatively inexpensive
- Permits quality, manufacturability, and profit to be designed into the system

Test Reduction

- High quality processes that are well characterized, controlled and repeatable permit testing to be reduced
- Continuous process improvement until the process, not inspection, guarantees quality
  - Reduces inspection points
- Reduced testing reduces opportunities to inject variability

Process Characterization Process

- Process definition
- Process capability
  - Establish current level of process performance
- Process optimization
  - Focus on key metrics
  - Determine which variables influence process output
- Process control

Learning Cycles

- Simulation packages model and predict performance
- Prototypes allow physical evaluation
- Pathfinding models handling, manufacturing and logistics activities

Conclusion

- Modern spacecraft manufacturing seeks to design-in quality and manufacturability to reduce cost and time to market.