National Aeronautics and
Space Administration

NASA Update on Webb & other topics

Astronomy & Astrophysics Advisory Committee Briefing

June 2018

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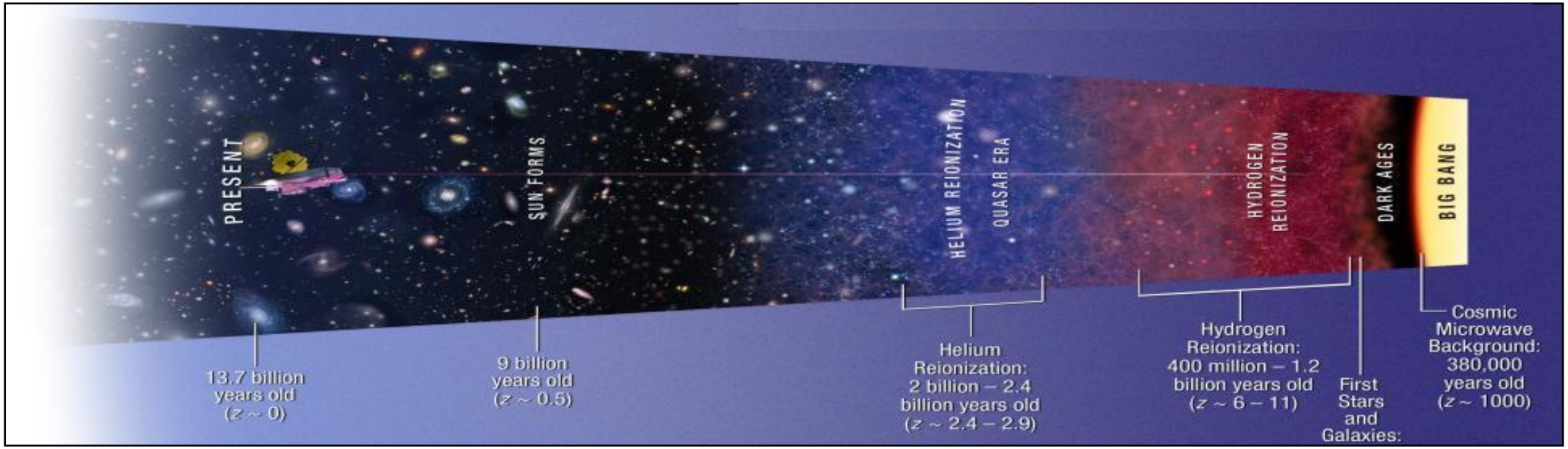
Summary

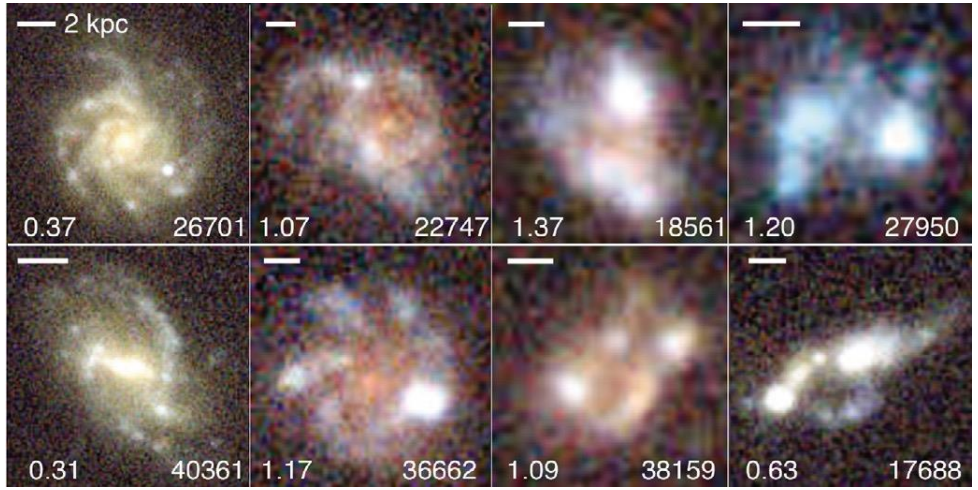
- JWST science is world class and compelling.
- Mission success is the driving consideration going forward.
- Technical complexities have greatly impacted the development schedule.
  - First of a kind developments.
  - Avoidable technical errors, especially human errors and embedded problems.
- Received report from the Standing Review Board (SRB) and the Independent Review Board (IRB).
- Focused on schedule and recommendations for mission success.
- SMD accepts the IRB recommendations.
- NASA & NGAS have initiated process controls and corrective actions to address the IRB recommendations.
- Revised schedule and cost reflect a 80% confidence level; consistent with SRB/IRB.
  - Conservative in accounting for unplanned inefficiencies.
  - UFE may be applied to unknown-unknown issues.
- Proposed total lifecycle budget is within IRB estimation of $1B additional cost.
  - $828M proposed NOA needed + $202M existing UFE = $1.03B.
- The congressionally mandated $8B development cost cap is exceeded by $803M.

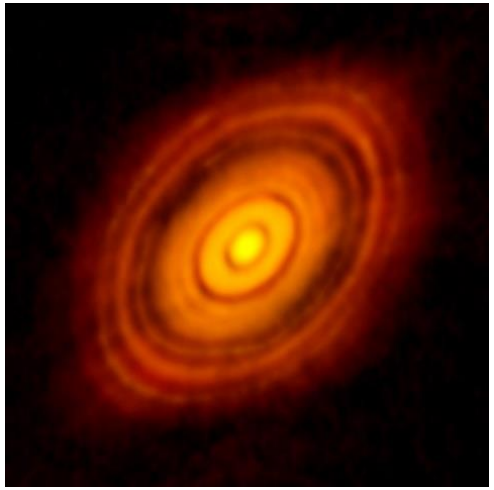
AGENCY AGREEMENT

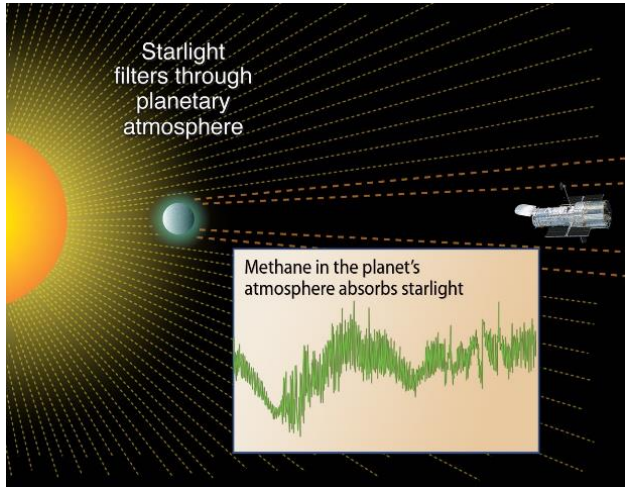
Proposed launch date: March 30, 2021
Proposed development cost: $8.803B
Proposed total lifecycle cost : $9.663B

Webb Science









Webb IRB* Charter

Evaluate all factors . . . influencing the JWST success, to ensure that NASA's approach to completing the Integration and Testing, the launch campaign and the commissioning of the Webb Telescope is appropriate for NASA's next flagship observatory.

* Independent Review Board (IRB)

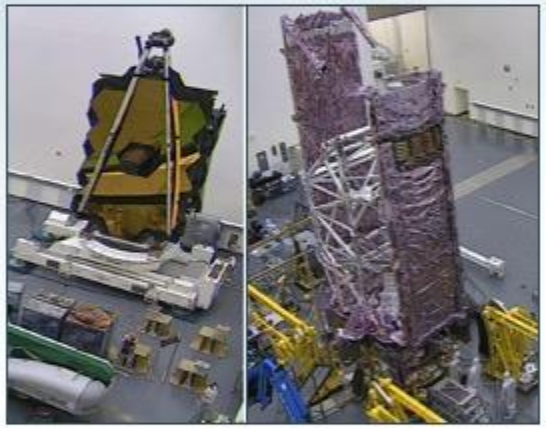
Webb IRB Guiding Principle

Maximize the probability of JWST mission success

Summary and Conclusion

- JWST is an observatory with incredible capability, awesome scientific potential and significant complexity, risk and first-time events.
- OTIS Integration and Test (I&T) is complete and has demonstrated the exceptional science capability of the system.
- Significant launch date delays and resulting cost caused by human errors, embedded problems, excessive optimism in I&T planning, lack of sunshield experience and system complexity have occurred. Small I&T problems can have a major impact upon schedule and cost.
- JWST inherent risk requires mission success be the highest priority in completing JWST development.
- The Webb IRB believes that implementing all recommendations contained in this report will contribute to maximizing the probability of mission success.
- Eliminating the schedule and cost impact of human errors and embedded problems is critical to completing the successful development of JWST.
- The Webb IRB believes that JWST should continue based on its extraordinary scientific potential and critical role in maintaining U.S. leadership in astronomy and astrophysics.

JWST Mission Work to Go



Integration and Test

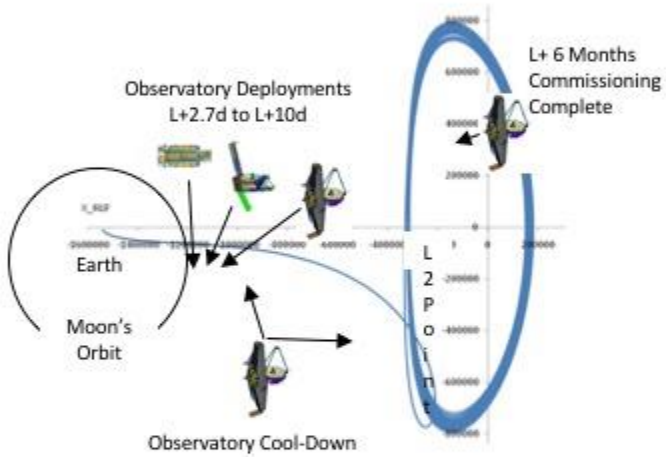
- Spacecraft Element (SCE) Integration and Test
- Observatory Integration and Test
- Operational Readiness Verification
- Certification of Readiness for Shipment

Shipment

- Observatory and equipment ship from Long Beach, CA through the Panama Canal to the Port of Pariacabo in Kourou, French Guiana
- MN Colibri Shipping Vessel operated by Compagnie Maritime Nantaise

Launch Campaign

- European Space Agency (ESA) Space Port in French Guiana
- 62 days at space port where Observatory and Ariane 5 Launch vehicle are prepared and launched



Observatory Commissioning

- 13 days early commissioning for deployment of sunshield and telescope assembly
- 165 days cooldown of telescope and commissioning of instruments

JWST "Firsts"

- Sunshield has no significant legacy.
- NASA experience with actively controlled segmented mirrors.
- NASA spacecraft launched on Ariane 5.
- NASA spacecraft transported by water from California to Kourou, French Guiana (South America) via the Panama Canal.
- NASA spacecraft processing and launch integration at Kourou, French Guiana.
  - Topex/Poseidon launched from Kourou, French Guiana in 1992 on an Ariane 4.
- Flight operations conducted by STScI.
- Large and complex observatory operations at Lagrange Point 2 (L2).

INDEPENDENT REVIEW BOARD (IRB) FINDINGS & NASA RESPONSE

The Webb Independent Review Board Report and the NASA Response are available for download

https://www.nasa.gov/press-release/nasa-completes-webb-telescope-review-commits-to-launch-in-early-2021

https://www.nasa.gov/sites/default/files/atoms/files/webb_irb_report_and_response_0.pdf

Findings and Recommendations (Human Mistakes During I&T)

Findings

- There have been human-induced errors that have had a significant impact on JWST launch schedule.
- Propulsion system problems are an example of the "human-induced errors" concern:
  - Wrong solvent used to clean propulsion valves.
  - Test wiring error that caused excess voltage to be applied to transducers.
- Observatory complexity causes small mistakes to have large implications to mission success, schedule and costs.
  - Fastener problem is a prime example.
- Human errors must be minimized; however, they cannot be totally eliminated.
- A "safety net" is essential to eliminate the negative impact of a human error.
- An effective "safety net" requires discipline and individual and organizational accountability at all levels.

Findings and Recommendations (Human Mistakes During I&T)

Recommendations

- NGAS functional organizations establish corrective actions in the following areas:
  - Processes – ensure current, accurate, implementable and not subject to interpretation.
  - Training – small errors produce large consequences.
  - Personnel certification – ensure people capable of performing the task at hand.
  - Discipline – ensure individual accountability and follow the process, call a halt if the process appears questionable.
  - Failure-proof "safety net" – testing, independent analysis, inspection.

Human Mistakes During Integration and Test

NASA/Northrop Grumman Aerospace Systems (NGAS) Response:

- **Agree**
  - NGAS stood down operations and performed an independent set of reviews and rewrites of all prop procedures including feedback from the performers. Also, applied Integration & Test (I&T) procedure expertise to manufacturing operations. To further enhance robustness in I&T NGAS will be incorporating cross program independent reviews of the table top and pre-task briefing processes.
  - Will ensure that, in addition to formal training and certification to processes, that critical operations also require individual performers to have expertise and prior successful execution of the tasks.
  - A process is in place to recognize and reward performers who say ‘Stop’. Additionally, brought in outside program leadership to meet with the performing organizations to hear feedback and incorporate into actions.
  - Recently, instituted an accountability process with checklist insuring independence of quality inspectors. Reinforced the importance of independence to insure first time success.

Findings and Recommendations (Embedded Problems)

Findings

- Embedded problems pose a significant risk to JWST schedule, cost and mission success.
  - Propulsion valve problem not detected until assembly on spacecraft.
  - Fastener issue not detected until acoustic test.

Recommendation

- GSFC and NGAS conduct an audit including forensic engineering, hardware pedigree assessment, drawing checks, etc. to identify potential embedded problems.

Embedded Problems

NASA Response:

- **Agree**
  - Activities initiated - solicited support from GSFC Engineering Directorate and NGAS engineering organization for a independent set of eyes.
  - Prioritize completion to support upcoming testing. NASA is auditing NGAS's verification processes of soft structure installation. Soft structure is more complex, and involve more organizational hand-offs than hard structure items.
  - NASA is auditing launch vehicle interfaces based on Falcon 9 Zuma incident.

Findings and Recommendations (Commissioning Risks)

Findings

- Observatory commissioning will take six months.
- Commissioning risks are dominated by the fact that verification by TAYF cannot be accomplished at the system level.
- Commissioning entails multiple deployments with significant risk due to a large number of SPFs.
- Sunshield deployment is mandatory for JWST success and a demanding part of commissioning.
- Working groups and other functions are appropriately focused upon individual elements of commissioning.

Findings and Recommendations (Commissioning Risks)

Findings (cont'd)

- Commissioning, though significantly longer in duration, has integration and complexity characteristics similar to the Entry, Descent and Landing (EDL) phase of Mars lander missions.
- The Mars Program has found placing EDL under the leadership of a "world class" systems engineer with total responsibility for EDL critical to achieving success.
- Contingency planning is a most important part of commissioning.
- Successful resolution of potential sunshield deployment anomalies may require sunshield hardware elements to replicate the anomaly.

Findings and Recommendations (Commissioning Risks)

Recommendations

- Establish the position of Commission Manager reporting to the GSFC JWST Project Manager. The Commission Manager position must be filled by “world class” systems engineer with total end-to-end responsibility for commissioning success.
- Determine and implement the required sunshield hardware and simulation elements necessary to support the potential for sunshield anomaly identification and resolution.

Commissioning Risks

NASA Response:

- **Agree** – The Project will identify a Commissioning Manager who has extensive systems engineering experience with JWST.
- **Agree** – Will adjudicate as part of the review and implementation of the “top ten” mission enhancement effort.

Findings and Recommendations (Mission Success)

Findings

- Webb IRB observed and believes that the leadership at NASA and NGAS are committed to mission success.
  - Management discussion and actions are dominated by schedule.
  - "Working level" personnel can be confused as to the priority of mission success versus cost and schedule.
- Proactive leadership is important in identifying items that will enhance JWST mission success.
- Webb IRB requested Goddard, NGAS, and STScI to generate a list of ten items that could be implemented to decrease risk and or increase the probability of mission success if cost and schedule were not constraints.
- Webb IRB was impressed with the "top ten" mission success items proposed.

Findings and Recommendations (Mission Success)

Recommendations

- Management unambiguously emphasize the priority of mission success to “working level” personnel.
- Employees must feel empowered to stop or slow down if the pace or procedures can jeopardize mission success.
- NASA assess “top ten” mission success enhancements (see following three charts) and implement where appropriate.

Mission Success

NASA Response:

- **Agree** – Mission success is the highest priority. As an example, during the OTIS vibration anomaly the project focused on mission success. The investigation took the required time to thoroughly resolve the issue.
- **Agree** – NGAS (and GSFC) will continue to emphasize the importance of stopping or calling attention to a concern. NGAS also provides special recognition and rewards for individuals who do so.
- **Agree** – The mission enhancement list is being implemented by the project and program office

Mission Success Enhancements

- IRB assigned action to GSFC, NGAS and STScI to develop “top ten” list of what could be done to enhance mission success disregarding cost and schedule
  - 27 total enhancements were developed
  - Like enhancements were combined, prioritized, and implementation decision completed by mission systems engineering without management influence

Priority	Consolidated Title
1	Increase and Retain Responsible Design Engineers (RDEs)
2	Sunshield Venting Model Validation Testing
3	Review Sunshield Deployment Start to Finish
4	Additional Fault Management Peer Review
5	Incorporate All Known Repairs Prior to Observatory Environment Tests
6	Cameras / Protocols for Review of Single Point Failures
7	NEA Characterization and Additional Spares
8	Visualization Tool for Operations
9	Commissioning Risk Mitigation:
10	Dynamic Flight Simulator for Deployments
11	Augment Sunshield Simulators
12	Improve STScI Power System

Priority	Consolidated Title
13	Archive instrument design information for future use
14	Extend scientific capabilities of data management and archive
15	Preparatory funding for Early Release Science (ERS) programs
16	Augment Sunshield IVA and Simulators
17	Improved EMTB / OTB Simulators:
18	Additional EMTB Tests
19	Deployment Test Risk Mitigations
20	Final Deployment Test with Mission Operations Center (MOC)

Enhancements Already Initiated

Enhancements To Be Implemented

Enhancements Not Being Implemented

Additional Findings and Recommendations

- The IRB report contains findings and recommendations in additional areas.
  - In the interest of time, these findings and recommendations – and the NASA response – have been moved to backup.

- Residual Risks
- I&T Staff Adequacy
- Responsible Design Engineer Role
- Transport and Spacecraft/Launch Integration
- Mission Success Dependence on Launch Vehicle
- Mission Operations
- Management Communication
- JWST Reporting
- Engagement of Science Working Group
- Employee Morale

Schedule Analysis Context

- JWST launch schedule (October 2018) remained unchanged for several years following the 2011 rebaseline.
- I&T issues resulted in significant erosion of the launch date.
  - Human errors
  - Embedded problems
  - Lack of experience in areas such as the sunshield
  - Excessive optimism
  - System complexity

Schedule Analysis Context

- Confidence and stability in the launch date requires specific actions.
  - The impact of human errors and embedded problems must be eliminated.
  - Lack of experience, excessive optimism and system complexity must be recognized in establishing revised launch date.
- A future I&T problem can have a major impact on the schedule.
- Caution above and beyond that required for a less complex mission must be implemented for each step in I&T, shipment to the launch site and launch preparations.

Launch Date Recommendation

- The Webb IRB recommends the launch date be established as March 2021 (based upon the Project's 5/18 assessment of the impact of the membrane cover assembly acoustic anomaly).
- The Webb IRB clearly recognizes that the establishment of a launch date is a NASA responsibility.
- Examples of risks that are not included in the recommended March 2021 launch date are:
  - I&T errors with multi-month impact.
  - Additional sunshield deployments beyond the currently planned two. (Potential impact approximately 3–5 months each.)
  - Removal of a spacecraft subsystem. (Potential impact approximately 6–12 months.)
  - Removal of a science instrument. (Potential impact approximately one year.)

Webb Baseline Schedule Commitment

- In March 2018, Launch Readiness Date (LRD) Recommended by Standing Review Board (SRB) was May 25, 2020
- Membrane Cover Assembly (MCA) Fastener Lose Hardware issue was discovered at end of April 2018.
  - Recovery plan has a 6-month schedule impact.
- Based on Independent Review Board (IRB) schedule analysis, additional conservatism on estimated duration of I&T activities as well as additional unliened schedule reserves have been incorporated into the baseline schedule.
  - Additional conservatism and schedule reserves has a 4-month schedule impact.

Replan Baseline Commitment for Webb Launch Readiness Date

March 30, 2021

Cost Impact

- The cost of the schedule impact of moving the launch date from October 2018 to March 2021 (29 months) is assessed by the Webb IRB to be approximately $1 billion. This does not include any costs to implement the Webb IRB recommendations in this report.
- The funding impact by fiscal year is a function of available reserves, available carryover, available operations funds that will not be needed as currently planned and required reserves for the additional 29 months.
- The Webb IRB clearly recognizes that revising the total JWST development cost, operations cost, and fiscal-year funding requirements is the responsibility of NASA.

Webb Baseline Cost Commitment

- Independent Review Board (IRB) estimates ~$1B additional cost to complete development
  - This is an estimate using a 29-month launch delay at the current burn rate of ~$35M per month through launch and commissioning
  - A detailed estimate by the project agrees with the IRB estimate; the project estimate includes planned work efforts at NGAS/STScI/GSFC, funded unliened schedule reserve, enhancements for mission success, and conservative cost reserves at all levels (NGAS, GSFC/project, HQ/program)
  - Approximately $200M of unexpended reserves offsets this requirement, so additional budget needed to complete Webb development is ~$800M
  - The new baseline cost commitment includes an inflationary adjustment for operations (Phase E) over the 5-year prime mission lifetime

	Prior Baseline	New Baseline	Change
Development	$7.998 B	$8.803 B	+ $805 M
Total Life Cycle Cost	$8.835 B	$9.663 B	+ $828 M
Launch Date	October 2018	March 2021	+ 29 months

Webb Replan Cost

- The new launch date is March 30, 2021 and the new development cost is $8.803B
  - The increased in development cost is $803M through commissioning (September 30, 2021)
  - Existing ops budget through FY21 is ~$310M, so need ~$490M additional funding in FY20-FY21
- Principles
  - NASA understands the Decadal Survey priorities
  - NASA will protect R&A and Explorers Program
- NASA believes that the anticipated cost growth on Webb is likely to impact other science missions

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- Mission success is the driving consideration going forward.
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  - First of a kind developments.
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AGENCY AGREEMENT

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BACKUP

Findings and Recommendations (Residual Risks)

Findings

- Maintaining insight into residual risk is particularly difficult with a large, complex mission with long duration development like JWST.
- GSFC, NGAS and JWST Project have a mature process for identifying, processing and adjudicating TAYF waivers, SPF waivers and processing and adjudicating test failures, constituting the “as designed” residual risks.
- GSFC, NGAS and JWST also have mature processes for monitoring these risks over time in order to determine, at the end of the development, the “as built” residual risks arising from these same items.

Findings and Recommendations (Residual Risks)

Recommendations

- GSFC conduct an audit of the JWST project residual risk, reviewing the objective evidence of (1) the completed TAYF and SPFs mitigation plans, and (2) failure corrective action effectiveness to determine the “as built” residual risk.
- Reconcile the “as built’ residual risk with the expected “as designed” residual risk.

Residual Risks

NASA Response:

- **Agree –** Project actively pursuing. Every year or after key test we review the complete risk list for accepted, watch, mitigated, and open risks for currency and relevance. Mission System Engineer (MSE) reports project status every month to the GSFC Engineering Directorate including any changes to TAYF and SPF waiver accuracy / risk level based on results of test, inspection or verification activities. The MSE is the project Independent Technical Authority and is a key member of this process.
- **Agree** – The project continuously reviews the “as-built” hardware compared to the “as-designed” assumption via the weekly Architecture Working Group (AWG). The status of “as-built” Single Point Failure verification is a monthly AWG topic.

Findings and Recommendations (I&T Staff Adequacy)

Finding

- Bench strength and staffing for the long-term duration of the I&T function is inadequate.

Recommendation

- Augmentation of staff critically important to execute the I&T program.

I&T Staff Adequacy

NASA Response:

- **Agree** – NGAS has already started augmenting the I&T staff

Findings and Recommendations (Responsible Design Engineer Role)

Findings

- In practice, RDEs have not been required to maintain consistent involvement with their element through all phases of the project.
- RDEs have a unique critical understanding and concern for the elements for which they are responsible.
- RDE involvement in I&T, launch operations and commissioning is a major contribution to mission success.

Recommendation

- RDEs be involved and responsible for their element through the successful commissioning of the observatory.

Responsible Design Engineer (RDE) Role

NASA Response:

- **Agree –** This is the GSFC standard approach to responsible engineers and NGAS is adopting this and bringing back any key RDEs who have left for other assignments at NGAS.

Findings and Recommendations (Transport and Spacecraft/Launch Integration)

Findings

- Shipping company has strong experience base in transporting high-value payloads.
- Undefined security plan for shipping transport to launch site.
- Contingency operations and sparing plan for spacecraft/launch integration are not defined.
- Limited access to launch integration site for integration rehearsals.
- Limited hardware for integration “dry runs” to mitigate integration/handling risk and more accurate schedule estimates.
- Contamination environment for shipping vessel not properly quantified for contingencies.

Findings and Recommendations (Transport and Spacecraft/Launch Integration)

Recommendations

- NASA define security requirements and plan for JWST transport to launch site.
- Develop contingency operations and sparing plan for spacecraft/launch site operations.
- Develop “pathfinder” JWST simulator and contamination protection systems for integration “dry runs.”
- Assess shipping vessel contamination environment and develop contingency plans for off-nominal shipping operations.

Transport and Spacecraft/Launch Integration

NASA Response:

- **Agree –** The project engaged United States Air Force (USAF) Transportation Command in 2015 to perform a risk assessment of the transport ~1 year before LRD. NASA is working with ESA on the details of security arrangements based on the threat analyses and identifying ways NASA can assist ESA in protecting the spacecraft and conducting launch site operations for JWST.
- **Agree –** Contingency operations and equipment sparing plans are being developed for the launch site.
- **Agree –** Pathfinder plans for launch site operations are underway and will be performed prior to Observatory shipment.
- **Agree –** The JWST shipping container is very robust so particle monitoring of the exterior to the container should not be necessary. Erring on the side of caution, the Project will place a witness plate in the hold area of the ship for information.

Findings and Recommendations (Mission Success Dependence on Launch Vehicle)

Findings

- Ariane 5 is a “world class” launch vehicle with excellent management.
- JWST Project Office has good working relationship with ESA.
- The JWST Ariane 5 launch vehicle will be among the last Ariane 5 launches.
- Ariane 6 is planned to be operational at the time of the JWST launch.
- NASA Launch Services Program (LSP) Office has a rigorous mission assurance process to support flight readiness certification for NASA missions.
- For JWST launch vehicle, LSP is in an advisory role.
- Aerospace Corporation has a rigorous mission assurance process to support flight readiness certification for national security missions.

Findings and Recommendations (Mission Success Dependence on Launch Vehicle)

Recommendation

- LSP shall be accountable for JWST launch success at the same level of responsibility they have for U.S. launches, or NASA should contract with Aerospace Corporation for similar accountability.

Mission Success Dependence on Launch Vehicle

NASA Response:

- **Agree with Intent**
  - NASA is working with ESA to establish a “Mission Success” plan.
    - It is important that any additional assessment be focused, concise, and bring value to the mission. A well-meaning assessment, if applied in the wrong areas, could be counterproductive and prove to be a distraction to the entire team.
    - LSP’s extensive experience can add value in certain key areas while ESA maintains accountability for the launch service.
      - ESA and CNES (government, not industry) are the design and qualification authorities for the highly reliable Ariane 5 and has an appropriate set of checks and balances between ESA/CNES and Arianespace (industry).
      - LSP can gain additional insight by reviewing key reports/documents to better understand the thoroughness of their processes and build more confidence – in work.
      - NASA engaging with ESA to develop a ‘go forward plan’ to increase LSP insight.
    - LSP can only be accountable for NASA procured and managed launch services.

Findings and Recommendations (Mission Operations)

Findings

- First time STScI will be performing flight operations.
- There is no high fidelity test bed that represents the entire observatory during operations, in particular to deal with commissioning and anomaly training, identification and resolution.
- Competition exists for human resources predominately NGAS RDEs to support I&T, launch operations and operational readiness exercises and rehearsals.

Findings and Recommendations (Mission Operations)

Recommendations

- Critically important that GSFC JWST Project Office maintain responsibility and provide adequate support to ensure STScI mission operations readiness.
- Review all simulators/testbeds and required usage against pre-launch tests and rehearsals, post-launch deployment anomaly resolution, fault isolation and correction.
- GSFC JWST Project Office develop a staffing plan that meets the needs of I&T and operational readiness.
- Develop and approve a transition plan that defines the level of mission operations responsibility for STScI as a function of time with independent gate reviews at transition points.

Mission Operations

NASA Response:

- **Agree** – The project maintains the responsibility for mission operations.
- **Agree** – An assessment of the readiness of the simulators and testbeds and their usages is being adjudicated as part of the “top ten” mission enhancement activity.
- **Agree** – The project has a staffing plan to support all the activities leading up to launch and has been coordinating with I&T team to ensure the proper support.
- **Agree** – The project is developing a transition plan that describes the changes in responsibility once commissioning is complete.

Findings and Recommendations (Management Communication)

Findings

- Multiple uncoordinated communications channels.
- Lack of accurate and timely communication negatively impacts JWST's reputation.
- Agency has not effectively communicated the risk and complexity of JWST to key stakeholders.
- Communications on status of some subjects found to be inconsistent.
- Assessment of criticality (red/yellow/green) of issue different at various levels within NASA.

Findings and Recommendations (Management Communication)

Recommendations

- GSFC and NGAS Project Offices established as consistent and factual source of all JWST mission status.
- Communications of status and details appropriate for stakeholders needs to be presented clearly and frequently.
- NASA HQ should be responsible for developing a “communication plan” (messaging strategy) for JWST.
- Communicating complexity, risk and science return for JWST is critically important.
- Same criticality and assessment charts used for all JWST reporting.

Management Communication

NASA Response:

- **Agree** – Program Office and Project will collaborate in communicating mission status.
- **Agree** – The Program Office Communications Plan will target the release Webb features at the conclusion of major milestones or as often as there is substantive material.
- **Agree** – The completed Webb Communications Plan is in review, and will be signed soon.
- **Agree** – Program Office Communications Team reviewing the Webb Communications Plan with the entire Webb team.
- **Agree** – Assessment charts will accurately communicate JWST status and risk in a consistent manner. Where there might be differences in risk posture, there may be legitimate differences (such as when HQ is holding UFE to mitigate a risk at the project level) in how the risk is being communicated. In those cases, the differences will be transparently identified at all levels within NGAS, the Project and the Program.

Findings and Recommendations (JWST Reporting)

Finding

- Current NASA reporting structure is complex, confusing and ineffective.

Findings and Recommendations (JWST Reporting)

Recommendations

- Implement JWST reporting structure as represented by accompanying diagram.
- Revise NASA policy directive consistent with recommendation.

JWST Reporting

NASA Response:

- **Agree with Intent of Both Recommendations** – The Program and Project understand the fundamental concern of the IRB and are developing a plan to better communicate the organizational roles and responsibilities at the Program and Project level.

Findings and Recommendations (Engagement of Science Working Group)

Findings

- Substantive involvement of SWG has varied over mission formulation and development.
- SWG represents important source of knowledge relevant to mission success from scientific and technical standpoints.
- SWG and community play important advocacy roles for the program.

Recommendations

- Ensure consistent, sustained and meaningful engagement of SWG.
- Appoint an executive committee of NASA-selected members of the SWG to act as conduits to broader community on mission challenges.

Engagement of Science Working Group

NASA Response:

- **Agree** – Reinstituted weekly teleconferences (started June 18), and three face-to-face meetings per year.
- **Agree** – Plan with the full SWG at their next meeting (July) how to most effectively harness their time and talents to act as conduits to the broader community on mission challenges.

Findings and Recommendations (Employee Morale)

Findings

- NGAS I&T working level morale is not great.
  - I&T is an inherently stressful and demanding environment.
  - Current work schedules require significant overtime, limiting time off.
  - Recent problems and schedule slippage are extending the time when the team is performing I&T.

Recommendations

- Augment I&T staff to achieve more realistic work schedules.
- Implement strategies for improving team morale, such as periodic science lectures for NGAS personnel and families.

Employee Morale

NASA Response:

- **Agree** – The project and NGAS have already adjusted I&T work activities to a sustainable schedule considering the new launch date.
- **Agree** – The project will bring world-class scientists where key hardware will be built and tested, including NGAS.