National Aeronautics and Space Administration

2005 ANNUAL REPORT

NASA Engineering & Safety Center

NESC strives to set the example for engineering and technical excellence in NASA.

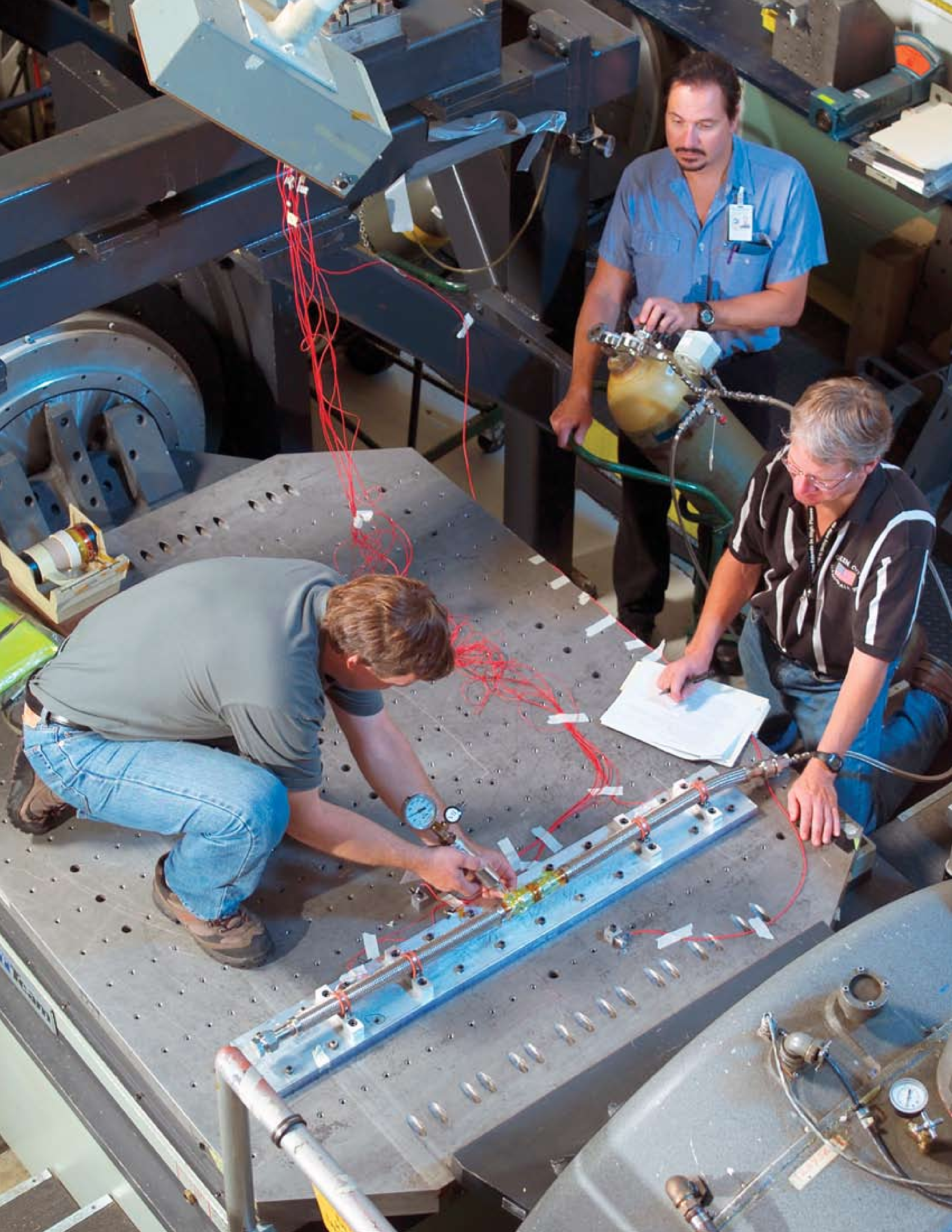

United States
NASA

FROM THE ADMINISTRATOR

Through its dedicated team of technical experts and its commitment to safety, NASA's Engineering and Safety Center (NESC) has set an example of engineering excellence within the Agency. By leveraging the technical expertise resident at our Centers, and by encouraging diverse perspectives, NESC has demonstrated its ability to provide independent technical assessment of issues for NASA's high-risk endeavors. In particular, NESC played a pivotal role in the Space Shuttle's return to flight, as well as provided significant contributions to numerous other critical NASA projects.

– Michael Griffin, Administrator,
National Aeronautics and Space Administration

Opposite Page: The Space Shuttle Program returns to flight on July 26, 2005 with STS-114



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Cover Page: Dr. Rebecca MacKay, Senior Materials Scientist of the Materials and Structures Division at Glenn Research Center, examines an Orbiter Reaction Control System Thruster for cracks in the Electron Optics Laboratory

Opposite Page: Laboratory Technicians (clockwise from left) Richard Czernec, Robert Butler and Bruce Frankenfield, prepare an International Space Station AN fitting for Leak Testing at the Structural Dynamics Laboratory, Glenn Research Center

CHRISTOPHER J. SCOLESE
NASA Chief Engineer

In the second year of NESC's operations, discipline experts from within and outside of the Agency were brought to bear on many significant engineering challenges. NESC's network of over 500 experts became operational and fully respected for its in-depth analysis and recommendations for engineering improvements. The safety risks of the Shuttle flight 114 were better understood through the efforts of these highly experienced engineers and scientists. At the same time, the NESC Academy was launched with the charter to transfer expert knowledge to younger engineers both within and outside of the Agency. This establishes another standard of engineering excellence for NESC and will contribute to Agency Engineering Excellence for the future.

BRYAN D. O'CONNOR
NASA Chief Safety and Mission Assurance Officer

NESC's second year was even more dramatic and noteworthy than its first. As the Agency went through the many boards and certification reviews in the return-to-flight effort, NESC provided key input to enable Shuttle program managers to better understand technical concerns and questions that had to be answered in the path to return to flight. I personally asked NESC to help me understand several safety questions I had before I was able to concur in our readiness to launch STS-114. I also asked NESC for special assessments of other flight activities for robotic spacecraft and independent assessments of risk management models. The successful mission of STS-114 and the successful year that NASA had in its space and aeronautic research activities were certainly in no small part due to the hard work and dedication of the members of NESC. NESC has truly met its charter to provide engineering and safety excellence to support NASA's missions.

Opposite Page: Full view of International Space Station from Discovery (STS-114) after undocking; background area shows part of the Caspian


Discovery

RALPH R. ROE, JR.
DIRECTOR, NASA Engineering and Safety Center

In October of this year, the NASA Engineering and Safety Center (NESC) initiated its 100th technical assessment. This significant milestone has demonstrated NESC's continuing ability to make a valuable contribution to the Agency. During our first two years of operation, NESC has built a strong technical team and solid processes that allow the organization to effectively provide the Agency with a critical resource. By drawing upon the technical expertise at the Centers and bringing them together with program personnel, NESC has been able to provide program managers with more robust solutions and the data needed to make more informed decisions.

The prime focus of NESC's activities during this year has been on the Space Shuttle's return to flight. NESC was engaged in many areas during the preparations for STS-114, including human factor considerations for External Tank foam application, peer review of the debris transport math models, and a review of the flight rationale used by the Shuttle program. In addition, NESC also performed technical assessments for all of NASA's Mission Directorates and provided expert support for external organizations, such as the U.S. Navy. We have highlighted a number of these activities in this Annual Report.

One accomplishment this year that I am very proud of is the creation of the NESC Academy. Our discipline experts represent literally hundreds of years of experience. The purpose of the NESC Academy is to pass along this wealth of information and insight to our younger engineers. By the end of the year, we will have successfully completed three pilot courses in Space Life Support Systems, Space Propulsion Systems, and Power & Avionics. Additional courses in other discipline areas will be offered throughout the coming year.

When NESC was created more than two years ago, it was chartered with the ambitious task to fill a technical void within the Agency. I can proudly say that the men and women of NESC have stepped up to meet this challenge and have demonstrated the true meaning of engineering excellence. We have begun to transition our staff back to leadership positions at the Centers. They bring back a broader perspective that will benefit their new organizations. In addition, the new technical talent within NESC ensures that we maintain a fresh and unbiased perspective.

During our third year of operation, NESC will begin to shift its focus to providing technical expertise and independent assessments for Exploration Systems. We will continue to share our knowledge across the Agency and work with senior leadership to implement the broadly applicable lessons learned discovered during the course of our activities. As NESC expands into new areas, we will remain committed to the premise on which we were founded – engineering excellence.

Opposite Page: Discovery (STS-114) photographed from the International Space Station during rendezvous and docking operation

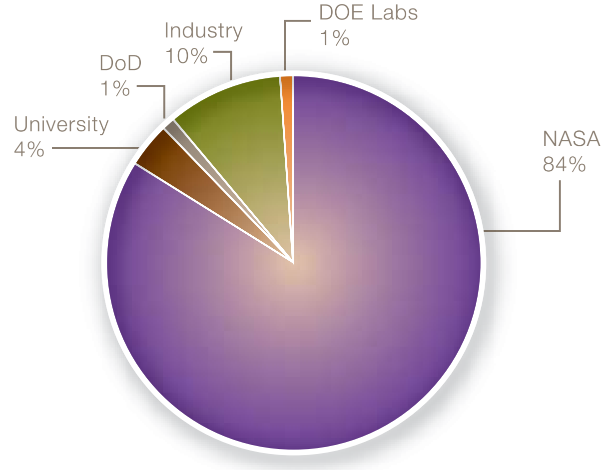
NESC IN 2005

Our mission is to perform value-added independent testing, analysis, and assessments of NASA's high-risk projects to ensure safety and mission success. We engage proactively to help NASA avoid future problems.

NESC is an independently funded NASA program with a dedicated team of technical experts that provides objective engineering and safety assessments of critical, high-risk projects. Its strength is rooted in the diverse perspectives and broad knowledge base that it draws upon to add value to NESC products, affording customers a responsive, alternate path for assessing and preventing technical problems while protecting vital human and national resources.

NESC's charter is founded on one essential principle – engineering excellence. Balanced with an independent and objective reporting structure, NESC represents a truly unique, valuable technical resource.

2005 NESC Super Problem Resolution Teams Composition



Engineering Excellence

NESC's organizational model is founded on a knowledge base of technical expertise derived from within all NASA Centers and among a group of partner organizations external to the Agency. For each technical assessment that is conducted, NESC accesses a ready group of engineering experts – called Super Problem Resolution Teams (SPRTs) – from 15 discipline areas. These teams, which are led by NESC Discipline Experts, work together to ensure that the highest standard of engineering excellence is achieved. In 2005, NESC's SPRTs consisted of NASA representatives, industry consultants, academia, and experts from other government agencies.

By drawing from the minds of leading engineers across the country, NESC consistently optimizes its processes, deepens its knowledge base, strengthens its technical capabilities, and broadens its perspectives, thereby further executing its commitment to engineering excellence.

Opposite Page: "Baggie Type" Helium Leak Test of AN Fittings performed by Brian Hurd, Structural Dynamics Laboratory Technician, Glenn Research Center

Independence & Objectivity

NESC performs technical assessments and provides recommendations based on independent testing and analysis, not subjective opinion. Independently funded through the Office of the Chief Engineer, NESC offers NASA Centers, programs, and other organizations an alternate reporting path through which objective assessments are conducted and alternative viewpoints are encouraged. A rigorous peer review process furthers NESC's commitment to achieving the highest possible safety standards.

A Unique Resource

NESC is a strong, Agency-wide technical resource that offers a forum for reporting technical issues and contributing alternative viewpoints for high-risk NASA programs. A multi-disciplined team of engineers serves as a distinctively unbiased assessment resource to NASA.

NASA Centers and Facilities Participating in NESC Activities

Select 2005 NESC Partnerships/ Collaborations

The Aerospace Corporation
The Boeing Company
Federal Aviation Administration
Institute of Nuclear Power Operations
Lawrence Livermore National Laboratories
Lockheed Martin
National Institute of Aerospace
National Transportation Safety Board
Nondestructive Testing Information Analysis Center
Sandia National Laboratories
School of Aviation Safety
Southwest Research Institute
Swales Aerospace
Wedeven Associates, Inc.

NESC's technical evaluation and consultation products are delivered in the form of written reports that include solution-driven, preventative, and corrective recommendations. With each assessment, lessons learned are communicated to Agency leadership through bi-annual briefings, and to engineers through the Agency Lesson Learned system, which better informs the technical community and, therefore, NESC's engineers, customers, and stakeholders.

NESC's range of services includes testing, analysis, and data review in the following 15 engineering disciplines:

- Flight Sciences
- Fluids/Life Support/Thermal
- Guidance, Navigation, and Control (GNC)
- Human Factors
- Human Space Flight Operations
- Materials
- Mechanical Analysis
- Mechanical Systems
- Nondestructive Evaluation (NDE)
- Power & Avionics
- Propulsion
- Robotic Missions
- Software
- Structures
- Systems Engineering

NESC proactively engages through technical discipline-advancing activities, and is currently leading NASA's efforts for independent data mining and trend analysis to identify potential concerns before they become major problems – both within and across NASA programs. NESC has established a Data Mining and Trending Working Group that includes representatives from all NASA Centers, as well as external experts. This Group will ensure that results are maximized, and that NESC comprehensively learns from previous efforts.

"We really value the expertise that NESC brings to independent reviews of technical issues. Its insight has helped managers to understand risks and make informed decisions on several different topics."

— Ellen Ochoa, Deputy Director, Flight Crew Operations, Johnson Space Center

2005 ACCOMPLISHMENTS

NESC concluded its second year of full operations in 2005. Efforts this year resulted in many accomplishments, both from an organizational perspective and through increased technical expertise. Some 2005 organizational achievements included:

- Initiating NESC's 100th Technical Assessment in October.
- Providing value-added recommendations to ensure the Space Shuttle Discovery's successful return to flight in July. NESC was integrally involved in the testing and objective assessment of engineering challenges critical to the Space Shuttle's launch.
- Completing projects for four of NASA's Mission Directorates – Space Operations, Exploration, Science, and Aeronautics Research. This represents the depth of NESC's engineering expertise and the reach of its value-added assessments.
- Launching NESC's Academy in September. The collective breadth and depth of NESC's knowledge base is transferred to NASA's engineers through the NESC Academy. To date, the Academy courses have attracted participation requests exceeding class capacity. A solid starting point has been provided for the 2006 class roster.
- Transitioning technical leaders back to their Centers.
- Hiring the next round of technical leaders.
- Completing a broad range of major technical accomplishments, which are included in the Technical Accomplishments section of this report.

NESC is proud of its successes during 2005, and is committed to further growth and increased achievements during 2006.

LOOKING FORWARD

In 2006, NESC's strategy will be driven by growth – in technical excellence, in the value its services provide to ensuring safety in critical missions, and in the increasingly broad reach of its impact. As a multi-disciplined One NASA organization, NESC strives to achieve the following organizational goals:

- To prevent future technical problems through proactive testing and assessment
- To develop new tools and techniques for improved data mining and trending across NASA programs.
- To increase its customer base to include a broader range of NASA programs, other government agencies, and external organizations.
- To continually enhance its knowledge base by attracting the best and brightest engineering minds.
- To constantly develop new processes and expand services to provide the best value to its customers.

NESC is a technically robust organization with great potential. Its strategy in 2006 is to further apply its technical expertise to areas of NASA that are of high-risk and importance. Some key technical areas that will be focused on in 2006 include the Space Shuttle, International Space Station (ISS), and Exploration Systems.

- The Space Shuttle represents NASA's highest area of risk because of its human element. NESC is committed to focusing its technical expertise to proactively ensure continued successful Space Shuttle launches in the future. Upcoming efforts for the program include night flights and replacing the maturing Shuttle fleet.
- The ISS is an important program for NASA. NESC's testing, evaluation, and assessment of the risks, resources, and interactions with the ISS will be of increased focus, as it continues to protect NASA's – and the country's – vital human and national resources, both on and beyond Earth.
- Exploration Systems is a growing area of concentration for NESC. The current Space Shuttle will retire by 2010. NESC will be engaged in the Constellation Program, which will develop the ability to travel to and explore the moon and Mars. NESC's work in proactive trending tools will also positively impact NASA's exploration efforts.

"NESC provides a valuable engineering resource that is available to all programs. The International Space Station Program has made extensive use of NESC on a variety of topics. These NESC inputs were invaluable in allowing the program to make key engineering decisions."

— Bill Gerstenmaier, Former Manager, International Space Station Program

2005 METRICS AND BUDGET

NESC provides its customers an immeasurable advantage by bringing together multi-disciplined teams of experts to solve complex problems. As a result, NESC is able to recommend improved, safer technical solutions, stronger checks and balances, and better inform decision makers through objective assessments. Customer reports about the value that NESC adds to their efforts to solve technical challenges has led to a steady interest in NESC in 2005.

The majority of NESC's projects this year have been technical assessments in space operations – more specifically, assessments in support of NASA's return-to-flight activities. Notably, however, NESC has completed projects across the NASA Directorates.

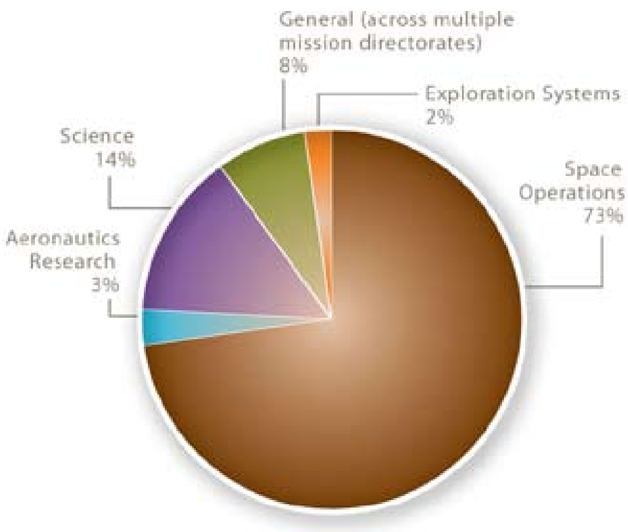
On October 6, 2005, NESC celebrated the acceptance of its 100th request since receiving its charter in 2003.

In its second year of operations, NESC experienced a continued increase in requests for its services. By October 31, 2005, NESC had accepted 44 requests.

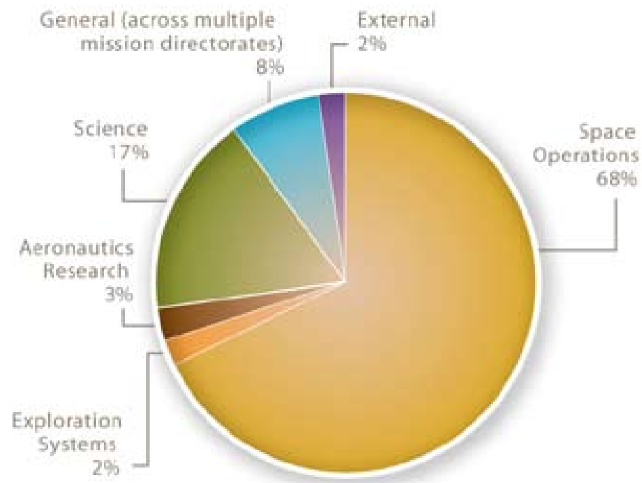
NESC is operating with a projected budget through 2010. Funding for NESC's activities - which were managed at Langley Research Center - reached $65.5 million in FY 2005.

Accepted Requests by Mission Directorate

2005 Calendar Year
44 Total as of October 31, 2005



Since 2003 Charter
106 Total as of October 31, 2005

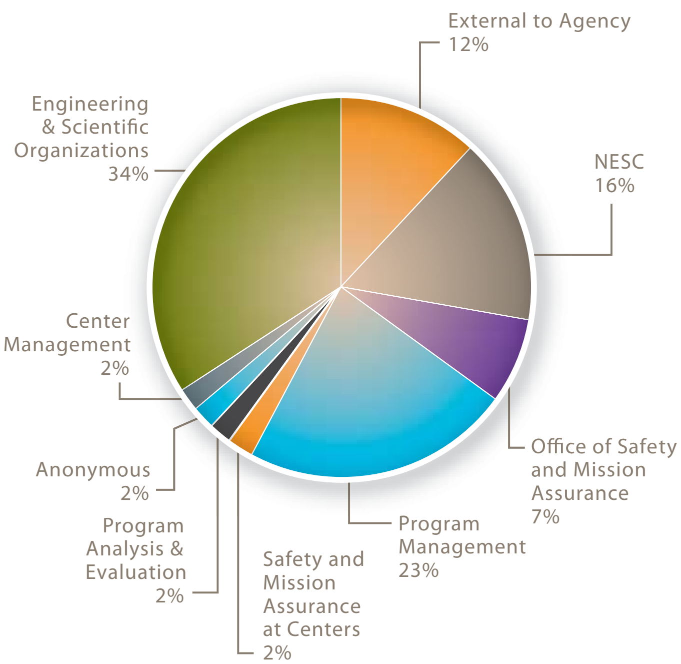


"We are about more than getting the Shuttle flying. We also work to ensure safety in the future. Therefore, NESC is an invaluable resource to NASA."

— Ken Cameron, NESC Deputy Director for Safety

Source of Accepted Requests

2005 Calendar Year
44 Total as of October 31, 2005



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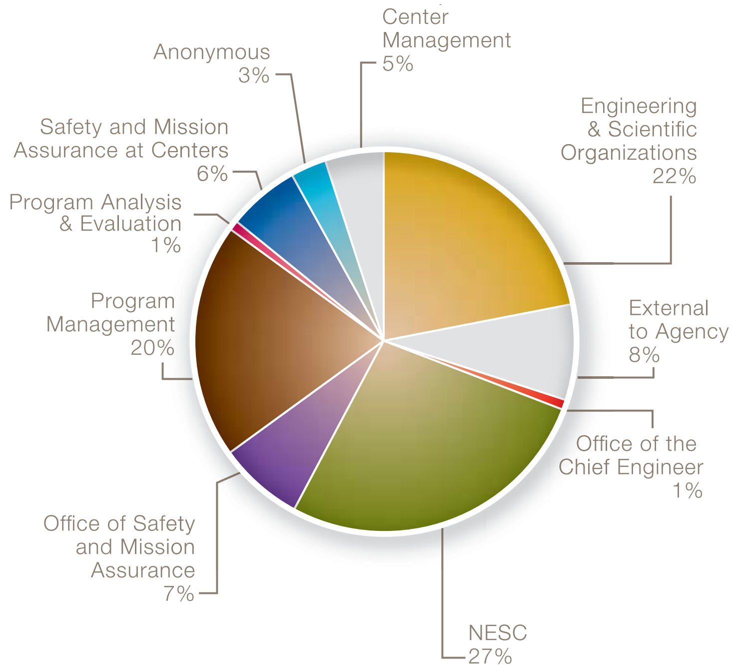
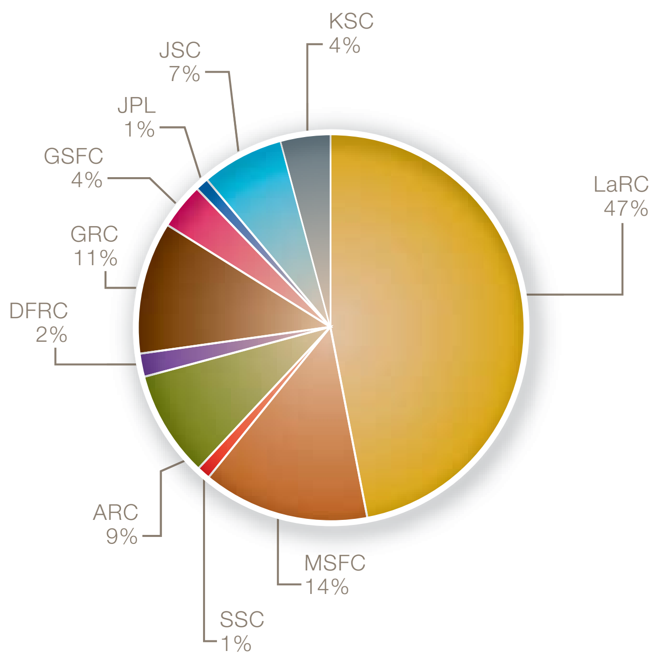
106 Total as of October 31, 2005



NESC Total Funding by Center – FY 2005



Our contributions to the return-to-flight effort were essential to the success of Discovery's launch in July. By providing an alternate place for NASA to turn for help with high-risk technical problems related to the Space Shuttle, we were able to positively impact the safety of the Shuttle's mission.

Given the vital human and national resources at risk when man enters space, NESC placed its focus in 2005 on helping the Space Shuttle return to flight. NESC's engineers were more than up to the task, given the breadth and depth of their experience, expertise, perspectives, and – most importantly – their dedication and determination.

Involvement in return-to-flight activities enabled NESC to demonstrate its value to NASA during the execution of a series of high-risk, historical activities. NESC's return-to-flight technical assessments were comprised of some of the following areas:

- Human Factors
- Feedline Bellows Ice Elimination
- Nondestructive Evaluation
- Foam Dissection Data
- Reaction Control System Thruster Cracks
- Debris Transport Math Models
- Wing Leading Edge Attachment Hardware Integrity
- Rudder Speed Brake Actuator
- Cure-in-Place Ablative Applicator Tile Repair
- BUMPER Micro Meteoroid/Orbital Debris
- T-0 Umbilical Interface
- Body Flap Actuator
- Recurring Anomalies

"During return to flight, NESC proved invaluable to the Shuttle Program. It performed independent tests and analysis and brought outstanding results back to the Program to be used in the decision making process. Safety through engineering excellence is exactly what NESC has provided."

— Bill Parsons, Former Space Shuttle Program Manager

Right Page: Launch of Discovery (STS-114)

Opposite Page: James E. Fesmire (Kennedy Space Center Cryogenic Laboratory Lead - rear left) and Ray E. Patrick (Director of Research and Development, Sealed Air Corporation) make final adjustments of the nanogel sacrificial retainer system on a liquid oxygen (LOX) feedline bellows test article prior to environmental testing


Discovery

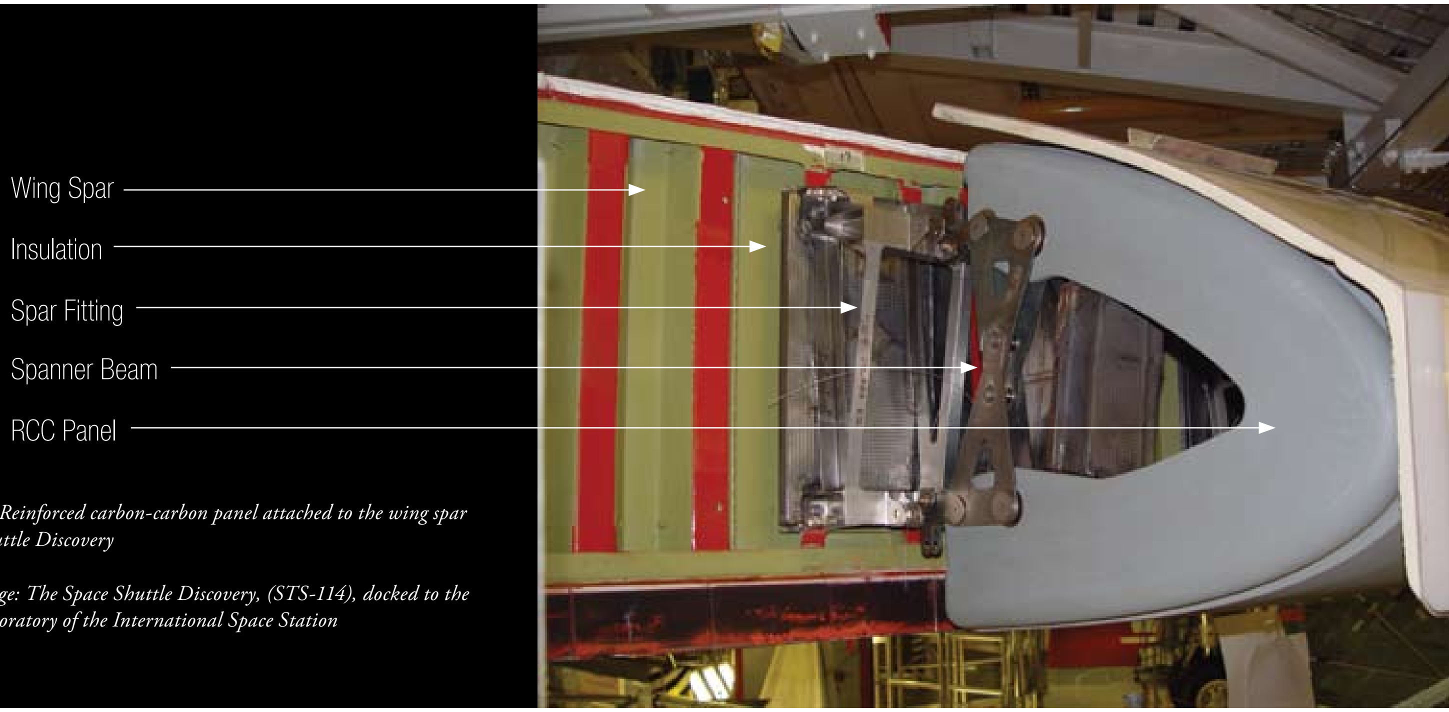
Orbiter reinforced carbon-carbon wing leading edge attach hardware integrity

Problem: A Columbia Accident Investigation Board member raised questions concerning the structural integrity of the wing leading edge (WLE) spar and reinforced carbon-carbon (RCC) attach hardware.

NESC Contribution: NESC conducted forensic metallurgical analysis of the debris from Columbia for anomalous failure mechanisms or indications of environmentally assisted aging. The team also conducted tests and metallurgical analyses of RCC attach hardware components removed from Discovery with a history of 30 flights, and reviewed inspection records for any indication of environmentally assisted aging. Flight thermal data and existing project thermal models were reviewed, the models were enhanced, and thermal analysis was performed to assess time and temperature exposure of spar and attach hardware. Time and temperature-dependent aging tests were conducted where insufficient engineering data was available to assess the performance degradation from service related thermal exposure. Existing project structural models were reviewed and enhanced. A case study was conducted to evaluate the capability of the WLE spar and RCC attach hardware to withstand a foam impact. Fracture and durability analysis was performed on WLE spar and RCC attach hardware components.

The team concluded from testing and analysis of the Columbia debris and of attach hardware components removed from Discovery that there is no indication of environmentally assisted aging of any components. The team further concluded based on testing, analysis, and review of the inspections performed on the Orbiters that there are no return-to-flight concerns with the existing spar and attach hardware. As a result of the assessment, the team identified secondary issues which were conveyed to the project as recommendations.

Lesson Learned: When commercially-available materials are used at or near their design limits, including the environments to which they may be exposed, it is critically important that all aspects of the materials' properties and how they can be affected by different environments are clearly communicated between the various disciplines involved in the design. In addition, this information must be clearly documented so that the engineers and technicians who implement, maintain, and ensure the quality of the vehicle have a clear understanding of the required material properties and environmental effects on those properties.



Right Page: Reinforced carbon-carbon panel attached to the wing spar of Space Shuttle Discovery

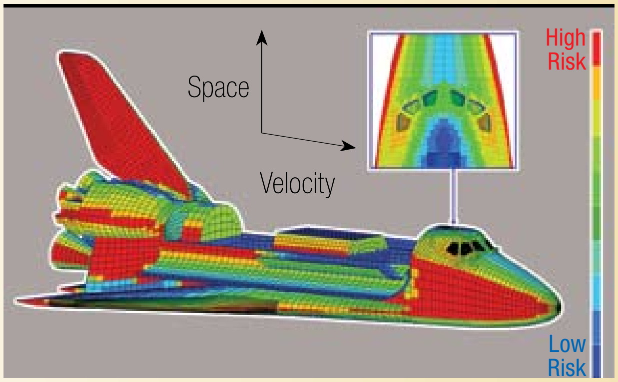
Opposite Page: The Space Shuttle Discovery, (STS-114), docked to the Destiny laboratory of the International Space Station

Micro Meteoroid and Orbital Debris Model Called BUMPER II

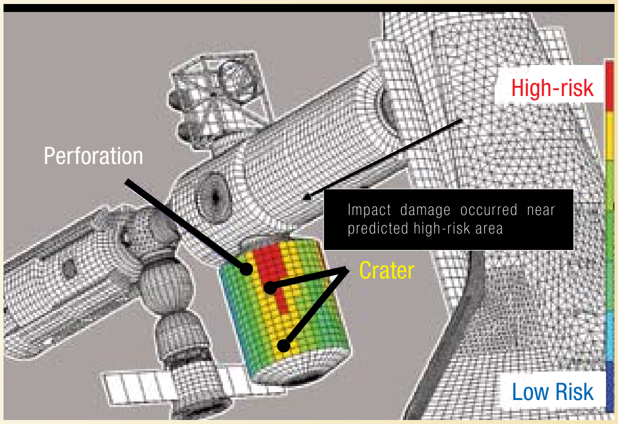
Problem: Micro meteoroid and orbital debris (MMOD) are a serious hazard for manned spacecraft. Micro meteoroids are naturally occurring particles that are created from the breakup of asteroids and comets while orbital debris is human-generated by spacecraft. Because these particles are traveling at many kilometers per second, even very small particles can cause loss of spacecraft critical systems or crew, in the case of manned spacecraft. NASA uses the BUMPER II code to calculate the risk of MMOD impact causing critical damage for each Space Shuttle mission, and the risk of MMOD penetration for the International Space Station (ISS), extravehicular activity suits, and other spacecraft. Space Shuttle mission operations have often been directly affected by risk predictions based on BUMPER II. NESC was requested to perform an independent validation and verification – that is, a line-by-line review of the BUMPER II software code, modeling assumptions, and potential error sources.

NESC Contribution: NESC examined the MMOD risk assessment process used for the Space Shuttle and ISS programs, the key general assumptions used in these assessments, the models built into BUMPER II, and the correctness of the BUMPER II code. Overall, the independent technical inspection provided 102 observations and recommendations regarding BUMPER II software improvement, ranging from general structure (e.g., combining the two codes into a single software core package) to the definition of units and constants. Many of the observed problems could produce errors in the output of BUMPER II. The assessment found that the code provides a point estimate of MMOD risk with no assessment of its associated uncertainty. Further, the uncertainties associated with underlying BUMPER II input models are largely unknown.

BUMPER II is the best tool currently available for vital Space Shuttle and ISS MMOD risk assessments. NASA recognizes the importance of providing uncertainty bounds, and work is underway to develop the tools and methodology needed to include uncertainty bounds with BUMPER II results. Reporting risk predictions with uncertainty bounds enables those performing the program's probabilistic risk assessments to fold the results into the assessment. Implementation of the recommendations will provide NASA missions with the MMOD tools needed for the Moon and Mars missions.



Shuttle impact risk from orbital debris ≥ 3mm diameter



BUMPER perforation risk plot with impact locations noted

Shuttle Kevlar Composite Overwrapped Pressure Vessels Safety for Flight Concern

Problem: NESC was tasked to evaluate the flight rationale for the Kevlar/Epoxy Composite Overwrapped Pressure Vessels (COPVs) used in Space Shuttle systems.

Gaseous nitrogen Composite Overwrapped Pressure Vessels installed in the Orbiter environmental control and life support system

NESC Contribution: As part of the evaluation, NESC examined the Space Shuttle Program's (SSP) Fleet Leader COPV, which had been pressurized under test conditions for 26 years. Also examined were flight hardware design certification and qualification test results, fleet leader test results, and stress rupture test results.

NESC determined that there is significantly less stress rupture life margin remaining in the SSP COPVs than was previously assumed. NESC assisted the Orbiter Project Office by: 1) accurately assessing the risk of COPV stress rupture failure, 2) developing flight rationale for return to flight, and, 3) outlining plans for future tests to complete COPV hardware certification for the future life of the SSP.

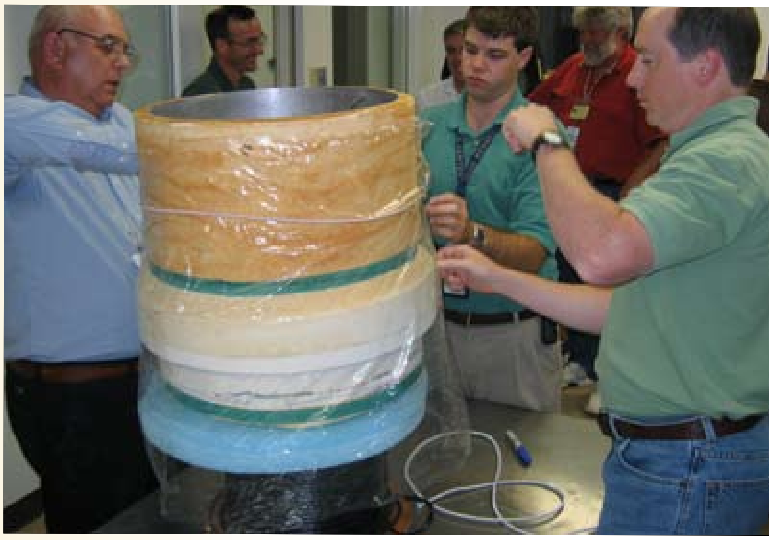
Lesson Learned: Increased use of composite structures in spacecraft requires comprehensive test programs to better understand potential failure modes, such as stress rupture. Future spaceflight programs should ensure that provisions for adequate long-term testing are included in the project requirements.

External Tank Liquid Oxygen Feedline Bellows Ice Prevention Design

Problem: Potentially damaging ice can grow on components of the Space Shuttle's External Tank (ET) once it is filled with cryogenic hydrogen and oxygen. In particular, the liquid oxygen (LOX) feedline bellows and LOX feedline support brackets are susceptible to the formation of ice because only a limited amount of thermal protection can be applied while still allowing for the required motion of the bellows and brackets.

NESC Contribution: NESC is developing designs that mitigate the risk to the Orbiter from ice debris shed by the ET during ascent. Through the use of a shrink wrap film filled with nanogel insulating beads, the formation of ice on the LOX feedline bellows was prevented under worst-case temperature and humidity environments during preliminary testing.

This design allows the bellows to move normally and the insulating system to separate from the bellows early in flight. Additionally, special coatings for the feedline brackets are being developed to influence the formation and adhesion of ice. Initial laboratory tests have shown that coatings can alter the ice adhesion strength and structural integrity. Ice liberation tests that rely on launch acoustic and vibration loads will be used to evaluate the effectiveness of candidate coatings.



Kennedy Space Center Engineers Charlie Stevenson, left, Wesley Johnson, center, and James Fesmire, right, install shrink wrap on a liquid oxygen bellows test article prior to cryogenic testing

Peer Review of the Math Model Tools to be Used to Assess Damage to Tile and Reinforced Carbon-Carbon Due to Debris Impact Assessment

Problem: The Space Shuttle Program requested that NESC perform a peer review of the Orbiter damage assessment math model tools.

NESC Contribution: A pre-flight and on-orbit assessment strategy involving a combination of new and existing math model tools was developed to determine the impact and damage tolerance of the Orbiter TPS (acreage tiles and reinforced carbon-carbon on the nose cap and wing leading edges) due to impacts from expected debris.

NESC peer reviewed an engineering data package for each math model tool. The peer review included an assessment of the end-to-end, integrated analysis strategy to address the compatibility of data exchange between the models, and the propagation of uncertainties from the initial definition of the impact event to the final estimate of the resulting damage.

The damage assessment tools were found to be acceptable for supporting return to flight. However, technical limitations in the use of each damage assessment modeling tool were identified. NESC and the NASA Independent Technical Authority have jointly funded additional NASA efforts to validate these models and better quantify uncertainty in the solution.

Lesson Learned:

A comprehensive test program using design of experiments logic is required to adequately verify and validate complex math model tools.

NESC reviewed models for predicting damage to reinforced carbon-carbon and tile caused by foam and ice being shed from the external tank during ascent

Ground Support Equipment T-0 Umbilical to the Space Shuttle Program's Flight Element Assessment

Problem: The Ground Support Equipment T-0 umbilical connections provide a command path from the Space Shuttle Orbiter to the Solid Rocket Booster (SRB) and holddown post pyrotechnic bolts so bolt separation can be initiated at T-0. NESC provided alternate viewpoints of several T-0 connection failures and concluded that a level of uncertainty remained despite the corrective actions implemented. The concern was that the root cause of the failures was never fully determined, which questioned the adequacy of the corrective actions and level of risk remaining for future Shuttle flights.

NESC Contribution: NESC assessed the T-0 umbilical ground processing changes, the testing and modeling performed by the Space Shuttle Program's (SSP) Tiger Team, as well as the safety margin expressed. NESC modeling work combined and augmented existing models to create a single integrated model suitable for supporting structural dynamic analysis, confirming the Tiger Team's results and demonstrating that the analyses were insensitive to underlying assumptions. The safety margin analysis performed by NESC indicated a very low likelihood of simultaneous failure of redundant circuits. Connector examination and testing performed by NESC confirmed that the corrosion failure mechanism proposed by the Program was credible.

An NESC recommendation to instrument the T-0 interface during launch to anchor the models was accepted by the SSP, and a directive to that effect was issued. The work performed by NESC led to a better understanding of the engineering data and reaffirmed the risk assessment for safety and mission success.

(continued on next page)

Lesson Learned: Programs with elements that share physical interfaces, and therefore risks, should ensure that responsibility for integrated hazards is clearly defined, integrated hazard reports are developed, and periodic system reviews of these hazard are reported.

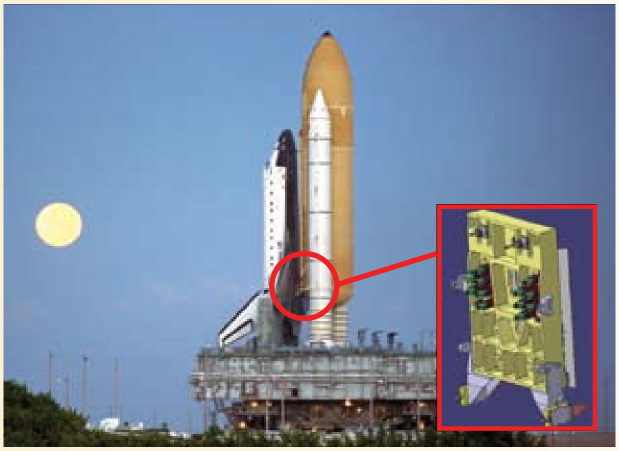


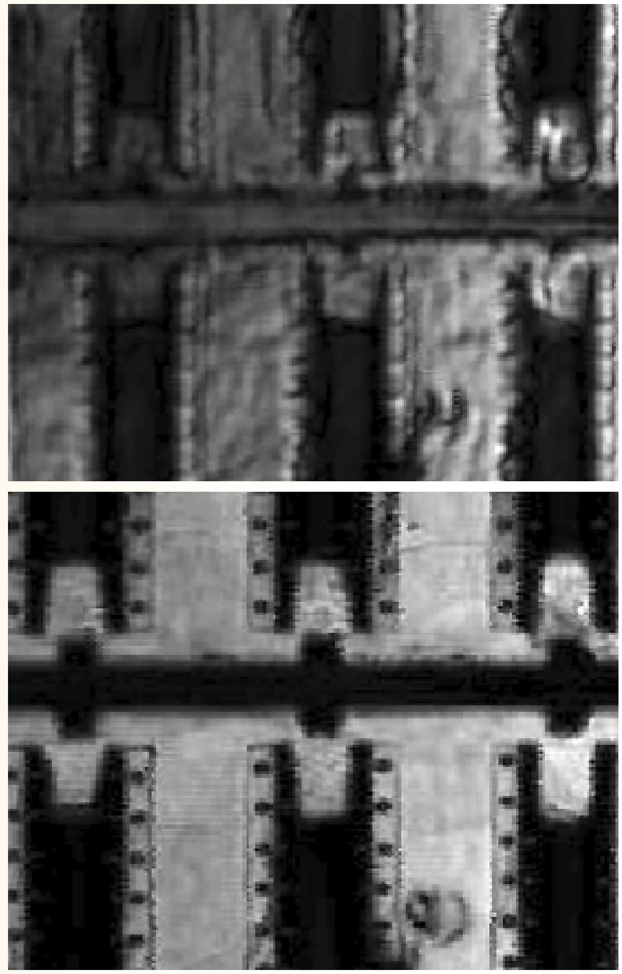
Illustration of T-0 interface

Nondestructive Evaluation for External Tank Thermal Protection System Closeout Verification

Problem: Nondestructive inspection technologies were not available for subsurface inspection of the sprayed-on foam insulation (SOFI) used on the Space Shuttle's external tank (ET). Efforts to develop new inspection technologies were having limited success. The development of inspection technologies was hindered by the lack of controlled inspection requirements and resulted in ever-changing instrument and software development efforts that led to probability of detection (POD) studies that were of limited value.

NESC Contribution: NESC developed a plan to stabilize the nondestructive evaluation (NDE) procedures and processes before initiating a POD study. Inspection criteria of the spatial distribution of flaw indications, nearest neighbor, size, location, type (shape), and orientation, including obtaining adequate representative POD test articles, are to be controlled and fixed before the POD study begins.

Lesson Learned: The development of NDE technologies to



Terahertz imaging of spray-on foam insulation
August 2003 capability–(Upper Photo)
Improved capability in May 2005–(Lower Photo)

Lesson Learned: The development of NDE technologies to meet ever-changing uncontrolled inspection criteria results in producing inspection technologies that may have limited impact. It is not recommended to initiate POD studies until both the NDE technologies and inspection criteria are fixed.

"The Terahertz Imaging System (inspection technology) has been sufficiently developed and listed as a new nondestructive evaluation technology. The System greatly increases the resolution of the technology as shown."

– Edward Generazio, Former NESC Discipline Expert

Orbiter Thruster Mounting Flange Bolt Hole Cracking

Problem: During a routine inspection of a Space Shuttle Orbiter Reaction Control System thruster, crack indications were detected in 9 of the 16 injector flange bolt counter bores. Further disassembly, in preparation for the failure analysis, also revealed cracking in the injector flange relief radius. Additionally, during removal and replacement of a thrust chamber for a follow-on thruster, it was found that the injector was incorrectly cleaned by immersion in Oakite Rustripper, an aggressive sodium hydroxide solution.

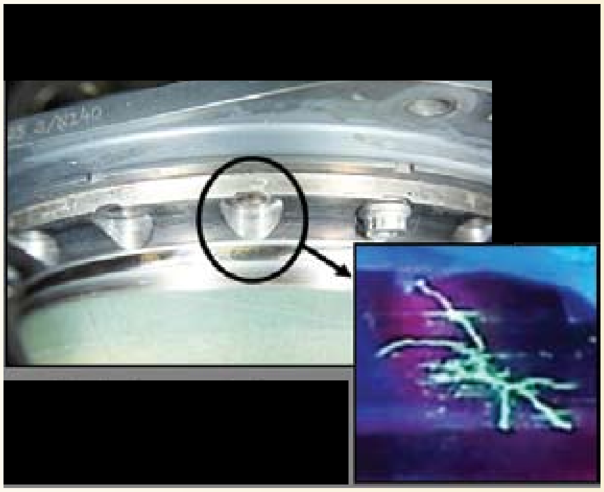
NESC Contribution: Two NESC teams were chartered to disposition the thruster cracking and sodium hydroxide exposure. A materials team was chartered to consult with the Orbiter materials team to determine the root cause of the injector cracking, determine the likelihood of crack propagation while in service, and disposition the thrusters that were exposed to sodium hydroxide. The second team was a nondestructive evaluation (NDE) team that consulted with the Orbiter NDE team to develop NDE techniques to examine thrusters to determine fit-for-service.

Extensive material testing, evaluation, and stress and fracture analysis established the root cause of the cracking and determined that the thrusters with crack indications have sufficient safety margins to fly for the remainder of the Space Shuttle Program. Although sodium hydroxide exposure can lead to compromised material properties, testing indicated that routine exposures occurring during nominal thruster processing do not create a structural concern. Although significant progress was made developing NDE techniques for measuring cracks in thruster injectors, the material, stress, and fracture analyses results eliminated the need for NDE for flight rationale.

"During the material analysis and testing, material test techniques were innovatively tailored to match the available material and configurations that established the injector material properties for the flight thruster. Specifically, fracture toughness and fatigue crack growth rates were established for these injector configurations, so that the properties could be qualitatively compared to nominal injector material properties and could be used in the safety margin evaluations."

– Mike Kirsch, NESC Back-Up Principal Engineer

Orbiter Reaction Control Thruster undergoing examination for cracks by the Near Field Emissions Electron Microscope in the Electron Optics Laboratory, Glenn Research Center



Typical counter bore cracks visible under UV light with dye penetrant

Cure-in-Place Ablative Applicator

Problem: NESC was requested to evaluate the technology readiness level of the Cure-in-Place Ablative Applicator utilizing STA-54, and to determine if the proposed system is sufficiently mature to perform an extravehicular activity (EVA) demonstration during the flight of STS-121.

NESC Contribution: NESC determined the STA-54 material formulation, processing, storage, and cure practices generate potential for gas bubble formation during the dispensing and cure cycles. If left uncharacterized or controlled, it could impact the performance of an on-orbit tile repair.

NESC concluded STA-54 is sufficiently characterized to meet the identified materials science evaluation objectives for the planned STS-121 EVA. The completed ground-based material and process sensitivity studies provide confidence that dispensed STA-54 can vacuum cure and provide acceptable thermal performance data with a range of gas bubble volume fraction. However, the planned STS-121 STA-54 application is considered a precursor to future on-orbit demonstrations that will evaluate the combined effects of microgravity, space vacuum, material/tool performance, and operations techniques. Additional material and process sensitivity studies are required to complete characterization of STA-54 as an effective on-orbit tile repair technique. NESC continues to provide technical oversight of STA-54 development in the areas of gas bubble formation prediction, STA-54/tile thermal expansion mismatch evaluation, and material uncured material compatibility/toxicity concerns.

Lesson Learned: Operational assumptions and boundary conditions set in the development phase have long-term implications that should be periodically revisited at interim design reviews to ensure the continued viability of the proposed design solution.

Onboard a KC-135 aircraft, astronaut Robert L. Curbeam rehearses extravehicular activity tasks for repairing damaged Shuttle tiles

Repairing of damaged Shuttle tiles: testing the application of STA-54 Cure-in-Place Ablative Applicator to simulated damage of the Orbiter's thermal protection tiles

Gaseous Hydrogen Vent Arm Behavior Prediction Model Review

Problem: The gaseous hydrogen (GH_2) vent arm is a launch pad structure designed to support the Ground Umbilical Carrier Panel (GUCP) and seven-inch hydrogen vent line flexhose during Shuttle processing. At T-0, the GUCP separates from the Shuttle external tank by means of a pyrotechnic device, and the arm drops away from the vehicle and into a restraint. During the STS-108 launch, the arm failed to engage the restraining device and impacted the pad structure with resultant damage to both the arm and the pad. Debris was also liberated during the incident, which could have caused significant damage to the Shuttle flight vehicle had it made contact. The GH_2 vent arm restraining device was modified and wind constraints established in the Launch Commit Criteria (LCC) to minimize the possibility of wind loads deflecting the arm and causing another mishap. Recent review of the math model created to validate this change resulted in a reduction of the LCC allowable vent arm wind limit from 34 knots to 24 knots.

NESC Contribution: The Kennedy Space Center Independent Technical Authority and Ground Operations Chief Engineer's office requested an NESC review of the math model to ensure it is not providing overly conservative or restrictive results. NESC reviewed and validated a computer simulation used to predict GH_2 vent arm behavior under wind loading.

Several concerns surfaced during the review. The winds are measured at the 60 foot level, not at the 250 foot level where the arm is located. The model did not account for wear and free-play in the arm joint mechanism, nor was the model fully validated. It was recommended to upgrade the wind measurement equipment at the launch pads to better characterize the wind speed and direction at the vent arm and additional testing be performed to validate the model. NESC concurred with the recommendation to lower the LCC for future Shuttle missions.

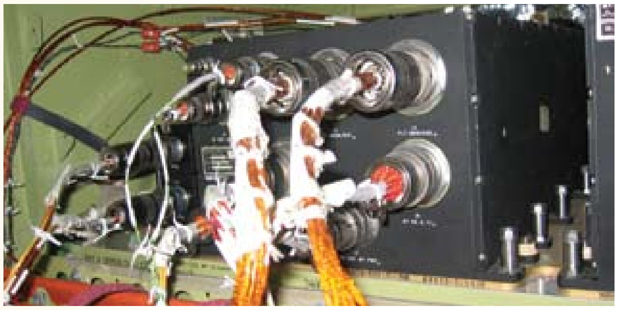
Hydrogen vent arm in the launch configuration

Space Shuttle Reaction Jet Driver

Problem: The Space Shuttle Reaction Jet Driver (RJD) avionics boxes control the thrusters that are used to maneuver the vehicle. A failed-on primary thruster for as little as two seconds during mated operations with the International Space Station could be catastrophic. The zero-fault tolerant RJD circuit design violates Space Shuttle Program requirements for a two-fault tolerance of critical systems. In addition, potential age degradation of RJD transistors and wiring were unknown.

NESC Contribution: NESC conducted extensive reviews, analyses, tests, and inspections to determine the RJD inadvertent firing risk. The testing of flown RJD transistors revealed no age concerns, and a modified box-level health check was instituted.

Lesson Learned: When extending components beyond their original design life, adequate screens for aging and/or degradation should be performed.



Reaction Jet Driver electronics box

Orbiter primary thrusters (three primary thrusters are visible closest to the nose cap on Endeavour)

Peer Review of the Flight Rationale for Expected Debris Assessment

Problem: Work recently completed by the Orbiter and External Tank (ET) engineering teams indicated that the Space Shuttle System could not be fully certified for flight through expected foam or ice debris liberated from the ET. Therefore, the flight rationale must be based on an accepted risk strategy. The Space Shuttle Program requested that NESC perform a peer review of the flight rationale strategy and the supporting engineering data.

NESC Contribution: NESC assessed the flight rationale logic for expected debris and identified the limitations and gaps in the supporting engineering data. The assessment included the standard deterministic methods to compute C/E, the Orbiter impact capability margin, where C is the impact capability of the Orbiter's reinforced carbon-carbon (RCC) and tile, and E is the foam and ice debris environment; and the Monte Carlo-based probabilistic estimate of the likelihood of critical impact of foam and ice debris damage to the Orbiter.

The probability of critical damage to the Orbiter nose cap and wing leading edge RCC was found to be sufficiently low enough to classify the risk as remote or improbable, depending on the debris source. Additionally, the higher risk of critical damage to Orbiter tiles from sources of foam debris and from ice debris (feedline brackets, mid and aft feedline bellows, and umbilicals) are categorized as infrequent. However, the ice controls specified in the Launch Commit Criteria are deemed adequate to render the risks acceptable. As new data becomes available from STS-114, the probabilistic risk assessment will need to be updated.

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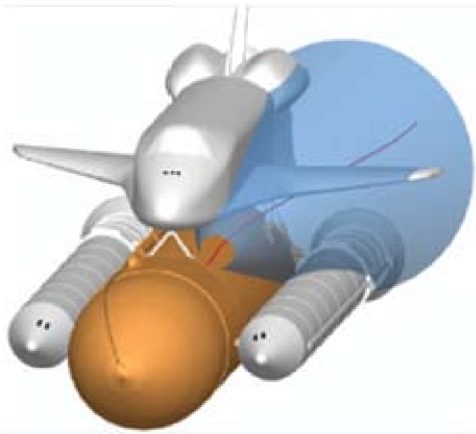
"NESC flight rationale recommendations were recognized by the Space Shuttle Program as value-added, and were implemented into the final results."

– John Stadler, NESC Systems Engineering Office

Lesson Learned: Comparing the operational environment with the certification requirements of a spacecraft, and resolving any discrepancies, must be a continuous process throughout the life of the spacecraft.

Debris Source



Debris Transport

Orbiter Thermal
Protection System Damage

Areas examined during NESC peer review of flight rationale

Space Shuttle Orbiter Rudder/Speed Brake Margins of Safety Assessment

Problem: The Space Shuttle Orbiter Rudder/Speed Brake (R/SB) system provides steering and braking for the Orbiter during descent and landing. An investigation was initiated after an inspection of the Discovery actuators was performed revealing damage to the gears that appeared to be propagated by a corrosion pitting mechanism.

NESC Contribution: NESC was requested by the Space Shuttle Program management to help determine what consequences could result from operating with the damaged hardware and to determine the cause of this damage. To investigate the causes of this damage and to determine the potential consequences, NESC formulated a detailed plan to examine the background and root causes of the damage. This knowledge, along with testing and analysis, was then applied to quantify the effects of this damage on system performance and margins of safety. This was accomplished through fundamental experiments, bench tests, analysis, and system level testing. The analysis revealed questionable assumptions regarding actuator-to-structure interface boundary conditions and the internal load distributions on planet gears and on individual gear teeth, resulting in a further reduction in the strength margin.

NESC's testing concluded that the micro pitting was actually fretting damage on the gears caused by high cycle, small dither motions at light loads mainly accumulated during powered Orbiter hydraulic systems ground checkout. In addition, testing demonstrated that the fretting cracks do not propagate when exposed to high-cycle loading at high loads, and that the gears' strength was essentially unchanged by the presence of the fretting damage. The system level test confirmed that the gears with fleet representative fretting damage and representative Orbiter interface stiffness can endure 1.25 times the design limit loads without failure or loss of efficiency. Considering these conclusions, NESC recommended the Orbiter Discovery was safe for return to flight.

Lesson Learned: When conducting a subsystem qualification

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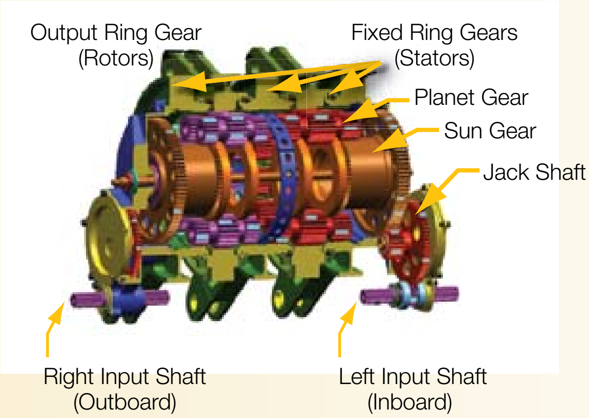
Lesson Learned: When conducting a subsystem qualification test on flight hardware, it is imperative that the induced environment conditions, and interface boundary conditions of flight and ground operations are accounted for and well understood.

Rudder/Speed Brake Actuator installed in an Orbiter tail section



Rudder/Speed Brake cut-away view

Orbiter Repair Maneuver

Problem: The Orbiter Repair Maneuver (ORM) is a complex and hazardous human/robotic contingency operation developed to support the repair of entry-critical Thermal Protection System (TPS) tiles and reinforced carbon-carbon damage at locations that cannot be reached with the Orbiter docked to the International Space Station (ISS) by either the Shuttle's or the Space Station's robotic arms. The ORM is intended to undock and position the Orbiter such that nearly 100 percent of the TPS tile is within reach of an extravehicular activity (EVA) astronaut positioned on the Space Station's robotic arm. The ORM is a contigency operation involving close proximity movements of SSP and ISS structure with limited back-out opportunities and reduced crew visibility. There is also a high potential for adverse control-structure interactions possibly resulting in large or unstable relative motion between the Orbiter and the EVA astronaut at the repair worksite.

NESC Contribution: NASA conducted an independent peer review of the ORM. The primary review objective was to assess the status, depth, and completeness of the pre-return-to-flight ORM dynamic modeling, simulation, and analysis work, as well as to assess the overall operational readiness of the ORM.

NESC found that while a significant amount of analysis had already been performed, some critical open work remained for the ORM Working Group and a number of these tasks would need to be completed prior to safely invoking the ORM as a viable on-orbit contingency. NESC provided additional recommendations that needed to be addressed prior to the first use of the ORM. In particular, NESC provided specific recommendations primarily focused on re-validating the stability robustness and rate damping performance of the ISS attitude control system used during the ORM. NESC also recommended that an independent validation of the ORM integrated, multi-body end-to-end dynamic software simulation be completed prior to first use of the ORM.

Lesson Learned: An early-on analytical checkpoint in the assessment of control system stability is the demonstration

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Lesson Learned: An early-on analytical checkpoint in the assessment of control system stability is the demonstration of a high-degree of correlation and agreement between linear and non-linear dynamic modeling results. A clear and straightforward technical rationale, based upon an in-depth physical understanding of the system's dynamics, is required to reconcile significant deviations between linear and non-linear modeling results.

"NESC team members were able to engage in a very detailed and productive technical dialogue from two very distinct sets of viewpoints and engineering experiences - that of Robotic Spacecraft control system designers and that of Human Space Flight control system designers. The diversity of both technical experiences and design guidelines helped NESC to draw out and focus on the critical issue, such as the very low phase margins in the International Space Station controller. Very spirited discussions about the degree to which the results obtained from the linear and the non-linear dynamic models should agree transpired. This led to the ORM team going back and doing a detailed re-examination and comparison between their models. This had a positive result of providing data that added a significant level of confidence that there will be adequate ISS controller stability during the ORM maneuvers should they need to be performed."

– Neil Dennehy, NESC Discipline Expert for GNC

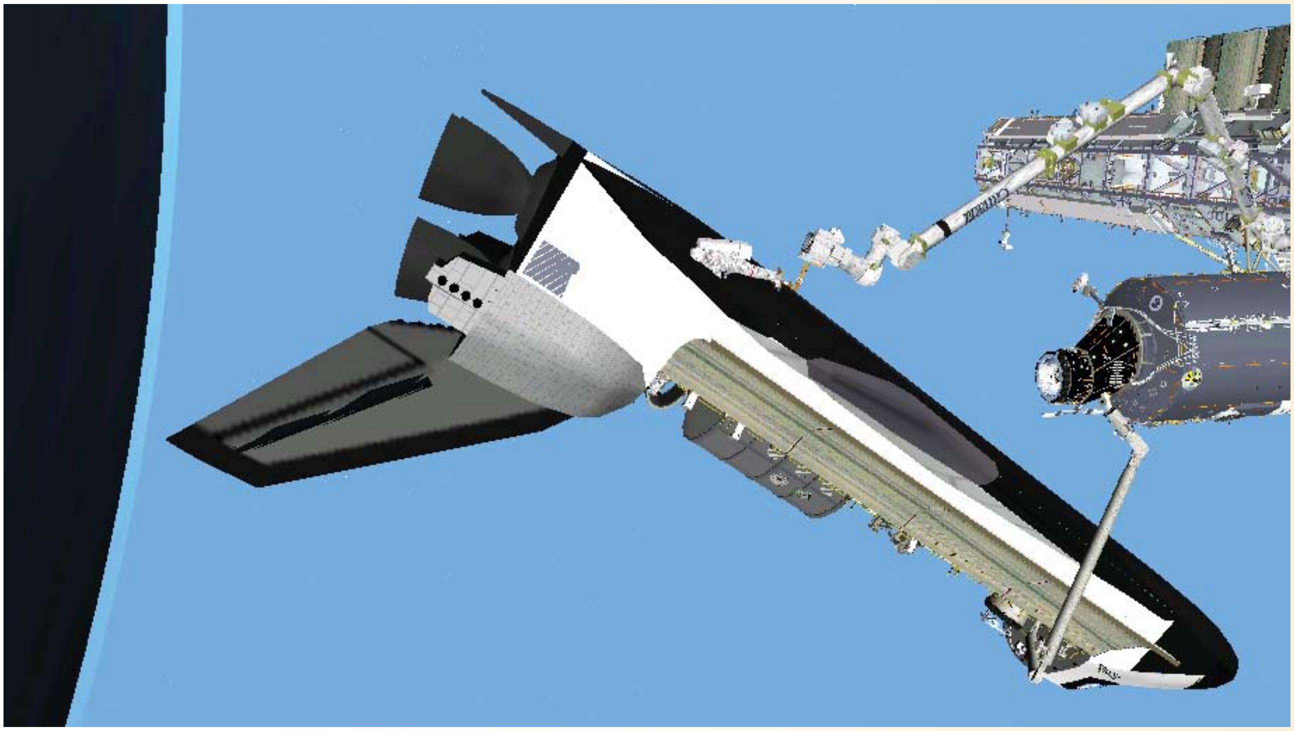


Illustration of Orbiter Thermal Protection System repair extravehicular activity; the Orbiter maintains position with its arm while the astronaut is on the end of the International Space Station arm

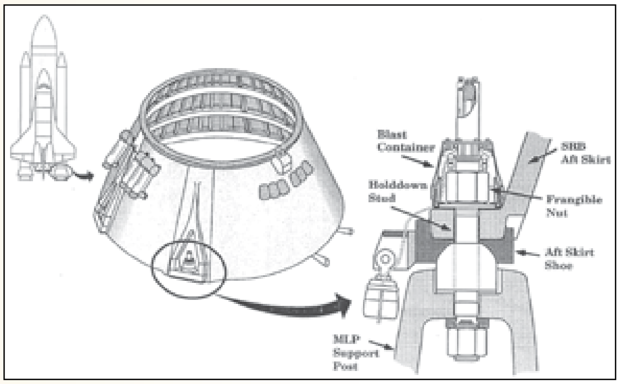
Space Shuttle Program and International Space Station Recurring Anomalies Review

Problem: The recurring anomalies review was a proactive activity to surface hidden risk in advance of a critical failure by applying fresh engineering talent and new insight to recurrent problems. An additional goal was to "connect the dots" in a manner that events had not been previously related before they manifested themselves as failures.

NESC Contribution: Six discipline-centered technical sub-teams were formed including mechanisms, structures, electrical, fluids, propulsion, and software. The teams began their work with a review of recurrent problems surfaced by the program data mining activities. Information was also drawn from the programs' various problem reporting databases, briefings, technical summaries, etc. The Space Shuttle Program (SSP) assessment was completed in January 2005, while the International Space Station analysis is complete and in the process of being compiled.

NESC's SSP assessment surfaced 26 technical issues for further action and 12 non-technical issues resulting in 63 recommendations. Two identified areas of concern – solid rocket motor nozzle ply lifting and solid rocket booster holddown post stud hang-up – are the subjects of the NESC parallel assessments. Six of the technical issues required SSP action prior to the STS-114 to return to flight.

Lesson Learned: Future problem reporting databases should be designed to facilitate proactive trending and analysis, while minimizing inconsistencies in record identifiers and maximizing comparisons across programs and projects.



The recurring anomalies review highlighted areas for additional program disposition, such as the solid rocket booster holddown post stud hang-up issue illustrated above

Cassini/Huygens Probe Entry, Descent, and Landing

Problem: The Cassini/Huygens mission is a joint effort between NASA and the European Space Agency (ESA) to explore Saturn and its satellites. NASA experts voiced concerns to NESC about portions of the Huygens probe entry, descent, and landing (EDL), based on experience and lessons learned.

NESC Contribution: NESC was actively involved in the EDL analysis focusing on the parachute deployment trigger performance and the resultant effects on the operation of the parachute system. NESC also evaluated ESA's prediction of the aerodynamic and radiative heating environment to be encountered by the probe at Titan and the corresponding Thermal Protection System response. NESC's assessment of the Huygens probe EDL on Titan included a data review and independent analyses.

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Cassini Spacecraft with Huygens Probe visible on the left behind the gold foil covered heat shield

The assessment results were shared with the Cassini program and with the ESA. Concurrent reviews, led by the Jet Propulsion Laboratory and ESA, relied on NESC's EDL assessment results to formulate a recommendation to not change any mission parameter. The recommendation was accepted and the Huygens probe was released nominally on December 24, 2004. A successful EDL was executed on January 14, 2005.

Lesson Learned: State-of-the-art tools and methods currently available to NASA, particularly in aeroheating, were only marginally sufficient to conduct this assessment in the time allotted. Future interplanetary EDL analyses should be identified and initiated early enough to allow adequate time to complete the required analysis.

Workers lower the infrared telescope into the cavity of the NASA Boeing 747SP (photo courtesy of L3)

The Stratospheric Observatory for Infrared Astronomy

Problem: The Stratospheric Observatory for Infrared Astronomy (SOFIA) modification to a NASA Boeing 747SP airplane includes a large open cavity in the aft fuselage section that is larger than any previously flown open cavity. Despite numerous wind tunnel tests and extensive analysis, there remain uncertainties regarding the acoustic environment within the cavity, especially in the off nominal failed door open descent flight regime, where some degree of acoustic resonance is expected to occur.

NESC Contribution: NESC was requested to determine if the approach taken by the SOFIA Project in the analysis, structural design, and proposed approach to flight test were sound and conservative.

The SOFIA project appropriately accounted for and designed an aperture treatment for flow control to mitigate or suppress telescope cavity resonances. There are uncertainties whether an uncontrolled cavity resonance will occur if the cavity door failed to close during descent to landing from cruise altitude. These uncertainties are mitigated through a thorough, incremental building-block approach to opening the door during the flight test phase of the program. Flight test planning indicates a cautious approach to hazardous testing and to areas where uncertainties exist. The cavity acoustic fatigue analysis and damage tolerance analysis was started, but not completed, during the time period of this assessment. The validity of some aspects of the proposed approach could not be substantiated and require verification prior to cavity open door flight.

"The Technical Assessment requestor stated a concern over the potential for structural damage caused by an acoustical resonance occurring at or near a structural mode. A worst-case scenario is that cavity Rossiter mode frequencies could align with the frequencies of the cavity acoustic resonances frequencies and cavity structure vibration mode frequencies. If such a possibility were to occur, one is confronted with a 'triple resonance', which would imply the potential for a catastrophic condition.

The team performed an analysis which disclosed that there is only a single set of frequencies at which cavity resonances occur. Contrary to the initial expectation, these frequencies are neither the structure's natural frequencies, nor the purely acoustic resonant frequencies of the cavity. The worst-case scenario places a Rossiter mode frequency at a coupled cavity-structural resonance, which is not a 'triple resonance' effect."

– Mike Kehoe, Former NESC Chief Engineer

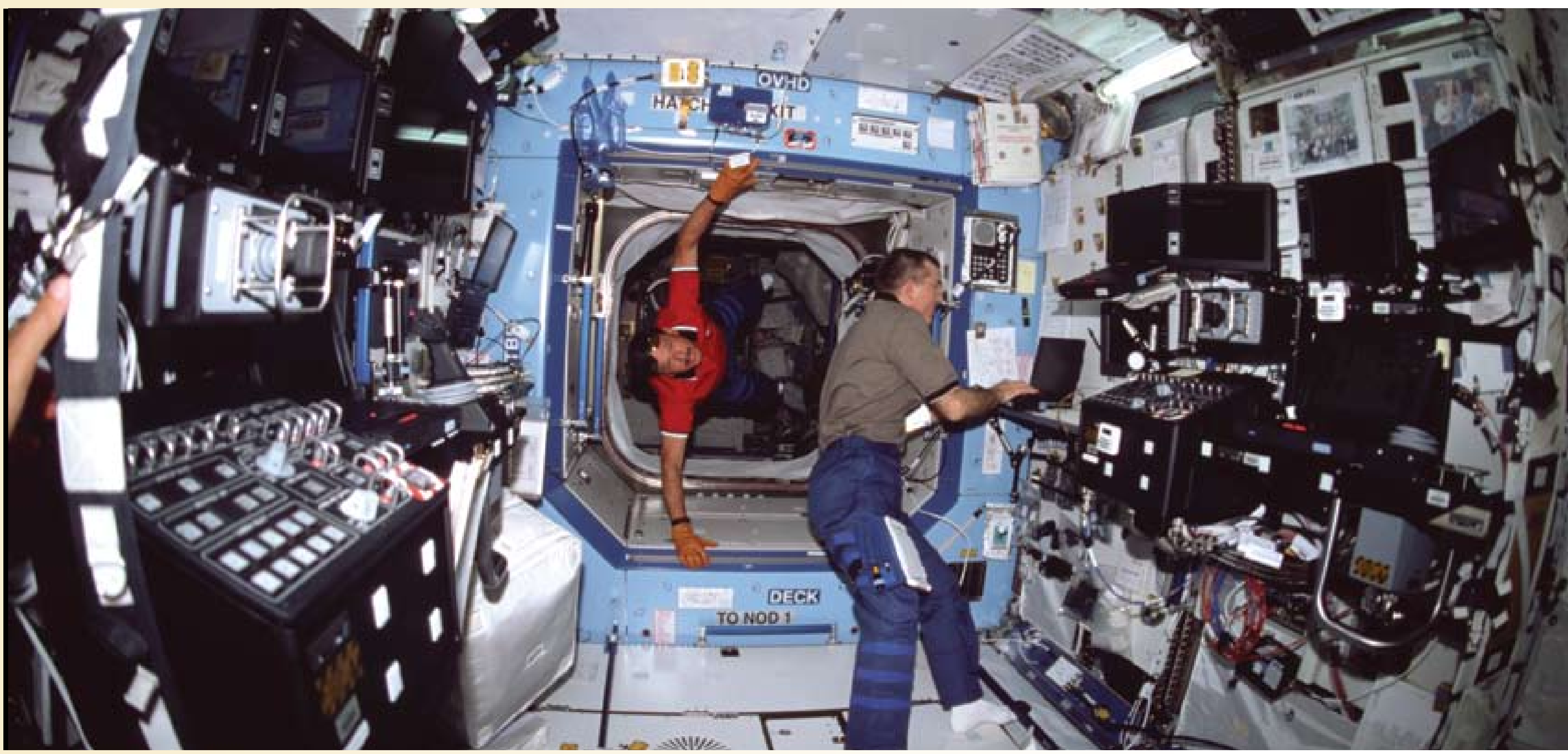
International Space Station Internal Active Thermal Control System Cooling Water Chemistry

Problem: The International Space Station (ISS) Program requested NESC support in assessing the approach and corrective actions proposed to address the observed chemical changes to the Internal Active Thermal Control System (IATCS) coolant chemistry, the potential for component life reduction, and requirements updates for crew protection.

The water-based IATCS collects heat from sources within the pressurized elements that are transferred to the External Active Thermal Control Systems via externally mounted ammonia-to-water Interface Heat Exchangers. The U.S. Laboratory IATCS on-orbit coolant chemistry has experienced deviation outside specification limits due to a combination of a high partial pressure of carbon dioxide (CO_2) and the gas permeable Teflon hoses used in the IATCS. Diffusion of CO_2 through the flexible hoses lowered the coolant pH and resulted in increased microbe population, hardware corrosion, and precipitate formation. Concerns were raised that continued elevated microbial levels and precipitation in the IATCS fluid could lead to fouling-related issues, galvanic and/or microbial corrosion, and reductions in cold plate/HX efficiencies.

NESC Contribution: NESC recommended seven antimicrobials for additional evaluations and characterization against the reference antimicrobial of glutaralde hyde. Additional collateral recommendations were provided on synergistic components of the IATCS coolant chemistry that included: borate/carbonate buffer additions, returned U.S. Laboratory hardware examination, and Nickel Removal Assembly and Phosphorous Removal Assembly characterization and implementation.

Lesson Learned: Closed-loop water-based cooling systems should not use gas permeable tubing and servicing units should be governed by the same configuration and coolant controls as flight systems to minimize the introduction of uncontrolled contaminants, microorganisms, and nutrients that could allow unanticipated changes to coolant stability.



U.S. Laboratory module of the International Space Station

Hubble Space Telescope Nickel Hydrogren Battery Charge Capacity Prediction Review and System Health Assessment

Problem: NESC provided sequential assessments concerning the nickel hydrogen (NiH_2) battery charge capacity prediction methodology and the current and anticipated state of the spacecraft subsystem health to support a robotic servicing mission (SM).

NESC Contribution: In the initial consultation, the proposed Hubble Space Telescope (HST) NiH_2 battery capacity prediction tool was viewed as conservative with the Hollandsworth/Armantrout model as having the greatest likelihood of accurately estimating the HST battery capacity over time. The second assessment involved the request to analyze the spacecraft subsystems and the parameters that describe the HST health to determine the timeliness of a robotic SM and whether a robotic SM is likely to provide the capability to extend the useful scientific life of HST by five years.

NESC concluded that there was a high likelihood of having a viable vehicle available for a robotic SM. Following successful equipment and instrument replacement during an optimized SM, the potential for at least five additional years of science discovery is very good. Overall, NESC observed the HST Program to be a resourceful team with extensive corporate knowledge that has repeatedly demonstrated the ability to react to, and plan for, adverse conditions. A number of innovation applications of HST systems to non-traditional roles are considered in fault planning. The HST team has operations rooted in established procedures and a layered approach to anomaly recognition and disposition.

Lesson Learned: The proper selection, preservation, and development of an operations and sustaining engineering workforce is critical in the identification of emerging performance trends and the generation of innovative corrective actions.

Hubble Space Telescope

Nickel hydrogen battery ground test unit undergoing long term capacity testing at the Marshall Space Flight Center

International Space Station Module Post Proof Nondestructive Evaluation

Multi-purpose logistics module in the Space Station Processing Facility at Kennedy Space Center

Problem: NESC was requested to determine associated risks and potential acceptance rationale of not performing post proof nondestructive evaluation (NDE) on five European manufactured International Space Station modules.

NESC Contribution: These modules were considered pressure loaded structures and not pressure vessels, thus allowing the use of leak-before-burst (LBB) criteria as a substitute for post proof NDE. The reliance on LBB criteria reduces the potential for detection of unacceptable weld flaws that could extend to a critical crack size and module rupture without adequate operational controls. In addition, the original structural analysis did not incorporate local stress magnifications from allowable weld peaking and mismatch features.

NESC recommended performing limited post proof inspections and specialized analyses to assess both the weld-as-designed and nonconformance conditions. This approach was augmented with empirical testing and statistical examination of inspection data from applicable welded structures.

Lesson Learned: While the use of LBB criteria as a design characteristic is acceptable, complex welded structures should be assessed using safe-life analysis techniques that utilize post proof NDE results, and incorporate weld drawing/specification dimensional discontinuities.

Chris McGougan, Marshall Space Flight Center, performs a weld peaking and mismatch measurement of a simulated International Space Station Aluminum Variable Polarity Plasma Arc weld

Lynn Hoffland prepares a test coupon for residual stress assessment

Improved Methods for Air Leak Detection on the International Space Station

Problem: The International Space Station (ISS) developed a small over board leak in a window purge metal bellows flex hose. Conditions that contributed to the difficultly in determining the leak rate and locating the leak site were: the leak rate was well below the ISS leak rate procedural plan for leak isolation; the leak rate was within pressure sensors accuracies; direct nitrogen (N_2) measurement was less than every two weeks (to extend sensor life); the leak event occurred during a time period with oxygen (O_2) pressure variations; and there was not an accurate ground console calculation for daily leak rate.

NESC Contribution: NESC recommended to the ISS Program Leak Team to improve the accuracy of atmospheric leak detection and leak measurement capabilities by creating a ground console automatic N_2 mass daily trending model. NESC recommended maintaining a continuous N_2 pressure reading with the mass spectrometer and resetting the trend curve after each ISS platform attitude change, and after the addition of N_2.

NESC identified the need for flexible seals in irregular surfaces of the module, and also the need for an infrared camera to aid in identifying the location of potential leaks and thermal problems. NESC further observed that attitude changes affect internal air temperature gradients for less than six hours after the change. ISS N_2 and O_2 storage tanks need temperature sensors and thermal attitude trending to provide early leak detection. Each tank should have a remote control isolation valve.

Cosmonaut and International Space Station - Expedition One crew member Yuri Gidzenko examines the ISS laboratory window and flex hose (visible at top of window)

ISS Window Flex Hose

Engine Cut-Off Sensor Anomaly Consultation

Problem: The liquid hydrogen (LH_2) Engine Cut-off (ECO) Sensors are thermal mass loss devices located at the bottom of the External Tank (ET). They are used to detect low propellant levels. The device is intended to protect the Space Shuttle Main Engine turbo-pumps from operating without fuel (dry). Testing of the sensors at cryogenic conditions during STS-114 launch countdown resulted in intermittent operation, with a failure mode that forces the ECO sensor electronics to falsely report the presence of fuel (wet) when there is none (dry).

NESC Contribution: NESC assisted with troubleshooting the ECO sensor problem and participated in the electronics analysis, ET thermal modeling, and sensor electronics thermal analysis.

A more detailed understanding of the ECO sensor and associated electronics was obtained, contributing to confidence to proceed with the launch of STS-114, even though the root cause of the failure was not identified.

An additional theory regarding the intermittent nature of the ECO sensor failure has been posited, focusing on the sensor terminals and the thermal conditioning environment seen prior to flight. This theory is currently being investigated further by NESC.

Support STS-114 Gap Filler Anomalies Tiger Team Investigation

Problem: An on-orbit video inspection performed during the STS-114 mission of Orbiter Discovery revealed that several Thermal Protection System gap fillers were protruding between tiles on Discovery's underbelly, requiring an extravehicular activity by the crew to remove them. The Orbiter Project Office created the Gap Filler Anomalies Tiger Team and requested that NESC work with this team in finding solutions to the gap filler bonding problem.

NESC Contribution: NESC worked closely with the Tiger Team's investigation to understand the current gap filler bonding techniques that led to Discovery's STS-114 protrusions, and development of improved gap filler bonding techniques and fleet-wide gap filler integrity checks. NESC performed an independent statistical review of a Design of Experiments (DOE) brought forward from within the Tiger Team to substantiate the new gap filler bonding process.

The NESC DOE investigated the influence between bond strength, gap filler layers, technicians, and quality control personnel. To determine if the pull loads applied to gap fillers during installation and verification tests are being transferred to the bond line, NESC developed a finite element analysis model to provide the Tiger Team confidence in its assumptions. While the new bonding and verification technique will increase the gap filler-to-Orbiter bond, the integrity of previously installed gap fillers throughout the fleet will be ensured by a robust verification technique.

Engine Cut-Off Point Sensor Electronics Box stimulates ECO Sensors and conditions signals received from them for processing by thE Orbiter and ground computers

(Lower Right) STS-114 Astronaut Steve Robinson holds the gap filler removed from Discovery's Thermal Protection System

(Lower Left) Gap filler undergoing the newly developed bonding process; tape is used to provide the necessary force to ensure gap filler bondline contact

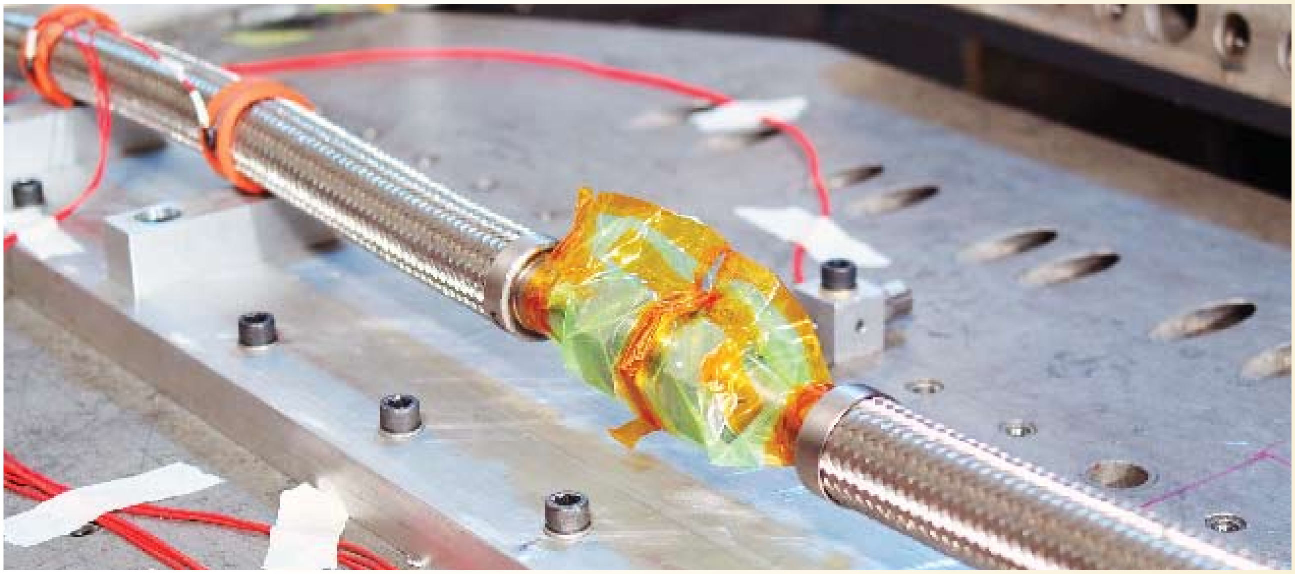
AN-Type Fittings in the International Space Station Node 2 Ammonia System

Problem: A concern was presented to NESC due to the Air Force-Navy (AN) fittings used in ground support systems at Kennedy Space Center having a history of leaking. The International Space Station (ISS) Node 2 element also utilizes AN fittings to connect its ammonia system piping together. The ISS ammonia system accepts the heat from critical ISS systems and rejects the heat by circulating ammonia through radiators which radiate the heat to space. A potential personnel hazard can occur should this system leak during ground processing. Depending on the type and severity of leakage on-orbit, the ammonia system could require more than the planned execution for replenishment or disablement of critical ISS systems.

NESC Contribution: NESC reviewed the assembly and testing documentation and a chronology of the documentation revealed a number of discrepancies and irregularities. Based on the issues raised by the documentation review, NESC recommended to the ISS Program that a Node 2 ammonia system pressure decay test be conducted to determine the system's integrity. This test was conducted with satisfactory results. It was also discovered that the ammonia system AN fittings were qualified by similarity with a much smaller AN fitting that was used in a different system and environment.

An exact chronological order of assembly and testing events was established based on interviews with personnel who participated in the Node 2 assembly and test. NESC developed and conducted a "mimic" test at Glenn Research Center, which tested a flight-like hardware configuration through all the pressurizations, depressurizations, and vibrations that the actual Node 2 hardware would encounter from initial assembly through on-orbit operations. Qualification launch vibrations were substituted for actual launch vibrations due to the aforementioned issues with qualification by similarity. All of these mimic tests had satisfactory results.

Preliminary NESC findings indicate that the current conditions of the AN fittings in the Node 2 ammonia system are acceptable to support ground and flight operations.



AN fitting being prepared for helium leak test

Problem: NESC received an anonymous request to examine and assess the Space Station to Shuttle Power Transfer System (SSPTS). The SSPTS is being designed to take 120 Volt Direct Current (VDC) International Space Station (ISS) power and send it to the Space Shuttle where it is connected to the Shuttle's 28VDC main power bus after being converted to 28VDC via the Shuttle's Power Transfer Unit (PTU). The requestor was concerned that there might be little to no supporting data that demonstrates the control of two potential hazards. The hazards could result in an overvoltage condition on the Space Shuttle main power bus, thus leading to a disabled Shuttle on-orbit. The concerns include whether an internal short circuit in the PTU that results in 120VDC at the Space Shuttle power buses will present a hazard to the Space Shuttle, and whether the Station design assures that it will not transmit more than 120VDC to the Shuttle due to a Station failure.

NESC Contribution: NESC initially reviewed prior analyses performed by the Shuttle Program, noting that these analyses found that three failures must occur to cause an overvoltage on the Shuttle's 28VDC main power bus. They concluded that the design meets the dual fault tolerant requirement per the safety requirements for avionics on catastrophic hazards. NESC then performed an extensive independent system analysis to assess whether an internal short circuit in the PTU or Station transmission of more than 120VDC could result in a credible overvoltage hazard to the Space Shuttle.

The team further analyzed various two-fault possibilities to verify that the latest architecture of the SSPTS tolerates two faults successfully and prevents the two hazards mentioned above.

Preliminary NESC findings indicate that the current conditions concluded that the referenced hazards have been adequately addressed by the present design implementation, which incorporates two-fault protection. The concerns raised by the anonymous requestor were adequately addressed.

The Space Station to Shuttle Power Transfer System will extend the amount of time an Orbiter can remain docked to the International Space Center by four to five days

Risk Assessment for the Battery Charge Electronics Single Point Failure Issue on the Mars Reconnaissance Orbiter, Stardust Entry, and Review of a Test Anomaly Resulting in Contamination of Elements of Mars Reconnaissance Orbiter Spacecraft

Problem: NESC provided significant support to a number of planetary missions, including Cassini/Huygens, Deep Impact, Genesis, Stardust, and the Mars Reconnaissance Orbiter (MRO). Specifically on the MRO mission that launched successfully to Mars on August 12, 2005, there were a number of issues that NESC provided in-depth independent technical analysis and review. The independent perspective provided by NESC was critical to satisfying management that the mission was ready for flight at an acceptable level of risk.

NESC Contribution: The areas where NESC was engaged were: 1) ring laser gyro laser intensity monitor degradation, 2) battery charge electronics potential single point failure that could overvoltage the bus and leave the batteries off-line for charging, and 3) solar thermal vacuum test contamination. The ring laser issue was resolved by establishing conservative screening requirements, which the project implemented.

After thorough analysis of the battery charge electronics failure mode, it was shown to not represent a single point failure for overvoltage. However, because the risk of the batteries being off-line for charging could not be fully mitigated by ground intervention (batteries could discharge before the next ground communication cycle), a change in the fault protection software was implemented to assure that the batteries would be placed on-line without the need for ground intervention. The work on the thermal vacuum test contamination involved a review of the project's assessment and corrective action, which was found to be thorough and accurate.

Artist rendition of the Mars Reconnaissance Orbiter in orbit

Solid Rocket Booster Holddown Post Stud Hang-Up

Problem: The Space Shuttle is held in place on the launch pad by eight large stud/nut assemblies. Four of these assemblies are connected to each of the Solid Rocket Boosters (SRBs) and held to the launch pad's holddown posts (HDP). At the instant of the Shuttle's launch, the nuts are pyrotechnically separated which allows the studs themselves to move into the HDP, away from the soon to be moving Shuttle. Over the course of the program, some of these studs have not dropped out of the way fast enough and have been pinched by the SRBs as the Shuttle moves up and laterally. Concerns have been raised as to the amount of lateral loads induced by these hang-ups into the Shuttle components. The purpose of NESC's Stud Hang-up Assessment is to determine the root causes of these hang-ups, and to propose recommendations to prevent future hang-ups.

NESC Contribution: To date, NESC has conducted a number of separate tests with spare flight hardware that have attempted to isolate and determine the various contributions of the numerous variables inherent in the design of this system. For example, each nut has two pyrotechnic devices for redundancy purposes. In a number of live firings, NESC has noted that if the pyros do not explode at the same time, also known as pyro skew, the time taken for the stud to get out of the way increases drastically. NESC has also determined that the causes for this skew rest almost exclusively with the electronic components feeding the firing signal to the pyros. Additionally, because this large pyrotechnic event happens entirely within an enclosure meant to contain debris, remnants of the nut can cause a significant decrease in stud exit time due to re-contact with the stud. NESC also developed high-fidelity simulation models and is using actual test data to refine the model.

While testing is still in progress, it is presently clear that there are multiple factors that affect whether a stud hangs up. NESC is currently working on how to mitigate these factors. The benefit of preventing future stud hang ups will resolve any concerns about exceeding any unanticipated loads on the Shuttle assembly at launch.

Doug Harrington (seated) and Scott Hacker from the Energy Systems Test Branch of the Energy Systems Division at the Johnson Space Center perform tests to characterize the explosive devices that split the holddown post nut at launch, freeing the Space Shuttle from the launch pad during liftoff

“ The NESC Academy has proven very effective in transferring the experience of NASA’s senior technical experts to the engineering community, both inside and outside the agency.”

— Rick Gilbrech, Former Deputy Director, NESC

NESC ACADEMY

The NESC Academy was successfully launched in 2005 to further execute our commitment to engineering excellence, and to support the spirit of One NASA.

Through the Academy, NESC is able to communicate the wealth of knowledge that NASA's senior engineers have gained throughout their careers by providing an outlet for them to share their expertise with the next generation of engineers.

The subject matter addressed through the NESC Academy spans across NESC's 15 engineering discipline areas. The courses, which provide an exceptional learning opportunity and require several months of preparation, last 2 or 3 days and are conducted at major colleges and universities across the country. Courses focus on developing technical expertise in problem resolution, and include classroom activities consisting of instruction, course related facility tours, and group problem-solving exercises. The Academy's first class, titled *Space Life Support Systems: Learning from the Past and Looking to the Future,* was taught in September by Hank Rotter at The University of Houston Clear Lake in Houston, Texas. Two more courses were conducted at the end of 2005 addressing Space Propulsion Systems and Power & Avionics. Academy courses are open Agency-wide and to outside contractors. To date, expressed interest in 2005 courses outweighed classroom capacity. As a by-product of the NESC Academy, NESC plans to reach out to college students in an effort to foster continued interest in NASA, and in the field of engineering.

The NESC Academy has uncovered a real desire within NASA to listen to and learn from NESC's senior engineers. As NASA prepares for future great journeys, the tradition of passing on Lessons Learned will become increasingly important.

Opposite Page: Hank Rotter (above left) and George Hopson (below left) were instructors for the first two NESC Academy courses

Attendance of the Space Propulsion Systems Class was over twice what was anticipated

NESC HONOR AWARDS

NESC honor awards are part of our incentive and recognition program. They are given each year to NASA Center employees, industry representatives, and other stakeholders for their efforts and achievements in the areas of engineering, leadership, teamwork, and communication.

These honorary awards formally identify individuals and groups who have made outstanding contributions to NESC's mission and who demonstrate the following characteristics:

- Engineering and technical excellence
- Fostering an open environment

There are four NESC Honor Award categories.

NESC Director's Award honors individuals who take personal accountability and ownership in initiating clear and open communication on diverse and controversial issues. A key component of this award is based on the process of challenging engineering truths.

NESC Engineering Excellence Award honors individual accomplishments of NESC job-related tasks of such magnitude and merit as to deserve special recognition.

NESC Leadership Award honors individuals who have had a pronounced effect upon the technical activities of NESC.

NESC Group Achievement Award honors a team of employees comprised of government and non-government personnel. The award is in recognition of outstanding accomplishment through the coordination of individual efforts that have contributed substantially to the success of NESC's mission.

On February 8, 2005, Langley Center Director, Roy E. Bridges, Jr. (left) and NESC Director, Ralph R. Roe, Jr. (right) presented Richard W. Powell (center) the NESC Director's Award for outstanding direction and technical leadership of the Cassini/Huygens Independent Technical Assessment Team

Opposite Page: Dr. Michael P. Nemeth, Senior Engineering Scientist at Langley Research Center, is working on a special-purpose combined-loads testing machine; this machine is used to study load introduction effects. Dr. Nemeth was awarded the NESC Engineering Excellence Award for his work in the area of structural mechanics as a member of the External Tank Independent Technical Assessment Team

Dr. Paul M. Munafo, Former NESC Deputy Director (far right), and his wife, Ginger (far left), view his NESC Engineering Excellence Award during an NESC Honor Award Ceremony in 2004

NESC is proud to recognize the following 2005 Honor Award recipients.

NESC DIRECTOR'S AWARD

Dewey B. Channell
(Marshall Space Flight Center) Posthumous

Honored for providing an alternate opinion, thus ensuring the T-0 interface was subjected to a rigorous technical engineering assessment.

Philip M. Deans
(Johnson Space Center)

Honored for providing an alternate opinion, thus ensuring the T-0 interface was subjected to a rigorous technical engineering assessment.

Pat B. McLaughlan
(Johnson Space Center)

Honored for submitting an alternate opinion regarding the safety and flight readiness of the Composite Overwrapped Pressure Vessels for the Space Shuttle.

Richard W. Powell
(Langley Research Center)

Honored for providing outstanding direction and technical leadership to the Cassini/Huygens Probe Entry, Descent, and Landing Independent Technical Assessment Team.

Robert J. Wingate
(Marshall Space Flight Center)

Honored for providing professional integrity and perseverance for challenging the prevailing certification approach to the External Tank's manually sprayed "fly-as-is" foam.

NESC ENGINEERING EXCELLENCE AWARD

James E. Fesmire

(Kennedy Space Center)

Honored for engineering excellence leading to the successful development of the Space Shuttle External Tank Liquid Oxygen Feedline Sacrificial Retainer System.

Lorie Grimes-Ledesma

(Jet Propulsion Laboratory)

Honored for engineering excellence on the NESC Composite Overwrapped Pressure Vessels Assessment Team.

Dr. Michael P. Nemeth

(Langley Research Center)

Honored for outstanding technical contributions in the area of structural mechanics as a member of the External Tank Independent Technical Assessment Team.

Dr. Stuart L. Phoenix

(Cornell University)

Honored for engineering excellence on the NESC Composite Overwrapped Pressure Vessels Assessment Team.

Tim Wilson, NESC Chief Engineer from Kennedy Space Center, accepts the NESC Group Achievement Award on behalf of the NESC Recurring Anomalies Review Team

Dr. Eugene K. Ungar

(Johnson Space Center)

Honored for outstanding technical contributions in the area of fluids/thermodynamic analysis as a member of the External Tank Assessment and NESC Flight Rationale for Expected Debris Peer Review Team.

NESC Honor Awards presented on June 7, 2005. Front row from left: Dr. Michael Nemeth (LaRC), Robert Wingate (MSFC), Pat McLaughlan (JSC), Kay Channell accepting for Dewey Channell (MSFC), Lorie Grimes-Ledesma (JPL), and Philip Deans, (JSC) Back row from left: Hank Rotter (JSC) accepting for Dr. Eugene Ungar (JSC), Ralph Roe, Jr. (NESC Director/presenter), Dr. Stuart Phoenix (Cornell University), Andreas Dibbern (KSC) accepting for James Fesmire (KSC), and Jerry Ross (NESC Chief Astronaut/presenter)

Flowliner Independent Technical Assessment Team

Honored for exemplary contributions conducting unique engineering analyses and tests to independently assess the flowliner cracking problem.

Flowliner Inspection Team

Honored for exemplary contributions developing an edge replication method to inspect slots for surface defects and fatigue cracks.

Cassini/Huygens Probe, Entry, Descent, and Landing Independent Technical Assessment Team

Honored for exemplary contributions in the modeling of the Huygens Probe Entry, Descent, and Landing on Titan.

Composite Pressure Vessel Safety for Flight Concern Independent Technical Assessment Team

Honored for providing engineering excellence in resolving difficult technical questions related to a potentially catastrophic failure mode of Kevlar Composite Overwrapped Pressure Vessels.

On February 8, 2005, Langley Research Center Director, Roy Bridges, Jr., and NESC Director, Ralph Roe, Jr., presented the NESC Group Achievement Award to the Cassini/Huygens Probe Entry, Descent, and Landing Independent Technical Assessment Team

NESC Group Achievement Award presented by Dr. Julian M. Earls, Director of Glenn Research Center, on August 30, 2005 to members of NESC's Recurring Anomalies Review Team and NESC's Reaction Jet Drivers Independent Technical Assessment Team

Management and Technical Support Office Staff Award

Honored for creating the business, administrative, and financial infrastructure for NESC.

Liquid Oxygen Feedline Bellows Ice Prevention Team

Honored for developing alternative solutions for the prevention of ice on the External Tank Liquid Oxygen Feedline Bellows.

Recurring Anomalies Review Team

Honored for the team's efforts to independently review the Space Shuttle and International Space Station Programs' recurring anomalies to proactively identify technical vulnerabilities.

Reaction Jet Drivers Independent Technical Assessment Team

Honored for outstanding contributions to the independent technical assessment of the Space Shuttle Orbiter Reaction Jet Driver inadvertent thruster firing hazard.

The first NESC Group Achievement Awards were presented at Langley Research Center to the Flowliner Inspection Team; team members pictured above are Scott A. Willard, William T. Howard, and John A. Newman

Most of the Flowliner ITA Team members are pictured above. Dr. Charles E. Harris, Principal Engineer leading the team effort, presented the awards on November 14, 2004

NESC LEADERSHIP TEAM
Rotation

Engineering excellence is the foundation of our charter. A fundamental objective for an organization driven by excellence is to promote exceptional leadership.

To meet this objective, the NESC organizational model provides for a formal leadership rotation.

A key component to the continued success of this organizational model is that leadership assignments are limited to approximately 2 years, allowing members to broaden their experiences and perspectives before returning to key leadership roles at NASA Centers. The NESC knowledge base also greatly benefits from the expertise and fresh perspectives that members bring to NESC during their rotations.

Members have entered the leadership team from positions across NASA and external to the Agency. During their rotations, members are afforded many opportunities that they might not otherwise gain exposure to during their careers. Some of the rewards alumni cite from participation on NESC's leadership team include:

- Opportunities to interact with some of the best technical experts in NASA
- Involvement in an increased number of projects and NASA programs
- Increased advancement opportunities following completion of their NESC assignment

Since 2003, 46 percent of the NESC leadership team completed their rotations and have moved into other leadership positions within NASA. These individuals have made significant contributions to NESC, and their rotation experiences will positively support their future career endeavors.

"Strong, focused leadership is paramount in maintaining the core principles of NESC."

— Steve Gentz, NESC Principal Engineer

"I am pleased to have Rick as my partner to lead Langley Research Center into the next hundred years of flight."

— Lesa B. Roe, Director, NASA Langley Research Center

Opposite Page: In the Kennedy Space Center Payload Hazardous Servicing Facility, the Mars Reconnaisance Orbiter is ready to be encapsulated before moving to the launch pad

Right Page: Rick Gilbrech accepting his new position as Deputy Director, Langley Research Center

During the NESC Conference held at Redondo Beach, California. Neil Dennehy, NESC Discipline Expert for Guidance, Navigation, and Control, Mike Hagopian, NESC Chief Engineer at Goddard Space Flight Center, and Tim Wilson, NESC Chief Engineer from Kennedy Space Center exchange information regarding NESC activities

Members of the NESC Leadership Team resident at Johnson Space Center (left to right): Steve Labbe, Hank Rotter and Julie Kramer White participate remotely via video conference in an NESC meeting

"My experience at NESC was very positive, and enabled me to interact with NASA's best expertise across not only my specific discipline, but the broad range of expertise represented within NESC. This has helped broaden my background and understanding of the various NASA programs, the engineering technical base, and the Agency's culture from Center to Center. It has been a privilege to be associated with such an outstanding group of people who are so focused on improving safety and mission success."

– Steve Labbe, Acting NESC Discipline Expert for Flight Sciences, Johnson Space Flight Center

NESC LEADERSHIP TEAM
Biographies

OFFICE OF THE DIRECTOR

Ralph R. Roe, Jr.
Director

Richard J. Gilbrech
Deputy Director

Kenneth D. Cameron
Deputy Director For Safety

Jerry L. Ross (JSC)
Chief Astronaut

David S. Leckrone (GSFC)
Chief Scientist

NASA HQ SENIOR S&MA INTEGRATION MANAGER

Wayne R. Frazier

NASA HQ OFFICE OF THE CHIEF ENGINEER REPRESENTATIVE

Keith L. Hudkins

MANAGEMENT AND TECHNICAL SUPPORT OFFICE

Marc S. Hollander
Manager

SYSTEMS ENGINEERING OFFICE

Dawn M. Schaible
Manager

PRINCIPAL ENGINEERS OFFICE

Clinton H. Cragg
Steven J. Gentz
Charles E. Harris

NESC CHIEF ENGINEERS (NCE)

Stephen F. Cash	MSFC
Derrick J. Cheston	GRC
Dennis B. Dillman	HQ
Michael G. Gilbert	LaRC
Michael Hagopian	GSFC
David A. Hamilton	JSC
Michael W. Kehoe	DFRC
Dean A. Kontinos	ARC
Brian K. Muirhead	JPL
Shamim A. Rahman	SSC
Timmy R. Wilson	KSC

NESC DISCIPLINE EXPERTS (NDE)

Cornelius J. Dennehy (GSFC)	GNC
Edward R. Generazio (LaRC)	NDE
George D. Hopson (MSFC)	PROPULSION
Robert A. Kichak (GSFC)	POWER & AVIONICS
Julie A. Kramer White (JSC)	MECHANICAL ANALYSIS
Steven G. Labbe ((JSC)	FLIGHT SCIENCES
John P. McManamen (JSC)	MECHANICAL SYSTEMS
Cynthia H. Null (ARC)	HUMAN FACTORS
Robert S. Piascik (LaRC)	MATERIALS
Ivatury S. Raju (LaRC)	STRUCTURES
Henry A. Rotter (JSC)	FLUIDS/LIFE SUPPORT/THERMAL
Steven S. Scott (GSFC)	SOFTWARE

BIOGRAPHIES

OFFICE OF THE DIRECTOR

Ralph R. Roe, Jr
NESC Director

Mr. Ralph R. Roe, Jr. serves as NESC's Director at Langley Research Center (LaRC). Mr. Roe has over 22 years of experience in human space flight program management, technical management, and test engineering. Mr. Roe previously held several key positions in the Space Shuttle Program, including Vehicle Engineering Manager, Launch Director, and Kennedy Space Center Engineering Director.

Dr. Richard J. Gilbrech
NESC Deputy Director

Dr. Richard J. Gilbrech was NESC's Deputy Director at Langley Research Center (LaRC). Dr. Gilbrech joined NESC at its beginning as a Principal Engineer from Stennis Space Center, where he served as Manager of the Program Integration Office responsible for NASA's rocket propulsion test facilities. Dr. Gilbrech has 14 years of combined experience in NASA propulsion, propulsion testing, and the Space Shuttle Program.

In October 2005, Dr. Gilbrech was selected as Langley Research Center's Deputy Director.

Kenneth D. Cameron
NESC Deputy Director for Safety

Mr. Kenneth D. Cameron is an Astronaut and NESC's Deputy Director for Safety at Langley Research Center (LaRC). Mr. Cameron was formerly an NESC Principal Engineer serving at LaRC. Mr. Cameron joined NESC after 7 years in private industry and a career in the U.S. Marine Corps. Mr. Cameron has over 25 years of experience in aeronautics and astronautics as a Naval Aviator, Test Pilot, and Astronaut, and is the veteran of three Space Shuttle missions: Pilot of STS-37 and Commander of STS-56 and STS-74.

Jerry L. Ross, Colonel
NESC Chief Astronaut

Mr. Jerry L. Ross is NESC's Chief Astronaut and is resident at Johnson Space Center (JSC). In addition to Mr. Ross' NESC assignment, he will continue in his current position as Chief of the Vehicle Integration Test Office at JSC. With over 35 years of flight, technical, and managerial experience with the U.S. Air Force and Shuttle Program, Mr. Ross is the veteran of seven Shuttle flights, including nine extravehicular activities, and was a Flight Test Engineer prior to joining NASA in 1979.

Dr. David S. Leckrone
NESC Chief Scientist

Dr. David S. Leckrone is NESC's Chief Scientist and is resident at Goddard Space Flight Center (GSFC). Prior to joining NESC, Dr. Leckrone served as the Senior Scientist for Large Aperture Telescopes at GSFC, and currently is the Senior Project Scientist for the Hubble Space Telescope Program. Dr. Leckrone has over 35 years of experience in NASA astrophysics programs.

BIOGRAPHIES
NASA HEADQUARTERS LIAISON

Wayne R. Frazier
NASA Headquarters Senior SMA Integration Manager

Mr. Wayne R. Frazier currently serves as Senior Safety and Mission Assurance Manager in the Office of Safety and Mission Assurance (OSMA), where he is assigned as the Liaison Officer to NESC, the Office of the Chief Engineer, the Software Independent Verification and Validation Facility in West Virginia, and other remote activities of OSMA. He was formerly Manager of System Safety in the OSMA at NASA Headquarters and has over 30 years of experience in System Safety, Propulsion and Explosive Safety, Mishap Investigation, Range Safety, Pressure Systems, Crane Safety, and Orbital Debris Mitigation.

Keith L. Hudkins
NASA Headquarters Office of the Chief Engineer Representative

Mr. Keith L. Hudkins is the representative from the NASA Headquarters Office of the Chief Engineer to NESC. Mr. Hudkins is resident in the Office of the Chief Engineer at NASA Headquarters, where he serves as the NASA Deputy Chief Engineer. Mr. Hudkins has over 35 years of experience in systems engineering and engineering management, served as the Chief Engineer for the Shuttle Program, and was the Shuttle Orbiter Program Director.

NESC PRINCIPAL ENGINEERS

Clinton H. Cragg
NESC Principal Engineer

Mr. Clinton H. Cragg is a Principal Engineer with NESC at Langley Research Center (LaRC). Mr. Cragg came to NESC after retiring from the U.S. Navy. Mr. Cragg served as the Commanding Officer of the U.S.S. Ohio and later as the Chief of Current Operations, U.S. European Command. Mr. Cragg has over 27 years of experience in supervision, command, and ship-borne nuclear safety.

Steven J. Gentz
NESC Principal Engineer

Mr. Steven J. Gentz is a Principal Engineer with NESC at Langley Research Center (LaRC). Mr. Gentz joined NESC from the Marshall Space Flight Center with over 22 years of experience involving numerous NASA, Department of Defense, and industry failure analyses and incident investigations, including Challenger, Columbia, Tethered Satellite System, and the TWA 800 Accident Investigations.

Dr. Charles E. Harris
NESC Principal Engineer

Dr. Charles E. Harris was a Principal Engineer with NESC at Langley Research Center (LaRC). Prior to joining NESC, Dr. Harris was the Director of the National Institute of Aerospace Management Office at LaRC and has 18 years in senior positions in NASA materials and structures organizations. Prior to joining NASA in 1987, Dr. Harris was a professor of Aerospace Engineering at Texas A&M University (1984-87) and a professor of Engineering Mechanics at Virginia Tech (1980-84).

In October 2005, Dr. Harris was selected to be the Director of the Exploration and Flight Projects Directorate–a newly formed office at LaRC.

BIOGRAPHIES

MANAGEMENT AND TECHNICAL SUPPORT OFFICE

Marc S. Hollander
Manager, Management and Technical Support Office

Mr. Marc S. Hollander is Manager of the Management and Technical Support Office at Langley Research Center (LaRC). Prior to joining NESC in February 2005, Mr. Hollander was the Deputy Assistant Secretary and Chief Financial Officer for the Science and Technology Directorate, Department of Homeland Security. Mr. Hollander started his federal career in 1987 with the Department of Energy (DOE) where he held several key management positions. In 2000, Mr. Hollander was appointed as the first Chief Information Officer for the National Nuclear Security Administration, a separately organized agency within DOE.

SYSTEMS ENGINEERING OFFICE

Dawn M. Schaible
Manager, Systems Engineering Office

Ms. Dawn M. Schaible is Manager of NESC's Systems Engineering Office at Langley Research Center (LaRC). Prior to joining NESC, Ms. Schaible was the Technical Assistant to the Director for the International Space Station/Payload Processing Directorate at Kennedy Space Center. Ms. Schaible has over 18 years of experience in systems engineering, integration, and ground processing for the Space Shuttle and International Space Station Programs.

NESC CHIEF ENGINEERS OFFICE

Stephen F. Cash
NESC Chief Engineer

Mr. Stephen F. Cash is NESC's Chief Engineer at Marshall Space Flight Center (MSFC). Mr. Cash came to NESC from MSFC, where he was the Deputy Project Manager for the Reusable Solid Rocket Motor. Mr. Cash has over 20 years of experience in the design, development, test, and manufacture of large solid rocket motors.

Derrick J. Cheston
NESC Chief Engineer

Mr. Derrick J. Cheston is NESC's Chief Engineer at Glenn Research Center (GRC). Mr. Cheston joined NESC from his prior position at GRC as Chief of the Thermal/Fluids Systems Branch. Mr. Cheston has 21 years of experience in aerospace engineering and management, including mechanical design and testing and thermal/fluids analysis.

Dennis B. Dillman
NESC Chief Engineer

Mr. Dennis B. Dillman is NESC's Chief Engineer at NASA Headquarters. Mr. Dillman came to NESC from the NASA Goddard Space Flight Center (GSFC), where he chaired design reviews for major projects, including the Hubble Space Telescope Servicing Missions, the James Webb Space Telescope, and several Earth Observing System satellites. Prior to his time at GSFC, Mr. Dillman worked at the NASA Johnson Space Center managing Shuttle Orbiter sustaining engineering efforts and training Shuttle flight crews.

BIOGRAPHIES

NESC CHIEF ENGINEERS OFFICE (continued)

Dr. Michael G. Gilbert
NESC Chief Engineer

Dr. Michael G. Gilbert is NESC's Chief Engineer at Langley Research Center (LaRC). Before joining NESC, he was Head of the LaRC Systems Management Office. Dr. Gilbert has over 28 years of engineering, research, and management experience with aircraft, missile, spacecraft, Space Shuttle, and International Space Station Programs.

Michael Hagopian
NESC Chief Engineer

Mr. Michael Hagopian is NESC's Chief Engineer at Goddard Space Flight Center (GSFC). Mr. Hagopian came to NESC from his position as Associate Chief of the Mechanical Systems Division at GSFC. Mr. Hagopian has over 21 years of experience in the development of space and Earth science satellites.

David A. Hamilton
NESC Chief Engineer

Mr. David A. Hamilton is NESC's Chief Engineer at Johnson Space Center (JSC). Mr. Hamilton came to NESC from JSC, where he served as Chief of the Shuttle/Station Engineering Office and also as the Chairman of the Shuttle Chief Engineers Council. Mr. Hamilton has over 38 years of combined experience in NASA manned space flight programs, including Apollo, Skylab, Apollo-Soyuz, ISS, Shuttle, and Mir.

Michael W. Kehoe
NESC Chief Engineer

Mr. Michael W. Kehoe was NESC's Chief Engineer at Dryden Flight Research Center (DFRC). Prior to joining NESC, Mr. Kehoe served at DFRC as the Center Chief Engineer and System Management Office Director. Mr. Kehoe has over 31 years of experience in aeronautical engineering, primarily in experimental flight test.

In October 2005, Mr. Kehoe was selected to be Dryden's liaison in the Crew Exploration Vehicle Flight Test Office at Johnson Space Center.

Dr. Dean A. Kontinos
NESC Chief Engineer

Dr. Dean A. Kontinos is NESC's Chief Engineer at Ames Research Center (ARC). Before joining NESC, he was Chief of the Reacting Flow Environments Branch at ARC, performing and managing research and development in aerothermodynamics, arc-jet testing, and planetary entry design tools. He has 15 years of experience in computational modeling of hypersonic flowfields and the thermal response of hypervelocity vehicles.

Brian K. Muirhead
NESC Chief Engineer

Mr. Brian K. Muirhead is NESC's Chief Engineer, as well as the Center Chief Engineer at the Jet Propulsion Laboratory (JPL). Prior to his position with NESC, Mr. Muirhead was Chief Engineer for the Mars Science Laboratory. Mr. Muirhead has over 28 years of combined experience managing space science missions and experience in spacecraft and instrument systems design, development, integration, test, and operations, including the Galileo, SIR-C, Mars Pathfinder, and Deep Impact missions.

BIOGRAPHIES

NESC CHIEF ENGINEERS OFFICE

Dr. Shamim A. Rahman
NESC Chief Engineer

Dr. Shamim A. Rahman is NESC's Chief Engineer at Stennis Space Center (SSC). Dr. Rahman came to NESC from SSC, where he served as the Chief Engineer for the Propulsion Test Operations Division. Dr. Rahman has 18 years of experience in the engineering of space launch vehicles and test systems, primarily in fluid, thermal, and propulsion systems.

Timmy R. Wilson
NESC Chief Engineer

Mr. Timmy R. Wilson is NESC's Chief Engineer at Kennedy Space Center (KSC). Prior to joining NESC, Mr. Wilson served as Deputy Chief Engineer for Shuttle Processing at KSC. Mr. Wilson has over 24 years of engineering and management experience supporting the Space Shuttle Program.

NESC DISCIPLINE EXPERTS OFFICE

Cornelius J. Dennehy
NESC Discipline Expert

Mr. Cornelius J. Dennehy is NESC's Discipline Expert for Guidance Navigation and Control (GNC) systems and is resident at Goddard Space Fight Center (GSFC). Mr. Dennehy came to NESC from the Mission Engineering and Systems Analysis Division at GSFC, where he served as the Division's Assistant Chief for Technology. Mr. Dennehy has over 25 years of experience in the architecture, design, development, integration, and operation of GNC systems, and space platforms for communications, defense, remote sensing, and scientific mission applications.

Dr. Edward R. Generazio
NESC Discipline Expert

Dr. Edward R. Generazio was NESC's Discipline Expert for Nondestructive Evaluation (NDE) and was a resident at Langley Research Center (LaRC). Dr. Generazio joined NESC after serving as the Branch Head of LaRC's NDE Sciences Branch. He was also responsible for executing the NASA Office of Safety and Mission Assurance Agency-wide NDE Program. Dr. Generazio has over 22 years of experience in NDE.

In October 2005, Dr. Generazio was selected as a Senior Research Engineer in the Research and Technology Directorate at LaRC.

George D. Hopson
NESC Discipline Expert

Mr. George D. Hopson is NESC's Discipline Expert for Propulsion and is resident at Marshall Space Flight Center (MSFC). Mr. Hopson came to NESC from the Space Shuttle Main Engine Project Office, where he served as Director. Mr. Hopson has over 43 years of combined experience in Space Shuttle main engine, space propulsion, space systems dynamics, and project management.

BIOGRAPHIES

NESC DISCIPLINE EXPERTS OFFICE (continued)

Robert A. Kichak
NESC Discipline Expert

Mr. Robert A. Kichak is NESC's Discipline Expert for Power and Avionics and is resident at Goddard Space Flight Center (GSFC). Mr. Kichak came to NESC from the Electrical Engineering Division at GSFC, where he served as the Division's Chief Engineer. Mr. Kichak has over 36 years of experience in spacecraft power, electrical, and avionics systems.

Julie A. Kramer White
NESC Discipline Expert

Ms. Julie A. Kramer White was NESC's Discipline Expert for Mechanical Analysis and is resident at Johnson Space Center (JSC). Prior to joining NESC, Ms. Kramer White served as the Chief Engineer for Orbiter Maintenance Down Period in the Orbiter Engineering Office at JSC. Ms. Kramer White has over 14 years of combined experience in Shuttle and International Space Station structures and mechanics.

In October 2005, Ms. Kramer White was selected as a back-up Principal Engineer in the NESC.

Steven G. Labbe
NESC Discipline Expert

Mr. Steven G. Labbe is NESC's Discipline Expert for Flight Sciences and is resident at Johnson Space Center (JSC). Prior to joining NESC, Mr. Labbe served as Chief of the Applied Aeroscience and Computational Fluid Dynamics Branch at JSC. Mr. Labbe has over 21 years of experience in aerodynamics research applied to programs that include Space Shuttle and X-38.

John P. McManamen
NESC Discipline Expert

Mr. John P. McManamen is NESC's Discipline Expert for Mechanical Systems and is resident at Johnson Space Center (JSC). Prior to joining NESC, Mr. McManamen served in a dual role capacity as the Engineering Directorate's Chief Engineer of the International Space Station and as Deputy Chief of the Shuttle/Station Engineering Office. Mr. McManamen has over 18 years of experience in mechanical systems of the Shuttle Orbiter and International Space Station.

Dr. Cynthia H. Null
NESC Discipline Expert

Dr. Cynthia H. Null is NESC's Discipline Expert for Human Factors and is resident at Ames Research Center (ARC). Before joining NESC, Dr. Null was a scientist in the Human Factors Division and Deputy Program Manager of the Space Human Factors Engineering Project. Dr. Null has 19 years of experience lecturing on Human Factors, and another 14 years of experience in Human Factors applied to NASA programs.

Dr. Robert S. Piascik
NESC Discipline Expert

Dr. Robert S. Piascik is NESC's Discipline Expert for Materials and is resident at Langley Research Center (LaRC). Dr. Piascik joined NESC from the LaRC Mechanics of Materials Branch and the Metals and Thermal Structures Branch, where he served as a Senior Materials Scientist. Dr. Piascik has over 21 years of experience in the commercial nuclear power industry and over 14 years of experience in basic and applied materials research for several NASA programs.

BIOGRAPHIES

NESC DISCIPLINE EXPERTS OFFICE

Dr. Ivatury S. Raju
NESC Discipline Expert

Dr. Ivatury S. Raju is NESC's Discipline Expert for Structures and is resident at Langley Research Center (LaRC). Dr. Raju was the Senior Technologist in the LaRC Structures and Materials Competency prior to joining NESC. Dr. Raju has over 30 years of experience in structures, structural mechanics, and structural integrity.

Henry A. Rotter
NESC Discipline Expert

Mr. Henry (Hank) A. Rotter is NESC's Discipline Expert for Fluids, Life Support, and Thermal Systems, and is resident at Johnson Space Center (JSC). Mr. Rotter joined NESC from the JSC Crew and Thermal Systems Division and the Space Launch Initiative Program, where he was Engineering Manager and the Orbital Space Plane Team Leader for life support and active thermal control teams. Mr. Rotter has over 38 years of life support and active thermal control systems experience during the Apollo, Shuttle, and Orbital Space Plane Programs.

Steven S. Scott
NESC Discipline Expert

Mr. Steven S. Scott was NESC's Discipline Expert for Software and was a resident at Goddard Space Flight Center (GSFC). Prior to joining NESC, Mr. Scott served as the Chief Engineer in the Applied Engineering and Technology Directorate at GSFC. Mr. Scott has over 15 years of experience in satellite software engineering.

In October 2005, Mr. Scott was selected as GSFC's Chief Engineer.

NESC ALUMNI

Frank H. Bauer
NESC Discipline Expert for Guidance Navigation and Control (2003-2004)

Currently participating in the Senior Executive Service Career Development Program at NASA Headquarters

J. Larry Crawford
NESC Deputy Director for Safety (2003-2004)

Left NESC to become Director of Safety and Mission Assurance at the Kennedy Space Center (KSC) and has since retired

Dr. Michael S. Freeman
NESC Chief Engineer at Ames Research Center (ARC) (2003-2004)

Retired

T. Randy Galloway
NESC Chief Engineer at Stennis Space Center (SSC) (2003-2004)

Currently the Deputy Director of SSC's Propulsion Test Directorate

Dr. Steven A. Hawley
NESC Chief Astronaut (2003-2004)

Currently the Director of Astromaterials Research and Exploration Science at Johnson Space Center (JSC)

Danny D. Johnston
NESC Chief Engineer at Marshall Space Flight Center (MSFC) (2003-2004)

Currently serving on a detailed assignment at MSFC in the NASA Chief Engineer's Office

Matthew R. Landano
NESC Chief Engineer at NASA's Jet Propulsion Laboratory (JPL) (2003-2004)

Returned to his assignment at JPL as the Director of Office of Safety and Mission Success

Dr. Paul M. Munafo
NESC Deputy Director (2003-2004)

Currently the Assistant Director for Safety and Engineering and Systems Technical Warrant Holder for Space Shuttle Propulsion at Marshall Space Flight Center (MSFC)

Stan C. Newberry
Manager of NESC's Management and Technical Support Office (2003-2004)

Left NESC to become the Deputy Center Director at Ames Research Center (ARC)

John E. Tinsley
NASA Headquarters Senior Safety and Mission Assurance Manager for NESC (2003-2004)

Currently the Director of the Mission Support Division at NASA Headquarters

NESC Team Members (left to right) Jerry Ross, Ed Generazio, Charlie Harris (in rear), Mike Kehoe, Bob Kichak, and Peggy Chun

Additional information about NESC and its activities can be found at

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Future Opportunities Within NESC

Positions available within NESC can be found through the NASAJobs website at www.nasajobs.nasa.gov

www.nasa.gov

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