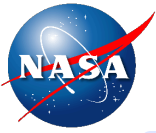




NASA Advisory Council Technology, Innovation and Engineering (NAC TI&E) Meeting

Office of The Chief Engineer

Joe Pellicciotti, NASA Chief Engineer
Katherine Van Hooser, NASA Deputy Chief Engineer
30 November 2023



Major Accomplishments in FY23



Office of the Chief Engineer (OCE)

Reducing Risk

Over two thirds of the FY23 budget was directed toward reducing risks or cross cutting challenges.

- LOX-Methane Quantity Distance Evaluation
- Aerospace Valve Reliability
- Conjunctions in LEO, including from Large Commercial Constellations
- High Purity Hydrazine (HPH) and Monomethyl Hydrazine (MMH) Supply for U.S. Government Space Missions
- Parachute System Reliability
- Thruster and small engine testing and evaluation
- Micrometeoroid/ Orbital Debris (MMOD) detection, collision prevention, and spacecraft design robustness

The OCE, including the NASA Engineering and Safety Center (NESC), continued to focus on reducing risk for the Agency's major priorities, with a large emphasis on Human Space Flight. Through Agency technical reviews, OCE ensured technical issues are fully vetted, and dissenting and divergent opinions were heard and appropriately considered. Engineering Technical Authority continued to support the Agency's programs, ensuring independent technical insight and assessment of programs at key programmatic milestones, such as:

Aeronautics Research Mission Directorate (ARMD):

- X-57 (Maxwell) Systems Test and Initial Flight-Testing Preparation.

Space Operations Mission Directorate (SOMD):

- International Space Station (ISS)
 - Continued flying safely with Engineering support for Anomaly Resolution and Certification of Flight Readiness (CoFR) Reviews for Crew and Logistics Visiting Vehicle Missions (CRS, CCP, Soyuz, Progress).
 - Supported anomaly resolutions and Program Investigation Team efforts.
- Commercial Crew Program (CCP)
 - Successful CoFR and completion of SpaceX Crew-5, 6 and the ongoing Crew-7 missions to ISS and certification preps for Crew-8.
 - Significant progress towards a Boeing CFT mission in 2024.
- Commercial Low Earth Orbit (LEO) Destinations
 - Completion of second successful Private Astronaut Mission to/from ISS.
 - Requirements released on an RFI to Industry.
 - Supporting several funded and unfunded SAAs with industry for destinations and transportation.
- Launch Services Program (LSP)
 - Certification and successful launch of a Falcon Heavy for the Psyche mission.



Major Accomplishments in FY23 (continued)



Office of the Chief Engineer (OCE)

Exploration Systems Development Mission Directorate (ESDMD):

- Artemis I Post Flight Assessment Review (PFAR) completed.
- Artemis I In-Flight Anomaly Resolution (IFA) work continues.
- RS-25 Production Restart Engine hot fire certification testing completed first of two samples in June 2023.
- Artemis II Preparations with Assembly Integration and Test (AI&T) at KSC.
- Artemis III SLS and Orion hardware assembly/delivery, and mission analysis and planning underway for the first human lunar landing mission.
- SLS B1B/EUS CDR completed with successful KDP-C and continues to progress in design, development, test, and production.
- EGS ML2 design/development progress in preparation for Artemis IV.
- Significant progress on Gateway elements including the PPE, HALO and IHAB. Significant progress on HLS Starship development with OFT/Flight and SpaceX.
- Selection of Blue Origin-National Team for the sustainable lunar lander provider that can be used for Artemis V plus.

Space Communications and Navigation (SCaN):

- Commercialization of Earth-Relay Services initiatives: Good progress being made with 6 companies awarded on-orbit communications demonstrations.
- Lunar services: Established plan for three ground stations for Lunar (Gateway) missions, to help offload Deep Space Network (DSN).

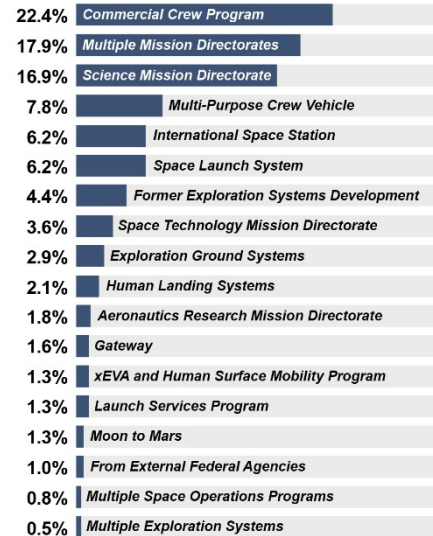
Science Mission Directorate (SMD):

- Surface Weather Ocean Topography (SWOT) – Completion of Safety and Mission Success Reviews leading to successful launch, commissioning, and transition to science operations.
- Psyche - Completion of Safety and Mission Success Reviews leading to successful launch on October 13, 2023.

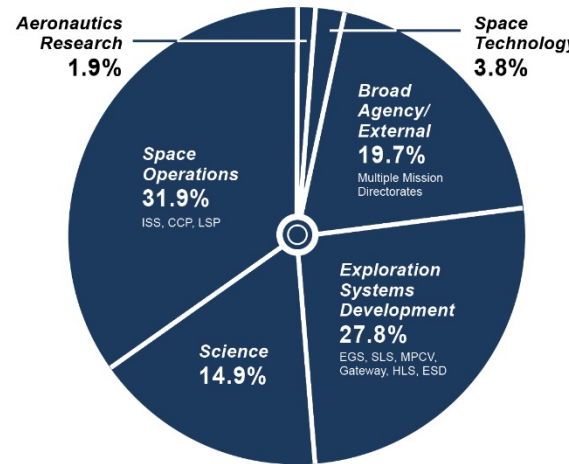
Space Technology Mission Directorate (STMD):

- Low Earth Orbit Flight Test of an Inflatable Decelerator (LOFTID): Launch and fully successful flight demonstration.
- Mars Oxygen ISRU Experiment (MOXIE): Completion of fully successful technology demonstration on Mars.
- Solar Electric Propulsion (SEP): Qualification testing began on thruster design for Gateway Power & Propulsion Element.
- On-Orbit Servicing, Assembly, & Manufacturing 1 (OSAM-1): Spacecraft bus delivered to GSFC from Maxar; began servicing payload integration & testing.

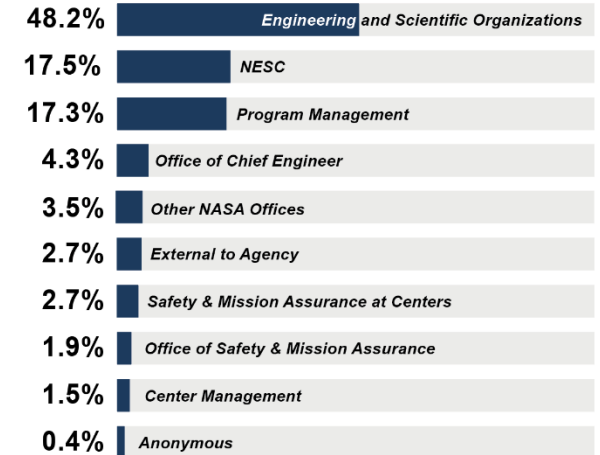
The NESC continued to deliver independent technical assessment of NASA’s highest risk programs, engaging in 160 technical efforts in support of all NASA Mission Directorates in FY23. 80 existing requests were completed with actionable recommendations delivered to the requesting stakeholders while an additional 80 new requests for assistance were received.



385 ACCEPTED REQUESTS BY ORGANIZATION
FY19-FY23



ACCEPTED REQUESTS BY MISSION DIRECTORATE
FY19-FY23



SOURCES OF ACCEPTED REQUESTS
FY04-FY23

Supporting Human Spaceflight - Over half of the NESC’s active work portfolio in FY23 directly supported human spaceflight.

Over half of the NESC’s active work portfolio in FY23 directly supported human spaceflight, while the balance supported science missions, space technology, or issues that impact multiple mission directorates. Approximately one-quarter of the portfolio was devoted to safely transporting crew to and from the ISS as well as sustaining the ISS, while another one-quarter directly supported the Artemis Exploration missions. Almost two-thirds of NESC activities completed in FY23 directly supported human spaceflight missions.



Major NESC Studies Completed in FY23



Office of the Chief Engineer (OCE)

Software Risk Analysis Guidelines

Characterize the quantity and severity of software defects across NASA's major programs and assess whether a given number of defects could be considered "in family" or "out of family" at key points in a program's life cycle with an emphasis on human-rated first flights and early phase. Compared problem removal rates and efficiency, defect severities, defect closures over time, and defect density for the final build of software prior to launch.

Consistent approach for collecting defect data across its programs/ projects, update NASA-HDBK-2203, NASA Software Engineering, to provide additional guidance on the use of tools to track workflow versus defect resolution and develop an Agency-wide defect-data repository to advance the software discipline.

Making an Impact on Spacecraft Safety and Reliability

Evaluating the complex behavior of composite overwrapped pressure vessels (COPV).

Resulted in corrections to NASGRO, a popular finite element modeling code used to predict crack growth. Recommendation update for ANSI/AIAA S-081B *Space Systems Composite Overwrapped Pressure Vessels* standard.

Enabling Higher Performance and Lower-Cost Missions

Incorporating commercial-off-the-shelf (COTS) electrical, electronic, and electromechanical (EEE) parts to meet challenging size, weight, power, and performance requirements relative to MIL-SPEC or radiation-hardened parts.

Develop a more unified approach and consensus to enable the use of COTS parts and have that approach and consensus reflected in updated Center-level and Agency-level standards and guidance.

Copper Wire Bonds for Space Programs







Economics and thermal/electrical properties of copper wire have driven the replacement of gold wire bonds in the majority of commercial semiconductor devices. To date, no military standard for copper-bondwire qualification or standards for destructive physical analysis and plastic encapsulated microcircuit construction analysis have been developed.

Team demonstrated reliability of copper wire bonds to be comparable to gold bonds. The team also developed screening and lot acceptance testing guidelines for evaluating copper-wire bonds in plastic parts for a range of NASA flight conditions and mission risk classifications.

Completed Activities*

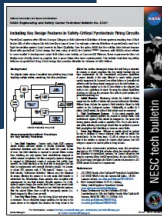
- Examination of Space Vehicle Ethernet Interconnects
- Analysis of Side Hatch Loads on the Orion Crew Module
- Ceramic Capacitor Microstructure Analysis Tool Development
- Evaluation of Launch Pad Modifications
- Autonomous Flight Termination Systems
- Applying Advanced CFD to Determine Dynamic Stability
- Human Factors Assessment of the design of the OSAM-1 Mission Operations Center

** Majority of NESC assessments and tech support have restricted markings (CUI, ITAR, EAR, Limited Rights Data, Proprietary Data and/or Commercial company limited rights.*

 <p>ENGINEERING REPORTS</p> <p>Documented results of independent testing and analysis delivered to the requesting stakeholders.</p> <p>22 in 2023</p>	 <p>TECHNICAL BULLETINS</p> <p>Critical engineering information or best practices captured in a one-page, quick-read format.</p> <p>7 in 2023</p>	 <p>JOURNAL ARTICLES & CONFERENCE PAPERS</p> <p>Citations for publications summarizing NESC technical activities for discipline-specific audiences.</p> <p>95 in 2023</p>
 <p>LESSONS LEARNED</p> <p>Useful knowledge gained from experience.</p> <ul style="list-style-type: none"> • <i>Lessons Learned Information System (LLIS)</i> • <i>NESC Academy</i> 	 <p>INNOVATIVE TECHNIQUES</p> <p>New and creative engineering approaches developed during NESC technical activities.</p> <p>3 in 2023</p>	 <p>TECHNICAL UPDATES</p> <p>Annual reports of NESC technical activities.</p>

Technical Bulletin 23.01

Including Key Design Features in Safety Critical Pyrotechnic Firing Circuits



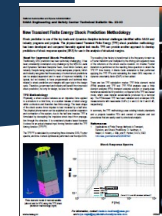
Technical Bulletin 23.02

Safety Considerations when Repurposing Commercially Available Flight Termination Systems from Uncrewed to Crewed Launch Vehicles



Technical Bulletin 23.03

New Transient Finite Energy Shock Prediction Methodology



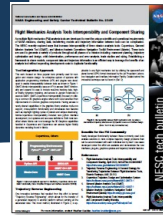
Technical Bulletin 23.04

Fast Coupled Loads Analysis Method: Norton Thevenin Receptance Coupling



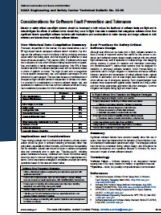
Technical Bulletin 23.05

Flight Mechanics Analysis Tools Interoperability and Component Sharing



Technical Bulletin 23.06

Considerations for Software Fault Prevention and Tolerance



Technical Bulletin 23.07

Best Practices for Fabrication of Microelectronic Devices





OCE will continue to ensure independent technical insight and assessment of the following programs at key programmatic milestones:

ARMD:

- X-59 first flight.

SOMD:

- ISS
 - First flights of vehicles providing new cargo capability with Sierra Space Dream Chaser and JAXA HTV-X.
 - Numerous SpaceX, Northrop Grumman cargo missions.
- CCP
 - SpaceX Crew-7 return from ISS, Crew-8 to/from ISS and Crew-9 to ISS.
 - Boeing Starliner CFT to ISS.
- CLDP
 - Third and fourth Private Astronaut Missions to/from ISS.
- LSP
 - PACE Falcon 9, GOES-U Falcon Heavy, and several Venture Class launches.

ESDMD

- Complete closure of Artemis I IFA in preparations for Artemis II.
- Continue Artemis II mission preparations with Assembly Integration and Test at KSC.
- Continue Artemis III development and mission analysis/planning for the direct Orion-to-Starship lunar landing mission.
- HLS – Starship milestones including the Orbital flight test-2, the propellant transfer flight test, and the long duration flight test.
- Gateway – Integrated Analysis Cycle.
- Continue EGS ML2 design/development in preparation for Artemis IV.



Plans for FY24 (continued)



Office of the Chief Engineer (OCE)

SCaN

- Artemis SCaN loading: Complete assessment of SCaN network needs with the demands from the Artemis missions, specifically Artemis III, Artemis V, and demonstration missions from HLS, and reconcile acceptable support posture.
- Commercialization of Earth-Relay Services initiatives: Working with commercial providers to enable early demonstration activities to inform agency's plans for TDRS flyout and user missions off-ramp. Continuing integration and testing phase for Polylingual wideband terminal flight demonstration this FY.
- Lunar: Complete upcoming design review milestones of three Lunar Exploration Ground Stations (LEGS), incorporating back-end data transport infrastructure to mission control centers. Perform evaluation responses to RFP for commercial lunar ground stations that can add to LEGS to increase supply of available communications links for Artemis.

SMD

- Plankton, Aerosol, Cloud, and ocean Ecosystem (PACE) and GOES-U, launch, commissioning, and transition to science operations.
- Continue development of the Dragonfly mission through CDR of the elements and project.
- Completion of Assembly, Integration, and Test (AIT) for the Europa Clipper mission.

NESC

- Continue to perform value-added independent testing, analysis, and assessments of NASA's high-risk projects to ensure safety and mission success.

STMD

- Deep Space Optical Communications (DSOC): Launched with Psyche and first year of flight demonstration.
- Solar Electric Propulsion (SEP): Begin lifetime qualification testing on thrusters for Gateway Power & Propulsion Element and delivery of first flight thruster.
- Cryogenic Fluid Management (CFM): SpaceX CFM Tipping Point flight demonstration with Starship.
- On-Orbit Servicing, Assembly, & Manufacturing 1 (OSAM-1): System Integration Review and KDP-D.
- Space Nuclear Propulsion (SNP): Reactor delta-PDR, engine PDR, and reactor CDR for Demonstration Rocket for Agile Cislunar Operations (DRACO).
- Polar Resources Ice Mining 1 (PRIME-1): Launch and lunar demonstration.
- Cooperative Autonomous Distributed Robotic Explorers (CADRE): Delivery of flight hardware for lunar demonstration.



Concluding Remarks



Office of the Chief Engineer (OCE)

The Office of the Chief Engineer is focused on the technical and programmatic readiness of the Agency's programs and projects.

- Serves as the principal advisor to the Administrator and other senior officials on matters pertaining to the technical readiness and execution of NASA programs and projects.
- Provides policy direction, oversight, and assessment for NASA engineering and ensures the continuity and application of critical knowledge throughout NASA's engineering workforce.
- Ensures that NASA's development efforts and mission operations are planned and conducted on a sound engineering basis with proper controls and management of technical risks.

OCE actively assesses and continues to evolve as missions and plans evolve.