

SDA—Structural Design and Analysis for Aerospace Engineers

Course Overview: This 24-hour course is a companion or follow-on to the teacher’s first course, “Space Mission Structures: From Concept to Launch” (SMS). SMS gives the big picture of spaceflight structures development, while SDA goes into much more detail on design and analysis of aerospace structures and is not specific to space and launch vehicles; most of the course applies to all flight structures, and much applies to ground support structures as well. Although we recommend people in the space industry start with SMS and follow with SDA, SMS is not a prerequisite.

Subjects include statics, dynamics, and mechanics of materials (with emphasis on practical applications); strength analysis (with emphasis on empirical and semi-empirical methods rather than sole reliance on finite element analysis); fatigue analysis (with practical applications); and structural design (philosophy, material selection, types of structures and their considerations, methods of attachment, and guidelines).

Participants should be prepared to work class problems.

Target Audience: Structural and mechanical design engineers, stress analysts, and others interested in the topic

Course Length: Three full days

Course Developer and Teacher:

Tom Sarafin is President and founder 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 well over 300 courses to more than 6000 engineers and managers in the aerospace industry. He teaches the following courses: Space Mission Structures, from Concept to Launch (SMS), 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

“Working at a company that asks for MEs to do both design and analysis, this was a great course to make sure my team and I have the knowledge and skillset required to build great products and meet our objectives with high confidence”

“Apples to Apples, this will probably always ring in my head during analysis now.”

“The theoretical and practical sides of design, analysis, and engineering in general blend together beautifully – with introspective as well as interactive presentation of the material an added bonus.”

“Fatigue assessment part was the most interesting part for me.”

“The course challenged a lot of my preconceptions about stress analysis and I liked how Tom broke down his explanations by consistently going back to the basics of using FBDs and the fundamentals. I appreciate how concepts were explained with practical examples and considerations and not just regurgitated from textbooks etc.”

“Common sense isn’t very common any more. Tom’s full of it and you can quote me.” (love this one!)

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Course Outline

Introduction

1. Structural Requirements and Design Criteria

- Structural requirements: what they are and what they are not
- Typical structural functions and constraints
- How flight loading environments affect the structure
- Standards and criteria
- Top-level criteria for strength
- Other commonly used structural design criteria

2. Review of Statics and Dynamics

- Static equilibrium and free-body diagrams
- Benefits of a statically determinate interface
- Statics examples and class problems
- Dynamic equilibrium
- Modes of vibration
- The equation of motion
- Transmissibility
- Mode shapes
- Applying what we learned

3. Mechanics of Materials

- Stress and strain
- Combined state of stress
- Principal stresses and Mohr's circle
- Beams and bending stress
- Unsymmetrical bending
- Torsion and the effects of warping constraint
- Thermal effects

4. Strength Analysis, Including Buckling

- An important thing to understand
- Accounting for variation in material strength: allowable stresses
- Revisiting the margin of safety
- Failure theories for materials
- Failure in practice and the benefits of ductility
- Understanding stress analysis from the engineer's perspective
- Common pitfalls
- An effective process for strength analysis
- Failure modes for fastened joints

- Forms of buckling
- Elastic buckling of columns
- Modified Johnson parabola
- Inelastic buckling and eccentric loading
- Buckling of plates and shells

5. Fatigue of Metals

- What is fatigue?
- Brief history of fatigue failures and ensuing research
- Stress concentration factor
- Terms defining a loading cycle
- Fatigue analysis process
- Quantifying fatigue life by test
- Presentation of fatigue data
- High-cycle (stress-life) vs. low-cycle (strain-life) fatigue
- Miner's rule
- Life (scatter) factor and fatigue analysis factor
- Fatigue notch factor and notch sensitivity factor
- The Goodman method and equivalent alternating stress
- Linear-elastic fracture mechanics
- Fracture control
- Generating a loading spectrum

6. Structural Design

- Opening thoughts on structural design
- Material selection
- Types of structures and important things to understand when designing them
 - Beams
 - Trusses and frames
 - Forms of lightweight panels and shells
 - Monocoque and semi-monocoque cylinders
 - Skin-stringer and panel-frame structures
- Methods of attachment
- Reducing cost by reducing the number of parts
- Designing an adaptable structure
- Summary: Structural design guidelines from a master

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>.