Passive Thermal Paper Session Abstracts

Passive Thermal Session #1
Chairs: Stephen Miller, Chris Kostyk

ID	Title	Author	Affiliation	Email
TFAWS2011-PT-001	A Projection-Based Model Order Reduction Simulation Tool for Spacecraft Thermal Analysis	Wang, Yi, et al	CFDRC	yxw@cfdrc.com
TFAWS2011-PT-002	Development of Space Vehicle Environments	Jalali, Siraj	Oceaneering	sjalali@oceaneering.com
TFAWS2011-PT-003	Thermal Response of Materials To A High Energy Radiation Heat Source	Carroll, Matthew	Texas A&M	carrollm@tamug.edu
TFAWS2011-PT-004	MMS Thermal Design Life Cycle	Zara, Rommel	Vertex/GS	rommel.n.zara@nasa.gov
TFAWS2011-PT-005	A Passive Thermal Analysis of a Small Satellite	Hurlburt, Wyatt	UA Fairbanks	wwhurlbut@alaska.edu
TFAWS2011-PT-006	Improvements to a Response Surface Thermal Model for Orion	Miller, Stephen	JSC/LaRC	stephen.w.miller@nasa.gov

Passive Thermal Session #2
Chairs: Stephen Miller, Chris Kostyk

ID	Title	Author	Affiliation	Email
TFAWS2011-PT-007	Statistical Analysis of Thermal Analysis Margin	Garrison, Matt	GSFC	Matthew.B.Garrison@nasa.gov
TFAWS2011-PT-008	FASTSAT Thermal Model Correlation	McKelvey, Callie & Ken Kittredge	MSFC	callie.s.mckelvey@nasa.gov ken.kittredge@nasa.gov
TFAWS2011-PT-009	Thermal testing and correlation of an instrument thermal simulator in the NASA Solar Furnace Facility	Smith, Kelly	SWRI	KDSmith@swri.edu
TFAWS2011-PT-010	Pressure Controlled Heat Pipes	Anderson, Bill, et al	ACT, Inc.	Bill.Anderson@1-act.com
TFAWS2011-PT-011	Variable Conductance Heat Pipe for a Lunar Variable Thermal Link	Peters, Chris, et al	ACT, Inc.	Chris.Peters@1-act.com
TFAWS2011-PT-012	Loop Heat Pipe with Thermal control Valve for Variable Thermal Conductance	Harenstine, John, et al	ACT, Inc.	John.Hartenstine@1-act.com

Passive Thermal Session #3
Chairs: Stephen Miller, Chris Kostyk

ID	Title	Author	Affiliation	Email
TFAWS2011-PT-013	Analytical Approach in DECOM	Patel, Deepak	GSFC	deepak.patel@nasa.gov
TFAWS2011-PT-014	DECOM Validation	Patel, Deepak	GSFC	deepak.patel@nasa.gov
TFAWS2011-PT-015	Autonomous Aerobraking Demonstration Using 2001 Mars Odyssey Data	Tobin, Steven	NCSU	satobin@ncsu.edu
TFAWS2011-PT-016	Thermal Analysis Workflow in Support to TPS Seams and Interface Design of Re-Entry Vehicles	Andrioli, Lorenzo	Alenia	lorenzo.andrioli@thalesaleniaspace.com
TFAWS2011-PT-017	International Space Station Passive Thermal Control System Analysis – Top Ten Lessons-Learned	Lovine, John	JSC	john.iovine-1@nasa.gov
TFAWS2011-PT-019	Benchmarking of NX Space Systems Thermal (TMG) for use in Determining Specular Radiant Flux Distributions	Poplawsky, Carl	Maya	carl.poplawsky@mayasim.com

Title: A Projection-Based Model Order Reduction Simulation Tool For Spacecraft Thermal Analysis

Author: Yi Wang, Hongjun Song, Kapil Pant, Hume Peabody, Jentung Ku, Charles D. Butler

Abstract:

Trends in recent years have been towards larger thermal models and have therefore placed additional computational demands on the thermal engineer. Attempts to verify designs by modeling and analysis rather than testing only further this burden. A research effort, awarded to CFD Research Corporation to investigate Model Order Reduction (MOR) techniques, led to the development of a mathematically rigorous algorithm and framework to automatically generate reduced thermal models for computation by fast, efficient Ordinary-Differential Equation/Differential-Algebraic Equation (ODE/DAE) solvers. The underlying principle of the MOR tool is to approximate a dynamic system response through projection onto the low-dimensional sub-space that is constructed by a combination of characteristic orthonormal basis vectors of the system. A testbed model consisting of constant sources, capacitances, and conductances and roughly 3000 nodes was used to evaluate a Trajectory Piecewise Linear Model Order Reduction (TPWLMOR) algorithm. A sinusoidal input disturbance was applied to the model to induce a thermal response beyond steady state. The full-scale model was reduced to a low-dimensional model with 64 nodes by the TPWLMOR algorithm, which was then computed by the ODE/DAE solver. The overall MATLAB solution of the reduced model took about 1 second compared to 300 seconds for the full-scale solution. A comparison of the two runs showed excellent agreement with the maximum absolute nodal temperature error spanning from -2.8°C to 2.9 °C (most between -1 °C and 1 °C) and the average relative error of less than 0.5%. While some computational expense is incurred to generate the reduced model, typical thermal models include many conductance and capacitance terms that are constant, thereby enabling the reusability of the reduced model and resulting in significant time savings for transient simulation and analysis. Having demonstrated the potential benefits to this approach, the next steps are to develop parameterized reduced thermal models to better address the model variations, optimize the MOR algorithm and implementation, and to incorporate this into standard NASA tools. A follow-on research effort has been awarded by NASA/GSFC to continue this development effort.

home

Title: Development of Space Vehicle Environments
Author: Siraj Jilali
Abstract:

Spacecrafts are exposed to various environments that are not present at the surface of the earth, like plasmas, neutral gases, x-rays, ultraviolet (UV) irradiation, high energy charged particles, meteoroids, and orbital debris. The interaction of these environments with spacecraft cause degradation of materials, contamination, spacecraft glow, charging, thermal changes, excitation, radiation damage, and induced background interference. The damaging effects of natural space and atmospheric environments pose difficult challenges for spacecraft designers. ISS and Orbiter thermal models were used to develop the program to determine the environments around the ISS/Orbiter. This method can be applied for any space vehicle orbiting any planet.

To determine the thermal environments around the ISS small 1 cubic foot cubes were placed 1 foot from top of the surfaces where thermal environments were needed. The ISS was placed in an orbit around the Earth with required beta, attitudes, and altitude. The applicable solar, Albedo, and IR fluxes were applied on the model depending upon summer or winter solstice. Model was analyzed in a thermal tool such that absorbed solar fluxes and surface temperatures of all cube surfaces were obtained. A routine was developed to calculate Infrared fluxes for all cube surfaces using cube absorbed solar fluxes and surface temperatures. Once solar and infrared fluxes were determined at cube locations the sink temperatures for any applicable optical properties of tools or crewmember suit materials were determined using those cube fluxes. The sink temperatures at cube locations for any tools or space suit are extreme temperatures those components will be exposed to at that location.

The cube flux method have been developed previously also, but the method presented here is efficient and simpler since the space vehicle model and flux generation routine (FLXGEN) are run from Thermal Desktop® in a single run, and Solar and IR fluxes for all cube locations are generated. The sink temperatures generation for required materials using Solar and IR fluxes can be included in the routine also.

home

Title: Thermal Response of Materials To A High Energy Radiation Heat Source

Author: Dr. Matthew C. Carroll

Abstract:

The calculation of temperature profiles in metals and other materials subjected to a high energy radiation heat source presents challenges because the radiation cannot be modeled as a surface heating condition. High energy particles penetrate the material surface and are attenuated; the energy deposition resulting from a particle flux at a given particle energy is therefore more accurately modeled as an exponential heat generation term within the material itself. In many cases the radiation is spectrally distributed, so multiple decaying exponential terms may be required to adequately describe the heat generation because of the energy-dependence of the material attenuation coefficients.

Analytical solutions for temperature profiles resulting from such heat generation terms is quite straightforward for a plane wall, but in cylindrical and spherical geometries numerical solutions are generally used because the radial spreading terms in the governing equations prevent a closed form solution by integration. It is possible, however, to develop analytical series solutions for cylindrical concave, cylindrical convex, spherical concave, and spherical convex geometries, and in this paper the author develops these solutions and investigates their viability as compared to standard finite difference methods in estimating these temperature profiles.

The methods developed in this paper are then applied to a sample problem whereby it is seen that accurate solutions can be obtained; the optimality of these methods as opposed to finite difference methods would ultimately be determined by a variety of factors, such as complexity of geometry and the number of materials involved.

home

Title: MMS Thermal Design Life Cycle

Author: Rommel Zara

Abstract:

The Magnetoshperic MultiScale (MMS) mission thermal environment includes a highly elliptical survival orbit with long eclipses up to 4 hours long. Comparatively, typical LEO and GEO missions have eclipses of no longer than 1.5 hours. These long eclipses create a problem for the thermal subsystem because not only do the temperatures drop in eclipse, but any heater power needed to maintain temperature requirements is limited by the capacity of the spacecraft battery. Thus, a passive solution was required to minimize heater power consumption and maintain positive energy balance.

One of the MMS solutions to this problem is a gold plated thermal coating on the thrust tube and separation rings. The gold plated coating has a high alpha-to-epsilon ratio that provides passive heating in sunlight while minimizing radiative heat losses in eclipse. Worst case thermal analyses performed shows that implementing the gold plated coating into the design can reduce the heater power demands significantly and meet the energy balance requirements of the MMS mission.

This paper describes the MMS thermal design, thermal analysis, energy balance and development tests related to the gold plated coating of the MMS thrust tube and separation rings. MMS is currently in the flight build phase and is scheduled to launch in August of 2014.

home

Title: A Passive Thermal Analysis of a Small Satellite

Author: Wyatt Hurlburt

Abstract:

This paper describes a developing work on a passive thermal analysis for a small satellite at the University of Alaska Fairbanks. Many universities are following a trend to develop small satellites known as CubeSats. Basic restrictions for these CubeSats are 1 kg, and a 10 cm cube. Two major thermal issues exist: physical limitations make passive thermal systems difficult to tailor to the specific orbit anticipated, and active thermal systems require a significant portion of the energy budget which make them impractical. A passive thermal analysis is necessary to ensure that the satellite remains functional for the lifetime of the satellite.

This three dimensional thermal analysis being developed using COMSOL software will address the basic energy balance, will provide a detailed thermal model for future CubeSat teams, and will be relevant to NASA and future launch providers by demonstrating that secondary payloads do not adversely affect the primary payload of a launch vehicle.

Comparing this thermal profile to existing thermal data will show that this will be representative of actual CubeSat characteristics. These results will answer questions such as: (1) what are the expected thermal characteristics of a CubeSat in orbit. (2) What environmental variables influence CubeSat heat management strategies? (3) What need heat management strategies are necessary?

home

Title: Improvements to a Response Surface Thermal Model for Orion
Author: Stephen Miller
Abstract:

A study was performed to determine if a Design of Experiments (DOE)/Response Surface Methodology could be applied to on-orbit thermal analysis and produce a set of Response Surface Equations (RSE) that predicted vehicle temperatures within ±10 °F. The study used the Orion Outer mold line model. Five separate factors were identified for study: yaw, pitch, roll, beta angle, and the environmental parameters. Twenty-three external Orion components were selected and their minimum and maximum temperatures captured over a period of two orbits. Thus, there are 46 responses. A DOE case matrix of 145 runs was developed. The data from these cases were analyzed to produce a fifth order RSE for each of the temperature responses. For the 145 cases in the DOE matrix, the agreement between the engineering data and the RSE predictions was encouraging with 40 of the 46 RSEs predicting temperatures within the goal band. However, the verification cases showed most responses did not meet the ±10 °F goal. After reframing the question to better align the RSE development with the purposes of the model, a set of RSEs for both the minimum and maximum radiator temperatures was produced which predicted the engineering model output within ±4 °F. Therefore, with the correct application of the DOE/RSE methodology, RSEs can be developed that provide analysts a fast and easy way to screen large numbers of environments and assess proposed changes to the RSE factors.

home

Title: Statistical Analysis of Thermal Analysis Margin
Author: Matt Garrison
Abstract:

Institutional rules at the NASA Goddard Space Flight Center require a minimum of 5C thermal analysis margin before launch for all passively-controlled components. This paper looks at pre-launch temperature predictions for 7 missions over the past decade and compares them with the temperatures seen on orbit. Actual temperatures were gathered over a period of time to construct a function giving the probability that the temperature will exceed the bounding predictions, allowing the margin to be assessed at various confidence levels. These are then grouped by component type and mission thermal environment to look for trends. A new philosophy for thermal analysis margin is then presented that reflects the experience with recent missions.

home

Title: FASTSAT Thermal Model Correlation

Author: Callie McKelvey, Ken Kittredge

Abstract:

This paper summarizes the thermal math model correlation effort for the Fast Affordable Science and Technology SATellite (FASTSAT-HSV01), which was designed, built and tested by NASA's Marshall Space Flight Center (MSFC) and multiple partners. The satellite launched in November 2010 on a Minotaur IV rocket from the Kodiak Launch Complex in Kodiak, Alaska. It carried three Earth science experiments and two technology demonstrations into a low Earth circular orbit with an inclination of 72° and an altitude of 650 kilometers. The mission has been successful to date with science experiment activities still taking place daily. The thermal control system on this spacecraft was a passive design relying on thermo-optical properties and six heaters placed on specific components. Flight temperature data is being recorded every minute from the 48 Resistance Temperature Devices (RTDs) onboard the satellite structure and many of its avionics boxes. An effort has been made to correlate the thermal math model to the flight temperature data using Cullimore and Ring's Thermal Desktop and by obtaining Earth and Sun vector data from the Attitude Control System (ACS) team to create an "as-flown" orbit. Several model parameters were studied during this task to understand the spacecraft's sensitivity to these changes. Many "lessons learned" have been noted from this activity that will be directly applicable to future small satellite programs.

home

Title: Thermal Testing and Correlation of an Instrumnet Thermal Simulator in the NASA Solar Furnace Facility
Author: Kelly Smith
Abstract:

BepiColombo is a joint mission of the European Space Agency and the Japanese Aerospace Exploration Agency, to visit Mercury. The mission consists of two primary spacecraft that will travel to the planet together, the Mercury Planetary Orbiter (MPO) and the Mercury Magnetospheric Orbiter (MMO). Upon arrival, they spacecraft will separate and enter two distinct orbits. The MPO spacecraft will enter into a 3-axis stabilized, Nadir orbit of 400 x 1508 km. MPO will include a full suite of imaging and particle detection instruments, of which, Southwest Research Institute (SwRI) is providing the Strofio instrument. Strofio complements the Serena instrument suite and is a high sensitivity, moderate resolution neutral mass spectrometer. Strofio will analyze Mercury's exospheric gas composition and is the single NASA hardware contribution to the BepiColombo mission. Strofio utilizes an external collimator and ionizing element assembly ("source") that focuses and feeds particles to an internal reflectron. The source is fully exposed to the Mercury environment at the MPO orbit, where temperatures of the hardware are expected to reach more than 300°C. Given this extreme thermal environment, the source poses significant engineering challenges to manage the heat from both the perspective of the instrument and the spacecraft. The instrument must not only survive in this environment, but also not adversely affect the performance of MPO by allowing too much heat transfer into or out of the protective shell of the spacecraft. A passive thermal design for the instrument has been baselined. This has been accomplished through extensive engineering efforts in material selection, hardware design and coating selection. Supporting this engineering effort is detailed thermal modeling and testing of prototype hardware. Finding facilities capable of simulating the Mercury environment is somewhat challenging. One such facility is the NASA Marshall Space Flight Center (MSFC) Solar Furnace Facility. The facility is capable of delivering nearly 10,000 watts of solar energy focused on an eleven centimeter focal plane within a vacuum chamber. Originally designed to perform engine testing, the team at MSFC modified the facility to more accurately simulate the Mercury thermal environment for testing the Strofio structural thermal model. Discussions of the chamber modifications, test setup, results of the testing and thermal model correlation are presented.

home

Title: Pressure Controlled Heat Pipes
Author: William G. Anderson, John R. Hartenstine, David B. Sarraf, Kara L. Walker
Abstract:

In a Variable Conductance Heat Pipe (VCHP), a Non-Condensable Gas (NCG) is added to the heat pipe to allow the conductance to vary. A Pressure Controlled Heat Pipe (PCHP) is a VCHP variant, where the heat pipe operation is controlled by varying either the gas quantity or the volume of the gas reservoir. This presentation discusses two applications for PCHPs: 1. Precise Temperature Control, and (2) Switching thermal power between multiple sinks. A prototype aluminum/ammonia PCHP was built and tested to demonstrate the capability of controlling the evaporator section of an aluminum/ammonia pressure controlled heat pipe to milli-Kelvin levels over an extended period of time. The external (simulated radiator or heat sink) temperature was varied and the heat input into the evaporator section was varied during those tests. Temperature set point changes were also demonstrated. PCHPs can also be used to switch power between multiple high temperature reactors. In a second program, a heat pipe solar receiver was designed to accept, isothermalize and transfer the solar thermal energy to reactors for oxygen production from lunar regolith. The receiver has two PCHPs and two CCHPs to supply heat to two reactors. During operation, one reactor is producing hydrogen at low solar power, while the other reactor is warming up a fresh batch of regolith. The PCHPs switch power between the two reactors as required.

home

Title: Variable Conductance Heat Pipe for a Lunar Variable Thermal Link
Author: Christopher J. Peters, John R. Hartenstine, Calin Tarau, William G. Anderson
Abstract:

The Anchor Node Mission for the International Lunar Network (ILN) has a Warm Electronics Box (WEB) and a battery, both of which must be maintained in a fairly narrow temperature range using a variable thermal conductance link. During the lunar day, heat must be transferred from the WEB to a radiator as efficiently as possible. During the night, heat transfer from the WEB must be minimized to keep the electronics and batteries warm with minimal power, even with a very low (100 K) heat sink. Three different variable thermal links were identified that could perform this function: 1. A mini-loop heat pipe (LHP), 2. A mini-LHP with a thermal control valve, or 3. A Variable Conductance Heat Pipe (VCHP) with a hybrid wick. The mini-LHP has the highest Technology Readiness Level (TRL), but requires electrical power to shut-down during the 14-day lunar night, with a significant penalty in battery mass. The VCHP incorporates three novel features in order to achieve the design targets of the ILN program. The first is a hybrid wick, which allows the VCHP to operate with an adverse tilt in the evaporator. The second is locating the reservoir near the evaporator, rather than near the condenser, to prevent the reservoir temperature from dropping during the lunar night. Third, a bimetallic adiabatic section is used to minimize heat losses due to conduction when the VCHP is shut down. Testing included 1. Freeze/thaw, 2. Simulated Lunar performance, with an adverse evaporator elevation, 3. Performance with a 2.54 mm (0.1 inch) adverse elevation, both for normal operation, and to demonstrate diode behavior when the condenser was heated. All of the tests were successful; however, the power with the heat pipe level was slightly lower than expected, probably due to problems with the hybrid wick interface.

home

Title: Loop Heat Pipe with Thermal Control Valve for Variable Thermal Conductance
Author: John R. Hartenstine, Kara L. Walker, William G. Anderson
Abstract:

It is often desirable to partially or completely shut down a Loop Heat Pipe (LHP), for example, to maintain the temperature of electronics connected to the LHP on a satellite during an eclipse. The standard way to control the LHP is to apply electric power to heat the compensation chamber, as required. The amount of electrical power to shut down an LHP during an eclipse on orbit is generally reasonable. On the other hand, for LHPs on Lunar and Martian Landers and Rovers, the electrical power requirements can be excessive. For example, the Anchor Node Mission for the International Lunar Network (ILN) has a Warm Electronics Box (WEB) and a battery, both of which must be maintained in a fairly narrow temperature range using a variable thermal conductance link. During the Lunar day, heat must be transferred from the WEB to a radiator as efficiently as possible. During the night, heat transfer from the WEB must be minimized to keep the electronics and batteries warm with minimal power, even with a very low (100 K) heat sink. A mini-LHP has the highest Technology Readiness Level, but requires electrical power to shut-down during the 14-day Lunar night, with a significant penalty in battery mass: 1 watt of electrical power translates into 5kg of battery mass. A mini-LHP with a Thermal Control Valve (TCV) was developed to shut down without electrical power. An aluminum/ammonia LHP which included a TCV in the vapor exit line from the evaporator was designed, fabricated and tested. The TCV could route vapor to the condenser, or bypass the condenser and route back to the compensation chamber, depending upon the temperature conditions. During test, the LHP condenser was decreased to -60ºC and the power input was decreased to near zero power: the evaporator remained above 0ºC.

home

Title: Analytical Approach in DECOM

Author: Deepak Patel

Abstract:

This paper discusses the Modeling method of a condenser through a simplified approach. The DECOM (Deepak Condenser Model) method utilizes user set initial parameters in-order to calculate the fluid to wall heat transfer value as well as fluid temperatures. Equations are derived for two sections of the condenser, a Two-Phase section and a Subcooled (Liquid) section. All Equations are based upon the Conservation of Energy Theory, from which temperature, and quality values are solved. In order to solve for the heat transfer value, between fluid and wall in two phase section, Lockhart-Martinelli correlation method was incorporated. For Liquid phase, the Reynolds number was used in-order to differentiate the flow state, either Turbulent or Laminar, and Nusselt to solve for the film coefficient. A flow chart is presented in order to display the execution process of DECOM. DECOM will solve for the Fluid Temperature and Heat Transfer Value between Fluid and Wall. DECOM integration into ATLAS instrument model will be discussed in order to understand the limitations and method of integration of DECOM.

home

Title: DECOM Validation

Author: Deepak Patel

Abstract:

DECOM method was validated against test Data from GLAS (GeoScience Laser Altimeter System). The success of this method is illustrated by the results after correlation to the test data. The modeling of the condenser, mocking the GLAS LHP Condenser, its limitations and problems encountered are also discussed in the paper. Results show the differences between model and test setup, also explains the probable cause for the differences, and the final results after including the percent error into the model. Substantial effort has been made in listing the possibilities to further develop DECOM, thus to make it more reliable, user-friendly, and better integration with generic SINDA models.

home

Title: Autonomous Aerobraking Demonstration Using 2001 Mars Odyssey Data
Author: Steven A. Tobin
Abstract:

Aerobraking is a technique used to place a vehicle in orbit around any planet with an atmosphere. It has been shown to significantly decrease the propellant used to achieve a science orbit and permits the use of a smaller and less costly launch vehicle. Operational aerobraking methods currently rely on maximum free stream heat flux for mission control to maintain the spacecraft within its temperature and mission timeline constraints. Major disadvantages of this method include the operational costs and risks involved with the thermal loading of the solar array, the most thermally vulnerable component of the spacecraft. Aerobraking leads to significant operational costs incurred due to personnel time in planning the necessary maneuvers to prevent overheating of the solar array. Both the cost and the risk can be reduced by developing and implementing a method that automates the aerobraking operations phase.

The proposed autonomous aerobraking (AAB) method is based directly on solar array maximum temperature. An AAB control algorithm must predict the maximum temperature of the solar array during the next drag pass. Based on the temperature prediction and the associated uncertainties the algorithm prescribes propulsive maneuvers at apoapsis that maintain the spacecraft within specified temperature limits throughout the following drag pass. Temperature predictions can be made by a thermal response surface which is based on a high fidelity finite element thermal model of the spacecraft.

The effectiveness of the AAB control algorithm will be evaluated by applying it to Mars Odyssey's aerobraking phase. The results of the algorithm are correlated to thermocouple and Mars atmospheric density data as Mars Odyssey's aerobraking phase is reconstructed. The correlation will allow for the refinement of the thermal response surface and the thermal model. Figure 1 shows the flow of data from the thermal model inputs to the AAB control algorithm. This paper describes the development of the Mars Odyssey aerobraking phase thermal model and how it is utilized in the thermal response surface. Details are also given on the construction of the thermal response surface and how the results will be correlated with Mars Odyssey mission data.

home

Title: Thermal Analysis Workflow In Support to TPS Seals and Interface Design of Re-Entry Vehicles

Author: Lorenzo Andrioli, S. De Palo, M. Antonacci

Abstract:

The thermal analysis methodological approach defined and implemented in the frame of the design of interfaces among different-type of Thermal Protection Systems and between Thermal Protection Systems and several subsystems of the ESA IXV re-entry vehicle is presented.
The Intermediate eXperimental Vehicle (IXV) is an atmospheric re-entry demonstrator to be launched by the ESA/Vega from the Centre Spatial Guyanais (CSG), which will perform a suborbital flight and will re-enter in the atmosphere experiencing the typical Low Earth Orbit re-entry thermal loads.

A comprehensive evaluation of the effects to which Thermal Protection System shall locally withstand has been performed. Moreover the presence of several different materials and items (composites, bulk metal items, textile/foam insulation and ablative material, textile parachute bridles, transmission devices and connectors) usually combined into a unique interface configuration constituted a challenging task.

To fulfil the relevant requirements a proper engineering workflow has been developed and implemented. The procedure is designed aiming to the maximum integration of the involved disciplines (thermal protection, thermal control, thermo-elastic behaviour). The iterative process actually provides a set of analyses aiming to a balanced evaluation of sealing items sizing in terms of geometry and suitable material. Particular attention has been devoted to an efficient interaction among the design chain constituents, reducing development times and iterations between different disciplines while minimizing and improving data exchange cycles among different analysis tools.

The implemented workflow played a key role into the evaluation of sneak flow impingement on sensitive items, thermal hot spots identification, and thermo-mechanical deformations to be implemented in system level vehicle models of the relevant disciplines.

home

Title: International Space Station Passive Thermal Control System Analysis, Top Ten Lessons-Learned

Author: John Iovine

Abstract:

The International Space Station (ISS) has been on-orbit for over 10 years, and there have been numerous technical challenges along the way from design to assembly to on-orbit anomalies and repairs. The Passive Thermal Control System (PTCS) management team has been a key player in successfully dealing with these challenges. The PTCS team performs thermal analysis in support of design and verification, launch and assembly constraints, integration, sustaining engineering, failure response, and model validation. This analysis is a significant body of work and provides a unique oppportinuty to compile a wealth of real world engineering and analysis knowledge and the corresponding lessons-learned. The analysis lessons encompass the full life cycle of flight hardware from design to on-orbit performance and sustaining engineering. These lessons can provide significant insight for new projects and programs. Key areas to be presented include thermal model fidelity, verification methods, analysis uncertainty, and operations support.

home

Title: Benchmarking of NX Space Systems Thermal (TMG) for use in Determining Specular Radiant Flux Distributions

Author: C. Poplawsky, C. Jackson, C. Blake

Abstract:

NX Space Systems Thermal (formerly TMG) offers two computer-based ray tracing approaches for predicting specular radiant flux distributions; they are Deterministic and Monte Carlo. Benchmarking has been conducted on some common reflective geometries using both approaches, to compare resulting radiant flux values against those determined using classical ray tracing techniques. Results suggest that both the Deterministic and Monte Carlo approaches provide acceptable reliability when compared against classical ray tracing techniques, and recent parallelizing of both methods provides significant run time improvements.

Mr. Poplawsky and Mr. Blake are both senior applications engineers for Maya Simulation Technologies. Dr. Jackson is a senior software developer for Maya Heat Transfer Ltd. Maya is a software development partner and reseller for Siemens PLM Software.

home