

23rd ATS Tutorials
October 9, 2006

Introduction to MIL-STD-1540E, *Test Requirements for Launch, Upper-stage and Space Vehicles*

Instructor: Mr. Alan J. Peterson, The Aerospace Corporation

Instructor Biography

Alan J. Peterson is a Senior Engineering Specialist in the Environmental Test and Ordnance Dept. of the Vehicle Systems Division at the Aerospace Corp. where he provides environmental test expertise and guidance to the program offices. He has participated in writing Mil-1540E, Aerospace System Handbook, and has provided environmental test systems engineering support for many SMC and National Programs. Prior to joining Aerospace in 1999, he worked for 35 years at Hughes Space and Communications Group on satellite environmental test and criteria definition for the Structural Mechanics Laboratory. He has published a number of papers on dynamic testing for satellite validation and verification. He served as Technical Co-chair, General Co-chair, and Session Chair for several past Aerospace Testing Seminars. He received his BS degree from Purdue Univ. in Mechanical Engineering in 1960.

Course Description

This course explains the requirements specified in the 1540E Standard for the testing of space articles. This Standard is being used as a compliance document in support of new government acquisitions. The course begins with an overview of why we test and what criteria lead to the specified requirements which provide a foundation for building a thorough test program. Test philosophies, criteria, and approaches will be presented and examined using historical data and lessons learned. The course includes strategies for document tailoring based on the rationale of equivalent verification. The student will learn how design verification through testing can achieve mission success with a high level of confidence.

Force Limited Vibration Testing

Instructors: Dr. Kurng Chang, Jet Propulsion Laboratory, California Institute of Technology

Dr. Kurng Chang is currently a technical leader at the Jet Propulsion Laboratory (JPL). He is responsible for establishing dynamic design requirements for flight projects, and coordinating research activities in environmental prediction, definition, and testing. He has over 30 years of experience specializing in the field of structural dynamics and its application to environmental requirements. Dr. Chang was the environmental test director of NASA's Galileo, Cassini and Deep Space 1 spacecraft programs. He received a B.S. from Cheng-Kung University in 1964, an M.S. from the University of Iowa in 1967, and his doctor degree in Engineering Mechanics from Columbia University in 1970.

Course Description

NASA-HDBK-7000B "Force Limited Vibration Testing" establishes a methodology for conducting force limited vibration tests for all NASA programs and projects. It may be cited in contracts and program documents as a technical requirement or as a reference for guidance. In this course the authors review and expand on the material presented in the handbook. Part I discusses the concepts of force limiting, derivation of force limits by coupled system and semi-empirical methods, force data from flight measurements vs. predictions, test instrumentation and supporting equipment required for performing the force limited tests. Part II covers the actual testing procedures and lessons learned from previous flight spacecraft and instrument tests. Examples of actual force limited vibration tests for space equipment will be presented and discussed. Part I will be presented by Dr. Terry Scharton and Part II will be covered by Dr. Kurng Chang.

Satellite Structural Testing

Instructor: Mr. Paul A. Larkin, Sandia National Laboratories

Instructor Biography

Mr. Paul A. Larkin has over 30 years of experience in structural design, analysis and test and brings a true practitioner's perspective to this unique course. He has contributed to the design, analysis, fabrication and test of major NASA programs such as LANDSAT, Solar Max Repair, Space Telescope Maintenance and Repair, UARS, GRO, TOPEX/POSEIDON, ACRIM, QuikTOMS, VCL and GALEX. He has also participated in the SGS Block I, GEOSAT/OIS, and MightySat programs for the Air Force. He was employed as a structural dynamics engineer by Fairchild Space Systems Division from 1979 until 1995. From 1995 until 1998, Mr. Larkin was president of his own consulting company where he contributed to such recent projects as the Indostar DBS Satellite, Earthwatch, TSX-5 and the NASDA RMS transportation and storage container. Since then, Mr. Larkin was employed by Orbital Sciences Corporation's Space Systems Group where he was responsible for the mechanical integrity of their space systems products and contributed to several commercial satellite programs such as OrbView, NSTARc and PanAmSat. Currently, Mr. Larkin is employed by Sandia National Laboratories where he participates in the dynamic analysis and test of structural systems.

Course Description

This course will present material and concepts necessary for the successful development and verification of spacecraft structural systems. Material covered will include requirements flow down, structural environments, test definitions, test flow, verification and test for: static, modal, sine, random, force limited vibration, shock and workmanship.

Integration and Test Systems Engineering, Parts I & II

Instructors: Mr. Bruce L. Arnheim and Ms. Julia D. White, The Aerospace Corporation

Instructor Biography

Mr. Bruce L. Arnheim is currently the Director of the Cross Program Research Office for the Aerospace Corporation. His work addresses industry-wide issues in the fields of test effectiveness, spacecraft failure assessment, lessons learned, schedule planning and modeling as well as program-specific concerns requiring a cross-program perspective. Mr. Arnheim has served the aerospace community for over 24 years having spent 19 of them with Hughes Space and Communications. At Hughes, now Boeing, his experience covers the disciplines of spacecraft design, test, and systems engineering. He holds a Dual Bachelors Degree in Engineering from Harvey Mudd College and Economics from Claremont McKenna College and a Masters in Business Administration from Pepperdine University.

Ms. Julia D. White is currently a Senior Engineering Specialist in the Cross Program Research Office for the Aerospace Corporation. Her work addresses industry wide issues in the fields of on-orbit spacecraft anomalies and lifetimes, lessons learned, satellite development comparisons, as well as program specific concerns requiring a cross program perspective. Ms. White has been with The Aerospace Corporation for 30 years, 18 of which were spent in the Space Test Program Office helping develop six R&D spacecraft. She holds a Dual Bachelors Degree in Physics and Astronomy from the University of Maryland and a Masters in Astronomy from the University of Massachusetts.

Course Description

This course presents the entire process of testing space articles. The course begins with an overview of why we test, addressing industry trends, cost and schedule elements, and the flow of requirements to provide a foundation for building a test program. The remainder of the two-part class addresses each element of the test pyramid, to provide students with the foundation for understanding how to balance these test elements in today's environment. Test philosophies, approaches and criteria will be presented and reinforced throughout the tutorial using an interactive approach to learning.

The second half of this course continues up the test pyramid with the higher levels of functional and environmental testing. The student will be involved in learning aspects of test problem solving techniques, anomaly handling, troubleshooting, and rework/retest. Both parts of the course will include data-driven recommended practices.

Applied High-Frequency Structural Dynamics, Shock and Acoustics

Instructor: Mr. Richard L. Foss, Jr., Lockheed Martin Space Company

Instructor Biography

Mr. Richard L. Foss, Jr. received his Bachelor's of Science degree in Engineering from Colorado School of Mines followed by Graduate course work in Mechanical Engineering at the University of Colorado. He began his engineering career at Lockheed Martin Space Company in Denver in 1983 where he has specialized in vibration, acoustics, mechanical design and test. His 23 years experience in the space industry have spanned a broad variety of challenging tasks ranging from Solid Rocket Motor integration and Liquid Engine health assessments to science acquisition mechanism design for space discovery missions. He currently works as a technical specialist in support of the Engineering Test Laboratories at Lockheed Martin Space Company.

Course Description

This course will cover basics associated with the high frequency structural excitation sources of shock and acoustics. Characterization of energy sources associated with these phenomena, the nuances of structural coupling, and how the sources and responses are measured and analyzed will be a central theme of this discourse. Statistically based environments derivation and the basis for N-th octave analyses commonly used will be presented, but predications based on spitting in the wagon or tossing chicken bones will be strongly discouraged. Typical curves for source shock, attenuation relations for common aerospace structures, and the basis of the Shock Response Spectra will be dissected. Acoustic field characterization, transmission loss, and empirical methods for predicting acoustic environments will be touched upon with emphasis on how structures couple with acoustic energy and the benefits and limitations of reverberant chamber testing. Statistical methods for characterizing acoustic fields and peak responses will be included along with basic data reduction guidelines and beneficial test procedures.

Introduction to EMI/EMC Testing

Instructor: Mr. Mark Simpson, The Aerospace Corporation

Instructor Biography

Mark Simpson graduated with a BSEE from the Pennsylvania State University. He has 22 years of industry experience. At Boeing, Mark was responsible for lightning analysis for the Atmospheric Electricity Hazards Protection Program and acted as a backup test conductor. He also validated the EMC interfaces between the Inertial Upper Stage and Space Shuttle. At McDonnell Douglas, Mark was the lead EMC engineer on the C-17 Globemaster III where he performed the lightning and EMP analyses and was responsible for planning the aircraft level EMC, lightning, and HIRF tests. Mark has spent the last 15 years at the Aerospace Corporation. He is currently the Senior Project Leader of the Electromagnetic Effects Section and is responsible for coordinating the EMC support to about a dozen Air Force space program offices. Mark has updated the EMC portions of MIL-STD-1540 and oversaw the rewrite of MIL-STD-1541. He has co-chaired the Mission Assurance Improvement Team's Specifications and Standard IPT and has coauthored an update of a list of all standards to be used by all Air Force space programs. He also a backup for independent avionics reviews. Mark has received numerous letters of commendation for his work and has published four papers.

Course Description

The participant will learn how to develop a MIL-STD-1540E(draft) compliant test program. The emphasis will be on learning concepts and principles. All experience levels are welcome. The course will cover the following topics:

- How to properly tailor the requirements when using MIL-STD-1541A with either MIL-STD-461C or MIL-STD-461E or when using MIL-STD-1541B(draft) with MIL-STD-461E
- Analyses and tests required for each phase of a program will be discussed (i.e., study, proposal, SRR, PDR, CDR, FCA/PCA, TRR).
- Critical facility choices, such as, when to use an anechoic chamber over an EMI shield room and the different types of anechoic chambers
- How changes to flight configurations, (i.e., load simulator, presence of solar arrays, installation of multilayer thermal blankets, and antenna deployments) can impact test results
- Required modes of operation and the difference between test and flight modes
- Success/fail criteria and why measuring performance directly is required
- Issues involved with testing radio frequency sensors, and receivers, and optical sensors
- Odds of passing EMI testing the first time and factors that include your chance of success
- Approaches to troubleshooting and isolating sources of noise and susceptible circuits using analysis, frequency maps, tenting, and selective turn-on

Software Testing, Parts I & II

Instructors: Ms. Suellen Eslinger and Mr. Douglas J. Buettner, The Aerospace Corporation

Instructor Biography

Suellen Eslinger is a Distinguished Engineer in the Software Engineering Subdivision at The Aerospace Corp. Ms. Eslinger has over 30 years of experience in software engineering and acquisition. Prior to her 17 years at Aerospace, she worked at Computer Sciences Corp. and General Research Corp., where she developed software and managed software development projects for DoD and NASA software-intensive systems. Ms. Eslinger has a BA and an MS in Mathematics, from Goucher College and University of Arizona, respectively.

Doug Buettner is an Engineering Specialist in the Software Engineering Subdivision at The Aerospace Corporation. Mr. Buettner has over 15 years of experience in the software industry holding quality assurance management and software test lead positions on software-intensive systems. In addition, he has been a repeat speaker at software testing conferences on advanced methods for testing algorithmically complex software. Mr. Buettner has a BS and a Masters Degree in Physics from Oregon State University where he did initial research of the hypervelocity intact capture phenomenon for the Jet Propulsion Laboratory. Mr. Buettner is an Aerospace Corporation Fellow currently working on a Ph.D. in Astronautical Engineering at the University of Southern California.

Course Description

This course provides the entire software testing process for software-intensive space systems in an interactive learning environment. The course begins with an overview of the key important aspects of systems engineering that feed software development. The variety of software development processes (for example waterfall, incremental, spiral and agile methods) will be discussed, where they are applicable to space systems development and how software testing is an integral part of each. Software testing terminology, philosophy, phases and best practices will be presented.

The second half of this course continues with a discussion of the revitalization of the software development and testing standards for space systems. The student will be involved in learning aspects of test problem solving techniques, anomaly handling, troubleshooting, the anatomy of a good bug report and what is it that the software engineer does to resolve that bug report in the first place.