

## **Loads and Dynamics: Forces and Responses that Affect Spacecraft through their Performance Lives**

The NESC Academy will present the course Loads and Dynamics from December 4–6, 2007 in Houston, Texas. Loads and dynamics combines mathematics, physics, statistics, probability, structural and mechanical engineering, and systems theory into one field vital to the safety and success of every NASA mission. This comprehensive subject will be taught by Dr. Curtis Larsen, the NASA Technical Fellow for Loads and Dynamics, and his colleagues from NASA and industry.

Dr. Larsen is resident at the Johnson Space Center. Before joining the NESC as a Technical Fellow, Dr. Larsen was the Technical Discipline Manager for Cargo Integration Structures in the Space Shuttle Program's Flight Operations and Integration Office. Prior to that assignment, he was a technical integration lead in the Space Shuttle System Integration Office responsible for structures, loads, and dynamics for both cargo elements and the Shuttle vehicle. Dr. Larsen has also served as the Shuttle/Station technical liaison for structures and as a member of the Shuttle Loads and Structural Dynamics Panel.

Dr. Larsen has more than 25 years of engineering experience. He first worked at the NASA Johnson Space Center from 1985 to 1990 as a structural engineer in the Loads and Dynamics Branch of the Structures and Mechanics Division. His particular areas of expertise and interest are in stochastic structural dynamics, structural safety, and probabilistic engineering applications. Before rejoining NASA in 2001, Dr. Larsen held various engineering research, development, and design positions with companies in the offshore oil construction, building construction, and aerospace industries, including McDermott Engineering, Boeing, and United Space Alliance.

The exploration of this topic will cover 15 different lessons:

### **Lesson 1: Introduction—Robert Siudzinski**

This lesson will welcome participants, orient them to the building, and introduce the class. Participants will be given background information on the NESC Academy and its courses. The course will be explained in terms of time, format, and content. Participants will learn the best ways to use their Participant Manuals and will be advised to expect a test and a chance to evaluate the course at the end of the three days. Faculty members will be introduced very briefly. The lesson will include a short activity to orient participants to the participant polling devices (PPDs). Finally, the introduction will be summarized and a preview will be given of the first content lesson.

### **Lesson 2: Introduction to Loads and Dynamics & System Integration—Curt Larsen**

This lesson on Loads and Dynamics highlights the discipline and its use of the Project Design Cycle Process and the Fundamental Load Process in system integration work. Overview of the Operations Life Cycle will also prepare participants for the sequence of course lessons.

**Lesson 3: Rollout Loads**—Curt Larsen and George James

This lesson will focus on the early roll out analysis concerning the Shuttle and the work done by the Loads panel. It will also focus on the effects wind, speed, and the various load types have on the rollout process, as well as the importance of integration within the NASA disciplines when testing.

**Lesson 4: Liftoff Facilitated Discussion—Apollo/Saturn and Shuttle Experience**—Alden Mackey; Tom Modlin; Bob Ryan; and Curt Larsen, moderator

This facilitated discussion will cover the complex variables involved in liftoff loads, including Mobile Launch Pad stiffness, SSME and SRM ignition, ignition over pressure (IOP), hydrogen ignition concerns, moment of liftoff, and wind and thermal induced loads. The lesson will also discuss load factors that can affect the vehicle during its long wait assembled on the pad, including seismic loads and the Van Karmen effect.

**Lesson 5: Stud Hang-up**—Curt Larsen, Clint Cragg, and George James

This lesson will describe the stud hang-up incidents and the problem-solving investigations that engineers have conducted to combat this challenge. It will also focus on how loads analysis is performed for each mission.

**Lesson 6: Ascent Flight Facilitated Discussion—Apollo/Saturn and Shuttle Experience**—Alden Mackey; Tom Modlin; Bob Ryan; and Curt Larsen, moderator

This facilitated discussion will focus on various aspects of ascent flight, after liftoff and before insertion into orbit. It will discuss the development and evolution of methods and tools for analyzing and calculating wind shear, wind loads, and ascent trajectories. It will also discuss the effects of the natural environment on the ascent trajectories.

**Lesson 7: Ascent Analysis—STS-107**—Curt Larsen and George James

This lesson will discuss the importance of ascent analysis. It will highlight several events that occur during ascent and how proper analysis and modeling can correct or prevent future occurrences.

**Lesson 8: Pogo Heritage, Part 1**—Hal Doiron

This lesson will discuss the basic causes of pogo and examine the approaches used to stop pogo in the Apollo program, prevent pogo in the Shuttle and Delta IV programs, and deal with pogo in the CLV and other future launch vehicles.

**Lesson 9: Pogo Heritage, Part 2**—George Zupp

This lesson will discuss the Saturn Program's difficulties with the pogo effect. The lesson will also cover the Space Shuttle Program's successful approach to addressing the pogo problem with a pogo suppression system. Finally, the lesson will describe how the Constellation program is approaching a pogo suppression system.

**Lesson 10: Vibro-Acoustic and Shock Prediction and Testing**—Dennis Kern

This three-part lesson will provide an overview of vibro-acoustics and shock prediction testing. Improvements in vibrational acoustic testing, modeling, and analysis have developed through years of lessons learned and technological advances in computing, though the complicated area of shock prediction testing is still rather underdeveloped, with testing approaches being more of an art than an established science.

**Lesson 11: On-Orbit Loads and Docking**—Curt Larsen and Siamak Ghofranian

This lesson will discuss the analysis of loads for the adaptation and development of docking mechanisms for Apollo-Soyuz, Space Shuttle/MIR/ISS, and future launch vehicles and include aspects of systems integration and multi-physics analysis. It will also examine the challenges of predicting and analyzing on-orbit loads on the International Space Station during its construction and 30-year lifespan.

**Lesson 12: Lunar Landing**—George Zupp and Tom Modlin

This lesson will discuss the approaches engineers used in designing the LM landing gear, overcoming the challenges of limited computer modeling capabilities available at the time. The lesson will also discuss the need to keep astronauts in the loop, because how a system will be used might not be how the designers intended. Finally, the lesson will cover the dynamic characteristics of Apollo command service and lunar module docked together.

**Lesson 13: Culture Panel**—All instructors, with Curt Larsen moderating

This panel discussion will focus on various aspects of the culture, both in and out of NASA and the international space community, related directly and indirectly to the Loads and Dynamics discipline.

**Lesson 14: System Integration—More Details, Recap, Organizational Comments**—Curt Larsen and Alden Mackey

This capstone lesson will review the flight phases and loads development processes discussed across the three days. This lesson will assist participants in synthesizing the overall course content, as it relates specifically to Loads and Dynamics and system integration.

**Lesson 15: Conclusion**—Robert Siudzinski

To apply for the Loads and Dynamics course, go to the “Courses” page and click on “Apply Now” in the “Upcoming Course” box at the top right side of the page.