



Agenda

- Integrated Producibility Approach
- Design for Manufacturing and Assembly (DFMA)
- TacSat 4 DFMA Workshop
- Summary

Integrated Producibility Approach

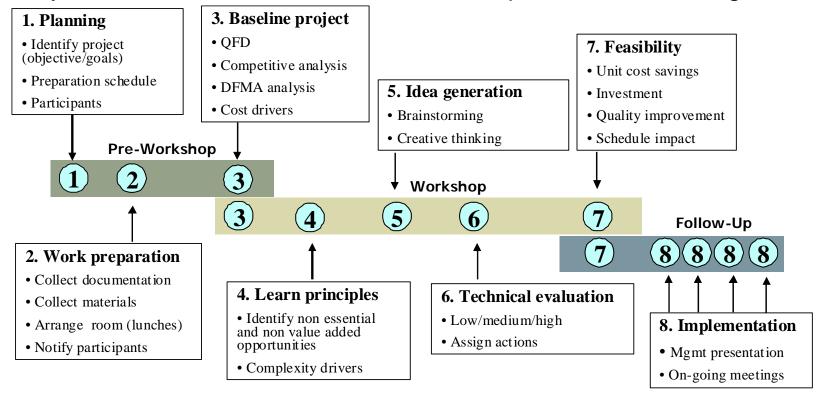
- System Engineering integrated approach is necessary to achieve both producibility and affordability
- Trades between performance and cost are evaluated throughout the concept refinement, requirements allocation and design development phases
- In the paradigm where Design "hands off" a design to Manufacturing, 70-80% of the product cost has already been determined
 - Design decisions affect product complexity
 - Parts, processes and specification limits drive cost
- The influence of the Manufacturing team on the final product cost, quality and schedule is only about 20-30%
 - Supplier purchase agreement negotiations
 - Production aids, special tooling implementation

An Integrated Product Team of Design, Manufacturing and the Business Elements can influence 100 % of the production cost



Design for Manufacturing and Assembly

 A Design for Manufacturing and Assembly (DFMA) workshop is a collaborative forum in which knowledge that affects product cost, quality and cycle time is collected, shared and incorporated in the design



DFMA Process enables individuals working together as a team to use a facilitated process to make products more competitive

DFMA Principles

- 1. Minimize the number of parts
- 2. Minimize the use of fasteners
- 3. Standardize
- 4. Avoid difficult components
- 5. Use modular subassemblies
- 6. Use multifunctional parts
- 7. Minimize reorientations
- 8. Use self-locating features
- 9. Avoid special tooling and test equipment
- 10. Provide accessibility
- 11. Minimize operations and process steps
- 12. Eliminate blind assemblies

"The best design is the simplest one that works"
- Albert Einstein

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DFMA Fastener Example

Before: HTS Clamshell design has 42 screws to fasten

Undesirable Assembly Practice

After: HTS R7 3-section design has 2 Marmon clamps with captive fasteners



TacSat 4 DFMA Workshop

- Raytheon is an original member of the Naval Research Laboratory-led Integrated Systems Engineering Team (ISET)
 - ISET is a joint government-industry working group with a charter to develop small satellite bus standards
 - Charter includes a plan to lower the cost of satellites, enabling the Operationally Responsive Space (ORS) vision for flexible satellite missions
 - Vision is to balance mission satellite utility with industrial know-how to reduce cost and produce an affordable constellation of off-the-shelf satellites
- Raytheon Missile Systems hosted a DFMA workshop with the ISET focused on applying mass-production techniques to Operationally Responsive Space
- Three focus areas of the baseline TacSat 4 design were presented and ideas were generated around these topics
 - Propulsion
 - Integration and Test
 - Harnessing

DFMA workshop selected to balance manufacturing effort and cost with the constraints of customer requirements



TacSat 4 DFMA Workshop Recommendations

- Producibility recommendations were developed in the following categories
 - Functional test
 - Provide test access points with adequate clearance
 - Provide built-in self-test and diagnostic resolution
 - Maximize testability coverage at the lowest assembly level possible
 - Design test equipment for quick and reliable interfacing
 - Assembly access
 - Allow access to all modules and units at the panel level
 - Maintain straight access to all mounting hardware at the satellite level
 - Allow module installation and removal from the top of the assembly
 - Part and process usage
 - Minimize the number of parts a part that is designed out can never fail
 - Standardize on the part types
 - Minimize process steps and use low defect processes
 - Design replacement parts to be fully interchangeable with the existing parts
 - Special tooling
 - Design special tooling (e.g., dollies and strong-backs) in parallel with the satellite design
 - Mechanical alignment
 - Eliminate precision mechanical alignment in the final integration facility
 - Minimize and simplify mechanical alignment during the mechanical mounting process

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TacSat 4 DFMA Workshop Recommendations (cont'd)

- Cable and harnessing
 - Connectorize and key cables and harnesses
 - Use quick connect connectors when possible
 - Predefine and prelocate cable harness tie points with keepouts observed
 - Minimize use of tie wraps on RF cables during integration
 - Combine assembly cabling and wiring into harnesses and bundles
 - Route cables and harnesses to permit access to module and unit mounting locations
- Center of Gravity (CG) measurements
 - Eliminate or minimize CG measurements during production for modules, units and panels – measurements at the satellite level is acceptable
 - Eliminate weight measurements during production for circuit cards, modules and units
 measurements for panels and satellites are acceptable
- Hardware handling and lifting methods
 - Design in lifting points in all units to interface with mechanical fixtures
 - Provide access to lifting points at the panel level for unit installation and removal
 - Permit vertical lifting and rotation of units with lifting points
 - Design in lifting points to interface with mechanical fixtures into the satellite
 - Ensure satellite lifting points are accessible during system integration and at the launch site

Execution of best design practices can be guaranteed by incorporating them into requirements documents

Summary

- System Engineering integrated approach is necessary to achieve both producibility and affordability
- Methodologies such as a Design for Manufacturing and Assembly (DFMA) workshop can be used to collectively address product cost, quality and cycle time early in the concept and design phases
- Focusing on cycle time reduction and commonality can reduce costly practices at all levels of assembly
- Incorporating design best practices that affect manufacturing into product specification requirements can transform recommendations into reality

Early incorporation of manufacturing considerations on design support the vision of improved cycle time to market and lower cost