NESC Leadership Briefing

May 12, 2004

Background

- On July 15, 2003, Administrator O'Keefe announced plans to create the NASA Engineering and Safety Center at Langley Research Center
- NESC Management Plan approved on October 3, 2003
- NESC Operational on November 1, 2003

The NESC provides a central location to coordinate and conduct robust, independent engineering and safety assessments across the Agency

Safety philosophy has 3 tenets:

- Strong in-line checks and balances
- Healthy tension
- “Value added” independent assessment

NESC provides independent assessment of technical issues for NASA programs and projects

NESC is cultivating a Safety culture focused on **engineering and technical excellence**, while fostering an **open environment** and attacking challenges with **unequalled tenacity**

Why are we here today?

- Recognize those individuals who have demonstrated the characteristics that the NESC holds in high regard:
  - Engineering and technical excellence
  - Open environment
  - Unequalled tenacity
- Inform you of the NESC's first 6 months of operation
- Share broadly applicable lessons learned
- Solicit your feedback

NESC Awards

To recognize those individuals who have made an outstanding contribution to the NESC's technical activities

NESC Director's Award

NESC Engineering Excellence Award

NESC Leadership Award

NESC Group Achievement Award

NESC Leadership Briefings

- Concept based on a similar model used by the US Navy's Board of Inspection and Survey (INSURV)
  - Inspection results are formulated into summary reports and presented to Commanders and Managers at periodic Leadership Briefings
- NESC Leadership Briefings will target senior leadership within the Agency
- Broadly applicable lessons learned will be communicated to those who can implement change within their organization

INSURV has been performing inspections of the Navy fleet for 136 years

NESC Model

- Decentralized organizational structure across all Centers reporting to the NESC management office at LaRC
  - Engineers need to be where the problems are to stay sharp
- Small core of engineering experts at Centers for insight into respective programs
- Recognized Agency discipline experts leading Super Problem Resolution Teams
- Use “ready” experts at each Center through formal task agreements
- Pool senior engineering resources to attack “trouble spots”
- Strong Systems Engineering function for proactive trending and identification of problem areas before failures occur

NESC Accomplishment during First 6 Months

- Established organization and processes
  - Selected Senior Leadership Team
  - Staffing 85% Complete
- Completed four Pathfinder activities:
  - CALIPSO
  - Orbiter Rudder/Speed Brake
  - X-43A
  - Mars Exploration Rovers
- Currently engaged in several Return to Flight activities
- As of May 1, 2004, NESC received 49 requests

What has the Agency received from the initial $45M investment?

- Strong technical organization established with processes defined and documented, and fully engaged in the Agency's programs
- Tangible results from four Pathfinder activities:
  - Office of Earth Sciences (CALIPSO)
  - Office of Space Flight (Orbiter Rudder/Speed Brake)
  - Office of Aeronautics (X-43A)
  - Office of Space Sciences (Mars Exploration Rovers)
- Strong technical evaluations involving issues with Agency assets
- A resource for the Agency to address the most challenging technical problems

NESC Leadership Team*

Office of the Director

AL

Roe, Ralph R.	Director
Munafo, Paul M.	Deputy Director
Vacant	Deputy Director for Safety
Hawley, Steven A. (JSC)	Chief Astronaut
Leckrone, David (GSFC)	Chief Scientist

NASA HQ Senior S&MA Integration Manager

Tinsley, John E.

NASA HQ Chief Engineer Representative

Hudkins, Keith L.

ALA

Management and Technical Support Office

Newberry, Stan C. Manager

ALB

Systems Engineering Office

Schaible, Dawn M. Manager (Acting)

ALC

Principal Engineers Office

Cameron, Kenneth D.
Cragg, Clinton H.
Gilbrech, Richard J.
Harris, Charles E.

ALD

NESC Chief Engineers (NCE)

Cheston, Derrick J.	GRC
Freeman, Michael S.	ARC
Galloway, T. Randy	SSC
Gilbert, Michael G.	LaRC
Hagopian, Michael	GSFC
Hamilton, David A.	JSC
Johnston, Danny D.	MSFC
Kehoe, Michael W.	DFRC
Landano, Matthew R.	JPL (Acting)
Wilson, Timmy R.	KSC

ALE

NESC Discipline Experts (NDE)

Bauer, Frank H. (GSFC)	GNC
Generazio, Edward R. (LaRC)	NDE
Hopson, George H. (MSFC)	Propulsion
Kichak, Robert A. (GSFC)	Power & Avionics
Kramer-White, Julie A. (JSC)	Mechanical Analysis
Labbe, Steven G. (JSC)	Flight Sciences
McManamen, John P. (JSC)	Mechanical Systems
Null, Cynthia H. (ARC)	Human Factors
Piascik, Robert S. (LaRC)	Materials
Raju, Ivatury S. (LaRC)	Structures
Rotter, Henry A. (JSC)	Fluids/Life Support/Thermal
Scott , Steven S. (GSFC)	Software

*Also NESC Review Board (NRB) Members

5/3/2004

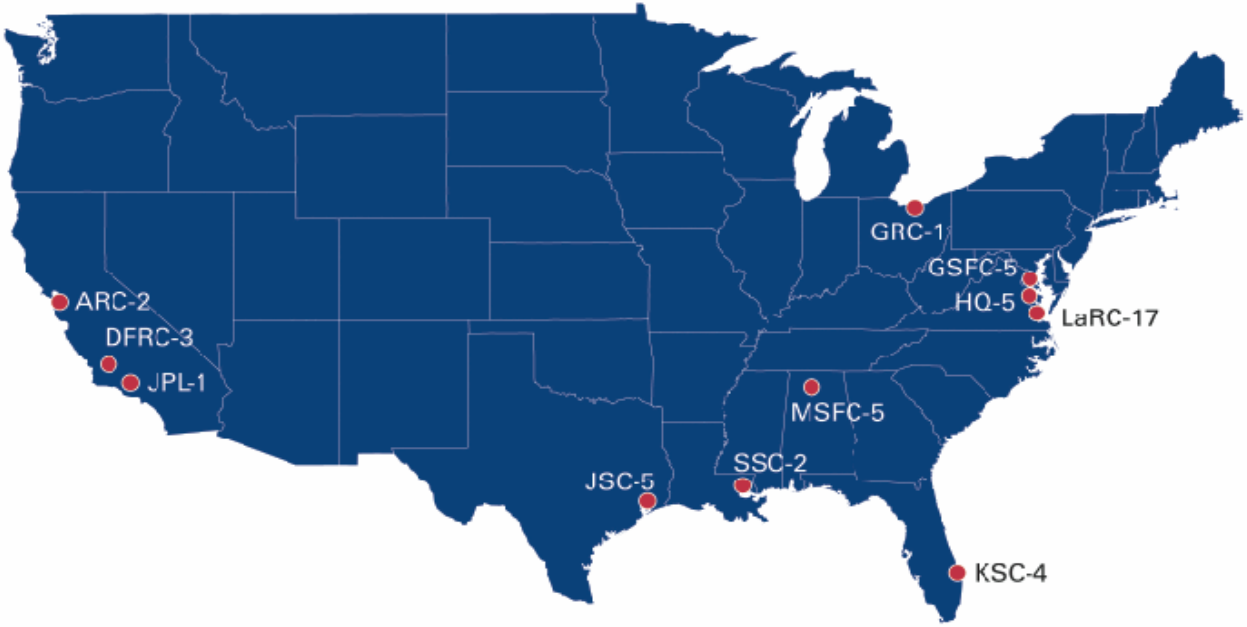
NESC operates as a true One NASA Organization by engaging all NASA Centers and Headquarters, in the mutual goal of increasing safety through engineering excellence

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

Several administrative hurdles were overcome in establishing the NESC, a One NASA Organization

Home Centers for Current NESC employees

Two employees were external to NASA

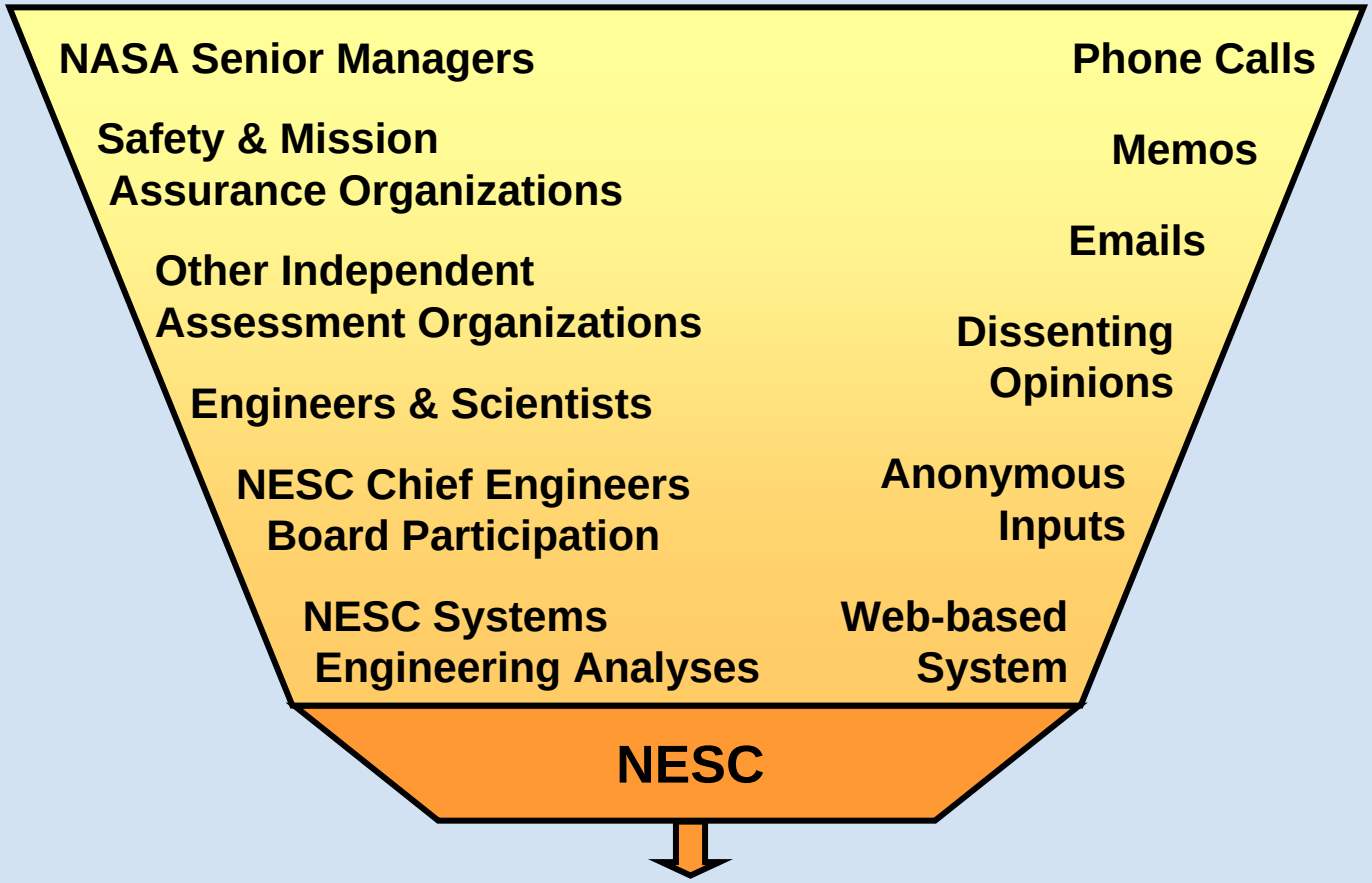


Lesson: For One NASA organizations to operate more efficiently and effectively, improvements to Agency's support functions should continue.

NESC Operations

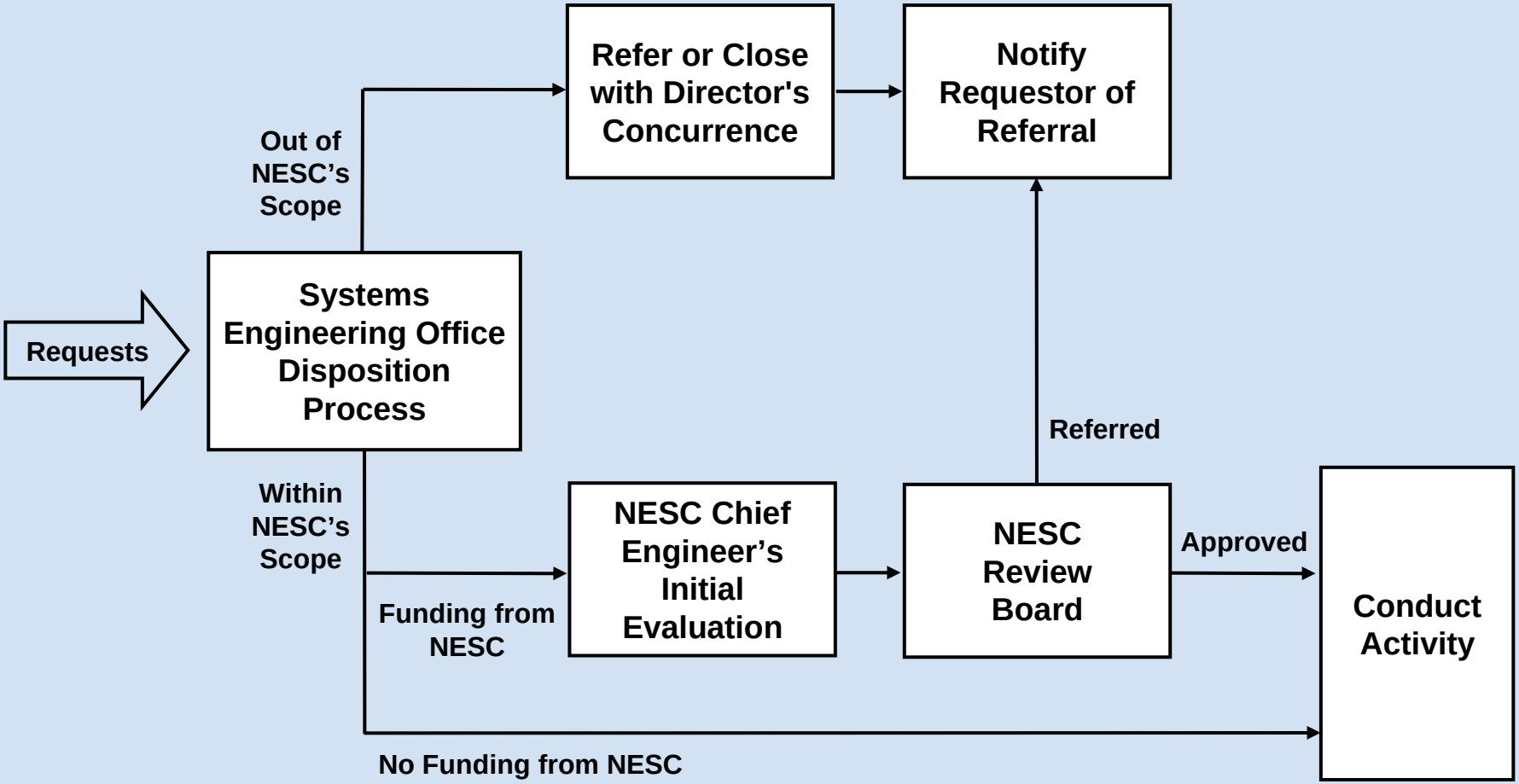
NESC gains insights and receives requests from a number of sources

Via different media

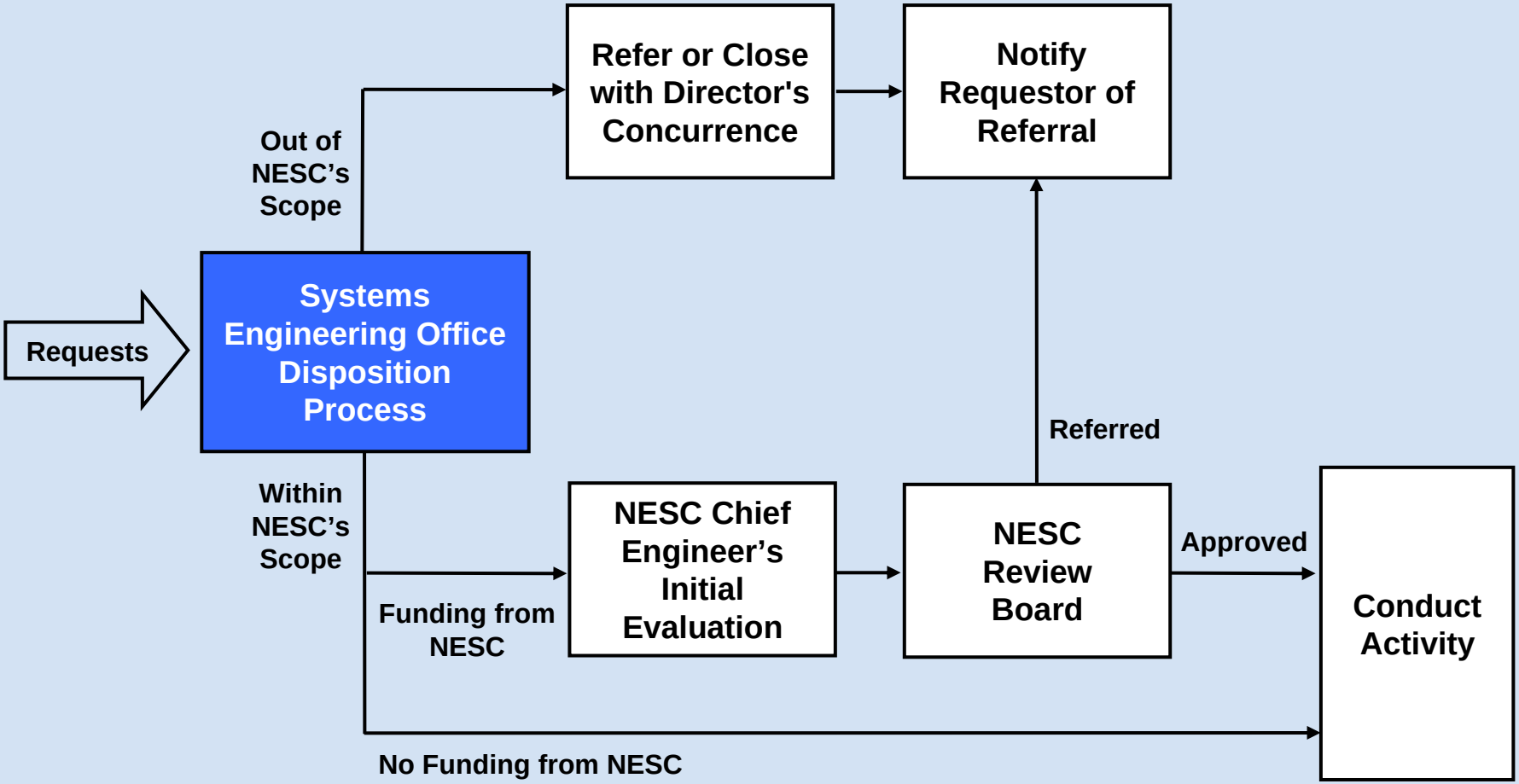


Selection/Prioritization Process

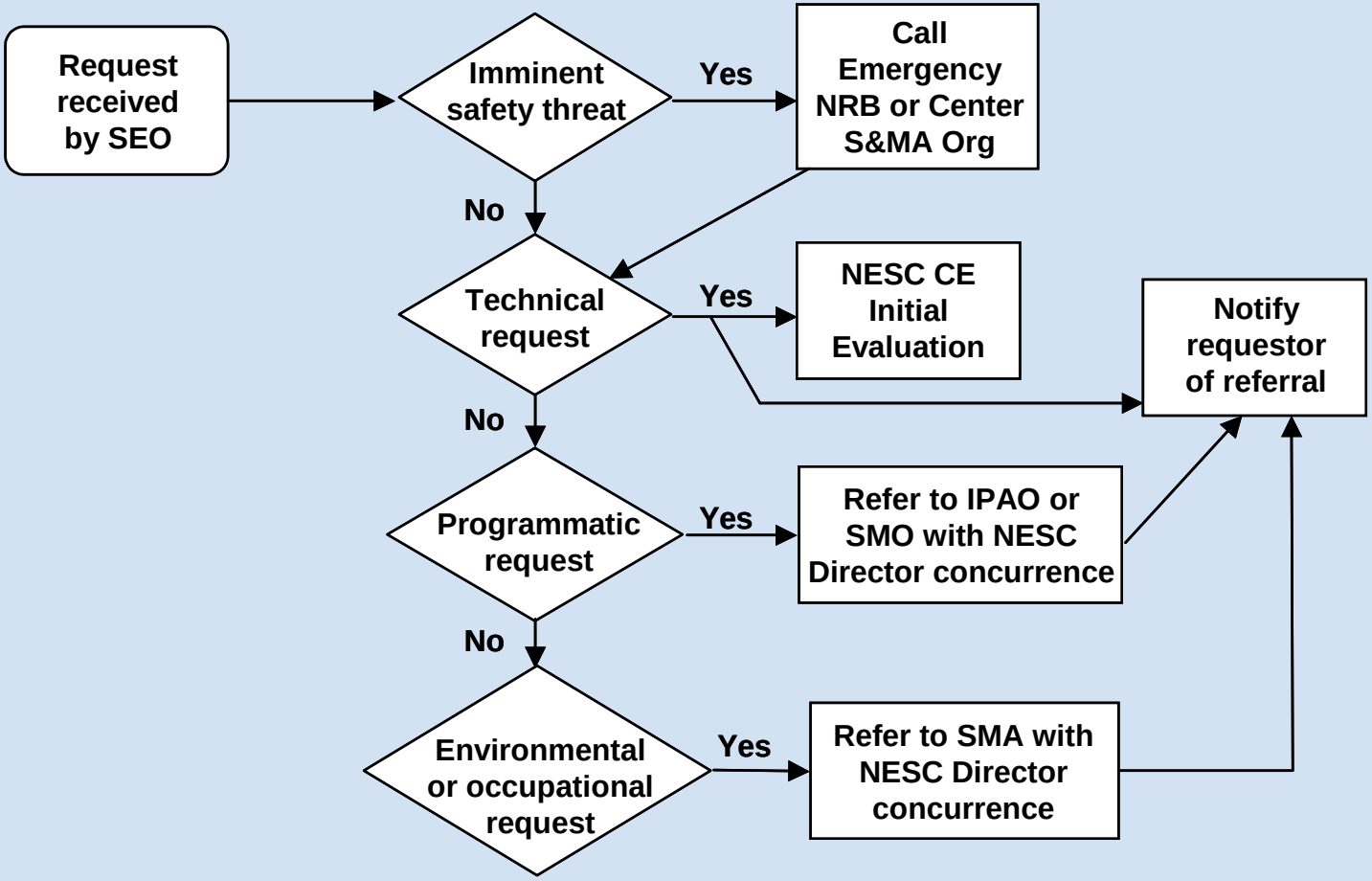
NESC Request Selection/Prioritization Process



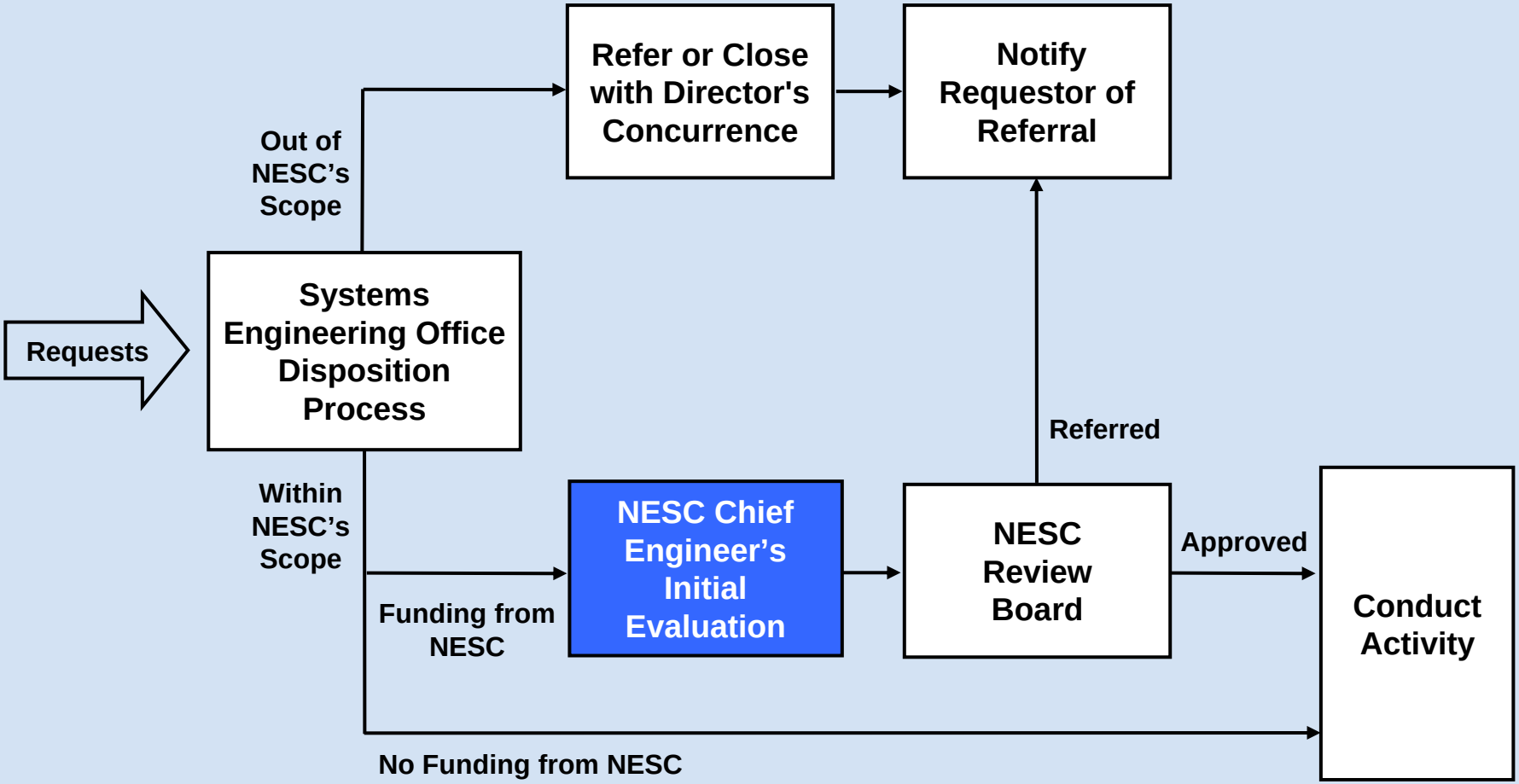
NESC Request Selection/Prioritization Process



Systems Engineering Office Disposition Process

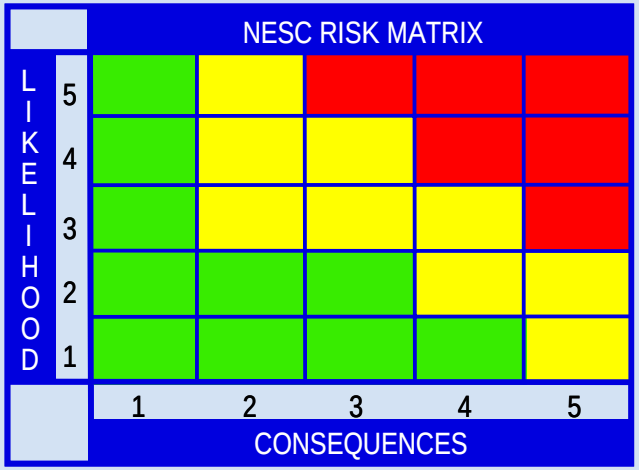


NESC Request Selection/Prioritization Process

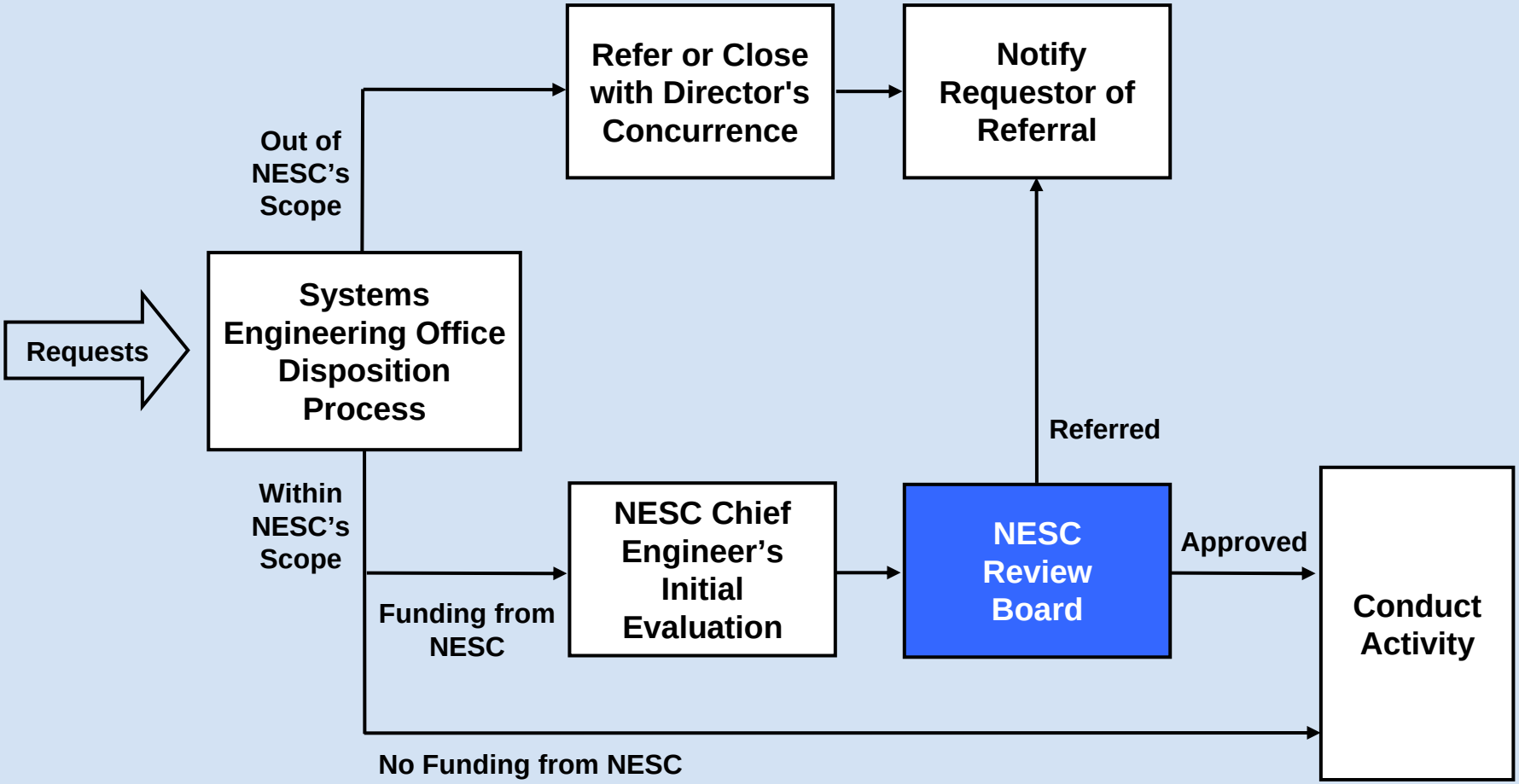


NESC Chief Engineer's Initial Evaluation

	Criteria
Risk	1. Risk – Safety
	2. Risk – Mission Success
	3. Risk – National Importance
	4. Involves Deviation from Accepted Specification, Standard, or Practice
Project	5. Project Not Actively Engaged in Resolving Issue
NESC Value	6. Potential for Advancing Discipline Knowledge Base
	7. Resolution Lends Itself to Test and Analysis
	8. Perceived Urgency



NESC Request Selection/Prioritization Process



NESC Review Board Approval Process

- NESC Chief Engineers present the results of their initial evaluation to the NESC Review Board
- NESC Review Board approves requests by consensus
- NESC Management assigns NESC lead to each approved request
- Declined requests are referred to other independent organizations, or back to the Program/Center for further disposition
- Feedback on NESC Review Board Disposition provided to Requestor

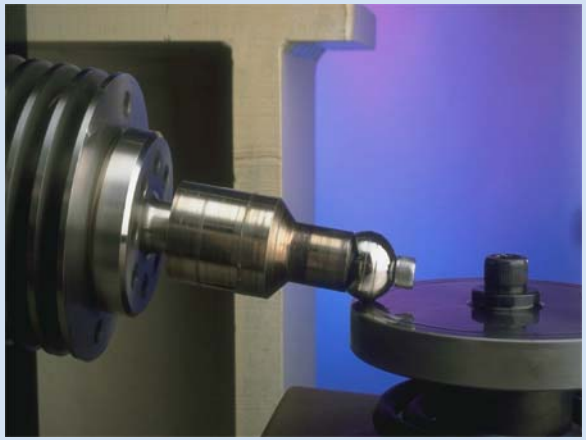
NESC Activities

Technical Assessments

Technical Consultations

Technical Inspections

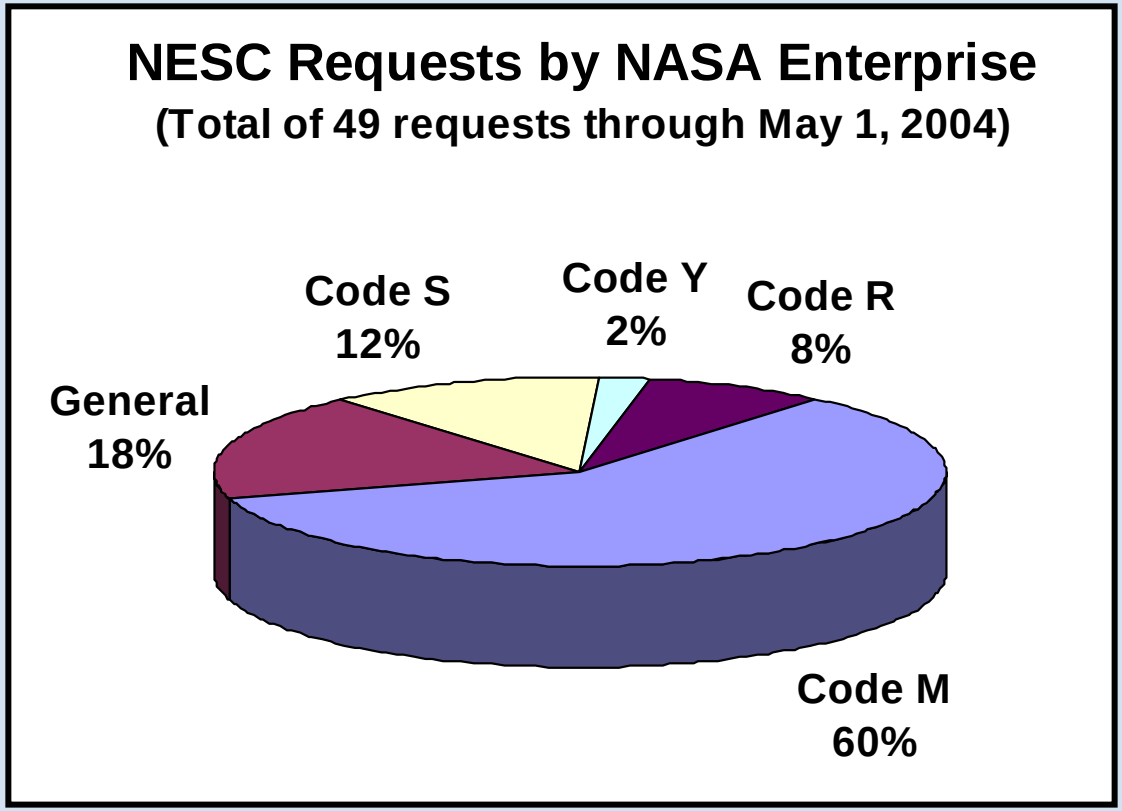
Technical Support



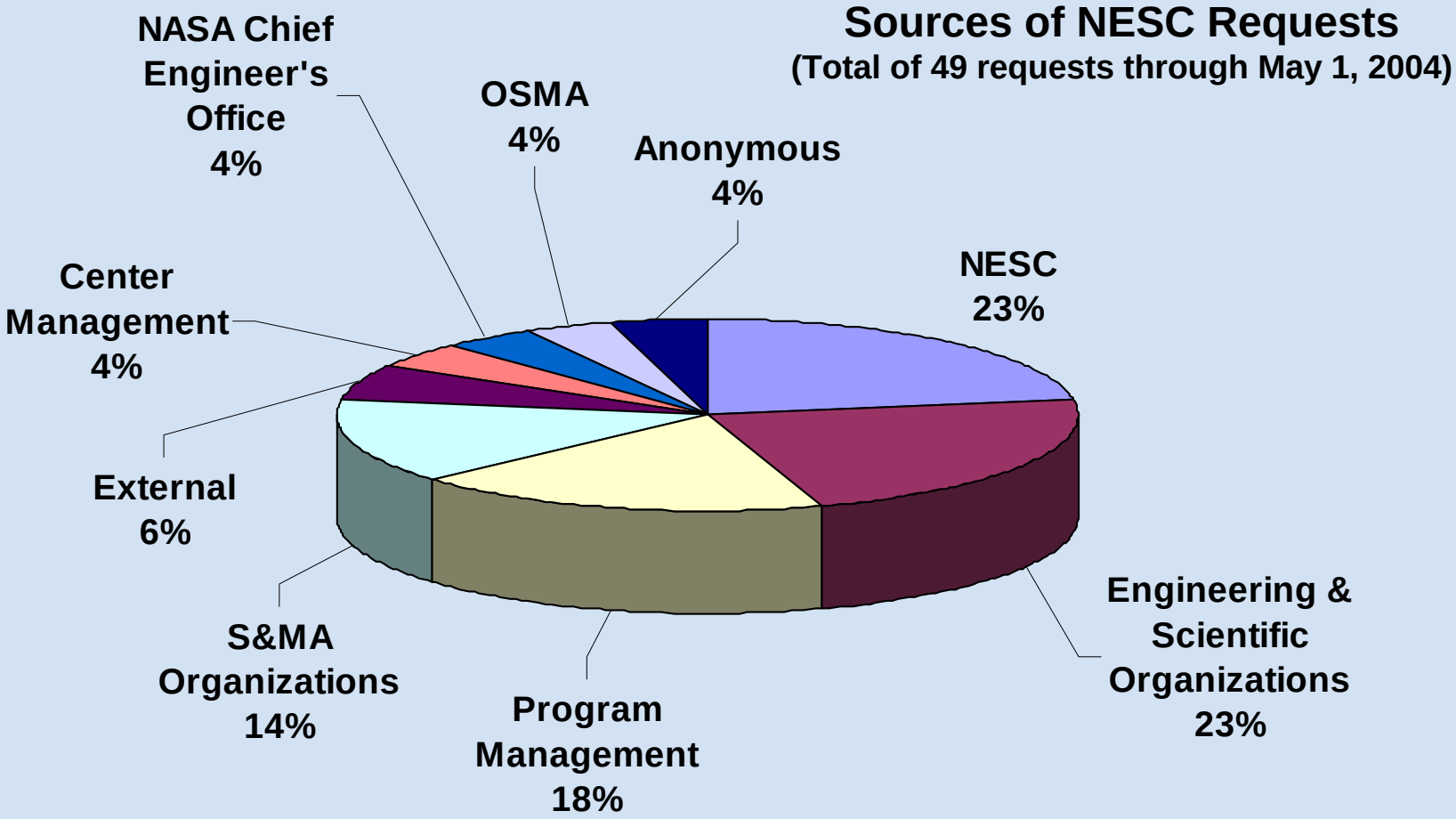
NESC Metrics

FY2004 NESC focus is on Code M

- Shuttle Return to Flight
- International Space Station

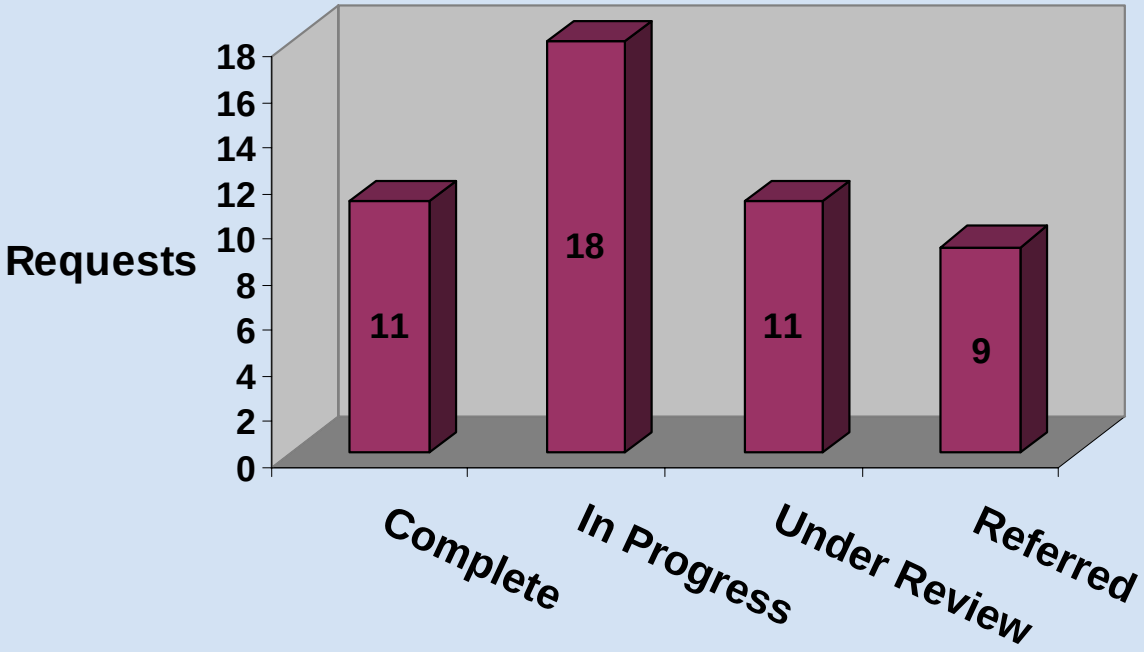


NESC Metrics (cont'd)



NESC Metrics (cont'd)

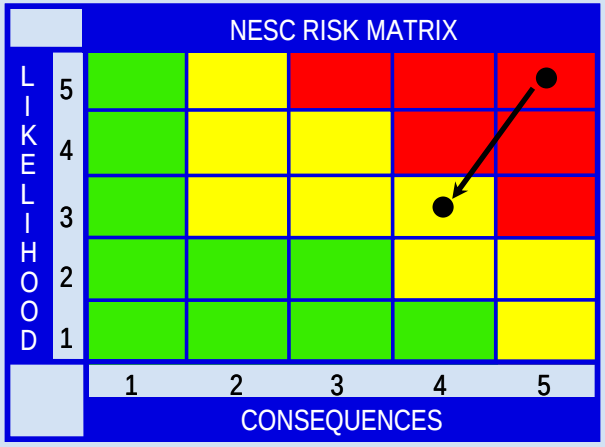
Status of NESC Request Activites
(Total of 49 requests through May 1, 2004)



Future metrics will:

- Focus on the evaluation of NESC progress towards NASA mission success through engineering excellence
- Present trends in the achievement of NESC goals over time
- Draw from measures of perceived risk reduction as a result of NESC involvement
- Include results from customer surveys

Notional example of risk reduction



NESC Systems Engineering Office Activities

- Perform Independent Trending Analysis
  - Proactively uncover technical vulnerabilities so that problems may be either prevented or corrected
  - NESC sponsored a Trending Workshop
    - Included participants from NASA, industry and academia
    - Provided recommendations for formulating an approach to trending across the Agency
    - NESC to facilitate an Agencywide Trending Working Group to determine best practices and improve data mining and trending within the Agency

NESC Systems Engineering Office Activities (cont'd)

- Perform Independent Trending Analysis (cont'd)
  - Challenges have been encountered in performing data mining within the Agency
    - An integrated approach currently does not exist
    - Many different databases without a common format, classification system or ontology
    - No common standard or requirement currently exists

Lesson: Establish Agency standards and best practices for data collection and the corresponding data taxonomy.

Overview and Lessons Learned from NESC Technical Activities

General Lessons Learned from Technical Activities

- In preparation for Technical Assessments, the NESC found extensive use of PowerPoint documentation in lieu of formal engineering reports
  - Confirming observation of Columbia Accident Investigation Board
- PowerPoint is a tool for top-level presentations, but should not be used for engineering documentation

General Lessons Learned from Technical Activities (cont'd)

- NESC will use formal engineering reports and position papers to document all work
  - Reviewed and approved by the NESC Review Board
- PowerPoint charts will be used only for status reporting and briefings
  - Includes a disclaimer that charts are for status only

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

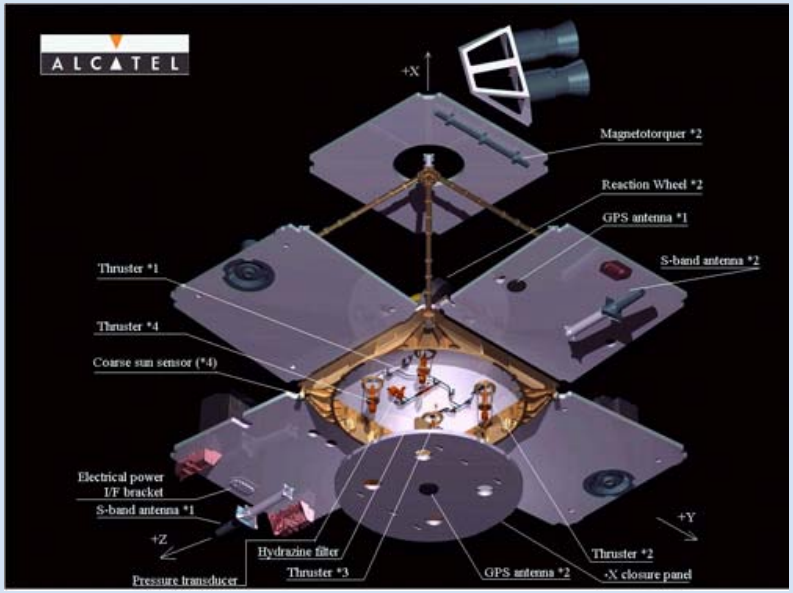
Lesson: Emphasis should always be on content not format, regardless of whether PowerPoint or an engineering report is used for communication.

Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) Independent Technical Assessment

- **NESC Lead: Rick Gilbrech, LaRC, NESC Principal Engineer**
- **Team Members:**
  - **John McManamen/JSC**
  - **Frank Robinson/GRC**
  - **Bill Schoren/GRC**
  - **Tim Wilson/KSC**
- **Initiated on November 6, 2003 by GSFC Center Management**
- **Final Report Document RP-04-01/03-001-E**

CALIPSO Independent Technical Assessment Overview

- The CALIPSO Spacecraft is a joint NASA and Centre National d'Etudes Spatiales (CNES) mission scheduled for launch on a Boeing Delta II at Vandenberg in 2005
- The hydrazine-fueled Proteus propulsion bus was manufactured by Alcatel Space Industries in Cannes, France
- GSFC raised concerns about the Proteus bus not meeting NASA fault tolerance design guidelines and Air Force Eastern and Western Range (EWR) requirements
- Concerns surrounded personnel hazards during launch processing (~36 day exposure window)



CALIPSO Independent Technical Assessment Overview (cont'd)

- The scope of the NESC Technical Assessment was a review of the Proteus propulsion bus design and an assessment of three potential hazards for personnel exposure to hydrazine propellant
  - Use of mechanical fittings instead of welded joints for propulsion system fluid connections
  - The potential for hydrazine leakage through thrusters
  - The potential for inadvertent thruster firing
- Loss of mission, or spacecraft, was not a part of the NESC assessment

CALIPSO Independent Technical Assessment Results and Forward Work

- Eleven NESC requirements levied on Program
- Action plan from Program reviewed by the NESC
- NESC Team Lead attending Alcatel Site Inspection May 12-15, 2004
- Final NESC position will be briefed at CALIPSO Integrated Program Management Council in June 2004 at LaRC

CALIPSO Independent Technical Assessment Lessons Learned

- A concern was voiced over the use of mechanical fittings instead of welded joints due to the possibility of hydrazine propellant leakage during ground processing.
- Process-sensitive assemblies, including welded joints and mechanical fittings, require strict attention to workmanship and verification.
- Properly welded fluid connections are inherently more reliable than mechanical fittings and should be incorporated in fluid propulsion designs employing hazardous commodities whenever possible.
- The CALIPSO spacecraft, as designed, can be safely processed given rigorous attention to assembly procedures and the strict application of ground safety controls.

Lesson: In the design phase of a project, 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 assessment consider potential hazards through the project's entire life cycle, including ground processing and integration.

CALIPSO Independent Technical Assessment Lessons Learned (cont'd)

- During the Technical Assessment it became clear that there was confusion over certain safety requirements among the organizations involved in CALIPSO
- The roles of the various safety organizations were not clearly defined

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.

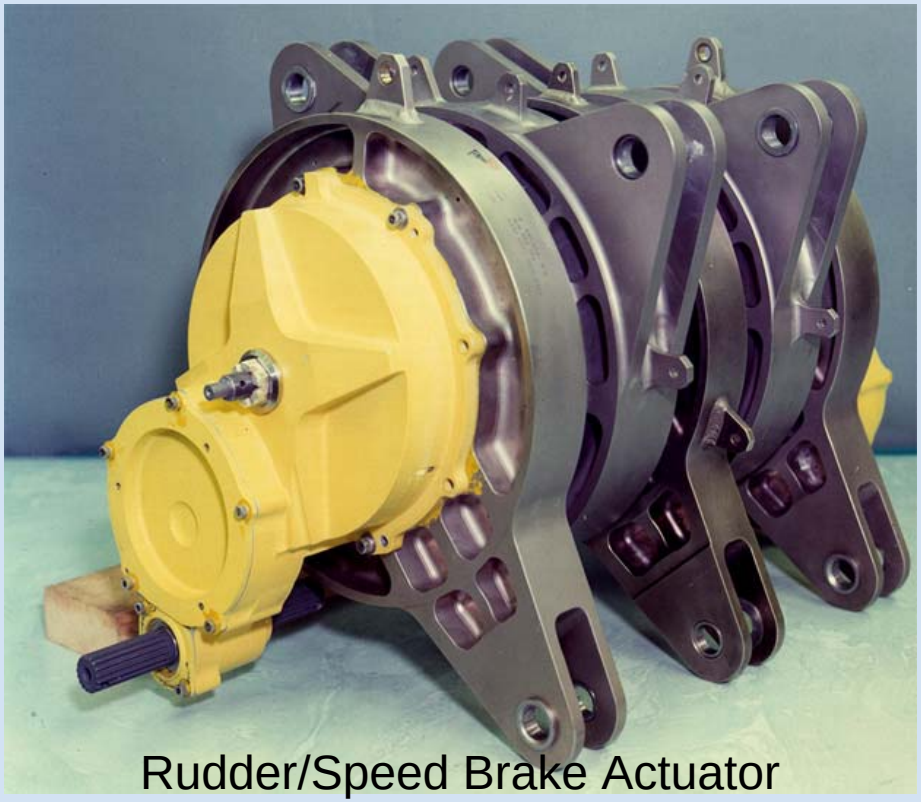
Lesson: NASA must establish unambiguous requirements for fault tolerance.

Orbiter Rudder/Speed Brake Braycote Grease Independent Technical Assessment

- **NESC Lead: Paul Munafo, LaRC, NESC Deputy Director**
- **Team Members:**
  - **Philip Hall/MSFC**
  - **Edward Devine/Swales**
  - **Michael Dube/Consultant**
  - **Timothy Jett/MSFC**
  - **William Jones/GRC, retired**
  - **John McManamen/JSC**
  - **Joseph Pelliccioti/GSFC**
  - **Roamer Predmore/GSFC, retired**
  - **Francisco Hernandez, JSC**
- **Initiated on November 6, 2003 by Space Shuttle Orbiter Project Management**
- **Concluded on February 19, 2004**
- **Final Report Document**
  RP-04-03/03-003-E

Orbiter Rudder/Speed Brake Braycote Grease Independent Technical Assessment Overview

- The Space Shuttle orbiter rudder/speed brake system provides steering and braking for the orbiter during landing
- During inspection of the OV-103 Rudder Speed/Brake Actuators corrosion, pitting, wear and some lubricant degradation was found.
- Actuators for OV-103 were being changed out utilizing single remaining set of (4) spares from inventory. Spares have been in storage for 17 years.



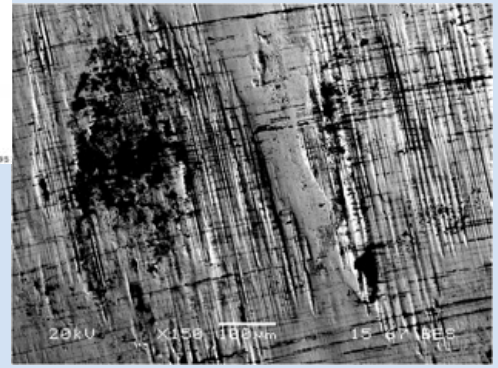
Rudder/Speed Brake Actuator

Orbiter Rudder/Speed Brake Braycote Grease Independent Technical Assessment Overview (cont'd)

- Concerns related to lengthy storage time, well beyond the original certified life:
  - Lubricity of separated grease
  - Chemical degradation of grease
  - Corrosion of the alloy steel of the internal housing, gears, and bearings

Gear with discolored Braycote grease

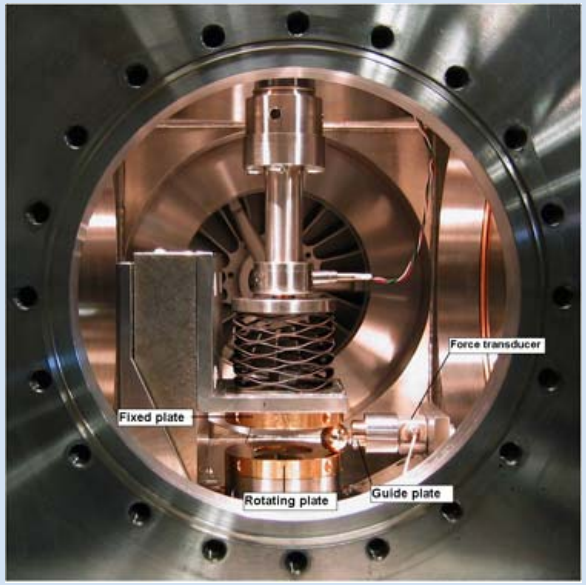
Gear with micro pitting



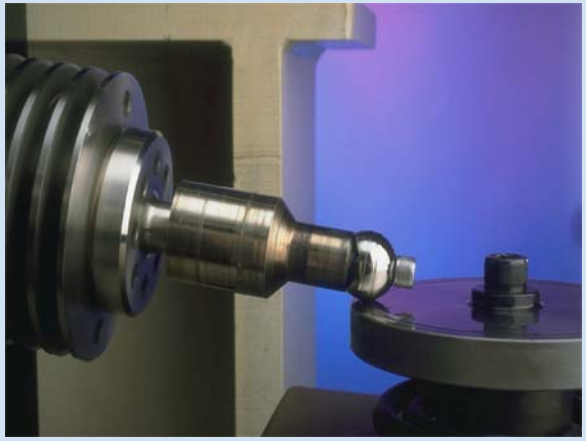
Orbiter Rudder/Speed Brake Braycote Grease Independent Technical Assessment Overview (con't)

The NESC conducted extensive testing to develop test data which was previously unavailable.

Falex Block-on-Ring at MSFC



Spiral Orbit Tribometer at GRC



WAM Test at Wedeven & Associates

Test data from these tests showed that there was no significant difference in lubricity due to separated or degraded grease. The pitting corrosion was shown to be tribologically induced, and not the result of chemical action

Orbiter Rudder/Speed Brake Braycote Grease Independent Technical Assessment Results and Lessons Learned

- The actuators removed from storage after 17 years were shown to be acceptable for flight on OV-103
- Based on testing data, there is no significant difference in lubricity due to separated or degraded grease and no evidence that the grease will degrade at steady state in ambient temperatures

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.

X-43A Prediction of Transonic Aerodynamics Dissenting Opinion Consultation

- NESC Lead: Steve Labbe, JSC, NESC Discipline Expert, Flight Sciences
- Team Members:
  - Michael Gilbert/LaRC
  - Michael Kehoe/DFRC
  - Frank Bauer/GSFC
  - John Ruppert/JSC
- Initiated on November 6, 2003 by a dissenting opinion
- Concluded on March 18, 2004
- Final Report Document RP-04-02/03-002-E

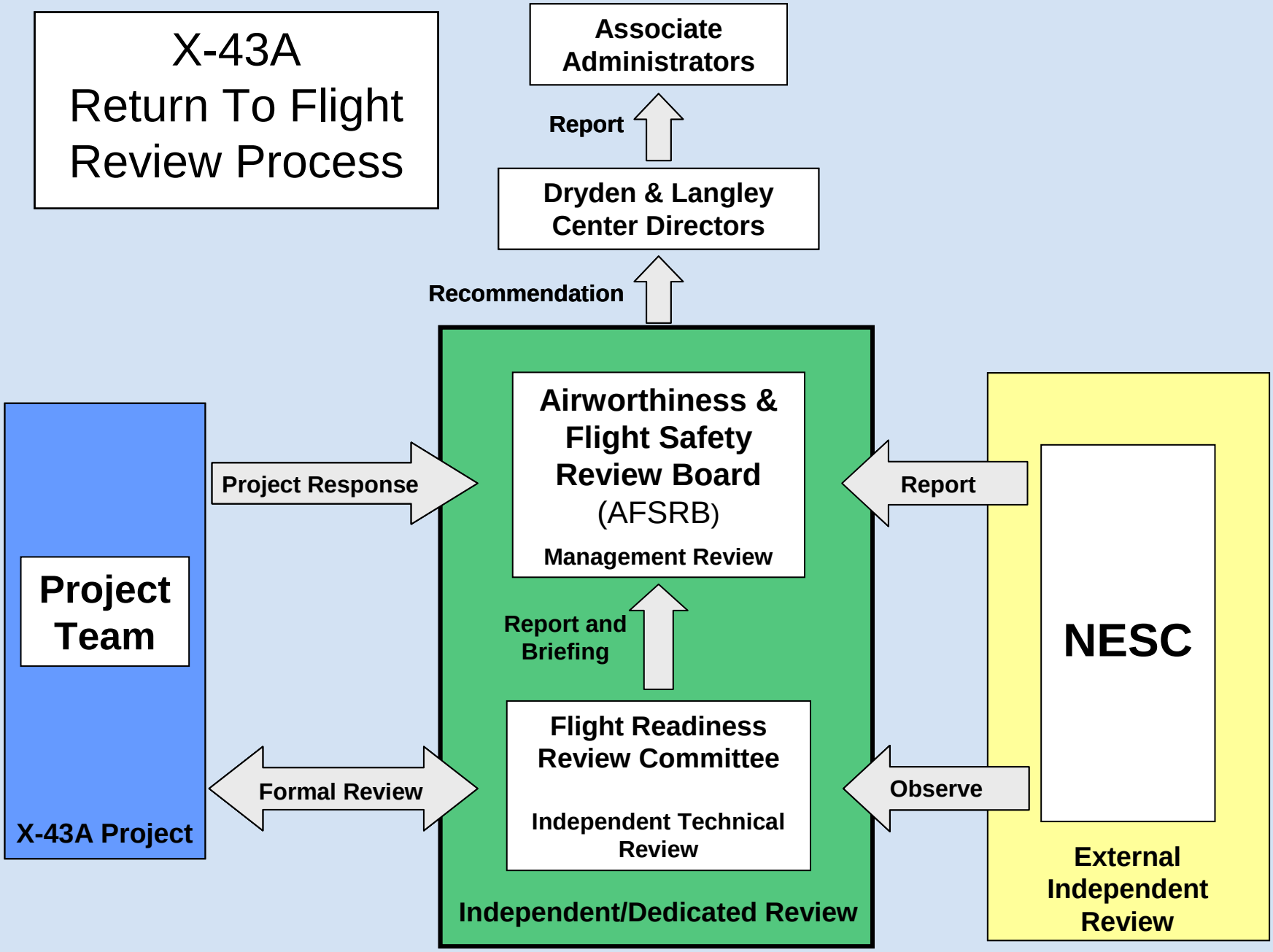
X-43A Prediction of Transonic Aerodynamics Dissenting Opinion Consultation Overview

Key Mission Events

X-43A Prediction of Transonic Aerodynamics Dissenting Opinion Consultation Overview (cont'd)

- NESC involvement was initiated by a dissenting opinion via e-mail message
- Concern raised with potential aerodynamic issues regarding the combined modified Pegasus Launch Vehicle / X-43A boost flight phase
- Worked with the X-43A Project to have issues addressed by the existing independent X-43A Flight Readiness Review (FRR) process
  - NESC observed and assessed the FRR process to ensure concern properly addressed
  - An Independent Technical Assessment was not performed

X-43A Return To Flight Review Process



X-43A Prediction of Transonic Aerodynamics Dissenting Opinion Consultation Results and Lessons Learned

- The X-43A Flight Readiness Review (FRR) process defined in Dryden Handbook DHB-X-001, provides for a robust review *process*
  - Allows for FRR initiated actions, necessary response time and appropriate follow up on the identified technical issues
  - Provides a mechanism for dissenting opinions via Request For Action (RFA)
  - Independently established from outside the program
  - Draws on the necessary expertise and skills from across the Agency as required
  - Reports independently to the Airworthiness and Flight Safety Review Board (AFSRB) on a program's flight readiness

Lesson: Dryden Flight Center's FRR 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.

X-43A Prediction of Transonic Aerodynamics Dissenting Opinion Consultation Results and Lessons Learned (cont'd)

- It takes courage and conviction to openly present and defend a dissenting opinion to a program or organization.
- It is in NASA's best interest to create an environment that encourages dissenting opinions within its programs.

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

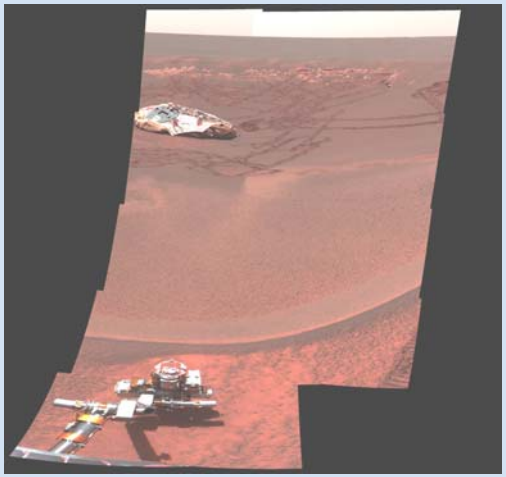
Mars Exploration Rovers Flight Operations Consultation

- **NESC Lead: Dave Leckrone, GSFC, NESC Chief Scientist**
- **Team Members:**
  - **Cynthia Null/ARC**
  - **John Caldwell/Brooks AFB**
  - **Claude Graves/JSC**
  - **Dean Kontinos/ARC**
- **Initiated on November 6, 2003 by JPL Safety and Mission Assurance**
- **Concluded on March 26, 2004**
- **Final Report Document RP-04-04/03-004-I**

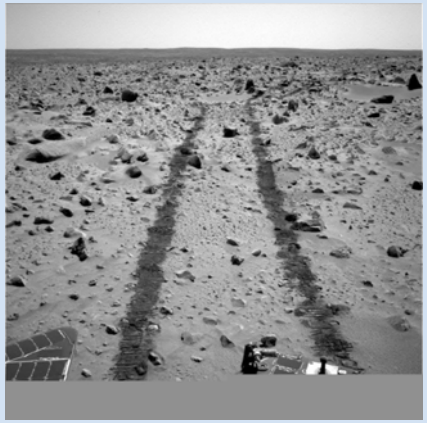
Mars Exploration Rovers Flight Operations Consultation Overview

- Mars Exploration rovers, Spirit and Opportunity were sent to Mars for geological exploration
- Spirit successfully landed on January 4, 2004
- Opportunity successfully landed on January 25, 2004
- Prior to these landings several critical readiness tests and reviews were conducted to maximize chances of mission success including:
  - Mission Operations Readiness Review, December 3-5, 2003
  - Spirit Entry, Descent, and Landing (EDL) Reconstruction “Red Team”, January 4-8, 2004
- NESC was requested to participate in two key areas:
  - Human Factors
  - Spirit EDL reconstruction assessment

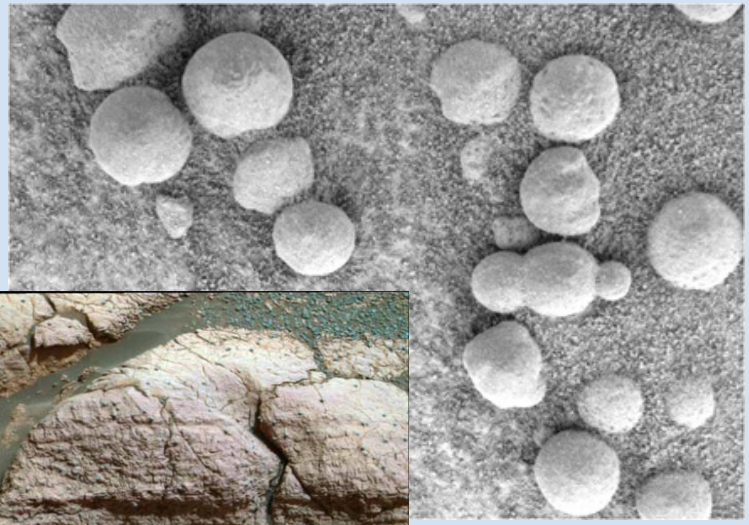
Mars Exploration Rovers Flight Operations Consultation Results and Lessons Learned

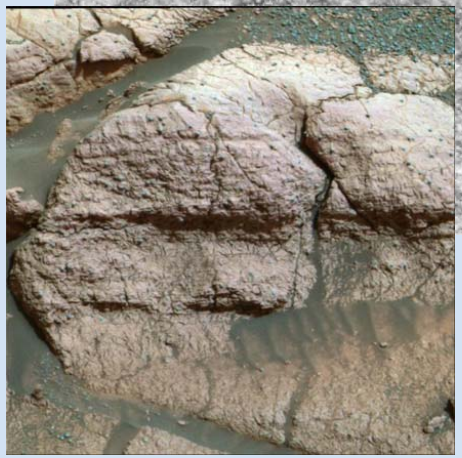


- Human Factors support by the NESC
  - Surface operations staff must cover work periods around the clock, but the Martian and Earth days differ in length so the start time of a work day moves 40 minutes each day
  - Concerns about performance of staff due to these shift changes were raised
  - Human factors experts were provided to assess the potential effects of the shift changes
  - Recommendations on fatigue and stress mitigation were provided to the project
  - Follow-up assessment was completed



Mars Exploration Rovers Flight Operations Consultation Results and Lessons Learned (cont'd)



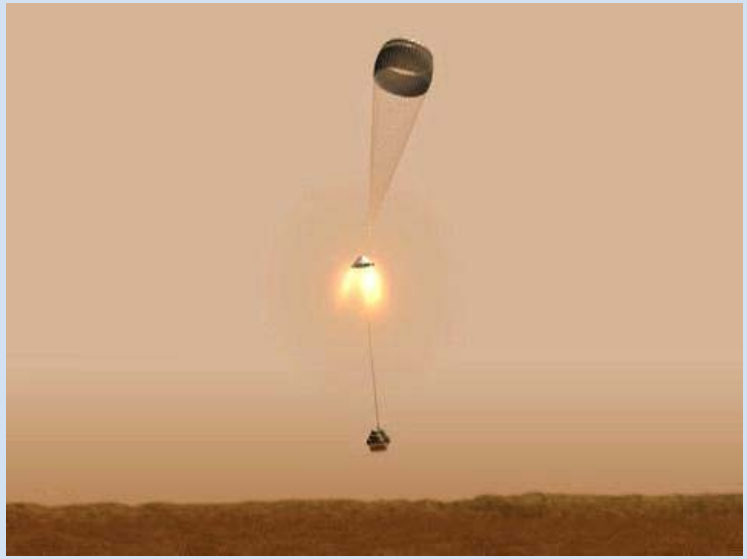


- Human Factors Reviewers recommended:
  - Appointment of an independent flight surgeon to evaluate fatigue status of all team members
  - Create alternative methods to get exhausted workers home
  - Establish maximum work limits and mandatory breaks from work
- MER Project was highly responsive to recommendations as applied to Civil Service and contractor staff; little leverage existed to influence science teams

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

Mars Exploration Rovers Flight Operations Consultation Results and Lessons Learned (cont'd)

- Entry, Descent, and Landing support by the NESC
  - NESC provided two experts in Flight Sciences to participate on the independent Red Team, chaired by Glenn Cunningham
  - Red Team's function was to assess the reconstruction activities of the Spirit Entry, Descent and Landing (EDL) team
    - The Red Team found that the Spirit EDL reconstruction was well executed, that the proper issues were analyzed, and proper recommendations were made relative to modifications for the Opportunity EDL



Mars Exploration Rovers Flight Operations Consultation Results and Lessons Learned (cont'd)

- Recommendations for Opportunity EDL to increase the probability of a successful landing
  - Increase the time margins for terminal descent
    - Reduce entry flight path angle (Considered but not required)
    - Increase the dynamic pressure at parachute deployment
  - While both vehicles were successful, deviations from the expected trajectory profiles/timelines for both Spirit and Opportunity raised several issues with relevance to future planetary missions

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

NESC Current Activities

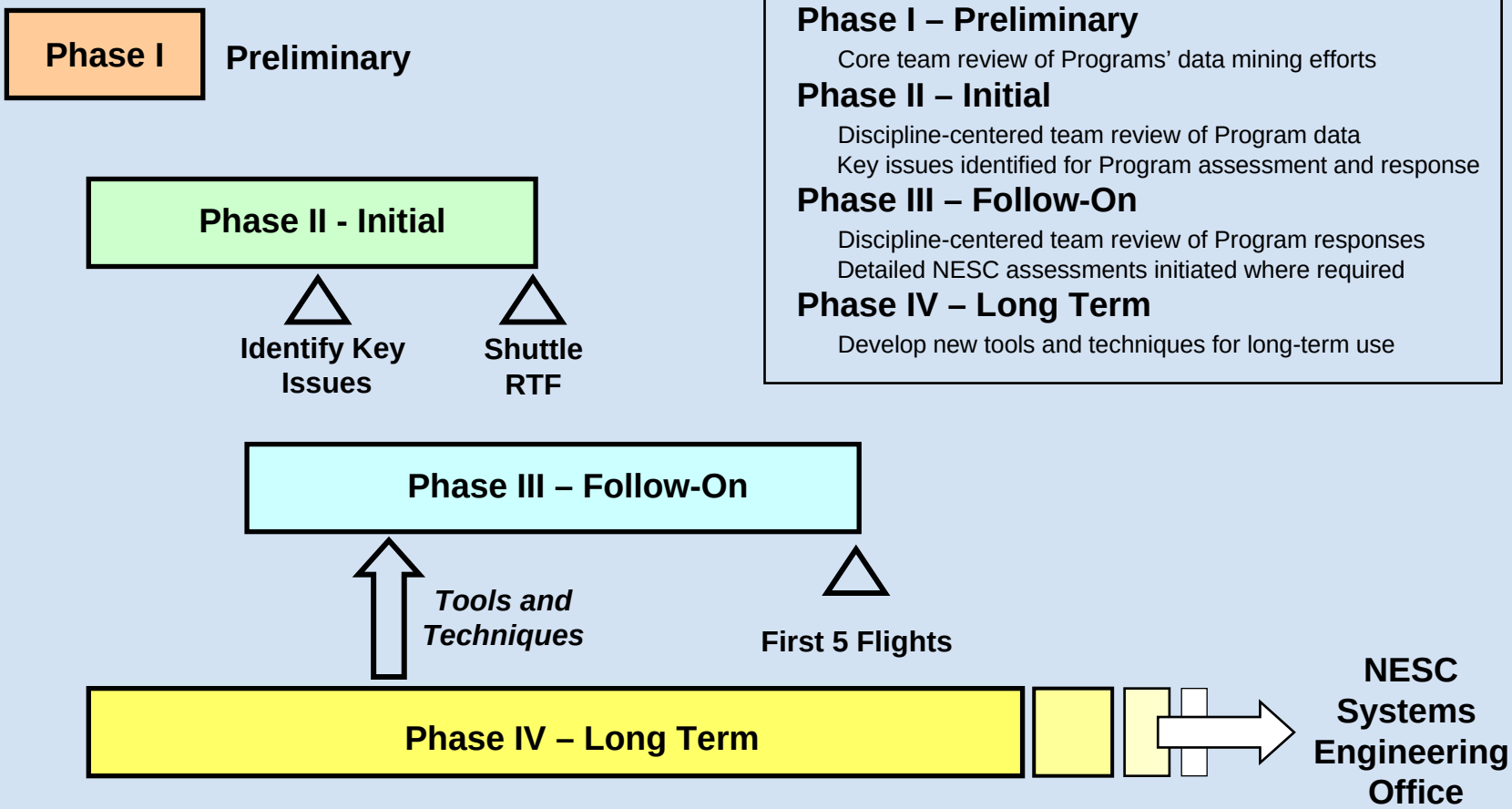
NESC Work in Progress:

- Establishing Super Problem Resolution Teams
  - Approximately 50% complete
  - Discipline teams need to be in place for NESC model to operate efficiently
- Overcoming challenges of NESC real-time involvement
  - NESC did not actively engage in MER Spirit real-time anomaly resolution to ensure no undue disruption to team
  - Establishing process for seamless real-time support
  - NESC real-time involvement with ISS Soyuz 7 helium leak was successful
- Independently reviewing Space Shuttle and ISS recurring anomalies

Independent Recurring Anomalies Review for Space Shuttle and International Space Station Programs

- Conduct independent review and assessment of recognized anomalies
- Build a mechanism for detecting unrecognized anomalies
- Answer two questions:
  - Are recurring anomalies telling us something we don't understand?
  - Can we "connect the dots" in ways we have not connected them before and highlight problems before they manifest themselves as failures?

Recurring Anomaly Phased Approach



Phase I – Preliminary

Core team review of Programs' data mining efforts

Phase II – Initial

Discipline-centered team review of Program data
Key issues identified for Program assessment and response

Phase III – Follow-On

Discipline-centered team review of Program responses
Detailed NESC assessments initiated where required

Phase IV – Long Term

Develop new tools and techniques for long-term use

Closing Remarks

- Appreciate Centers & Headquarters support by providing outstanding people to fill NESC positions, and technical support to technical teams
- Updates and final reports on NESC activities can be found on our website: www.nesc.nasa.gov
- NESC Leadership Briefings and brochures emphasize our broadly applicable lessons learned
- NESC will work with NASA Chief Engineer and OSMA to identify actions to implement lessons learned
- NESC Leadership Briefings will be held each Spring and Fall