Space Mission Structures

From Concept to Launch

SMS

Course Overview

This 3-day course presents the structure for a space or launch vehicle as a system. Originally based on the instructor's book, *Spacecraft Structures and Mechanisms: From Concept to Launch*, this course has evolved and been improved continuously since 1995.

If you are an engineer involved in any aspect of spacecraft or launch-vehicle structures, regardless of your level of experience, you will benefit from this course. Subjects include functions, requirements, environments, stress analysis, fracture mechanics, finite element analysis, configuration development, preliminary design, improving the loads-cycle process, verification planning, quality assurance, testing, and risk assessment. This course is three full days or five 5-hour days.

The objectives are to provide a systems perspective of space mission structures and improve your understanding of …

- structural functions, requirements, and environments
- how structures behave and how they fail
- how to develop structures that are cost-effective and dependable for space missions

Target Audience

Structural design engineers, stress and dynamics analysts, systems engineers, and others interested in the topic

Course Materials

Course book containing presentation materials and a copy of the instructor's 850-page reference book, *Spacecraft Structures and Mechanisms: From concept to Launch* [1995]

Course Developer & Teacher

Tom Sarafin is President and Chief Engineer of Instar Engineering and Consulting, Inc. He has worked full time in the space industry since 1979 as a structural engineer, a mechanical systems engineer, a project manager, and a consultant. Since founding Instar in 1993, he's consulted for NASA, DARPA, the DOD Space Test Program, Lockheed Martin, DigitalGlobe, Space Systems/Loral, Spaceflight Industries, and other organizations. He was a key member of the team that developed NASA-STD-5020, "Requirements for Threaded Fastening Systems in Spaceflight Hardware" (March 2012). He is the editor and principal author of *Spacecraft Structures and Mechanisms: From Concept to Launch* and is a contributing author to *Space Mission Analysis and Design*. He's also the principal author of a series of papers titled "Vibration Testing of Small Satellites." Since 1995, he has taught over 250 courses to more than 5000 engineers and managers in the aerospace industry.

Testimonials:

"This course is a 'must take' for every engineer and analyst involved with space hardware/systems."

"Many really good examples." "Excellent presentation—a reminder of how much fun engineering can be."

"An excellent course. It gave me a lot to think about." "Good stuff, and a very clear presentation."

"Very valuable. Relates classroom knowledge to actual experiences in the space industry."

"I wish I had taken this class 20 years ago. Possibly the best course I've ever taken."

"I really enjoyed it! I feel I am a better engineer because of this course."

"Great course!"—Retired Chief Engineer who helped develop the Saturn family of launch vehicles

Instar also offers the following courses: "Ten Principles for Successful Space Programs" (TenP), "Engineering for Success in the Space Industry" (ESSI), "Design and Analysis of Bolted Joints' (DABJ), "Structural Test Design and Interpretation" (STDI), "Vibration Testing of Small Satellites" (VTSS), and "Vibration Testing on an Electrodynamic Shaker" (VTES). Go to instarengineering.com/available_courses.html for details.

SMS Course Outline

1. Overview of Space Mission Structures

- Structural functions and requirements
- Effects of the space environment
- How launch affects things structurally
- Dispelling some myths
- Top-level criteria for strength
- Understanding verification
- Relating verification to requirements

2. Launch Environments and How Structures Respond

- Overview of the mechanics of vibration
- Breaking down the launch environment
- Quasi-static loads
- Transient loads and coupled loads analysis
- Sinusoidal vibration
- Acoustics
- Random vibration
- Mass/acceleration curves
- Pyrotechnic shock

3. Assessing Structural Integrity: Stress Analysis

- Stress and strain
- Accounting for strength variation
- What it means to assess structural integrity
- Government standards for factors of safety
- Understanding stress analysis and its dependence on test
- An effective process for strength analysis
- Common pitfalls and case histories
- Fatigue and fracture mechanics
- Fracture control
- Structural design criteria

4. Overview of Finite Element Analysis

- Idealizing structures
- Introduction to FEA and stiffness matrices
- Effective use of FEA
- Quality assurance for FEA

5. Configuration Development and Preliminary Structural Design

- A process for preliminary design
- Configuring a spacecraft
- Types of structures and forms of construction
- Materials and methods of attachment
- Reducing cost by reducing the number of parts
- Designing an adaptable structure
- Providing direct load paths
- Estimating weight and managing weight growth

6. Improving the Loads-Cycle Process

- The traditional loads-cycle process with coupled loads analysis (CLA)
- Ideas for improving the loads-cycle process
- Managing payload math models
- Integrating stress analysis with CLA
- Potentially eliminating the need for mission-specific CLA for launch of small spacecraft
- Sensitivity analysis for large spacecraft

7. Verification and Quality Assurance

- Whose job is this?
- Attending to details
- Controlling the configuration
- Proactive verification
- Verification methods and logic
- Philosophies for product inspection
- Establishing a test program
- Designing an effective test
- Documenting and presenting verification

8. Final Verification and Risk Assessment

- Overview of final verification
- Addressing late-arising loads problems
- What does it mean to “understand” a risk?
- Hypothetical example: Negative margin of safety
- Making the launch decision

9. A Case Study: The FalconSat-2 Small Satellite

(available for on-site courses only as an optional substitute for Sec. 6, Improving the Loads-Cycle Process)

- Overview of the FalconSat program
- Approach to structural design and verification
- Testing the engineering model
- Designing the flight structure
- Qualification and acceptance testing
- Launch (and FalconSat-2 today)
- Process changes for FalconSat-3
- Conclusions

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