Interdisciplinary Paper Session Abstracts

ID	Title	Author	Affiliation	E-Mail	Phone
TFAWS2011-IN-01	Quantification of Margins and Uncertainties for Model-Based Qualification of Flight System Performance	Lee Peterson	JPL	Lee.D.Peterson@jpl.nasa.gov	818-354-3346
TFAWS2011-IN-02	An Assessment of the Sandia Sierra Mechanics Simulation Suite for High Precision Spacecraft Thermal Models	Lee Peterson	JPL	Lee.D.Peterson@jpl.nasa.gov	818-354-3346
TFAWS2011-IN-03	Thermostructural Analysis of the SOFIA Fine Field & Wide Field Imagers Subjected to Convective Thermal Shock	Chris Kostyk	DFRC	Chris.B.Kostyk@nasa.gov	661-276-5443
TFAWS2011-IN-04	External Occulter Analysis and Design using the Cielo Finite Element Software	Mike Chainyk	JPL	mchainyk@jpl.nasa.gov	818-393-7555
TFAWS2011-IN-05	Wide-field Infrared Survey Explorer (WISE), Solid Hydrogen Cryogenic Support System	Brian Thomson	SDL	brian.thompson@sdl.usu.edu	435-713-3358
TFAWS2011-IN-06	Aerodynamic Analysis Including Moving Structures	Ted Wertheimer	MSC	Ted.Wertheimer@mscsoftware.com	408-962-4633
TFAWS2011-IN-07	Recent Advances in a Coupled Multiphysics Analysis Capability for Hypersonic Vehicle Structures	Scott Miskovish	ATA	scott.miskovish@ata-e.com	724-941-4672

Title: Quantification of Margins and Uncertainties for Model-Based Qualification of Flight System Performance

Author: Lee D. Peterson

Abstract:

Future flight systems are being considered that will operate under conditions that are difficult or impossible to adequately replicate on the ground. For systems like large microwave Earth science sensors, astrophysical telescopes, and planetary entry-descent-and-landing systems, flight performance certification will rely on test-validated models. Should this become practice, it would represent a substantial risk itself that could threaten the viability of such missions. This paper will discuss methods and practices that, when combined, hold the promise of establishing the risk of using models for flight qualification. Part of this is QMU (Quantification of Margins and Uncertainties), which is an analysis methodology that tries to estimate system performance margins and risks. QMU combines subsystem and component test data with hardware-realistic, multiphysics models within an uncertainty quantification framework centered on model verification and validation. In addition, certain practices are used that systematically analyze the QMU process itself, so as to establish its credibility and to present decision makers with a fair assessment of the results. This paper will provide an overview of QMU technology, and present an example that involves structural and thermal mechanics to illustrate the basic principles. It will also discuss implications of the QMU process for technology development and flight practice and planning.

back

Title: An Assessment of the Sandia Sierra Mechanics Simulation Suite for High Precision Spacecraft Thermal Models

Authors: Lee D. Peterson, Kevin Anderson, Eric Sunada, Robert Stephenson, Greg Agnes TBD from Sandia

Abstract:

The Sierra mechanics suite of codes were developed as part of the Department of Energy's need to certify the safety and readiness of the US nuclear weapon stockpile. These tools were developed with extraordinarily high resolution, model fidelity, and multiphysical realism so as to produce high fidelity simulations of complex systems with quantified uncertainties. While the tools were developed for a specific need, they are general purpose, including fluid, thermal, solid mechanics, shock and vibration capability. All these physics can be coupled inside a single simulation using direct mapping of mesh quantities from one domain to another. This paper will assess the Sierra thermal modeling capability for space applications, and discuss the implications of this capability for numerical mesh convergence, error estimation, and high resolution coupled thermal-structural response. While state-of-the-practice tools might be able to handle, for example, perhaps 50,000 radiation surfaces, with perhaps a few million non-zero viewfactors, and compute a steady-state response in a few days, we have demonstrated thermal models with Sierra that include 250,000 radiation surfaces, over a billion non-zero viewfactors, in about an hour on a modest (128 processor) computational cluster. Results such as these imply the Sierra codes provide both fast turnaround and convergent, high precision model resolution.

back

Title: Thermostructural Analysis of the SOFIA Fine Field & Wide Field Imagers Subjected to Convective Thermal Shock

Author: Chris Kostyk

Abstract:

The originally designed SOFIA aircraft configuration included a system to pre-cool the telescope cavity on the ground before flight, however, due to various factors in the history of the project that system was not installed. This lack of ground pre-cooling was thus the source of the concern over whether or not the imagers would be exposed to a potentially unsafe thermostructural environment when the telescope cavity door was opened at altitude. This concern was in addition to the already existing concern that the air temperature rate of change during flight (both at the same altitude as well as ascent or descent) could cause the imagers to be exposed to an unsafe thermostructural environment. Four optical components were identified as the components of concern – two of higher concern (one in each imager) and two of lower concern (one in each imager). The requirement was to perform transient, coupled thermostructural analyses to determine whether the stress would ever achieve unsafe levels in these components. The analysis effort began by analyzing one component, after which the analyses for the other components was deemed unnecessary.

back

Title: Designing External Occulters for Exoplanet Missions

Authors: Eric Cady, Mike Chainyk, Claus Hoff, Andy Kissel, and Greg Moore

Abstract:

Using existing instruments and technology, more than 800 distant suns have been identified. As this number continues to increase, the next level of investigation centers on identifying, with adequate precision, if there are planets of appropriate mass, proximity, and of an atmospheric composition to support life. Future proposed exoplanet missions attempt to resolve this question of whether planets reside within the habitable zone. A key challenge in the design of these instruments revolves around providing sufficient levels of contrast to enable detection of the planetary photons as well as their emission spectrum. In this presentation we describe the design of a space-based telescope using an external star shade to occult the light from the distant sun and enable planetary detection. The design process is centered on multidisciplinary analyses carried out using the Cielo finite element solution platform integrated with optical performance software developed within MATLAB. The single model design platform enables the computation of high fidelity resolution of optical performance metrics under conditions of repositioning, local star shade rotations, and perturbations in geometric design and materials selection.

back

Title: Wide-field Infrared Survey Explorer (WISE), Solid Hydrogen Cryogenic Support System

Authors: Brian Thompson, Scott Schick, Brett Lloyd

Abstract:

The Wide-Field Infrared Survey Explorer (WISE) is a JPL managed MIDEX mission to perform an infrared all-sky survey. The WISE instrument, developed by the Space Dynamics Laboratory (SDL), is a 40-cm cryogenically-cooled telescope which includes a cryogenic scan mirror and four infrared focal planes (2-HgCdTe, 2-SiAs). Cooling of the instrument to the desired temperatures is accomplished by a two-stage, solid hydrogen cryostat, provided by Lockheed Martin Advanced Technology Center (LMATC). Required temperatures for the instrument optics and SiAs focal planes are <13 K and < 7.6 K respectively. To extend the cryogen lifetime, the vacuum shell is isolated from the spacecraft via composite struts and radiatively cooled to <200 K. The telescope aperture is protected from on-orbit environmental loads via a two-stage radiatively cooled aperture shade. WISE was successfully launched into a 530 km, polar orbit on December 14, 2009, and completed its all sky survey in the infrared on July 17th of the following year. This paper provides an overview of the cryogenic subsystem and on-orbit thermal performance and modeling.

back

Title: Aerodynamic Analysis Including Moving Structures

Author: Ted Wertheimer, PhD

Abstract:

This paper presents the results using a recent particle based approach to solving computational fluid dynamics. A novel capability is the ability to simulate behavior where moving parts exist in the structure such as Rotating Blades in Helicopters, Flaps, and Landing Gear Deployment. Examples will be presented in this area highlighting this new procedure. The Lattice Boltzmann method is used to solve the equations of fluid mechanics. This procedure is applicable to subsonic, hypersonic and supersonic domains. The statistical distribution functions arising from the boundaries are updated at each time step to account for the moving boundaries. The boundary layer effect of these moving boundaries is also accounted for. The computational procedure uses a particle-based Lagrangian method which does not require the generation of a traditional mesh, which greatly reduces the preparation time. A cell based grid is still required to control the accuracy of the solution. The Wall-Adapting Local Eddy viscosity method is used to capture the turbulence modeling.

back

Title: Recent Advances in a Coupled Multiphysics Analysis Capability for Hypersonic Vehicle Structures

Authors: *R. S. Miskovish, E. L. Blades, E. A. Luke, M. Nucci and P. Shah*

Abstract:

The United States Air Force has identified multiphysics coupled analysis capability as an enabling technology to the design of future high-speed vehicles that must withstand extreme aero-thermal and aeroacoustic environments. Such hypersonic vehicles are subjected to extreme combined environments that may require a multiphysics solution to accurately characterize the structural response. The expected benefit of such a tool is a more accurate response prediction of the aerothermoelastic phenomena of panel hot spots, snap-through, and/or flutter, to enable designs that do not carry a weight penalty due to overspecification of thermal protection systems.Previous work by ATA Engineering, Inc. (ATA) and Mississippi State University (MSU) [Blades 2010] focused on the phenomena of thermal buckling, panel snap-through, and/or flutter. This work demonstrated that small panel deformations can generate significant local hot spots in hypersonic environments, and that snap-through may be generated for representative vehicle panels under sufficiently elevated fluctuating pressure loads. This previous work also demonstrates a need for full thermalstructural-aerodynamic simulation capability. In response to this need, ATA and MSU are currently developing a coupled multiphysics analysis tool for application to hypersonic vehicle structures. This tool combines the CFD capabilities of the MSU Loci-CHEM open-source computational fluid dynamics (CFD) code with the non-linear structural and thermalcapabilities of Abaqus through the recently released SIMULIA Co-simulation interface. A high-level discussion of the coupling framework, recent results from coupled, quasi-static aerothermoelastic panel simulations, and near-future enhancements are presented.

back