
NICER
Neutron star Interior Composition ExploreR
Lessons Learned
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NASA
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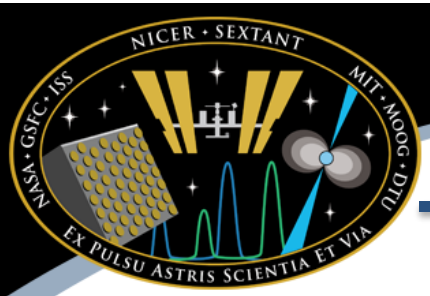
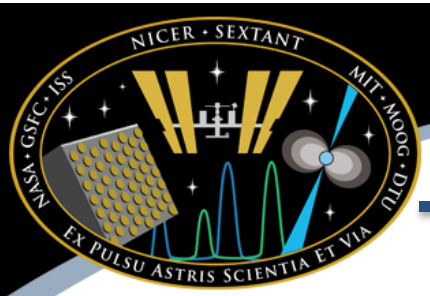


NICER's Success Built on Lessons Learned

- GSFC has a strong history of Class D mission success
- GEMS mission was cancelled in 2012
- NICER was one of the first Class D mission after the GEMS Mission cancellation
- GEMS lessons learned included Project and Center lessons
- GSFC has implemented changes to address GEMS lessons
  - Established Instrument Projects Division
  - Established new Director role in Engineering Directorate for staffing and resources
  - Established Product Development Lead (PDL) training
- NICER implementation plan addressed GEMS lessons
  - Experienced leadership and maintaining continuity
  - Clarify in-house PI mission management
  - Pay close attention to staffing
  - Keep all stakeholders informed
  - Establish clear implementation expectations and executable funding profile
  - SMEX cost-cap cannot tolerate technology development

"There is only one thing more painful than learning from experience, and that is not learning from experience" - Archibald MacLeish

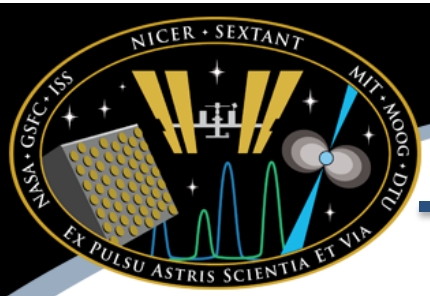


Tailoring for Success

- GSFC released "Class D Constitution" at NICER selection in Spring 2013:
  - Constitution was Guideline for tailoring 7120.5E for Class D
  - Develop project implementation plan that streamlines processes, documentation, and establishes project-level authority
    - NICER Project Implementation Plan (PIP) included many documents that were typically standalone documents
    - Tailored lifecycle reviews
      - Eliminated SIR and replaced it with equivalent ISS reviews
    - Received waiver for Earned Value Management
    - Streamlined reporting
      - Single monthly review inviting all stakeholders
  - Rigorous approach to risk management
  - Reduced reporting through timely communication and transparency
  - Senior Executive champion to help remove obstacles
  - Manage mission assurance by gaining insight into contractor practices. Focus is on the basics including AS9100 compliance.

Everything Can Be Tailored Except Safety

- NICER was Class D mission with a Class A interface
- Safety requirements drive design
  - NICER made design changes to address safety requirements
- Safety reviews require unique experience
  - Class D risk decisions occur daily. Experienced personnel are best suited to these real-time decisions.
    - NICER was fortunate to have CSO and Safety Officer with ISS experience
  - NICER relied on personnel with ISS experience to navigate the ISS processes and priorities
    - Example: ISS safety review – Speaking the language of safety
      - Phase 0/1 review raised concerns based on how information was presented
      - Change in strategy at Phase 2 review was successful
        - » ISS Payload Safety Review Panel Chair (PSRP) Chair: "The NICER Project is the model for human space flight safety."

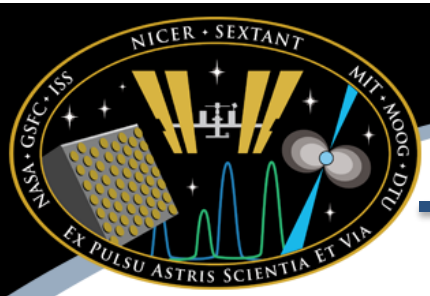


Communicating Vision and Team Continuity

- Continuity of key roles on NICER was critical to success
- Key Management and Engineering roles were maintained from Phase A-E.
- PI clearly communicated vision and involved in selection of all key personnel
- Continuity enabled:
  - Holding successful Systems Requirements Review in Phase A prior to selection
  - Running start in Phase B for level 4 and 5 requirements development and supporting long lead procurements
  - Seamless transition from Phase D to Phase E
    - Phase C/D test conductors transitioned to mission operations

Establish Strong Relationships

- Step 2 Debrief weakness stated that "NICER team relied too much on personal relationships... rather than documented agreements"
- Building strong, personal relationships were one of the keys to NICER's success.
  - NICER was able to build strong relationships with stakeholders, partners, and launch vehicle provider
  - Program Executive was strong advocate for NICER at HQ and JSC
    - Examples: KDPs and managing critical exceptions
  - Research Integration Manager at JSC was a strong advocate for NICER to overcome multiple issues
    - Examples: EPIC Box funding, Keep out Zone issue
  - Maintained excellent working relationships with partners
    - Example: Moog-Broadreach - building ETU boards at GSFC
  - Worked well with SpaceX to ensure NICER requirements were addressed
    - "Ship and shoot" policy and contamination bag

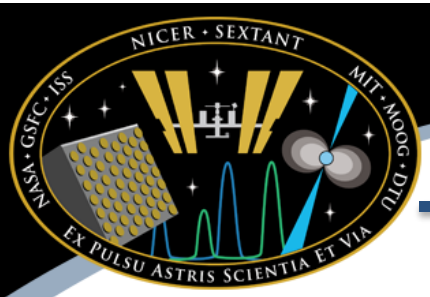


Create and Maintain a Class D Culture

- Ensure team members share a common Class D vision
  - Cost and schedule are equal considerations with meeting technical requirements
  - Class D is about making risk-informed choices
- Risk management is not just for the management team
- Rapid risk-informed decision making at all levels of Project
- Class D culture requires maintenance throughout lifecycle

Maintaining Schedule

- **NICER was able to deliver in June 2016, 2 weeks ahead of a schedule that was predicted in the Concept Study Report submitted in July 2012. Keys to maintaining schedule by Phase:**
  - **Phase A**
    - Establishing Partnership Opportunity Documents (PODs) in Phase A
  - **Phase B**
    - Use simplified acquisition process (<$150K) to establish small contracts with major contractors allowing contractors to participate in requirements development.
    - Mobilized the team to focus on requirements development and statements of work (SOWs)
    - Higher than expected funding in Bridge Phase allowed NICER to accelerate procurements and rapidly get major contracts in place.
      - Change in Phasing left NICER vulnerable for low carryout due to cost growth
    - Used reserves early by adding Engineering Test Units to key contract deliverables
      - Significantly mitigated risk by allowing earlier testing and schedule savings by allowing FSW, Electronics and X-Ray Navigation to occur in parallel.
  - **Phase C/D**
    - Hold milestone review dates with rigorous planning and engineering peer reviews for subsystems.
    - Built Structural Verification Unit (SVU) to correlate model and mitigate late coupled loads changes
    - Instrument TVAC – added scope, training ground for pipeline processing and operations team
    - Reacted quickly to issues
      - Built flight 120V to 28V converter box in 1 year
      - Built High Power Switching box to accommodate for lack of switching capability on ISS
      - Keep Out Zone Issue



ISS Lessons Learned

- **Challenges:**
  - **Large number of requirements ~400, many of which are outdated from Shuttle era**
  - **Requirements lack a rationale, or have additional requirements in the verification text**
    - **Much higher level of systems support needed than originally planned ~ 5 FTE at peak**
    - **NICER addressed challenge by providing input to Revolutionize ISS for Science and Technology (RISE) initiative**
  - **RIM and PIM support large number projects and spread very thin**
    - **Built strong relationship with RIM and PIM to get necessary support**
  - **RIM and PIM are supported by engineers in parallel organizations (no direct line of authority)**
    - **RIM and PIM managed by influence and provided direct access between NICER team and ISS discipline engineers**
  - **Verification and exception approval is slow, inefficient and not consistent with SMD payload development lifecycle**
    - **Carried risk for each exception, which maintained awareness for all stakeholders and kept pressure on ISS**

SpaceX Lessons Learned

- SpaceX was the launch vehicle provider for NICER
- NICER was manifested with two other payloads
- Challenges:
  - Timeline for key ISS provided information is not compatible with Payload life-cycle timeline. Coupled loads analysis can be provided as late as 2 months before launch.
    - NICER's solution: build structural verification unit to qualify hardware and correlate model
    - Payload developers will need plan on addressing late coupled loads
  - ISS managed the SpaceX cost using a "ship and shoot philosophy."
    - NICER team pushed back to get more payload developer involvement in final integration activities to SpaceX Hardware, including discipline lead support.
  - SpaceX integration facility and SpaceX-11 co-manifested payloads were incompatible with NICER contamination control requirements
    - NICER team pushed back to get support
    - Other payloads have different cc requirements

Enjoy the Ride

NICER PI Keith Gendreau and Deputy PI Zaven Arzoumanian's Post Launch Assessment