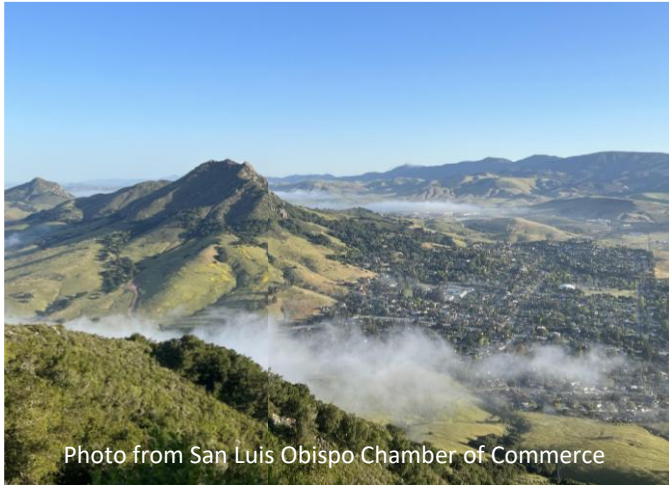


FLVT—Force Limited Vibration Testing

A Practical Introduction and Workshop for Aerospace Engineers

Hosted by Maverick Space Systems in San Luis Obispo, California



The objectives of this course are to improve your understanding of force limiting as a method of avoiding excessive loading during a vibration test, including ...

- Technical rationale
- NASA’s semi-empirical method
- Deriving force limits
- Implementing force limiting principles without the use of force sensors, with response limiting and manual notching

Course length: two full days

Limited to 12 total participants maximum

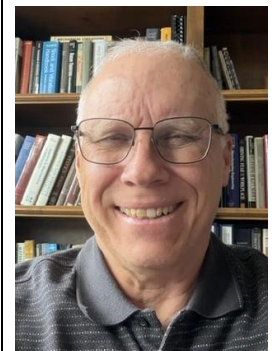
Before delving into force limiting, the course provides a review of vibration mechanics and explains sine sweep testing (both low- and high-level) and random vibration testing. The detailed yet understandable coverage of force limiting includes several examples. The course ends with a computer workshop (bring your laptop!), in which the class will use provided spreadsheets to design force limited, response limited, and manually notched tests.

Class will be held in the building that houses Maverick’s vibration test lab. The class will visit the lab multiple times so that Maverick’s personnel can demonstrate important topics covered in class. Demonstrations will use a small satellite simulator (SatSim-125M), mounted to a Motorized Lightband simulator, which in turn is mounted on a force limiting fixture with piezoelectric force sensors.



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 (Vantor), Sierra Nevada Corp (Sierra Space), and many other organizations. 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. His other courses include Space Mission 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), and Vibration Testing of Small Satellites (VTSS).



FLVT—Force Limited Vibration Testing

FLVT is a new course, developed in 2026.

But here are some testimonials from Tom Sarafin’s related VTSS course:

“Anyone involved with the mechanical structure of a spacecraft or test engineering of ensuring a spacecraft survives launch should take this course – very well taught!”

“The course was very interactive and tailored to the class’ needs. I enjoyed this class very much.”

“Whether you’re a novice engineer with little to no experience in vibration testing of a more experienced engineer with vibration testing history, you’ll walk away from this class feeling you’ve learned a lot.”

“A must have for anyone involved in vibration testing. You have a great ability to take complicated concepts and make them completely understandable.”

Course Outline

Introduction

1. Overview of Vibration Testing

- Electrodynamic shakers
- Vibration test objectives
- Review of vibration mechanics
- Transmissibility
- Common types of vibration tests on shakers
- Qualification and acceptance testing
- Protoflight, flightproof, and protoqualification
- Limitations of testing on a shaker, and common approaches
- Taking responsibility for verification

2. Sine Sweeps: Low-level and High-level

- Objectives and test parameters
- Examples of response data
- **Lab demo:** low-level sine sweep for SatSim-125M
- Criteria for pre- and post-test comparisons
- High-level sweeps: sine vibrate testing
- NASA’s guidance for sine vibrate testing

3. Random Vibration Testing

- Introduction and objectives
- Power spectral density: understanding g^2/Hz
- Root-mean-square acceleration
- Understanding probability for random vibration
- Decibels
- Test levels
- Transfer functions, and how random vibrate response relates to sine sweep response
- **Lab demo:** low-level random vibration for SatSim-125M, viewing time histories to identify peak response, comparing transfer functions to sine sweep results

4. Introduction to Force Limiting

- Impedance: apparent mass
- The dynamic absorber effect
- Measuring base force and moment
- Estimating base force and moment without force sensors; class problem for SatSim-125M
- NASA’s Semi-Empirical Method for force limiting

5. Deriving C^2 for Use with the Semi-Empirical Method

- Common methods for deriving C^2
- The Simple TDFS method
- Deriving C^2 from measured or predicted interface acceleration and force; example
- Setting C^2 to keep the base force from exceeding flight limit load; example
- Force limiting for sine vibrate testing

6. Force Limiting Without Force Sensors, and Other Justification for Notching

- Response limiting to simulate force limiting
- Manual notching to simulate force limiting
- Other technical rationale to justify notching

Summary

Force Limiting Workshop, immediately following presentation of the prepared slides

- Introduction to the provided spreadsheets
- Filling in equations and designing force limits, response limits, and manual notches for a representative problem
- Designing force limits, response limits, and manual notches for SatSim-125M
- **Lab demo:** force limited, response limited, and manually notched random vibrate tests for SatSim-125M

Soon available: Download a PDF file containing all the course materials, other than the force limiting spreadsheets, at no charge, along with PDF files for Tom’s other courses, at <https://instarengineering.com/resources.html>. The force limiting spreadsheets are available only to course participants.