James Webb Space Telescope
JSTUCC

Project Status
Dec 11, 2020
Project Status Topics

- Observatory Status
- Ground System and Operations
- Launch Vehicle Status
- Launch Site Planning
- Commissioning
- Top Issues
- Schedule
- Conclusion
Observatory Status
Completed CST #4 – first OBS level CST
- Completed GSEG #3 – first OBS test from MOC
- Completed Observatory level acoustics test
- Completed Observatory sine vibe test
- Removed EM battery and installed flight battery
- Completed Solar array, GAA, Aft Flap, and STSA deployments
- Completed UPS deployments
- Completed Membrane Cover Assembly roll-ups
  - 1 section from each side has been removed to repair pre-existing small tears
- Completed mid-boom deployments
- Initiated Membrane Tensioning
Transfer to Vibe Table
10/29/20: Configured for AFT UPS Deployment
10/30/20: AFT MCA Release/Deployment
11/4/20: FWD UPS Deployment
Remaining I&T Activities

- Spacecraft Elem. Post-environmental Deployments: Completed
- Observatory Pre-environmental Deployments: Completed
- Observatory Environmental Tests: Completed
- Observatory Post-environmental Deployments: In Progress
- Observatory Final Build

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OBS I&T Integration Flow
Ground System and Operations Status
Science and Operations Center (S&OC) and Operations Preparations

- **S&OC Status**
  - All Observatory control, science planning and science data processing operational systems are on schedule.
  - S&OC subsystems have been and will continue to be used to support Observatory integration and test

- **Testing and Exercises**
  - Commanded Observatory flight hardware from the Mission Operations Center (MOC) during Ground Segment Test #3 (GSEG-3) July 13-19. All Observatory subsystems were successfully exercised while accommodating COVID protocols and remote access.
  - Completed Normal Operations Exercises #8.1 (July) and #9 (August), practicing station keeping, momentum unloads and wavefront visits.
  - Executed of Launch Readiness Exercise #1 from the MOC the week of November 2.

- **Operations Product Development Status**

  - **ISIM flight product status:**
    - 460 real-time command procedures and 256 standard operating procedures needed for flight
    - 6 products in revision (MIRI, cryocooler)

  - **SC / OTE flight product status:**
    - 278 real-time command procedures needed for flight and 184 standard operating procedures
    - 10 new products, 2 in revision

  - **Deployment flight product status**
    - 188 real-time command procedures needed for flight
    - Testbed/simulator certification is complete; flight certification will finish up during Observatory I&T

  - **OSS flight product status:**
    - 785 scripts are required
    - Testbed/simulators certification is complete; flight certification will finish up during GSEG-4 (January 2021)
# JWST Rehearsal Campaign

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<tr>
<th>Timeline/Activity</th>
<th>LRE-1</th>
<th>ICE-1</th>
<th>ICE-2</th>
<th>D2</th>
<th>LRE-3</th>
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- **Pre-launch**: X
- **L&A and MCC**: X, X**
- **SC Sys**: X
- **Depl – UPS & DTA**: X
- **Depl – SS**: X, X***
- **Depl – OTE**: X
- **Mirror Depl**: X
- **OTE**: X, X
- **SI/Cryocooler**: X, X
- **Cooldown**: X
- **LOS**: X, X
- **Instruments**: X
- **MDR**: X

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* LRE5 will contain deployment activities TBD based on previous exercises.

** One shift only for Purple and Green

*** Five days of Sunshield activities.

LRE2 Sunshield activities are mid-boom and tensioning.
MOT Completed Rehearsals

- The formal launch rehearsal campaign (6 exercises) began with Launch Rehearsal Exercise #1 (LRE1) in November 2020.

- To date, the MOT has completed 19 rehearsals.

Focused rehearsals; not specific to one portion of the timeline as the others.

### Early Commissioning Exercise (ECE)
- Jul 18, 2018: ECE-1
- Mar 5, 2019: ECE-2
- Mar 6-8, 2019: D1
- Jun 10-12, 2019: MD1
- Oct 8-10, 2019: MD2
- Nov 5-7, 2019: ECE-3
- Feb 11-12, 2020: ECE-4

### Wavefront Rehearsal (WFR)
- May 7-10, 2018: WFR-1
- Oct 4-6, 2018: WFR-2
- Apr 9-12, 2019: WFR-3
- Dec 9-13, 2019: WFR-4
- May 7-10, 2018: WFR-1
- Oct 4-6, 2018: WFR-2
- Nov 12-18, 2018: SIR-1
- May 13-18, 2019: SIR-2

### Operational Readiness Exercise (ORE)
- May 2-4, 2017: ORE-1
- Sep 12-14, 2017: ORE-3
- Dec 5-7, 2017: ORE-4
- Oct 2-4, 2018: CPR-1
- Sep 23-26, 2019: CPR-2/3

### Contingency Planning Rehearsal (CPR)
- May 2-4, 2017: Normal Ops
- Jun 27-28, 2017: Normal Ops
- Sep 12-14, 2017: Normal Ops
- Dec 5-7, 2017: Normal Ops
- Oct 2-4, 2018: Contingency
- Sep 23-26, 2019: Contingency

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**Abbreviations**
- ECE: Early Commissioning Exercise
- D: Deployment
- MD: Mirror Deployment
- WFR: Wavefront Rehearsal
- SIR: Science Instrument Rehearsal
- ORE: Operational Readiness Exercise
- CPR: Contingency Planning Rehearsal
- Normal Ops
- Contingency
Team Exercises

- Led by individual MOT teams
- Internal cross-training opportunities
- Allows focus on specific team activities
- Prepares team for MOT rehearsals
- Exercised with similar simulators and ground system as MOT rehearsals and modified as necessary for individual team needs

Mission Operations Team (MOT) Rehearsals

- Led by MOT rehearsal team
- Cross-team interactions
- Focuses on critical commissioning activities
- Ensures team can conduct operations through commissioning and normal operations
Launch Vehicle Status
Began Final Mission Analysis Review (RAMF) Cycle

- Delivered final inputs to Arianespace (AE) for DCI 1/10: baseline for RAMF

- Provided summary of Observatory Acoustic and Sine Vibration test results
  - Assert that Observatory responses match models sufficiently

- Held virtual RAMF kick-off with AE and ESA on 9/14, solidifying plans for:
  - Thermal analysis (flight phase; ground phase already completed)
  - Trajectory and Separation
  - CCAM and EOLM
  - RF and EMC (reconfirm previous analyses)
  - LV configuration, with KASSAV-1 (independent LV position) & VIKI camera

- AE drafted work package and held internal kickoff with ArianeGroup 10/21
  - RAMF results planned for delivery to NASA L-6 months, review at L-5 months
Launch Vehicle Progress July - October

- JWST rocket hardware status:
  - PLF in work at RUAG; completion of inspections by February 2021
  - ESC-A+ upper stage electrical integration began September 2020
  - Vulcain II cryo engine has been integrated to the main stage

- Delta-qualification of A5ECA+ completed by ArianeGroup (AG); internal System Qualification Review successfully completed July 2020 (ESA/AG/AE)
Launch Site Processing
Launch Site Operations Overview

- Critical Path:
  - Obs Prep for Shipment & Load to OSTTARS: 6 days
  - Ship Leaves Port: 12 days
  - Ship travels to Launch Site: 3 days

- Parallel:
  - C5 Arrives: MGSE & EGSE Unpacking
  - HST3 LAN Network Setup
  - HEPA & Purge Setup
  - Control Room LBC 1 & 3 EGSE Setup
  - EGSE Validations

- Observatory Inspections, STM, and Aliveness: 4 days
  - CST-6 and RF Testing: 10 days
  - Prop Deconfig. And DSN Config.: 3 days
  - Final Observatory Closeouts: 4 days
  - PA Integration and CCU3 Ops: 4 days

- ¾” NEA Operations
  - Parallel Propulsion (MOP, Gas Flow)
  - TDRSS End to End Test

- SSB Propellant Loading: 12 days
  - OBS Move to BAF & Transfer to HE: 2 days
  - JWST Hoist to Launcher: 1 day
  - Final Red Tag/Green Tag & MLI Closeouts: 1 day
  - Fairing Integration: 4 days

- MDR Aliveness, EEPROM: 1 day
  - Launcher Processing: 4 days
  - Roll out and start countdown: 1 day

Launch: 16 days

- 55 days total OBS processing at LS (includes weekends)
- 28 days Processing S5C
- 12 days Propellant Loading S5B
- 15 days Integration to Launcher and Launch
Launch Site Planning Critical Milestones

- **March**
  - HEPA Filters Received at Godard
  - Import/Export Initial Review
  - Launch Site BOE’s delivered
  - MN Contract Definitized

- **April**
  - Engaged US Transportation Command on Route Assessment
  - Finalized Master Equipment List
  - HEPA Dolly Delivery to GSFC
  - HEPA Performance Test Plan Complete
  - Power Management Module (PMM) final check out at NGSS

- **May**
  - HEPA Unit Systems Testing in B29
  - Master Equipment List ITAR Classification

- **June**
  - OSTTARS Proof Testing
  - HEPA Unit S5B Configuration Complete
  - Hot Flow procedures delivered to KSC

- **July**
  - ¾ NEA reach and access verified at NGSS
  - HEPA Testing completed in B9
  - OSTTARS completed proof testing
  - Submitted and approved work package to Center for access to begin packaging launch site equipment

- **August**
  - OSTTARS racking study and shim prescription
  - Update Contamination Predictions
  - Completed Small Rack (NASA network rack)

- **September**
  - PMM Final check out
  - Complete Tall Rack (NASA Network)
  - OSTTARS Pathfinder Ops-1x mass

- **October**
  - OSSTARS road test
  - Oxidizer and Fuel sampling system completed

- **November**
  - Review US TRANSCOM recommendations
  - OSSTARS delivery to NGSS
  - Drape demo at TF-2 (VLS, drape, lift train)
  - ITAR Equipment Import/Export Review

- **December**
  - System Verification Networks (GSFC)
  - MN Nantes Contract Signed

- **January**
  - Package HEPA units/CC equipment
  - Hot Flow Test at KSC
  - Spare Procurement

- **February**
  - Final procedures for propellant to AE
  - Refurbish NGSS propellant cart (PCMU)
  - Package all GSE at GSFC for shipment to LS
  - NGSS perform MOP and Thruster Test

- **March**
  - Ocean container’s to NGSS
  - LS Purge Review (configuration)

- **April**
  - Ship to LS-HEPA, CC equipment, Tube Trailers, Propellant
  - Observatory Transportation Plan Review
Completed modifications to OSTTARS: new tombstone, spacers and tent frames
- Completed the fabrication and assembling
- Completed the proof testing
- Completed the distortion testing
- Defined shim prescription
- Completed 1x mass sim demo
- Completed the instrumentation
- Completed road testing
- Next - shipment to NGSS
Launch Site HEPA Wall Completed

- Completed assembly of 6 HEPA filter dollies (2 units per dolly)
  - Each dolly is 18’ high x 10’ wide
- Contamination testing was performed in GSFC B29 high bay to confirm performance.
- CCE refined predicted fallout rates for contamination budgeting and EOL determination
  - ✓ SSB Fallout Reduction: 80%
  - ✓ S5C Fallout Reduction: 93%
  - ✓ BAF Fallout Reduction: 91%
  - ✓ ISO 7 air particle levels achievable around the JWST Observatory using the portable HEPA walls at launch site
  - ✓ Molecular contamination expected to meet or do better than 50 Å maximum accumulation
  - ✓ Particle fallout rates expected to meet maximum accumulation for the Secondary Mirror and Primary Mirror
- Units will be packaged (heat shrink) at GSFC and stored in ocean containers until ready to ship to launch site
- No hearing protection is required (70db) OSHA requirement is 85db while in use at launch site

One side of HEPA filter wall (3 dollies 2 HEPA units per dolly)

Six HEPA Dolly Push-Push Configuration using RST mock-up
On-Orbit Commissioning
Commissioning Planning Status

Commissioning Reviews

- Detailed audits and technical review of all Commissioning activities complete
  - April 20-23 – Spacecraft Commissioning (Launch and Ascent, Mid-Course Corrections, Spacecraft Subsystem Activation and Checkout)
  - April 28-30 – Wavefront Control/Line of Sight (Attitude Control and Fine Guiding)
  - May 12-14 – ISIM Systems, Cooler, Cool-Down
  - September 1-2 – Deployments
- Commissioning Roll-up Summary Review complete
  - October 26-27
- Released L-1 Timeline
  - Incorporates all trades, risk reductions, and lessons learned from prior rehearsals
Commissioning Planning Status

- All engineering trades complete and incorporated into timeline.

- Kicked off final deployment study related to audit actions.
  - Refine on-orbit response to specific partially deployed solar array configurations
  - Assess and develop preferred partially deployed configuration for MCC2 burn.
    - Prior study in 2016 determined burn possible in all configurations.
  - Assess efficacy of twirl/shimmy on non-time critical deployment example (i.e. Sunshield UPS release), to assess analysis times and develop tools needed to support operational contingency decisions.
  - Investigating benefit/risk of earlier ADIR deployment

- Remaining Work
  - Complete final deployment contingency study
  - Support rehearsals
  - Closeout all audit actions
  - Complete and review all necessary documentation (contingency plans, launch commit criterial, early orbit mission rules)
TOP ISSUES
• Pressure data from Ariane Flight VA 253 (launched in July) showed a pressure drop at fairing jettison of 0.31 mBar, unfortunately higher than expected for this flight.
  ■ Fairing had vents fully open and honeycomb was sealed

• Analytical models correlated to previous flights predicted pressures below 0.20 mBar.
  ■ These models assumed negligible contributions from the payload and from a fully sealed fairing honeycomb.

• The Project initiated efforts to determine if the observatory could tolerate pressure drops of 2X previous requirement of 0.18 mBar or higher, and if not make appropriate modifications
  ■ Primary areas of interest were the Sunshield Membrane Release Devices (MRDs) and membranes.

• Analysis is currently on going (to be concluded this month)
  ■ A number of MRDs may need to be replaced with stronger material (new MRDs already being manufactured)
  ■ Some locations on the SS will require “doublers” to be installed
Fastener Torque Issue

- Based on issues encountered on other NGAS programs where fastener “run in torque” (RIT) was specified and not recorded, NGAS conducted a reach audit for JWST. This resulted in an explicit change in process that requires the measurement of run in and final torque which took effect in Oct 2018.
  - JWST has many fasteners with callouts on their drawing specifying applied torque over RIT: “torque to XX above run-in torque”

- Fasteners torqued prior to Oct. 2018 were evaluated assuming values for running torque determined by lot sample averages for given fastener types vs measuring each specific fastener.

- NGAS audited all fasteners with RIT requirements installed prior to Oct. 2018 and GSFC has been performing an independent cross-check audit
Fastener Torque Audits

● NGSS Audit Summary
  ■ Completed Top-Down Audit
    • 12,321 Fasteners with Over Running Torque Requirements
      – Pre-Environments
        » 454 fasteners were re-torqued
      – Post Environments (these were fasteners which were determined safe to defer until after environments)
        » 160 found to require re-torque
    • Alignment Exoneration Complete - no recommended rework or measurements above baseline plan
    • Deployment Exoneration Complete – no additional work identified

● NASA Independent Audit Summary
  ■ The team identified and assessed individual run-in-torque items for their risks to flight performance.
    • 95% of these have been successfully exonerated as good for flight.
    • Risks of the remaining 5% can be mitigated by burn-down steps recommended by the GSFC Team.
    • Burndowns cover: Improved documentation, additional inspections, gap checks, additional alignment measurements, refined analyses, review of deployment test data, review of post deployment test alignments data, potential retorques
  ■ Recommendations and burndowns will be implemented and completed before observatory final stow.
RF output power measurements taken after June 2020, have consistently shown a power decrease between 0.45 dB (10% loss) and ~1.00 dB (20% loss).

NG opened a Failure Review Board to address the issue
- NG independent review believes 0.8 dB is more likely to be attributed to calibration equipment due to the large losses and calibrating at much lower power levels than expected
  - Finding 0.8 dB of additional loss in the flight path would indicate a large increase of loss in the flight path. However, finding 0.8 dB of additional loss in the test path would indicate a small increase of loss in the test path.

NASA Independent Conclusions on Ka-Band Power Loss
- Based on time domain reflectometry (TDR) measurements to detect the location of faults in transmission, it is unlikely that a problem exists in the flight network.
  - This would imply a gross waveguide misalignment or obstruction and would likely show a signature on the TDR results.
- NASA believes the more likely cause lies in the electrical ground support equipment (EGSE) waveguide and or cables.
- NASA has called for additional investigations to further isolate the issue to the EGES and are currently being implemented
Schedule
Schedule Reserve Status

● 70 days of schedule reserve to ship at beginning of replan
  ■ 14 Days of reserve dedicated to Environmental Testing were encumbered
    • Actualized Vibe testing delays (10d)
      – Grounding issue investigation
      – Contamination ‘spike’ investigation
      – Test set issue (Telemetry issue)
      – Additional Z-axis vibe run
      – Z-axis to X-axis configuration took longer than planned
    • Getting back to Integration Stand (4d)
      – Ka-Band Power (ARB investigation)
      – J2 Panel Alignments (ARB investigation)
      – Reaming APCO adapter bolt holes
      – Strain gauge investigation
  ■ Working Single Swim Lane (Environments) Did Not Allow For Re-Sequencing Optimization

● 56 days of reserve to ship remain unencumbered

● Schedule Liens (future work approved but still looking at ways to reduce impact)
  ■ 13 Days Future Work
    • Re-Torques for ORIT (3d currently, originally 20d then 5d)
    • Battery Diode Module installation (4d)
      – ESD discovery that had reach across to battery umbilical discovered post schedule risk assessment
    • Sunshield tear mitigations (6d)

● Schedule threats (potential future work not approved, working to mitigate/eliminate)
  ■ Preemptive SS Patches
  ■ Fairing Depress SS Doublers
### JWST Schedule

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**Spacecraft Element I&T**

**OTIS I&T**

**S&OC Integration & Testing**

- GSEG-2
- S&OC Rel 2.1
- S&OC Rel 2.2

**Launch Site**

- 72 days of Critical Path Reserve

**Primary Critical Path**
- 86 days

**Secondary Critical Path**

**Reserve**
JWST Schedule Reserve Burndown

Current Margin: 72 days
GPR Requirement: 59 days

Re-baseline to "New LRD 10/31/21"

Delays due to vibe, Ka band measurement & APCO Adaptor

JWST Project Actuals

GSFC Requirement to Agency Commitment

Ship to Launch Site

Agency B/L Commitment
Conclusion

JWST made excellent progress in spite of impacts from COVID-19

JWST Is On Track For October 2021 Launch!