SCS—Spacecraft Structures
From Concept to Launch

Course Overview: This 3-day course, formerly called "Space Mission Structures" (SMS), presents a spacecraft structure as a system. Originally based on the teacher'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, fatigue and fracture mechanics, finite element analysis, configuration development, preliminary design, improving the loads-cycle process, verification planning, quality assurance, testing, and risk assessment.

The objectives are to impart a systems perspective of spacecraft 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

The teacher shares numerous case histories and experiences to drive the main points home.

Target Audience: Structural and mechanical design engineers, stress analysts, loads and dynamics engineers, systems engineers, engineering managers, and others interested in the topic

Course Length: Three full days

Course Developer and Teacher:

Tom Sarafin is President of Instar Engineering and Consulting, Inc. He has worked 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 (Maxar), Sierra Nevada Corp (Sierra Space), and many 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*. Since 1995, he has taught over 350 courses to more than 6000 engineers and managers in the space industry: Spacecraft Structures, from Concept to Launch (SCS), Design and Analysis of Bolted Joints (DABJ), Structural Design and Analysis for Aerospace Engineers (SDA), Structural Test Design and Interpretation (STDI), Vibration Testing of Small Satellites (VTSS), Notching and Force Limiting Workshop (NFLW), and Ten Principles for Successful Space Programs (TenP).

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

SMS—Space Mission Structures

From Concept to Launch

Course Outline

Introduction

1. **Overview of Spacecraft Structures**
   - Structural functions and requirements
   - Effects of the space environment
   - How launch affects things structurally
   - Debunking some myths
   - Top-level criteria for strength analysis
   - 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
   - Shock
3. **Assessing Structural Integrity: Stress Analysis**
   - Stress and strain
   - What it means to assess structural integrity
   - Government standards for test options and factors of safety
   - Accounting for strength variation
   - What failure theory applies to ductile rupture?
   - Understanding stress analysis from the engineer's perspective
   - Common pitfalls and case histories
   - An effective process for strength analysis
   - 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; FireSat example
   - Types of structures and forms of construction
   - Materials and methods of attachment
   - Reducing cost by reducing the number of parts
   - Designing an adaptable structure
   - Designing for manufacturing
   - Using analysis to design efficient structures
   - 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 math models
   - Integrating stress analysis with CLA
   - Improving efficiency of methodology and software
   - Norton-Thevenin Receptance Coupling (NTRC)
   - 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

Summary

Download a PDF file containing all the course materials at no charge, along with PDF files for Tom Sarafin's other courses, at https://instarengineering.com/resources.html.