

# NASA Engineering and Safety Center 2004 Annual Report



**Engineering Excellence**



“The talented and dedicated men and women working for the NASA Engineering and Safety Center are doing exactly what we had hoped when we initiated this important Center last year. Through an uncompromising attitude toward safety, the NESC is helping NASA to raise the safety bar in everything we do. The results of NESC-led in depth independent engineering assessments, testing, analyses, and evaluation can be seen today in our progress toward returning the Space Shuttle safely to flight, in the flights of the record-breaking hypersonic X-43A research aircraft, and in the history making exploration journeys of the Mars Exploration Rovers Spirit and Opportunity. I am confident that the NESC will play a prominent role in helping to advance NASA’s activities to implement the Vision for Space Exploration in the months and years ahead.”

Sean O’Keefe  
Administrator, National Aeronautics and Space Administration

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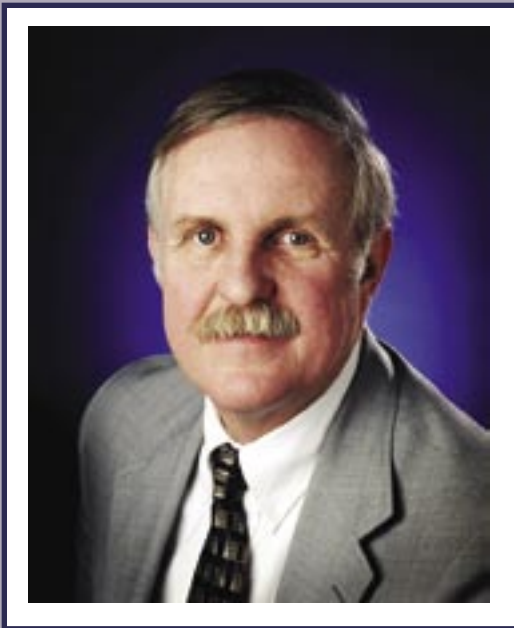
**Bryan D. O'Connor**  
**NASA Chief Safety and Mission Assurance Officer**

“Among the things we learned during the investigation of the Columbia tragedy was the need to dedicate Agency resources to independently assess technical issues for NASA programs and projects. This was the purpose of the NASA Engineering and Safety Center. In its first year of operation the NESC has worked with people across the Agency, from individuals with a concern about mission safety to program managers challenged with complicated technical issues. As we move forward with our return to flight efforts and other Agency flight projects, the NESC is helping us focus on the future of our technical and safety imperatives. We have a responsibility to make our programs as safe and as sound as possible. The realization of the NESC raises our commitment to unprecedented levels.”



**Theron M. Bradley, Jr., NASA Chief Engineer**

“It’s one thing to pledge engineering excellence, it’s another to deliver it. The NESC has some of the top discipline experts from around the Agency and beyond working on Agency priorities. One of the keys to the success of NESC is that these experts are not somewhere in an ivory tower, they are distributed throughout the Agency—forming a vibrant network of ready expertise. This world-class technical team has already conducted or helped conduct numerous assessments representing each NASA Mission Directorate. The NESC has quickly developed into a valuable resource for program managers, engineers, and scientists throughout the Agency.”



**Roy D. Bridges, Jr.**  
**Director, NASA Langley Research Center**

“Last year, when NASA Administrator Sean O’Keefe announced plans to create an independent Engineering and Safety Center, he charged its leadership with improving the Agency’s ability to share technical information, practices and talent, and independently ensure that we are in the best position to achieve mission success. Today, after the first 12 months of operation, the NESC has substantially achieved that goal. A strong team has been assembled, programs and projects around the Agency have benefited from NESC consultations and in depth assessments, and the demand for NESC assistance is rapidly growing. I look forward to the next 12 months, as the NESC is now poised to provide an informed look at our high-risk, high-pay-off initiatives and to do so more proactively.”





*NESC Team - Fall 2004 Conference.*



**Ralph R. Roe, Jr.**  
**Director NESC**

This year has seen one of NASA's newest organizations grow into an accomplished technical team supporting the Agency's high-risk endeavors. On July 15, 2003, Administrator Sean O'Keefe announced plans to create the NASA Engineering and Safety Center (NESC) at Langley Research Center with the purpose of providing a central location to coordinate and conduct robust, independent engineering and safety assessments across the Agency. Within its first year of operation, the NESC has demonstrated its ability to perform independent, in depth, value-added technical assessments, analyses, and tests. We have received nearly 100 requests for involvement from all across the Agency, as well as from external sources. While our priority this year has been the Space Shuttle and International Space Station Programs, we have been involved with each NASA Mission Directorate.

The NESC performs all of its activities using a diverse mix of talent from across the Nation. Our success is due in large part to the impressive team that we have established by drawing from the best and brightest at each Center. We owe a debt of gratitude to the Centers for allowing their technical experts, and future leaders, opportunities to help meet the Agency's overall goals. The NESC has demonstrated the true spirit of One NASA and has reaped the benefits that come from sharing our knowledge, experiences, and resources.

As we begin our second year of operation, we will look for innovative ways to proactively uncover problems and issues within NASA projects and programs. We will continue to communicate our broadly applicable lessons learned to the Agency's senior leadership and the entire NASA community. We will also establish new ways to share the tremendous knowledge that is resident in our expert teams.

As the NESC team evolves and our processes mature, we will continue to set an example of technical rigor, open communications, and perseverance in meeting our goal of safety through engineering excellence—we will not settle for less!

# NESC

## NESC Background

The NASA Engineering and Safety Center (NESC) is chartered to serve as an Agency-wide technical resource focused on engineering excellence. The NESC's objectives are to improve safety by performing in depth, independent engineering assessments, testing, and analysis to uncover technical vulnerabilities and to determine appropriate preventive and corrective actions for NASA's high-risk programs, projects, and institutions.

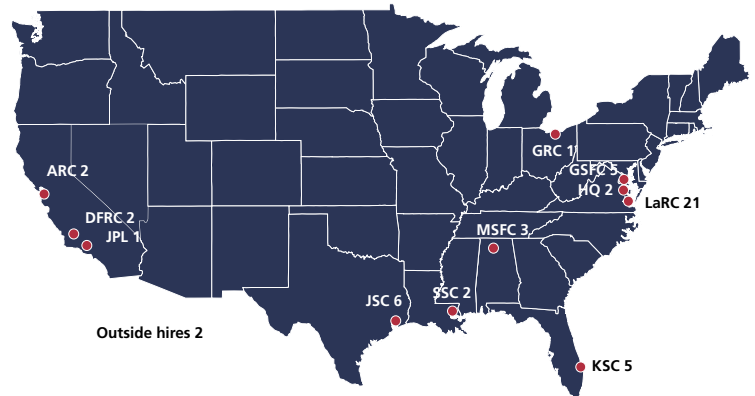
Historically NASA's safety philosophy has had three tenets: (1) strong in-line checks and balances, (2) a healthy tension between design and operations organizations, and (3) value-added independent assessments. The NESC strives to set an example for a strong safety culture by providing knowledgeable leadership to perform value-added technical independent assessments in an open environment while attacking problems and issues with unequaled tenacity.

The NASA Chief Safety and Mission Assurance Officer and the NASA Chief Engineer jointly establish direction and provide guidance for the NESC. The NESC gains its independence through two means. First, the NESC is funded through the Chief Safety and Mission Assurance Office. Second, the NESC provides an independent line of communication to ensure all NASA employees have an alternate path to report technical concerns and to encourage consideration of all points of view regarding critical technical issues.

To accomplish its goals, the NESC draws upon the best engineering expertise from across the Agency and utilizes partnerships with other government agencies, national laboratories, universities, and industry. In addition, the NESC operates as a true One NASA organization, engaging all NASA Centers and Headquarters in the mutual goal of increasing safety through engineering excellence.



On July 15, 2003, NASA Administrator Sean O'Keefe announced plans to create the NESC.



The NESC is a true One NASA organization with members selected from all NASA Centers and external to the Agency (as of September 30, 2004).

# Overview

The NESC's unique insignia has its roots in the early Mercury Program.

“ ... I named my spacecraft Sigma Seven. Sigma, a Greek symbol for the sum of the elements of an equation, stands for engineering excellence. That was my goal—engineering excellence. I would not settle for less ... ”

—from “Schirra’s Space” by Wally Schirra

For the NESC, the Sigma also represents engineering excellence. While Wally Schirra’s spacecraft represented the seven Mercury astronauts, the ten in the NESC insignia represents the ten NASA Centers. The NESC draws upon the resources of the entire Agency to ensure engineering excellence.



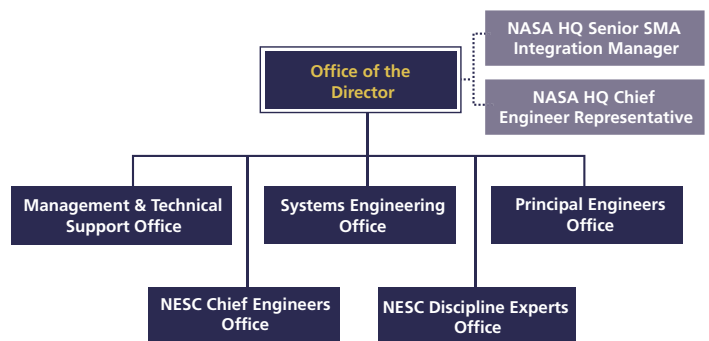
## NESC Model

The NESC model is based on best practices from the U.S. Navy’s Submarine Safety (SUBSAFE) program, the Naval Nuclear Propulsion Program, and the Board of Inspection and Survey, which has been performing inspections of the Navy fleet for over 135 years. The NESC model consists of a decentralized organizational structure reaching across all NASA Centers and reporting to the NESC management office at Langley Research Center (LaRC).

NESC Chief Engineers, resident at each Center, provide insight into their Centers’ programs and projects. The NESC Discipline Experts lead Super Problem Resolution Teams, which are made up of discipline experts across the Agency, industry, and academia. This concept positions the technical experts where the problems are so that they stay sharp.

NESC Principal Engineers provide leadership for teams of discipline specialists performing independent technical reviews, assessments, tests and analyses of complex, multidisciplinary systems. The Management and Technical Support Office is responsible for all business management and administrative support to the NESC. The Systems Engineering Office is responsible for conducting independent systems engineering reviews and for providing proactive trending and identification of problem areas before failures occur.

The NESC relies on matrixed personnel support from the NASA Centers to conduct its activities. The use of these “ready experts” is negotiated with each Center. In addition, collaborations with external organizations including other federal agencies, national laboratories, universities, and expert consultants supplement the NESC work force, as appropriate.



*NESC leadership team offices.*

## NESC Operations

The NESC remains active by participating in major program reviews and control boards to gain insight into program decisions and technical rationale. This insight is used to determine if a situation warrants an independent technical assessment or analysis of known risk areas. The NESC also accepts requests for involvement from all across the Agency, as well as from numerous external sources.

The NESC reviews and processes all requests for involvement in a timely manner. The NESC Systems Engineering Office first reviews the request to determine if the concern is within the scope of the NESC's charter. If not, the request is referred to another organization for further action, with concurrence from the NESC Director. Requests within scope are assigned to an NESC Chief Engineer (NCE) for further evaluation. The NCE will investigate details regarding the concern, evaluate actions taken by the project, and assess relative risks to safety, mission assurance, and national importance. The NCE will then present the findings to the NESC Review Board, which reviews and approves all requests based on a selection and prioritization process.

Once the review board approves a request, a team is assembled to address the specific issue at hand. The NESC's goal is to provide engineering data to back up its judgments and positions. As a result, many NESC activities include independent testing and analysis.

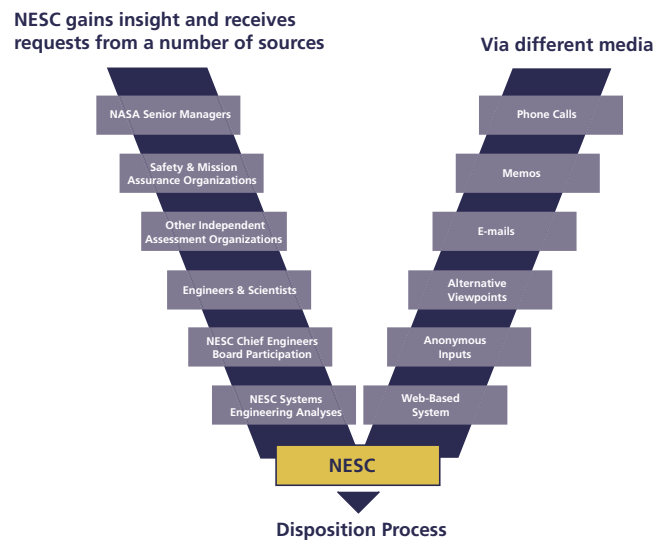
The NESC Review Board is made up of the NESC leadership team and represents all NESC organizational offices. In addition to initial request approvals, the NESC Review Board also provides peer reviews of ongoing assessments; ensures consistency and technical adequacy of all reviews prior to release to the customer; determines if any follow-up activity is required after the review; and provides direction for use of all resources including critical skills, facilities, testing, and analysis.

The final product of all official NESC technical activities is a report or position paper. The technical discipline and rigor that peer-reviewed formal documentation achieves are important to the NESC in its mission to provide engineering excellence.

## NESC Activities

NESC requests for involvement are typically implemented through one of four NESC activity categories:

**Technical Assessments** include the testing, analysis, and evaluation to determine appropriate preventive and corrective actions for recognized problems, trends, or issues within NASA programs. A multidisciplinary team of experts conducts each technical assessment. This approach has been modeled after the "tiger team" concept often used by programs to solve the most challenging problems.



*The NESC uses many methods to determine where technical issues exist.*

**Technical Inspections** are used to proactively evaluate the technical adequacy of a particular area within a program, even if a problem has not yet been detected. Examples of potential inspection areas include math models, analytical tools, manufacturing procedures, test procedures, vehicle processing, troubleshooting techniques, manufacturing tooling, ground support equipment, or special test equipment.

**Technical Consultations** are provided when the scope of a problem or concern does not warrant a full assessment. A technical consultation can also be provided when an NESC member joins an existing review team or monitors an existing operation or process.

**Technical Support** is provided by making the NESC's network of experts and catalog of resources available to programs, projects, and NASA Centers. The requesting organization funds the effort, which is not considered an NESC endorsed activity. The NESC remains independent of the activity, and any individuals called upon by the requesting program or NASA Center would not be available to perform a Technical Assessment on the same issue.

Through the aforementioned activities, the NESC provides technical advocacy and encourages alternate viewpoints. The NESC serves as a technical advocate by providing technical expertise, testing, or analysis in support of SMA organizations, institutional engineering, and programs and projects as deemed necessary. The NESC is also refining the skills of key personnel to provide the Agency with individuals qualified to lead mishap investigations.



The NESC promotes the positive actions taken by individuals, programs, or projects to correct identified technical inadequacies. The NESC has established a disciplined process to encourage this open environment and to solicit alternate perspectives. As a matter of practice, each Independent Technical Assessment will seek out alternate viewpoints for review and evaluation. Each report and briefing will document and address these viewpoints.

### **Proactive Nature of NESC**

The NESC's Super Problem Resolution Teams are working to advance the level of knowledge within their disciplines by proactively engaging in issues across the Agency, reviewing trends, and seeking out opportunities to develop new technologies. The NESC will also test and analyze critical issues that no particular program is currently working.

The Agency has chartered the NESC with performing independent trend analysis, not only within programs but also across programs, to identify potential concerns before they become major problems.

Currently, there are multiple independent efforts underway within NASA to improve trending and data collection; however, without uniform requirements, new and dissimilar standards are evolving. Therefore, the NESC has assumed the lead for independent technical data mining and trending in the Agency. The goal is to find unknown indicators of future problems, not to duplicate the program-specific trending efforts. The data critical for detecting these indicators exist in a plethora of dissimilar nonconformance databases without a common format or taxonomy. However, one common database is not required if the right standards and electronic tools can be employed.

The NESC began its trending effort by hosting a workshop for trending experts from industry, academia, and government in the spring of 2004. Current efforts are focused on the Space Shuttle and International Space Station Program Recurring Anomalies review and the evaluation of electronic tools to facilitate trending. Near-term plans include holding workshops to review best practices and pitfalls in the areas of data mining and trending, developing a common data taxonomy to facilitate trending objectives, and benchmarking electronic tools to enable these activities.

*LaRC technician William T. Howard examines the results of a new testing method developed by the NESC to detect microscopic cracks in a specific area of the Space Shuttle Orbiter Main Propulsion System.*



## Communication – Lessons Learned and Leadership Briefing

Following NESC activities, lessons learned are submitted to NASA knowledge management systems. Working with the Office of the Chief Engineer and the SMA community, the NESC ensures that implementation plans are developed and executed for the most important broadly applicable lessons learned. A compilation of NESC lessons learned is included later in this report.

The NESC has also instituted biannual Leadership Briefings. These briefings are based on a similar model used by the U.S.

Navy's Board of Inspection and Survey that formulates inspection results into summary reports and presents them to commanders and managers at periodic Leadership Briefings. The NESC Leadership Briefings target senior leadership within the Agency, communicating broadly applicable lessons learned to those who can implement change within their organizations. The NESC held the first Leadership Briefing on May 12, 2004, at NASA Headquarters. Subsequent briefings will be conducted in conjunction with Agency Administrator Retreats.



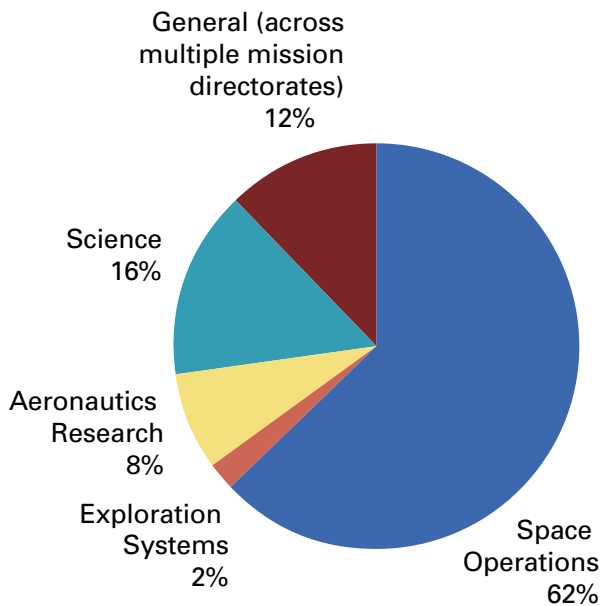
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## First Year Metrics and Budget

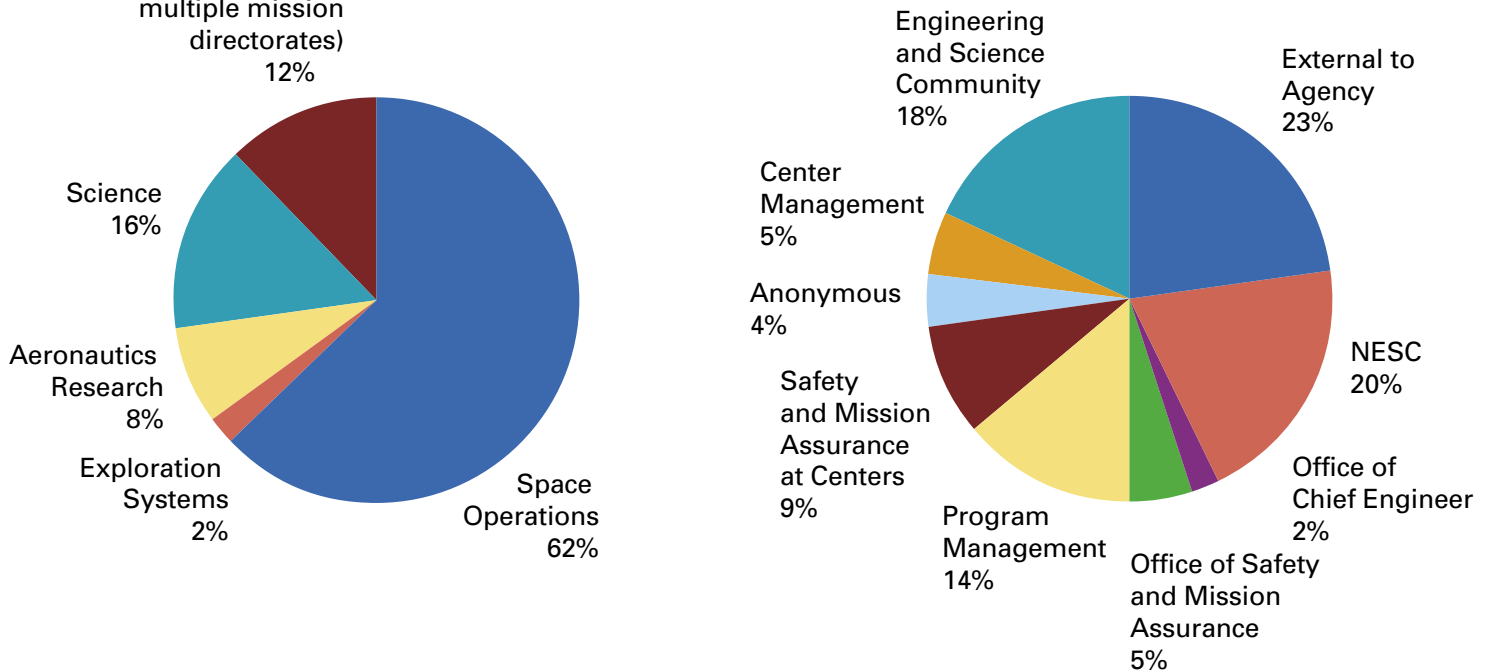
During its first year of operation, the NESC has seen a steady increase in requests for its technical expertise with nearly 100 requests processed by September 30, 2004. While a majority of the NESC's efforts in FY04 have been in support of the Space Shuttle and International Space Station Programs, the NESC has also assessed high-risk programs across all Mission Directorates, including CALIPSO, Cassini, Genesis, Hubble Space Telescope, and X-43A.

The NESC's major product line in its portfolio is Independent Technical Assessments. A significant portion of the NESC's funding goes directly to conducting these assessments. Over the first year, experience shows that these assessments vary widely in duration and cost. NESC funding is also dedicated to establishing the underlying capability to manage and support these assessments along with numerous other products.

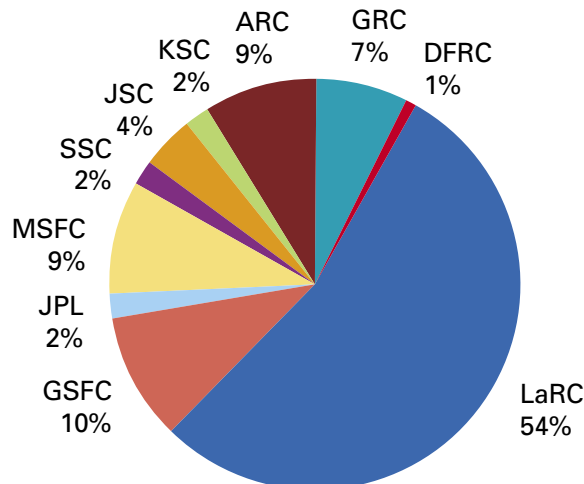
NESC Requests by Mission Directorate

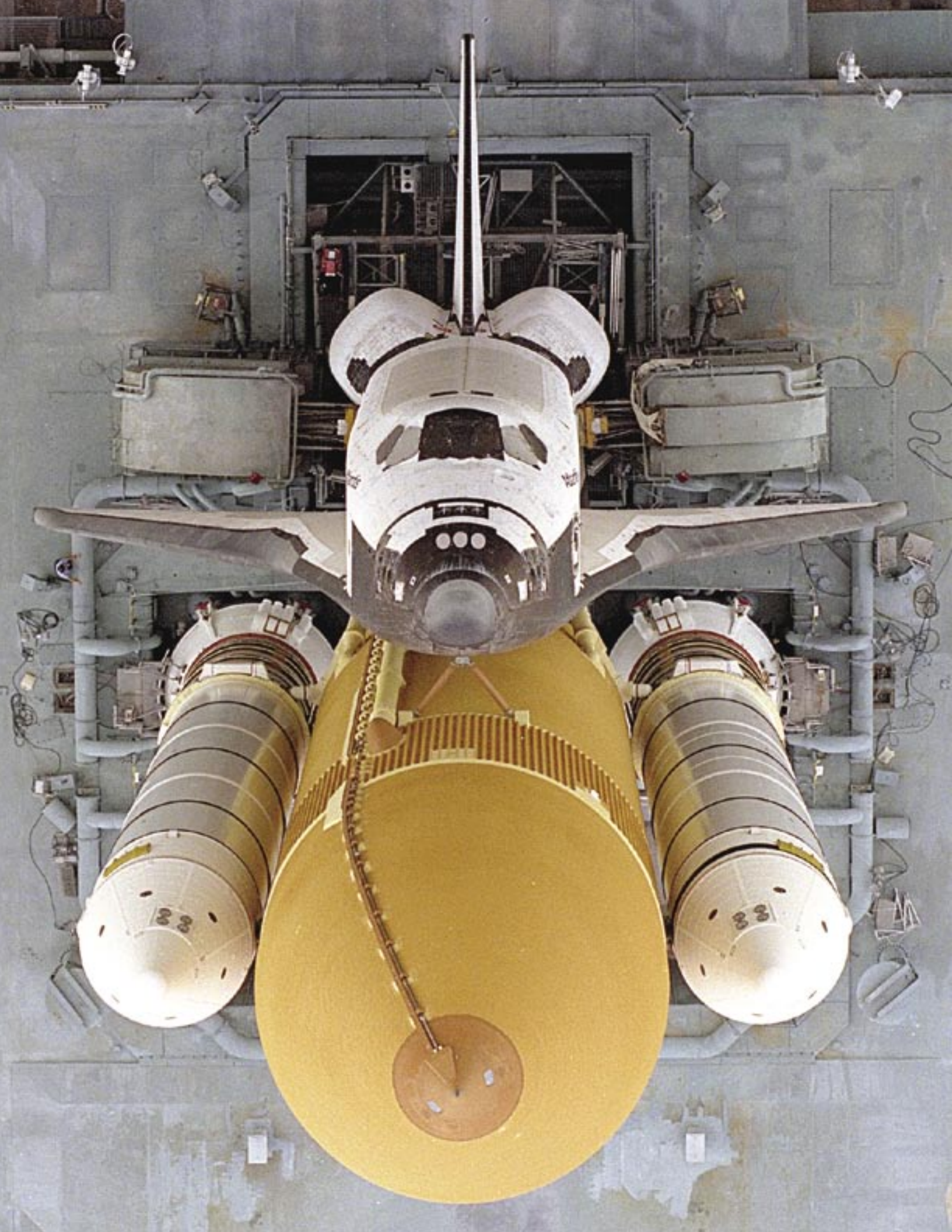


Sources of NESC Requests



NESC FY 2004 Expenditures (\$45M)





# Major Technical Assessments Completed

## Space Operations

### Space Shuttle Orbiter Rudder/Speed Brake Braycote® Grease

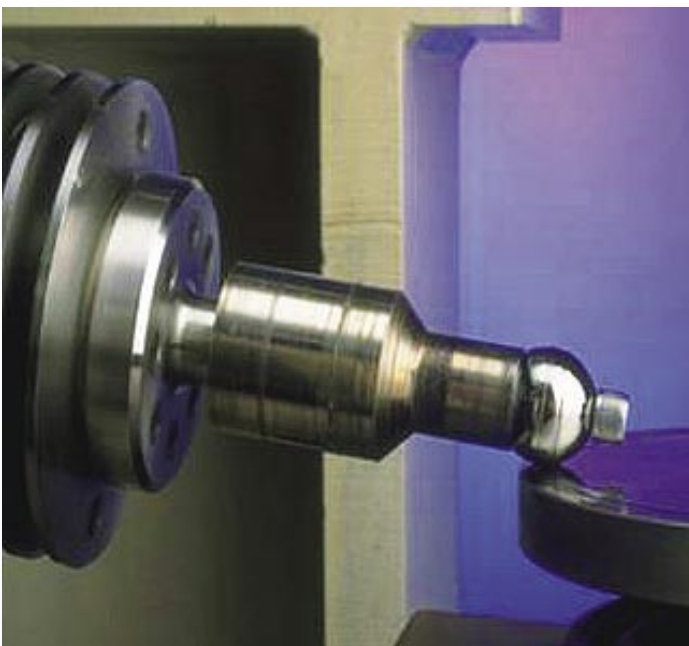
The Space Shuttle Orbiter rudder/speed brake system provides steering and braking for the Orbiter during landing. After the decision was made to replace Orbiter Discovery's rudder/speed brake actuators with spares that had been in storage, concerns were raised over effects of potential grease degradation because storage time exceeded the original certified life. The NESC conducted extensive testing and performed analyses to determine that while separation of the grease did occur, it did not adversely affect its lubrication properties. Furthermore, analysis showed that the chemical breakdown of the grease into acidic components, and

resultant corrosion, could not occur during static storage. The NESC recommended that the stored actuators were safe for use on the Orbiter Discovery.

**Lesson:** Programs should periodically review hardware components to ensure that they are operating within qualification and certification limits. When hardware exceeds these limits, testing or analysis should be performed to properly envelop the actual operational environment.



*Rudder/speed brake and parachute fully deployed.*



*Wedeven Associates Machine test apparatus simulates rolling and sliding wear conditions in the rudder/speed brake actuator gears.*



*Looking up at an Orbiter's vertical stabilizer. Three rudder/speed brake actuators are visible.*

## Orbiter Main Propulsion System Liquid Hydrogen Feedline Flowliner

Each Space Shuttle Main Engine (SSME) burns liquid hydrogen and liquid oxygen to develop over a half-million pounds force of thrust. Inspections revealed cracks in the gimbal joint flowliners that direct liquid hydrogen into the low pressure fuel turbopump of the SSME. Each gimbal joint has a mated pair of 12-in. diameter thin walled flowliners (upstream and downstream) to facilitate flow through the movable joint. The cracks were located at the flowliner slots that facilitate cleaning during manufacturing and allow release of trapped propellant. Flight critical issues included loss of flowliner structural integrity and metallic foreign object debris ingestion by the SSME. All detectable cracks were repaired through welding and all slot edges were polished to remove defects that could start new cracks. Subsequent ground tests conducted in the SSME test stand at the Stennis Space Center resulted in measured strains considerably higher than expected in two different flowliner test articles. These results cast doubt on long-term validity of the postrepair flight rationale.

Responding to a request from the Orbiter Project Office, the NESC determined that the most likely root cause of the cracks was high cycle fatigue due to flow-induced vibration. Stress concentrations due to slot geometry and surface defects from the manufacturing process accelerated crack initiation and growth. The NESC con-

cluded that repair actions taken in 2002 rendered the Orbiters safe to fly but required postflight inspections of the flowliners. The most difficult challenge to overcome in the NESC assessment was the high degree of uncertainty in loads acting on the flowliner. This uncertainty was due to differences between the ground test article and the flight hardware. To analyze flowliner issues, the NESC developed fatigue loading spectra for nominal flight conditions and refined three-dimensional fracture mechanics analysis methods that couple crack growth kinetics directly to the structural dynamics. The NESC also developed a high fidelity inspection method for in situ examination of the flowliner slots. The NESC qualified the edge replication method, which can detect fatigue cracks down to 0.005-in. in length and characterize the flowliner slot surface finish. The NESC used results of these efforts to establish a strategy for developing a flight rationale for the flowliner flight certification.

**Lesson:** Ground testing should be conducted in a configuration as close to flight as possible. Where differences between ground and flight configurations or environments are necessary, every effort to correlate the ground test data to actual flight situations must be made. Complex subsystems like propulsion may require ground test articles to be maintained throughout a program's lifetime.



*Scott Willard of LaRC identifying cracks in the Space Shuttle Main Engine flowliners. Flowliner slot surface replicas are made (right inset) and then examined under a scanning electron microscope.*

## Space Shuttle Reaction Jet Driver

Four avionics boxes on each Orbiter, known as Reaction Jet Drivers (RJDs), control the six vernier and 38 primary reaction control thrusters 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. An NESC assessment of this scenario focused on two RJD failure modes: shorting of the RJD Darlington pair transistor switch and a “smart” wire-to-wire short between a power wire and an RJD thruster command wire.

New failure mechanisms, such as age degradation and latent manufacturing defects, were identified during the assessment. Whereas some transistors and wires in the Orbiter fleet are over 25 years old, no data exist on aging effects and no known test is currently available to assess age degradation of the Space Shuttle’s Kapton® wiring. The various probabilistic risk assessments (PRAs) performed by both the Space Shuttle Program and the NESC produced a wide range of results. All transistor PRAs used MIL-HDBK-217 as an absolute source for field (in-service) failure prediction, despite the handbook’s known limitation as a design trade tool.

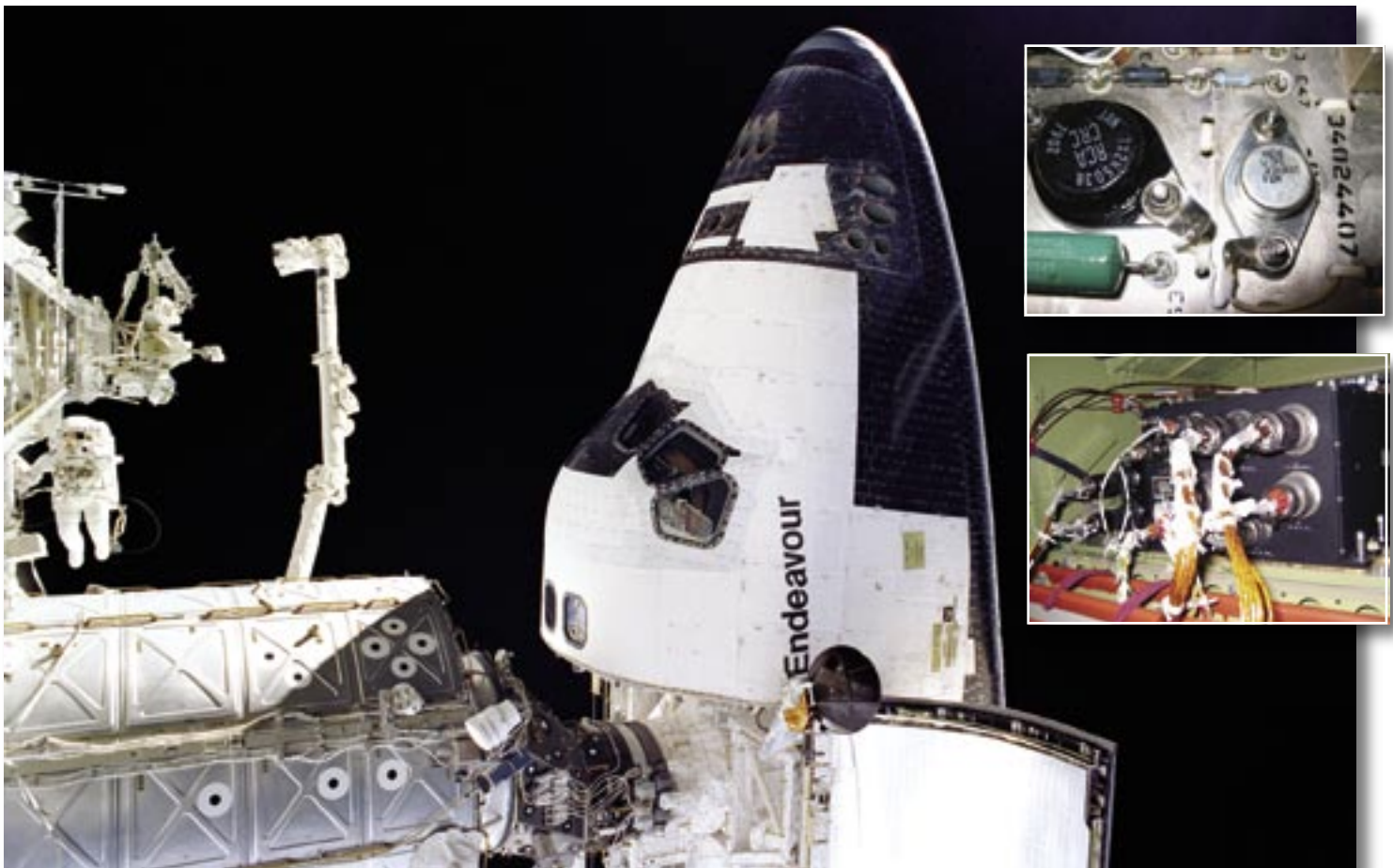
Due to uncertainty in the various PRAs, the NESC, in coordination with the Space Shuttle Program, is conducting electrical

characterization testing and destructive physical analysis of RJD transistors from flight assets to determine the potential effects of aging and manufacturing defects. The NESC recommended adding a new preflight leakage current test to assess transistor health and replacement of RJD command wires with new, better protected wiring that would be separated from power wires. Both recommendations are under consideration by the Space Shuttle Program and will be discussed jointly with the International Space Station Program for final disposition.

**Lesson:** Effects of aging, operation, and environmental exposure should be factored into expected operational life of new vehicle designs. Reliability prediction methods should include aging effects.

**Lesson:** MIL-HDBK-217 is not suited as an absolute quantitative tool to predict the likelihood of electronic part failures in space systems and does not include parts aging, leading to potential overestimations of part reliability.

**Lesson:** Programs that share physical interfaces, and therefore risks, should ensure that responsibility for integrated hazards is clearly defined and that the system requires periodic reviews of these hazard reports.



*RJD electronic components and wiring (inset) are undergoing analysis. Endeavour’s forward thrusters are visible.*

## Kennedy Space Center PCGOAL Data Integrity

The Kennedy Space Center (KSC) SMA organization requested that the NESC assess an analytical approach developed to evaluate and retire Space Shuttle data corruption Critical Item List (CIL) items. Many CIL items resulted from a System Assurance Analysis (SAA) performed on the KSC engineering advisory tool PCGOAL (Personal Computer Ground Operations Aerospace Language). This computer system is used to verify test requirements, make critical launch commit criteria violation calls, and support real-time decisions during hazardous testing. Space Shuttle Program requirements drove a quantitative look at undetected errors and the risk of data corruption inherent in network equipment. In response, the KSC engineering community developed a method of assessment intended to eliminate CIL items entirely by classifying the failures as “not credible.” Resolution of this issue has the potential for wide application to many additional data corruption SAAs.

The NESC was in general agreement that the method and analyses proposed by the KSC engineering community are consistent with good engineering practice. The assessment team identified some areas for additional work and recommended independent verifica-

tion and validation of PCGOAL. It was noted that a small possibility of undetected errors can always exist in networked systems. To classify undetected errors as “not credible” requires that clear metrics and reliability or availability criteria be defined and agreed upon. While quantitative requirements for the PCGOAL system were not provided, performance is continually monitored and has been acceptable. The NESC concurred with the validity of higher level network provisions, such as error detection and correction and standard packet transmission protocols, as appropriate mitigations for transmission errors. The NESC concluded that it would be technically acceptable, and in fact preferred, to include the entire network path as a single item on the CIL for the purpose of assessing data integrity risks. Individual components need not be identified and tracked as critical items as the CIL process currently requires, but are subject to appropriate performance monitoring and tracking by a network problem reporting and corrective action system.

**Lesson:** The existing CIL process is not well suited to complex data processing networks. Programmatic requirements to allow alternate approaches may require further discussion.



*PCGOAL is used to support engineering analysis during testing and launch operations at the KSC Launch Control Center.*



## CALIPSO

The Cloud-Aerosol LIDAR and Infrared Pathfinder Satellite Observation (CALIPSO) spacecraft is a joint science mission among the Centre National d'Etudes Spatiales, Langley Research Center, and Goddard Space Flight Center. The Earth Science satellite mission is scheduled for launch on a Boeing Delta II rocket from Vandenberg Air Force Base in 2005. Concerns raised about the hydrazine-fueled spacecraft propulsion bus led to the NESC providing a review of the bus design and an assessment of the potential for personnel exposure to hydrazine propellant. During the NESC review of the propulsion bus design, it became evident that concerns about early design decisions were still prevalent, even though the bus assembly was already complete. Contributing to these lingering concerns were the different interpretations by each organization involved of an ambiguous requirement for fault tolerance. Following assessment, the NESC issued a final report outlining 11 requirements for the CALIPSO Project to address in order to ensure the risk to personnel is acceptable.

**Lesson:** NASA must establish unambiguous requirements for fault tolerance.

**Lesson:** In a project's design phase, a thorough risk assessment must be performed to ensure the final design presents the overall minimum risk to personnel, the mission, and the environment. While current NASA policy does require a risk assessment, it is important that an assessment consider potential hazards through the project's entire life cycle, including ground processing and integration.

**Lesson:** At the beginning of a project involving outside partners, NASA must clearly define and document its expectations, including the standards, specifications, and processes that should be followed by all parties.

### *The NESC Safety and Mission Assurance Working Group*

*The NESC Deputy Director for Safety chairs a Safety and Mission Assurance (SMA) working group, which includes membership from each Center's SMA organization. The working group meets to discuss NESC activities and communicate information on significant program problems or issues under SMA review at each Center. The working group provides an independent avenue for SMA organizations to bring their problems forward to the NESC.*



*The CALIPSO satellite, an international partnership with the French Space Agency, CNES, is prepared for environmental testing in Cannes, France.*

## Mars Exploration Rovers

The Mars Exploration Rovers (MERs), Spirit and Opportunity, were designed to geologically explore the surface of Mars. Prior to Rover landings on Mars, the NESC provided technical expertise in support of two MER reviews. The first included a human factors review of ground operations. Because Martian and Earth days differ in length, the staff and mission scientists must cover work periods around the clock that change in start time by 40 minutes each day. In preparation for Opportunity's landing, the NESC also supported the MER data review process of Spirit's entry, descent, and landing phase. Deviations from the expected angle of attack of the entry vehicle during entry, descent, and landing for Spirit and Opportunity raised several issues potentially relevant to future planetary missions. Instrumentation currently flown (or planned for future missions) is not adequate to distinguish the separate effects of density and drag coefficient value errors on aerodynamic forces encountered during entry, descent, and landing.

**Lesson:** NASA should implement and enforce the work time limits for critical operations across the Agency as outlined in NASA Procedural Requirement 1800.1.

**Lesson:** Future planetary missions should include instrumentation to assess entry performance and adequately characterize the environment encountered during entry, descent, and landing.

*"The NASA Engineering and Safety Center is an important resource to have for both the hardware development and on-orbit operations of the International Space Station".*

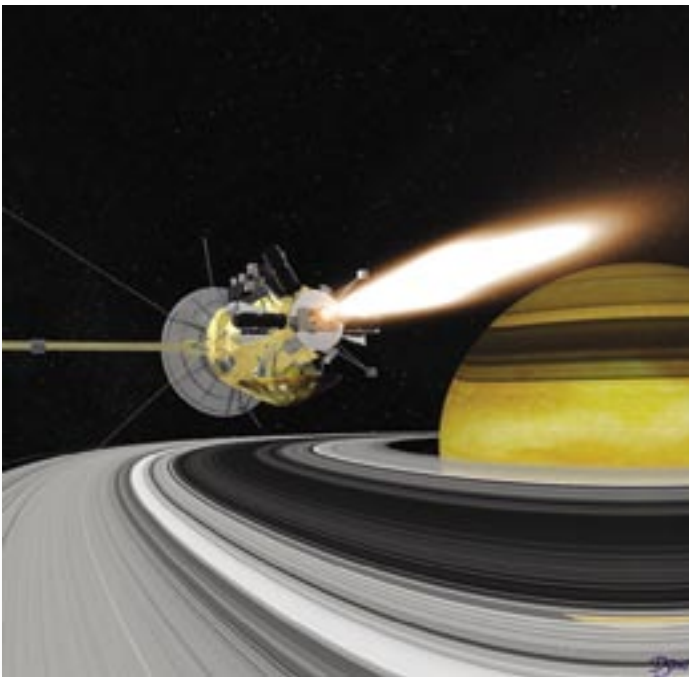
*William H. Gerstenmaier  
Manager, International Space Station Program*



*Mars Exploration Rover Opportunity looks back at its lander in the Eagle Crater and the surrounding plains of Meridiani Planum, Mars.*

## Cassini Saturn Orbit Insertion

NESC team members, with expertise in systems engineering, guidance, navigation and control, and propulsion, supported the Cassini Critical Events Readiness Review and subsequent meetings that led to the Saturn Orbit Insertion (SOI) maneuver. While the team agreed that the project was well prepared for the Saturn Orbit Insertion maneuver, the NESC and Cassini Project Team boards identified several items that needed to be addressed prior to SOI. The consultants expressed concerns over the SOI fault protection logic and recommended that an independent review team pour through this logic to ensure it is robust. They also recommended hiring a dedicated lead for the Operations Readiness Team to improve operations simulations and contingency planning prior to SOI.



*An illustration of the Cassini spacecraft performing its Saturn Orbit Insertion maneuver.*

## Genesis Reviews

NESC team members attended the Genesis Systems Risk Review and two Critical Events Risk Reviews prior to the reentry activities. They provided guidance to the Genesis team that proved invaluable during the entry operations. In particular, the NESC members' recommendation to flesh out a more stringent reentry contingency plan put the Genesis team in a better preparedness state for the unfortunate events that were to come. The unexpected hard landing of the Sample Return Capsule required engagement of landing site contingency procedures that the NESC stressed during these reviews. Other NESC findings from these reviews helped produce more robust nominal and contingency operations procedures. These procedures enabled the team to clearly articulate how navigation predictions relate to expected vehicle landing sites.

## Genesis Sample Return Capsule Reentry Data

Reentry of the Genesis Sample Return Capsule on September 8, 2004, was the first reentry occurring at superorbital speed since the Apollo Program. Several others will follow at such speeds over the next decade. The NESC was approached with a proposal to use a U.S. Air Force aircraft outfitted with instrumentation and expertise provided by the Search for Extraterrestrial Intelligence (SETI) institute to observe the event and acquire spectroscopic data (optical, infrared, and ultraviolet) as well as high-definition television imaging. Imaging of the reentry segment of the Genesis Sample Return Capsule could provide highly leveraged data for the design, analysis, and risk management of future entry systems. The data would be particularly relevant to the Exploration Mission Office, which will have Earth return segments from the Moon and Mars. The NESC funded a spectrographic observation campaign to obtain spectral intensity of the high temperature gas flowfield around the vehicle. The NESC could then compare total radiative intensity with existing models used for aerothermodynamic design to either validate or refine prediction methods.



*"The NESC's purpose is to provide independent technical expertise for engineering, safety, and mission assurance to augment the capabilities inherent in NASA's programs."*

*Sean O'Keefe, NASA Administrator*



## X-43A Prediction of Transonic Aerodynamics

The X-43A is a prototype hypersonic aircraft mounted on a modified Pegasus booster rocket that accelerates the X-43A to its test speed and altitude. The modified Pegasus/X-43A stack is launched from the NASA B-52B aircraft. The NESC received a dissenting opinion concerning validity of the aerodynamic database used for flight control design with a potential consequence of vehicle control loss during flight and failure to achieve mission objectives. Working in conjunction with the X-43A project, the NESC ensured that the aerodynamic issues were properly addressed through the program's existing independent Flight Readiness Review (FRR) process. The role of the NESC was to confirm that the independent FRR committee adequately reviewed, investigated, and responded to the dissenting opinion. The NESC concluded that the FRR process used by Dryden Flight Research Center for the X-43A provides a more robust review process than the single meeting method used by many programs.

Committee membership is established independently of the project and comprises the necessary technical expertise required to provide a thorough assessment. The committee reviews project readiness at several stages prior to flight, allowing adequate response time for FRR initiated actions and appropriate follow-up of identified technical issues. This process also provides a mechanism for receiving and resolving dissenting opinions and can draw upon expertise and skills from across the Agency. Adequate and thorough assessment of dissenting opinions can produce a better understanding of engineering data, leading to either modification or reaffirmation of risk assessment for safety and mission success.

**Lesson:** Dryden Flight Research Center's Flight Readiness Review process (Dryden Handbook DHB-X-001) provides for a robust, independent review of a project's readiness for flight and should be adopted across the Agency.

**Lesson:** The NESC is implementing a strategy for addressing dissenting opinions. Other organizations within NASA need to develop strategies for handling dissenting opinions.



*The second X-43A research vehicle is prepared for its record setting flight.*

## Hubble Space Telescope Battery and System Health Assessment

The Agency is investigating alternate servicing for the Hubble Space Telescope (HST). Two efforts in support of this activity involved NESC assessments of the nickel-hydrogen (Ni-H<sub>2</sub>) battery remnant life and overall system health of the HST. These assessments generated recommendations that aided in an Agency decision to continue with the robotic service mission concept to the Critical Design Review phase.

The assessments identified several observations. One observation resulted from the fact that the battery bays were not redesigned to accommodate generation of additional charging heat when nickel-cadmium batteries were replaced with Ni-H<sub>2</sub> batteries. This change resulted in a narrow heat dissipation margin, which constrained the options for battery capacity maintenance. Another observation was that while a total ionizing dose exposure level evaluation was performed for the 15-year design life of the original HST electronic components, it was not readily verifiable that an updated analysis was performed for the extended 2013 end-of-life.

NESC assessments generated recommendations involving improved battery life predictions and potential reconditioning protocol to minimize additional capacity losses. In addition, the system health evaluation identified several subsystems that require further examination for potential life reduction impacts and made recommendations to the servicing manifest.

The NESC also recognized the HST Program's foresight in maintaining skilled operations and sustaining engineering experts capable of observing subtle performance changes, in generating inventive work arounds and in preparing multilevel contingency plans. The HST Program's commitment to retain engineering units and test facilities enabled verification of proposed enhancements and proved invaluable in demonstrating the robotic servicing concept.



*HST batteries (flight spares).*

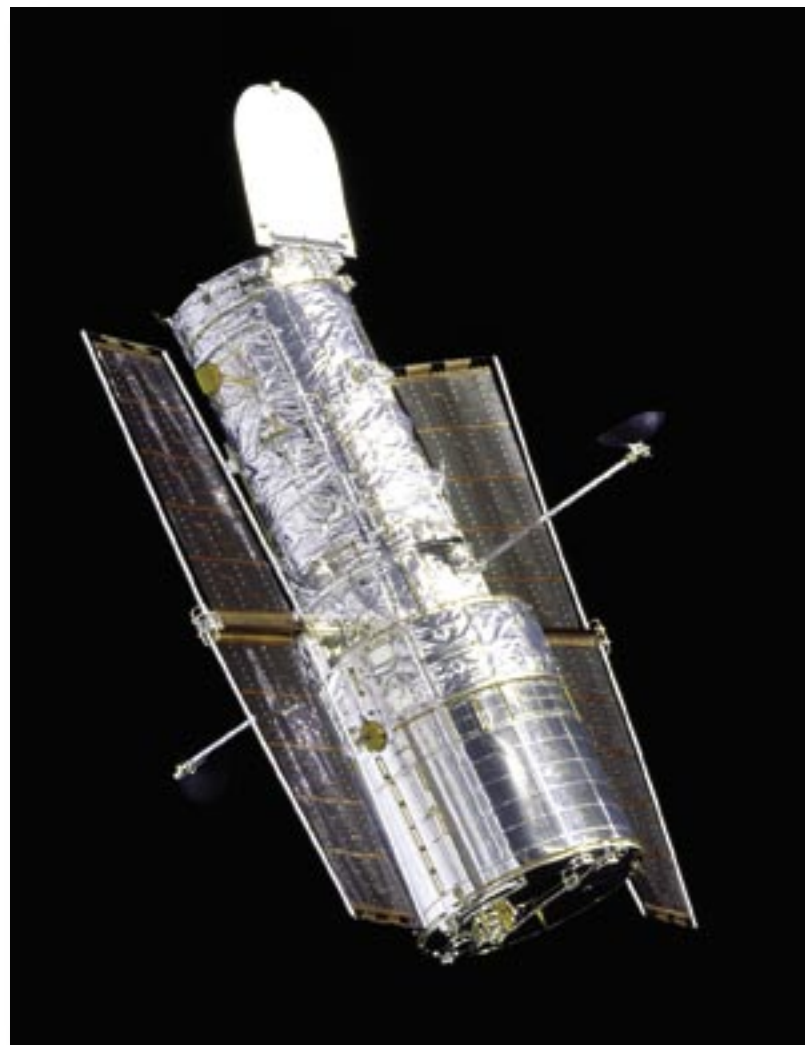
**Lesson:** Capability of a system's original hardware requires verification following any changes in operating environments from planned performance and life extension upgrades.

**Lesson:** Design changes occurring late in the development phase should be thoroughly evaluated by all engineering disciplines to minimize the risk for unforeseen operational constraints and limitations.

**Lesson:** Maintenance of high fidelity engineering units and mockups is vital to developing and certifying hardware and software improvements on the ground before implementation on-orbit.

**Lesson:** Proper selection, preservation, and development of an operations and sustaining engineering work force is critical to identification of emerging performance trends and generation of innovative corrective actions.

**All final reports and position papers from completed NESC activities can be found at <<http://www.nesc.nasa.gov>>.**



*The HST is expected to remain operational through 2008.*



# Status of NESC Work in Progress

This section highlights several activities the NESC is currently evaluating. As with the majority of NESC endeavors, experts from all NASA Centers, other government agencies, national laboratories, academia, and industry are involved in conducting these activities.

## Space Shuttle and International Space Station Recurring Anomalies Review Team

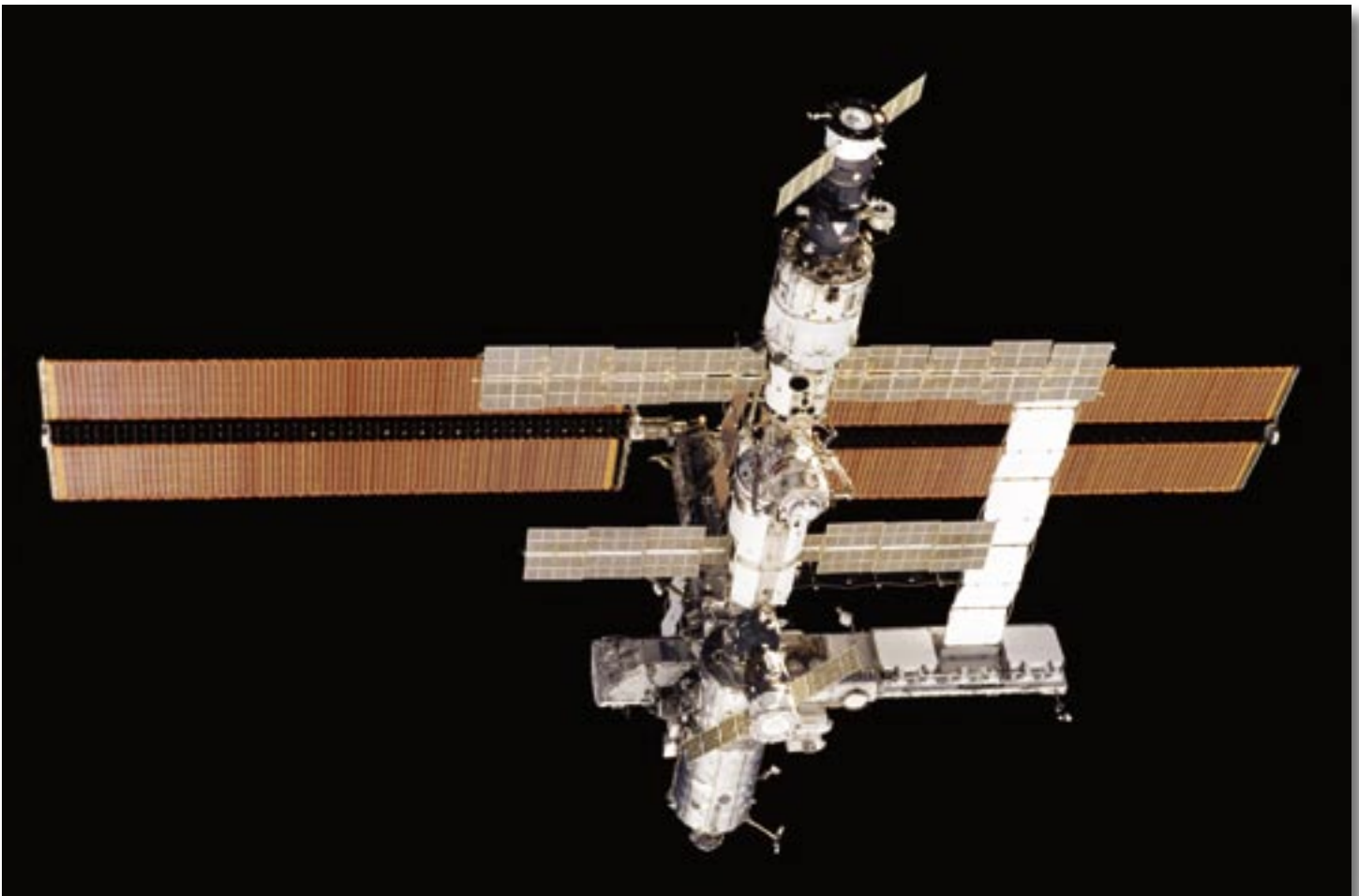
The NESC formed a multidiscipline team to review recurrent Space Shuttle and International Space Station technical problems and to ensure that the program understands and addresses identified risks.

*“The independent evaluation of the NESC provides a different perspective on issues. This additional dimension helps us arrive at better decisions.”*

*William H. Gerstenmaier  
Manager, International Space Station Program*

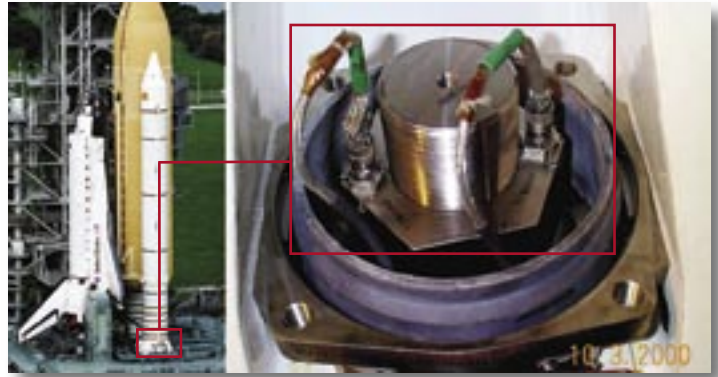
The NESC Recurring Anomalies Review Team is organized around eight discipline-centered subteams whose members review and assess program problem reports, corrective actions, and flight rationale. As the Space Shuttle Program data review nears completion, the review team has identified a number of issues for further program action. The NESC has initiated in depth investigations into several of these identified areas of concern, including solid rocket booster hold-down post stud hang-ups and reusable solid rocket motor nozzle ply lifting, both of which are described in greater detail subsequently.

After completion of the Space Shuttle review, the NESC Recurring Anomalies Review Team will begin assessing the International Space Station Program. Future activities will include the development of tools and techniques for long-term data mining and trending across all NASA programs.

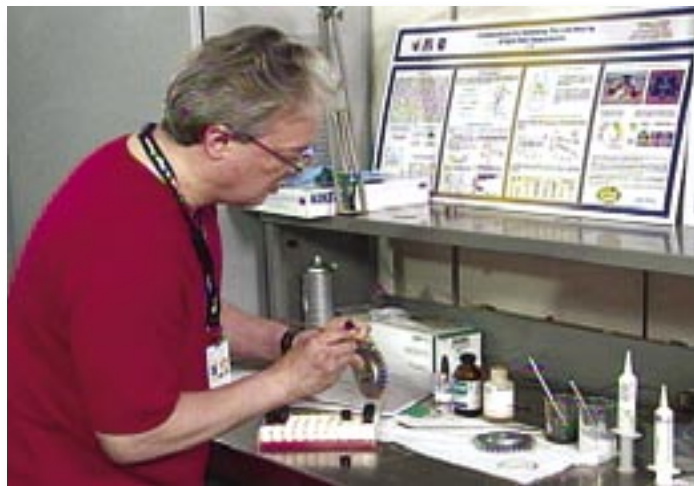


## Space Shuttle Solid Rocket Booster Hold-down Post Stud Hang-up

The NESC Recurring Anomalies Review Team identified the Space Shuttle solid rocket booster (SRB) hold-down post stud hang-ups as an area requiring further investigation. Each SRB is secured to the launch pad with four large studs and explosive nuts. The explosive nuts are fired at lift-off and the stud drops into a container within the mobile launch pad. Over the Shuttle Program's history, a number of missions have experienced stud hang-ups during lift-off. The NESC is conducting a thorough set of tests to determine the root cause of the problem. Statistical analysis and computational techniques will guide this test program, which is using the resources of multiple NASA Centers.



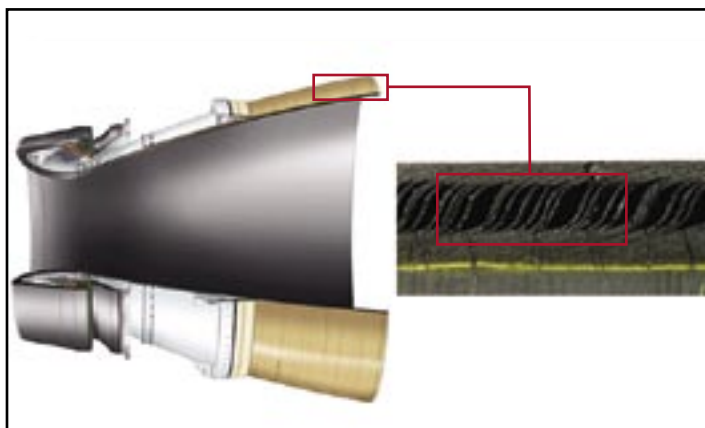
*Solid rocket booster hold-down stud and explosive nut.*



*Dr. Wilfredo Morales gathers grease samples from a gear for analysis of grease degradation.*

## Space Shuttle Orbiter Rudder/Speed Brake Gear Margins

During the NESC's assessment of Braycote® grease separation on the spare Orbiter rudder/speed brake actuator gears, the discovery of corrosion and associated pitting and cracking in the gear teeth put into question the flight rationale for existing inventory. Most hardware affected has already been replaced, but plans are to reuse selected gears and bearings. The NESC has reproduced observed damage in the laboratory, confirming the prevailing hypothesis that most corrosion and pitting occurs during ground handling operations. Tests are now in progress to measure any performance degradation that might be attributable to the corrosion and pitting under both static and fatigue loading conditions.



*Ply lifting of reusable solid rocket motor nozzle.  
(courtesy of ATK Thiokol Inc.)*

## Space Shuttle Reusable Solid Rocket Motor Nozzle Ply Lifting

Ply lifting is characterized by separation and lifting of carbon cloth plies in the aft exit cone of the reusable solid rocket motors. This phenomenon has been observed periodically in solid rocket motor static tests and has likely also occurred during flight. The NESC Recurring Anomalies Review Team's assistance was requested by the Space Shuttle Program to determine if this issue is a benign design deviation or if it has the potential to create a more serious problem.

*"Among the things we learned during the investigation of the Columbia tragedy is the need to independently verify our engineering and safety standards."*

*Sean O'Keefe, NASA Administrator*



## Structural Integrity of Space Shuttle Orbiter Wing Leading Edge Attachment Hardware

NASA is currently implementing recommendations of the Columbia Accident Investigation Board (CAIB). One CAIB recommendation, R3.3-2, requires “determination of the actual impact resistance of current materials and the effects of likely debris strikes.” Along with establishing impact resistance of the reinforced carbon composite (RCC) wing leading edge panels, structural integrity of the wing leading edge spar and the metallic substructure that attaches the RCC to the spar must be verified for debris impact loads. This is the scope of the Technical Assessment the NESC is conducting. In addition, this assessment is addressing potential effects of service life (aging) that may reduce the design allowables below values used in the original wing certification or that would result in a failure mode that was not included in the original certification.



*Orbiter RCC wing leading edge (gray) is secured to the wing spar (green) via attachment hardware.*

## International Space Station Structural Assessment of European Modules

NESC participation was requested in technical discussions aimed at determining the associated risks, and potential acceptance rationale, of not performing postproof nondestructive evaluation of five International Space Station modules manufactured in Europe. The NESC has recommended additional safe-life analyses and simulated service materials testing in order to assess both the module's as-designed and nonconformance conditions. This approach is also being augmented with a statistical examination of applicable inspection data from other spacecraft elements.



*ISS Node 2 module.*

## International Space Station Internal Active Thermal Control System Coolant Water Chemical Stability

The International Space Station internal active thermal control system provides coolant to the U.S. Laboratory and airlock modules. Since early 2002, the on-orbit coolant chemistry has deviated from specification limits. This deviation is a result of high onboard carbon dioxide levels that permeated through the system's flexible Teflon® hoses. Further investigation into this coolant water instability raised a concern over increased microbial levels and biofilm development. An ideal solution would be the identification and implementation of one antimicrobial that would not pose additional material compatibility, toxicity, or result in increased fouling of the coolant loop. It was recognized, however, that a suite of antimicrobials may be required for use in cooling systems to combat the ultimate development of resistant microbes.



*Astronauts James Voss and Scott Horowitz in the International Space Station Destiny module (STS-105).*



such as investigation of human factors in foam spraying, non-destructive evaluation, and statistical assessments. The NESc is also providing independent technical expertise to critical design reviews and technical interchange meetings.



*NESC Human Factors Discipline Expert Dr. Cynthia Null evaluates an improved method for the hand spraying of foam on specific areas of the external tank.*

### **BUMPER II Micrometeoroid/Orbital Debris Analysis Software Stability**

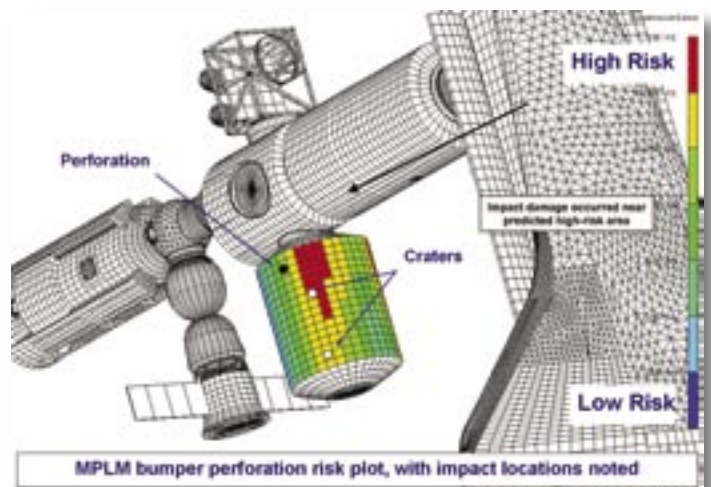
BUMPER II is the primary software program used to assess Micrometeoroid/Orbital Debris (MM/OD) risks for the Space Shuttle, International Space Station, and a number of other missions. The NESc was asked to perform an independent verification and validation of BUMPER II MM/OD software in response to an independent study of MM/OD critical risk assessment practices performed by the Institute for Defense Analyses. The NESc will independently verify and validate both Space Shuttle Orbiter and International Space Station versions of the code as well as examine and analyze the BUMPER II environmental models.



*Good lighting is essential for the accurate application of external tank foam and the performance of inspections. Photographs taken before and after NESc involvement.*

### **Space Shuttle External Tank Technical Assessment**

As part of the overall Space Shuttle return to flight effort, the Space Shuttle Program established an Independent Technical Assessment Team to provide technical oversight, independent analysis, and advice. The NESc is currently assisting this team in specific areas



*BUMPER II risk assessment of micrometeoroid and orbital debris impact to a multi-purpose logistics module (MPLM).*

## Cassini/Huygens Probe Entry, Descent, and Landing

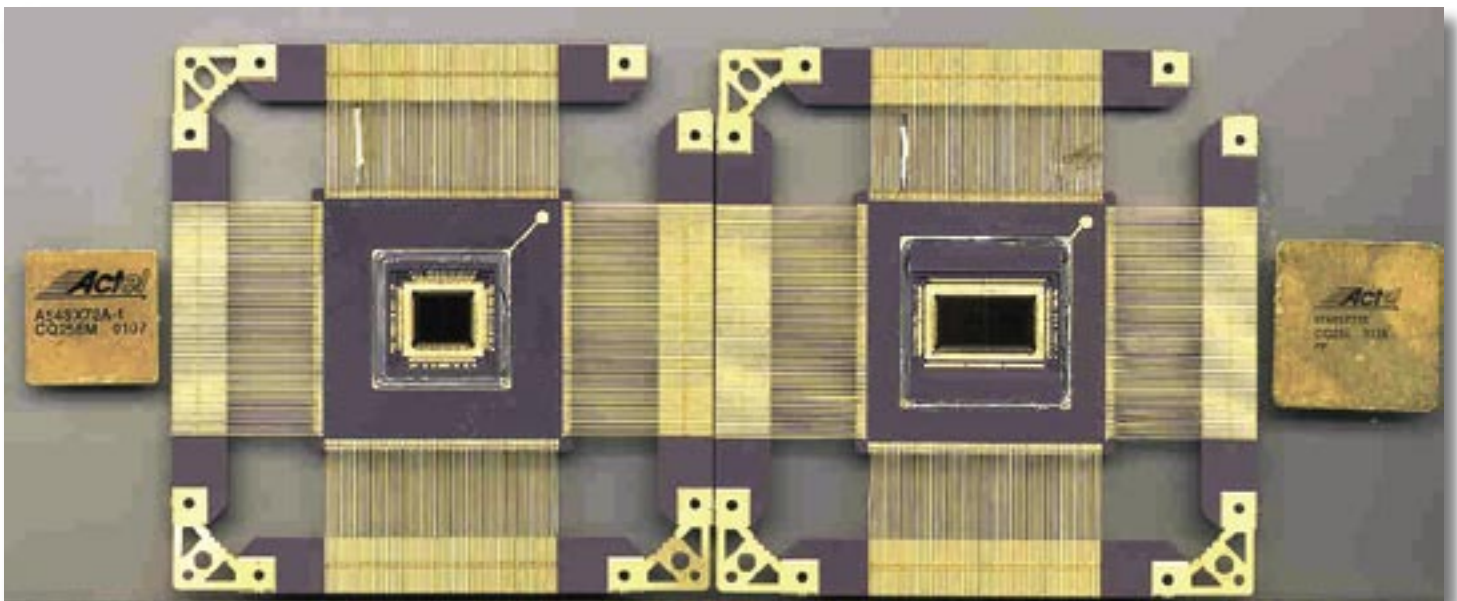
The Cassini/Huygens mission is a joint program of NASA and the European Space Agency (ESA) to explore Saturn and its satellites. The Cassini/Huygens spacecraft is currently in orbit around Saturn following the successful Saturn Orbit Insertion burn on July 1, 2004. As currently scheduled, the Huygens probe will separate from the Cassini spacecraft on December 25, 2004. On January 15, 2005, Huygens will enter the atmosphere of the satellite Titan, descend on parachutes, and land on Titan's surface. The NESC is currently assessing the Huygens entry, descent, and landing flight phase using analytical tools that are readily available within NASA. This assessment will entail the development of a full entry, descent, and landing simulation model for Huygens, the results of which will be shared with the Cassini program and with ESA, thus providing an independent check on the currently accepted entry, descent, and landing solution. The NESC will provide recommendations to the Cassini project and ESA regarding any modifications to areas such as flight trajectory, entry flight path angle, and communications plan.

## Field Programmable Gate Array Independent Verification and Validation

The NESC is funding a 2-year study into potential applicability of software development and testing methodologies to independent verification and validation of Programmable Logic Devices (PLDs), which are like Field Programmable Gate Arrays (FPGAs). This study will examine whether existing software development, verification, and validation techniques, like formal inspections, will add value to the development of PLDs/FPGAs, or whether completely new techniques need development and adoption. Many PLD/FPGA problems resemble software problems, and this study will also determine if the resemblance is deep enough for application of software techniques to the independent verification and validation of device designs.



*Cassini spacecraft with Huygens probe just visible behind the gold foil covered heat shield.*



*Commercial use FPGA (left) and a space use FPGA (right).*

## Independent Testing of Field Programmable Gate Arrays

The NESC is funding an independent test program to evaluate the reliability of 0.25-micron technology FPGAs in typical application environments. The SX-S series of FPGAs are space-grade devices used in NASA flight electronics in a wide variety of manned and robotic missions, many of which are mission and safety critical. At the test program's initiation, there were approximately one dozen confirmed failures in user applications in the SX-S/SX-A series of FPGAs. In response to these failures, the FPGA manufacturer has revised its antifuse programming algorithm, which is believed will either eliminate or significantly reduce the size and/or sensitivity of the outlier population. NESC sponsored independent testing will determine the effectiveness of the modified SX-S programming algorithm in reducing or eliminating outlier antifuses through a rigorous program evaluating a statistically significant number of SX-S series FPGAs. Additionally, the testing will determine whether any unintended side effects have been introduced.



FPGAs are used in the MER cameras.

## Other NESC Technical Activities

In addition to the activities described above, the NESC is currently engaged in numerous other efforts across the Agency. A sampling of these efforts includes work in such areas as Kevlar® and graphite epoxy composite overwrapped pressure vessels, Shuttle ascent debris transport analysis review, reinforced carbon-carbon impact team, Stratospheric Observatory for Infrared Astronomy (SOFIA) acoustical resonance investigation, and support to the Genesis mishap investigation board. These activities represent various levels of involvement by the NESC. Along with standard assessments, the NESC has also engaged in several real-time troubleshooting activities, namely the Soyuz 7 propulsion system helium leak and the International Space Station control moment gyroscope failure.



Soyuz 7 in a predocking maneuver with the International Space Station.



Space Shuttle composite overwrapped pressure vessels being pressure tested.



The NESC is focused on the potential for acoustic resonance generated by the infrared telescope cavity in the side of the NASA 747SP aircraft.

*“Establishment of the NASA Engineering and Safety Center has been invaluable in providing an expert assessment of the challenging issues facing us as we move closer to Return to Flight,”*

*“The dedication, perseverance and support of the NESC to make the Shuttle fleet safer than ever before shows that an organization not even in existence about a year ago, can provide an independent evaluation, where appropriate, of the ongoing work throughout the Program.”*

*William Parsons,  
Space Shuttle Program Manager*

# Lessons

As part of the semiannual NESC Leadership Briefings, the NESC presents broadly applicable lessons learned to Agency leaders. In conjunction with the Office of Chief Engineer and the Safety and Mission Assurance community, the most significant lessons are then tracked through implementation. Listed below is a synopsis of the broadly applicable lessons learned identified by the NESC in its first year of operation, and as presented at the first two Leadership Briefings.

## **Cloud-Aerosol LIDAR and Infrared Pathfinder Satellite Observation (CALIPSO)**

Lesson: NASA must establish unambiguous requirements for fault tolerance.

Lesson: In a project's design phase, a thorough risk assessment must be performed to ensure the final design presents the overall minimum risk to personnel, the mission, and the environment. While current NASA policy does require a risk assessment, it is important that an assessment consider potential hazards through the project's entire life cycle, including ground processing and integration.

Lesson: At the beginning of a project involving outside partners, NASA must clearly define and document its expectations, including the standards, specifications, and processes that should be followed by all parties.



*NESC KSC Chief Engineer Mr. Timmy Wilson discusses the CALIPSO activity.*

## **X-43A Prediction of Transonic Aerodynamics**

Lesson: Dryden Flight Research Center's Flight Readiness Review process (Dryden Handbook DHB-X-001) provides for a robust, independent review of a project's readiness for flight and should be adopted across the Agency.

Lesson: The NESC is implementing a strategy for addressing dissenting opinions. Other organizations within NASA need to develop strategies for handling dissenting opinions.

## **Space Shuttle Orbiter Rudder/Speed Brake Actuator Grease**

Lesson: Programs should periodically review hardware components to ensure that they are operating within qualification and certification limits. When hardware exceeds these limits, testing or analysis should be performed to properly envelop the actual operational environment.

## **Mars Exploration Rovers**

Lesson: NASA should implement and enforce the work time limits for critical operations across the Agency as outlined in NASA Procedural Requirement 1800.1.

Lesson: Future planetary missions should include instrumentation to assess entry performance and adequately characterize the environment encountered during entry, descent, and landing.

## **Space Shuttle Orbiter Main Propulsion System Liquid Hydrogen Feedline Flowliner**

Lesson: Ground testing should be conducted in a configuration as close to flight as possible. Where differences between ground and flight configurations or environments are necessary, every effort to correlate the ground test data to actual flight situations must be made. Complex subsystems like propulsion may require ground test articles to be maintained throughout a program's lifetime.

## **Space Shuttle Orbiter Reaction Jet Driver**

Lesson: Effects of aging, operation, and environmental exposure should be factored into expected operational life of new vehicle designs. Reliability prediction methods should include aging effects.

Lesson: MIL-HDBK-217 is not suited as an absolute quantitative tool to predict the likelihood of electronic part failures in space systems and does not include parts aging, leading to potential overestimations of part reliability.

Lesson: Programs that share physical interfaces, and therefore risks, should ensure that responsibility for integrated hazards is clearly defined and that the system requires periodic reviews of these hazard reports.

# Lessons

## Kennedy Space Center PCGOAL Data Integrity

Lesson: The existing CIL process is not well suited to complex data processing networks. Programmatic requirements to allow alternate approaches may require further discussion.

## Hubble Space Telescope Battery and System Health Assessment

Lesson: Capability of a system's original hardware requires verification following any changes in operating environments from planned performance and life extension upgrades.

Lesson: Design changes occurring late in the development phase should be thoroughly evaluated by all engineering disciplines to minimize the risk for unforeseen operational constraints and limitations.

Lesson: Maintenance of high fidelity engineering units and mock-ups is vital to developing and certifying hardware and software improvements on the ground before implementation on-orbit.

Lesson: Proper selection, preservation, and development of an operations and sustaining engineering work force is critical to identification of emerging performance trends and generation of innovative corrective actions.



Former NESC Deputy Director Dr. Paul Munafo discusses the Space Shuttle Orbiter Braycote® grease assessment.



NESC Flight Sciences Discipline Expert Mr. Steve Labbe discusses the X-43A activity.

## General Lessons from NESC Activities

Lesson: Performance of data mining and trending analysis across NASA programs is difficult due to numerous and dissimilar non-conformance databases. These databases exist without a common format and taxonomy.

Lesson: Engineering organizations should use reports to document technical results.

Lesson: Emphasis should always be on content, not format, regardless of whether a PowerPoint presentation or an engineering report is used for communication.

## General Lessons from Establishment and Operations of NESC

Lesson: Diversity in experience can result in the ability to overcome many problems. Programs and Centers should take advantage of all Agency resources and not be limited to what is available within their own organizations.

Lesson: For One NASA organizations to operate more efficiently and effectively, improvements to Agency support functions should continue.





# Education and Collaboration

## NESC Academy

The NESC is working to capture the extraordinary amount of knowledge resident in the Super Problem Resolution Teams. Many team members have decades of experience in solving technical problems and this knowledge would be of immense benefit to NASA's junior engineers in carrying on the NASA tradition of engineering excellence.

Work is underway to create an academy wherein the NESC experts can teach and mentor junior NASA engineers. Participation by universities will help inspire the next generation of engineers and scientists. The concept involves not only classroom training, but also hands-on training and a Web-based system that will have lectures, lessons learned, and practical examples from the discipline expert's field.

*"We need to have our best technical expertise available when and where it is needed most. The NESC will help to make that possible."*

*Ralph R. Roe, Jr.  
Director, NASA Engineering and Safety Center*

## External Collaboration

A major focus in the NESC's creation was to benchmark the U.S. Navy's Board of Inspection and Survey, the Naval Nuclear Propulsion Program, and the SUBSAFE programs. The NESC has incorporated into its processes many best practices from this benchmarking effort. Subsequently, the NESC began discussions with the Institute of Nuclear Power Operations with the goal of sharing lessons in promoting a strong safety culture.

To provide specialized training opportunities for NESC employees, agreements with the National Transportation Safety Board and the Aviation Safety Office at the Naval Postgraduate School are being established. The NESC has also worked with the National Institute of Aerospace (NIA), which includes the University of Virginia, Virginia Polytechnic Institute and State University, Georgia Institute of Technology, the University of Maryland, North Carolina State University, and North Carolina Agricultural and Technical State University. The NIA has sponsored several NESC workshops and has facilitated participation from academia on several NESC assessment teams. The NESC has also established a contract with The Aerospace Corporation to provide independent and objective technical support for NESC activities.



*The NESC has incorporated a number of best practices from the U.S. Navy into its processes.  
Opposite page: NESC Chief Astronaut Jerry L. Ross, STS-110 mission specialist, works to install the International Space Station's Airlock Spur while anchored to the Canadarm2.*

# NESC Honor Awards

In addition to other incentive awards and recognition programs, the NESC created four honorary NESC awards in its first year of operation. These honorary awards formally identify individuals internal and external to NASA who have shown remarkable leadership and commitment in promoting engineering excellence and safety, made an outstanding contribution to the NESC's technical activities, and demonstrated characteristics the NESC holds in high regard.

- Engineering and technical excellence
- Promotion of an open environment
- Attacking problems with unequalled tenacity

## The Four NESC Honor Awards

**NESC Director's Award:** Recognizes 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:** Recognizes accomplishments of NESC job-related tasks of such magnitude and merit to deserve special recognition.

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

**NESC Group Achievement Award:** Recognizes a team of employees comprising both government and nongovernment personnel for outstanding performance through the coordination of individual efforts that have contributed substantially to the accomplishment of the NESC mission.

The first NESC Honor Awards were presented at the Leadership Briefing on May 12, 2004, at NASA Headquarters. NESC Director Ralph R. Roe, Jr., and Chief Safety and Mission Assurance Officer Bryan D. O'Connor gave opening remarks. Space Shuttle Commander Eileen Collins and STS-114 Mission Specialist Charles Camarda presented awards to the following individuals:

### NESC Director's Award

Mr. Richard M. Wood, LaRC  
Honored for personal commitment to advocating further assessment of the aerodynamic risks associated with the flight of the modified Pegasus/X-43A launch vehicle.



*Mr. and Mrs. Michael Massie accept the NESC Director's Award from NESC Chief Astronaut Jerry Ross.*

Mr. Erwin V. Zaretsky, GRC  
Honored for exemplary contributions and personal leadership in advocating further inspection and testing of the Space Shuttle Orbiter Rudder/Speed Brake actuators.

### NESC Engineering Excellence Award

Mr. Timothy R. Jett, MSFC  
Honored for extraordinary leadership that contributed to engineering excellence in support of the Rudder/Speed Brake Independent Assessment Team.

### NESC Leadership Award

Mr. Luat T. Nguyen, LaRC  
Honored for exceptional leadership in responding to a dissenting opinion regarding the modified Pegasus/X-43A launch vehicle aerodynamics.

Dr. Michael G. Ryschkewitsch, GSFC  
Honored for exceptional leadership in promoting an environment wherein technical concerns are brought forward and appropriately addressed.

A second NESC Honor Awards ceremony took place on October 26, 2004, at the fall NESC Conference in Los Angeles, California. NESC Director Ralph Roe, Jr., and NESC Chief Astronaut Jerry Ross presented awards to the following individuals:

**NESC Director's Award**

Mr. Michael Massie, The Boeing Company  
 Honored for exemplary contributions and technical rationale for corrective action on the Space Shuttle's zero fault tolerant Reaction Jet Driver design.

Dr. Jeffrey D. Scargle, ARC  
 Honored for exceptional contributions in support of the statistical analysis of the external tank foam dissection data.

**NESC Engineering Excellence Award**

Mr. Phillip B. Hall, MSFC  
 Honored for extraordinary leadership that contributed to engineering excellence on the Orbiter Rudder/Speed Brake and Body Flap Actuator Team.

Dr. Paul M. Munafo, MSFC  
 Honored for outstanding direction, technical leadership, and engineering excellence regarding the Orbiter Rudder/Speed Brake System.

Dr. Robert S. Piascik, LaRC  
 Honored for engineering excellence in providing inspection methods and determining the root cause of original cracks in the Orbiter liquid hydrogen feedline flowliners.



*NESC Honor Awards May 12, 2004 at NASA Headquarters. From left to right: Bryan O'Conner, Charlie Camarda, Luat Nguyen (LaRC), Michael Ryschkewitsch (GSFC), Timothy Jett (MSFC), Mike Gilbert accepting for Richard Woods (LaRC), Erwin Zaretsky (GRC), and Eileen Collins.*

*NESC Honor Awards October 26, 2004 (Los Angeles, California). From left to right, Ralph Roe (NESC Director), Phillip Hall (MSFC), Dr. Paul Munafo (MSFC), Dr. Jeffrey Scargle (ARC), Michael Massie (Boeing), Jerry Ross (NESC Chief Astronaut), not pictured is Robert Piascik (LaRC).*



# NESC Leadership Team

## NESC Office of the Director



**Ralph R. Roe, Jr.**  
**Director**  
**NASA Engineering and Safety Center**

Ralph R. Roe, Jr., serves as NESC Director at Langley Research Center. Mr. Roe has over 21 years 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. Paul M. Munafo**  
**Deputy Director**  
**NASA Engineering and Safety Center (former)**

Dr. Paul M. Munafo was the first Deputy Director of the NESC at Langley Research Center. Dr. Munafo came to the NESC from the NASA Materials, Processes, and Manufacturing Department. Dr. Munafo has over 40 years experience with materials science, fracture mechanics, and stress corrosion control in many NASA programs, including Saturn, Apollo, and Space Shuttle.



**Dr. Richard J. Gilbrech**  
**Deputy Director**

Dr. Richard J. Gilbrech is the Deputy Director of the NESC and is resident at Langley Research Center. Dr. Gilbrech came to the NESC 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 13 years combined experience in NASA propulsion, propulsion testing, and the Space Shuttle Program.

*"My first priority is establishment of the NASA Engineering and Safety Center that will enhance and reinvigorate safety through independent assessment and analysis.*

*Comprised of the best technical experts in the Agency and in the nation, the NESC will act as a 'fresh set of eyes' to look at systems and processes associated with the Agency's high-risk, high-payoff initiatives."*

*Roy D. Bridges*  
*Director, NASA Langley Research Center*



**Larry Crawford**  
**Deputy Director for Safety (former)**

Mr. Larry Crawford was the first NESC Deputy Director for Safety. Mr. Crawford came to the NESC at Langley Research Center from his position as Director of the Research Engineering Directorate at Dryden Flight Research Center. Mr. Crawford has over 34 years experience in Department of Defense and NASA programs in system safety and engineering management.



**Dr. Steven A. Hawley**  
**Chief Astronaut (former)**

Dr. Steven A. Hawley served as the first NESC Chief Astronaut. Dr. Hawley came to the NESC from the NASA Space and Life Sciences Directorate where he served as Associate Director for Astromaterials Research and Exploration Science. Dr. Hawley is a veteran of five space flights: STS-41D in 1984, STS-61C in 1986, STS-31 in 1990, STS-82 in 1997, and STS-93 in 1999.



**Jerry L. Ross, Colonel, USAF, Ret.**  
**Chief Astronaut**

Mr. Jerry L. Ross is the NESC Chief Astronaut and is resident at Johnson Space Center (JSC). Mr. Ross joins the NESC and will continue in his current position as Chief of the Vehicle Integration Test Office at JSC. With over 34 years of flight, technical, and managerial experience with the U.S. Air Force and Shuttle Program, Mr. Ross is a veteran of seven Shuttle flights, including nine extravehicular activities, and was Flight Test Engineer prior to joining NASA in 1979.



**Dr. David Leckrone**  
**Chief Scientist**

Dr. David Leckrone is the NESC Chief Scientist and is resident at Goddard Space Flight Center (GSFC). Prior to joining the 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 34 years experience in NASA astrophysics programs.

## NASA Headquarters Liaisons



**John E. Tinsley**  
**NASA Headquarters Senior SMA Integration Manager (Former)**

Mr. John E. Tinsley currently serves as a Senior Safety and Mission Assurance Manager in the NASA Headquarters Office of Safety and Mission Assurance (OSMA), represents the NESC at Agency-level meetings, and serves as a liaison between the NESC Director and the OSMA Associate Administrator. Prior to joining the NESC, Mr. Tinsley was a Senior Advanced Systems Engineer with the Office of Space Flight Advanced Systems Office. Mr. Tinsley has over 24 years experience in systems and safety engineering and engineering management in Shuttle processing and upgrades and spacecraft mission planning.



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

Mr. Keith L. Hudkins is the representative from the NASA Office of the Chief Engineer to the 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 34 years 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



**Kenneth D. Cameron**  
**Principal Engineer**

Mr. Kenneth D. Cameron is the NESC Principal Engineer serving at Langley Research Center. Mr. Cameron came to the NESC after 7 years in private industry and a career in the U.S. Marine Corps. Mr. Cameron has over 24 years 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.



**Clinton H. Cragg**  
**Principal Engineer**

Mr. Clinton H. Cragg is a Principal Engineer with the NESC at Langley Research Center. Mr. Cragg came to the 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 26 years experience in supervision, command, and ship-borne nuclear safety.



**Dr. Charles E. Harris**  
**Principal Engineer**

Dr. Charles E. Harris is a Principal Engineer in the NESC at Langley Research Center (LaRC). Prior to joining the NESC, Dr. Harris was the Director of the National Institute of Aerospace Management Office at LaRC. Dr. Harris has over 32 years experience in aerospace engineering, structures and materials, and structural mechanics.

## Management and Technical Support Office



**Stan C. Newberry**  
**Manager, Management, and Technical Support Office (former)**

Mr. Stan C. Newberry was the former Manager of the Management and Technical Support Office at Langley Research Center prior to becoming the Deputy Center Director at Ames Research Center. Mr. Newberry came to the NESC from his position as NASA Representative to the Headquarters Air Force Space Command. Mr. Newberry has spent much of his career with NASA managing high-value programs.

## Systems Engineering Office



**Dawn M. Schaible**  
**Acting Manager, Systems Engineering Office**

Ms. Dawn M. Schaible is Acting Manager of the NESC Systems Engineering Office at Langley Research Center. Ms. Schaible is detailed to the NESC from her position as Technical Assistant to the Director, International Space Station/Payload Processing Directorate at Kennedy Space Center. Ms. Schaible has over 17 years experience in systems engineering, integration, and ground processing for the Space Shuttle and International Space Station Programs.



## NESC Chief Engineers Office



**Derrick J. Cheston**  
**NESC Chief Engineer**

Mr. Derrick J. Cheston is the NESC Chief Engineer for Glenn Research Center (GRC). Mr. Cheston joined the NESC from his prior position as Chief of the Thermal/Fluids Systems Branch. Mr. Cheston has 20 years experience in aerospace engineering and management, including mechanical design and testing and thermal/fluids analysis.



**Dr. Michael S. Freeman**  
**NESC Chief Engineer**

Dr. Michael S. Freeman is the NESC Chief Engineer at Ames Research Center (ARC). Dr. Freeman joined the NESC from ARC where he served as the ARC Primary Representative to the NASA Software Working Group. Dr. Freeman has spent his NASA career primarily engaged in developing the International Space Station.



**T. Randy Galloway**  
**NESC Chief Engineer**

Mr. T. Randy Galloway is the NESC Chief Engineer at Stennis Space Center (SSC). Mr. Galloway came to the NESC from SSC where he led the Propulsion Test Operations Division. Mr. Galloway has 18 years experience in space flight hardware, primarily in the International Space Station.



**Dr. Michael G. Gilbert**  
**NESC Chief Engineer**

Dr. Michael G. Gilbert is the NESC Chief Engineer at Langley Research Center (LaRC). Before joining the NESC, he was Head of the LaRC Systems Management Office. Dr. Gilbert has over 27 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 the NESC Chief Engineer at Goddard Space Flight Center (GSFC). Mr. Hagopian came to the NESC from his position as Associate Chief of the Mechanical Systems Division at GSFC. Mr. Hagopian has over 20 years experience in the development of space and Earth science satellites.



**David A. Hamilton**  
**NESC Chief Engineer**

Mr. David A. Hamilton is the NESC Chief Engineer at Johnson Space Center (JSC). Mr. Hamilton came to the 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 37 years combined experience in NASA manned space flight programs, including Apollo, Skylab, Apollo-Soyuz, ISS, Shuttle, and Mir.



**Danny D. Johnston**  
**NESC Chief Engineer**

Mr. Danny D. Johnston is the NESC Chief Engineer at Marshall Space Flight Center (MSFC). Prior to joining the NESC, Mr. Johnston was a Senior Staff Engineer in the Engineering Directorate at MSFC. Mr. Johnston has over 37 years combined experience in NASA programs, including Apollo J2 engines, guidance, navigation and control in Apollo and Skylab, Hubble Space Telescope, Chandra, and Space Shuttle.



**Michael W. Kehoe**  
**NESC Chief Engineer**

Mr. Michael W. Kehoe is the NESC Chief Engineer at Dryden Flight Research Center (DFRC). Prior to joining the NESC, Mr. Kehoe served at DFRC as the Center Chief Engineer and System Management Office Director. Mr. Kehoe has over 30 years experience in aeronautical engineering, primarily in experimental flight test.



**Matthew R. Landano**  
**Acting NESC Chief Engineer (former)**

Mr. Matthew R. Landano is the NESC Chief Engineer at NASA's Jet Propulsion Laboratory (JPL). Mr. Landano came to the NESC from the Office of Safety and Mission Success where he served as Director. Mr. Landano has over 35 years at JPL where he worked on Viking, Voyager, and Galileo spacecraft design and management.



**Timmy R. Wilson**  
**NESC Chief Engineer**

Mr. Timmy R. Wilson is the NESC 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 23 years of engineering and management experience supporting the Space Shuttle Program.

## NESC Discipline Expert Office



**Frank H. Bauer**  
**NESC Discipline Expert**

Mr. Frank H. Bauer is the NESC Discipline Expert for Guidance Navigation and Control (GNC) systems and is resident at Goddard Space Flight Center (GSFC). Mr. Bauer came to the NESC from the Mission Engineering and Systems Analysis Division at GSFC where he served as the division's Chief Engineer. Mr. Bauer has 25 years experience in GNC as well as extensive experience in space borne applications of global positioning systems.



**Dr. Edward R. Generazio**  
**NESC Discipline Expert**

Dr. Edward R. Generazio is the NESC Discipline Expert for Nondestructive Evaluation and is resident at Langley Research Center (LaRC). Dr. Generazio came to the NESC after serving as the Branch Head of LaRC Nondestructive Evaluation Sciences Branch and also was responsible for executing the NASA Office of Safety and Mission Assurance Agency-wide Nondestructive Evaluation Program. Dr. Generazio has over 21 years experience in Nondestructive Evaluation.



**George D. Hopson**  
**NESC Discipline Expert**

Mr. George D. Hopson is the NESC Discipline Expert for Propulsion and is resident at Marshall Space Flight Center (MSFC). Mr. Hopson came to the NESC from the Space Shuttle Main Engine Project Office where he served as Director. Mr. Hopson has over 42 years combined experience in Space Shuttle main engine, space propulsion, space systems dynamics, and project management.



**Robert A. Kichak**  
**NESC Discipline Expert**

Mr. Robert A. Kichak is the NESC Discipline Expert for Power and Avionics and is resident at Goddard Space Flight Center (GSFC). Mr. Kichak came to the NESC from the Electrical Engineering Division at GSFC where he served as the division's Chief Engineer. Mr. Kichak has over 35 years experience in spacecraft power, electrical, and avionics systems.



**Julie A. Kramer White**  
**NESC Discipline Expert**

Ms. Julie A. Kramer White is currently the NESC Discipline Expert for Mechanical Analysis and is resident at Johnson Space Center (JSC). Prior to the NESC, Ms. Kramer White served as the Chief Engineer for Orbiter Maintenance Down Period in the Orbiter Engineer Office at JSC. Ms. Kramer White has over 13 years combined experience in Shuttle and International Space Station structures and mechanics.



**Steven G. Labbe**  
**NESC Discipline Expert**

Mr. Steven G. Labbe is the NESC Discipline Expert for Flight Sciences and is resident at Johnson Space Center (JSC). Prior to the NESC, Mr. Labbe served as Chief of the Applied Aeroscience and Computational Fluid Dynamics Branch at JSC. Mr. Labbe has over 20 years 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 the NESC Discipline Expert for Mechanical Systems and is resident at Johnson Space Center (JSC). Prior to the 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 17 years experience in mechanical systems of the Orbiter and International Space Station.



**Dr. Cynthia H. Null**  
**NESC Discipline Expert**

Dr. Cynthia H. Null is the NESC Discipline Expert for Human Factors and is resident at Ames Research Center (ARC). Prior to the 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 18 years experience lecturing on Human Factors and another 13 years experience in Human Factors applied to NASA programs.



**Dr. Robert S. Piascik**  
**NESC Discipline Expert**

Dr. Robert S. Piascik is the NESC Discipline Expert for Materials and is resident at Langley Research Center (LaRC). Dr. Piascik came to the 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 20 years experience in the commercial nuclear power industry and over 14 years experience in basic and applied materials research for several NASA programs.



**Dr. Ivatury S. Raju**  
**NESC Discipline Expert**

Dr. Ivatury S. Raju is the NESC Discipline Expert for of 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 the NESC. Dr. Raju has over 29 years experience in structures, structural mechanics, and structural integrity.



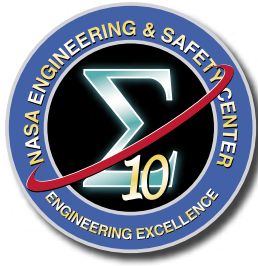
**Henry A. Rotter**  
**NESC Discipline Expert**

Mr. Henry A. Rotter is the NESC Discipline Expert for Fluids, Life Support, and Thermal Systems and is resident at Johnson Space Center (JSC). Mr. Rotter joined the NESC from the JSC Crew and Thermal Systems Division and the Space Launch Initiative Program, where he was Engineering Manager and Orbital Space Plane Team Leader for the life support and active thermal control teams. Mr. Rotter has over 37 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 is the NESC Discipline Expert for Software and is resident at Goddard Space Flight Center (GSFC). Prior to joining the NESC, Mr. Scott served as the Chief Engineer in the Applied Engineering and Technology Directorate at GSFC. Mr. Scott has over 14 years experience in satellite software engineering.



Additional information can be found at <http://www.nesc.nasa.gov>.

All general questions and requests for NESC technical reviews should be sent to: [nesc@nasa.gov](mailto:nesc@nasa.gov)

If you would like to submit a technical request anonymously, please mail it to:

NESC  
NASA Langley Research Center  
Mail Stop 118  
Hampton, VA 23681

Media inquiries should be directed to:

Keith Henry  
[H.K.Henry@nasa.gov](mailto:H.K.Henry@nasa.gov)

### **NASA Field Center Contacts**

Each NASA Field Center has a local NESC representative who serves as a point of contact for Center-based issues related to the NESC. Find information for your local contact through the NASA X.500 directory.

NASA Ames	Michael S. Freeman
NASA Dryden	Michael W. Kehoe
NASA Glenn	Derrick J. Cheston
NASA Goddard	Michael Hagopian
Jet Propulsion Laboratory	Brian Muirhead
NASA Johnson	David A. Hamilton
NASA Kennedy	Timmy R. Wilson
NASA Langley	Michael G. Gilbert
NASA Marshall	Danny D. Johnston
NASA Stennis	T. Randy Galloway

### Future Opportunities within NESC

NASA employees interested in supporting the NESC can also contact the NESC Chief Engineers located at each Center to inquire about NESC opportunities.

When new positions are made available within the NESC, you can find out about them through the NASAJobs Web site located at <http://nasajobs.nasa.gov>.

