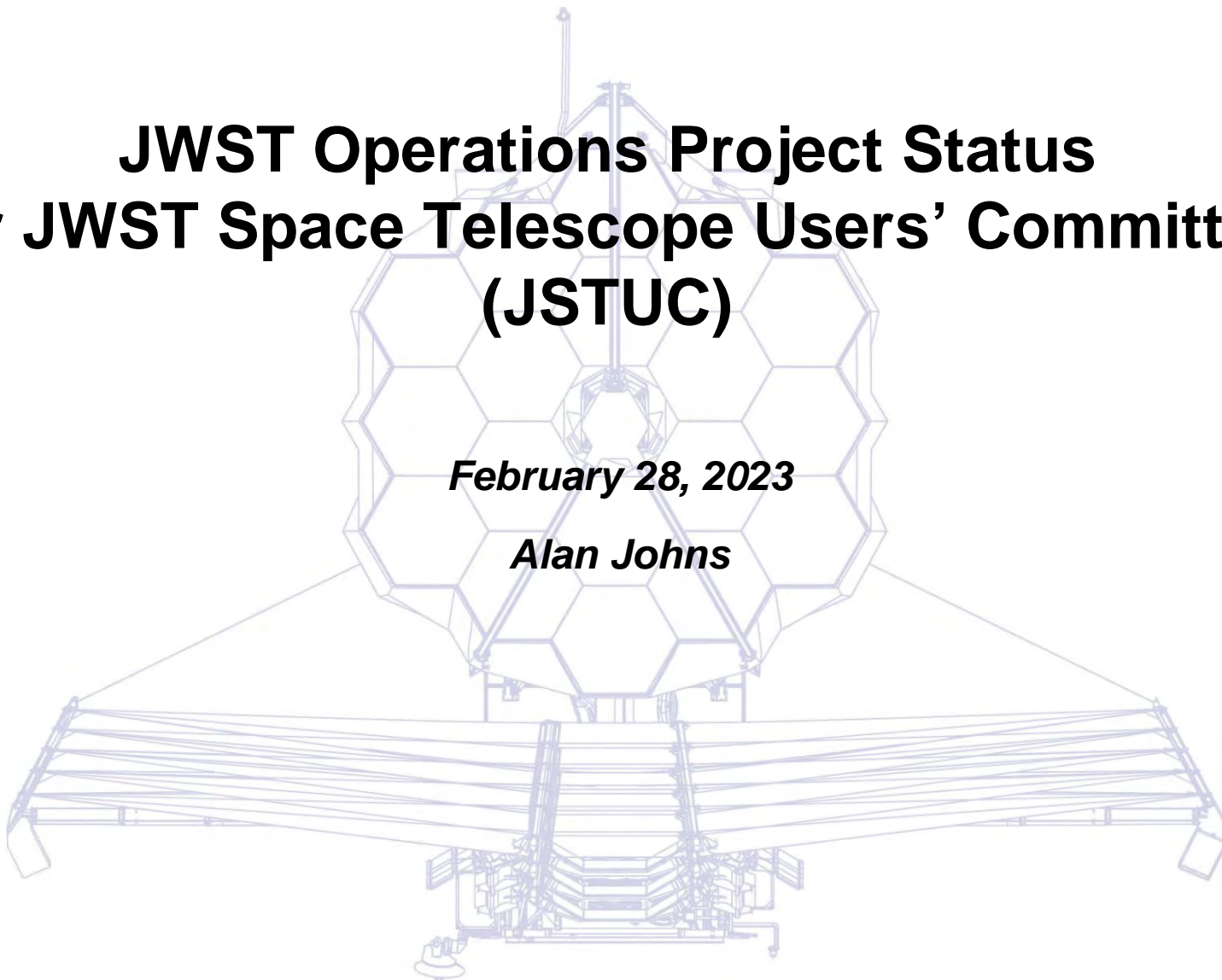




# **JWST Operations Project Status for JWST Space Telescope Users' Committee (JSTUC)**

***February 28, 2023***

***Alan Johns***





# Since the August 2022 JSTUC Meeting...

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## ● The Good

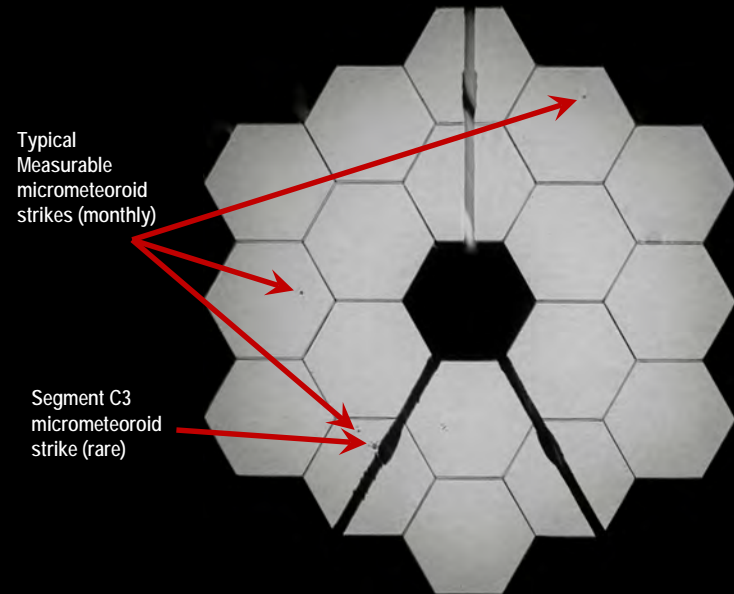
- Observatory performance continues to be outstanding; all technical performance metrics continue to meet or exceed requirements.
- Spectacular science results and images abound; STScI and NASA communications groups have done a great job in engaging the public with JWST.
- Response to Cycle 2 call for proposals has been fantastic.
- Issues reported at the last JSTUC meeting have not significantly impacted JWST operations
  - Micrometeoroids – status from Lee Feinberg on following chart
  - CFDP latency – continuing to happen on occasion but more of an irritant than anything else; more details in S&OC Status presentation
  - Artemis-1 impacts on DSN coverage – once Artemis-1 finally launched, there was no impact to JWST's DSN coverage

## Summary:

- To date, the rates of micrometeoroids hitting the primary mirror are fairly consistent with pre-launch predictions
  - Since launch, total of 28 micrometeoroid impacts that have had a measurable change in wavefront. Contribution of all of these except the C3 impact in May '22 is <1nm RMS on total WFE
  - Total of 53 additional smaller particles detectable in pupil image but have caused no change to wavefront error
- Of those measurable, all but one are consistent with error budget allocations for micrometeoroid effects over expected lifetime (assumed to be 5 years)
- Between May 22-24 last year, we had a larger the expected strike on segment C3, increasing system wavefront from 50 to 59 nanometers rms, versus a requirement of 150nm in the most stringent channel (NIRCAM Shortwave). Much looser requirements in other channels.

## Analysis:

- Team used the measured and detected micrometeoroid rate data and pointing history to assess the statistically likely energy of the C3 strike
- Team performed 3D hydrodynamics impact and finite element modeling of cryogenic mirror using the statistically likely energy
- Best explanation is the C3 micrometeoroid was a higher energy particle (statistically unlikely) and hit a particularly sensitive part of the mirror and structure. Based on this, strikes similar to C3 can occur but will be infrequent (and a statistical distribution)



## Status/Mitigations:

- To be cautious and in light of the potentially long lifetime (two plus decades), team implemented minimizing number of observations pointing in the RAM direction during Cycle 2 call (only time dependent observations will face RAM). Team assumed a 70 degree from RAM avoidance zone.
- Team has begun micrometeoroid testing of Kapton insulation used on sunshield and the back of the primary mirror and a test of a cryogenic beryllium mirror is planned this spring which will be used to further validate models.



# Since the August 2022 JSTUC Meeting...

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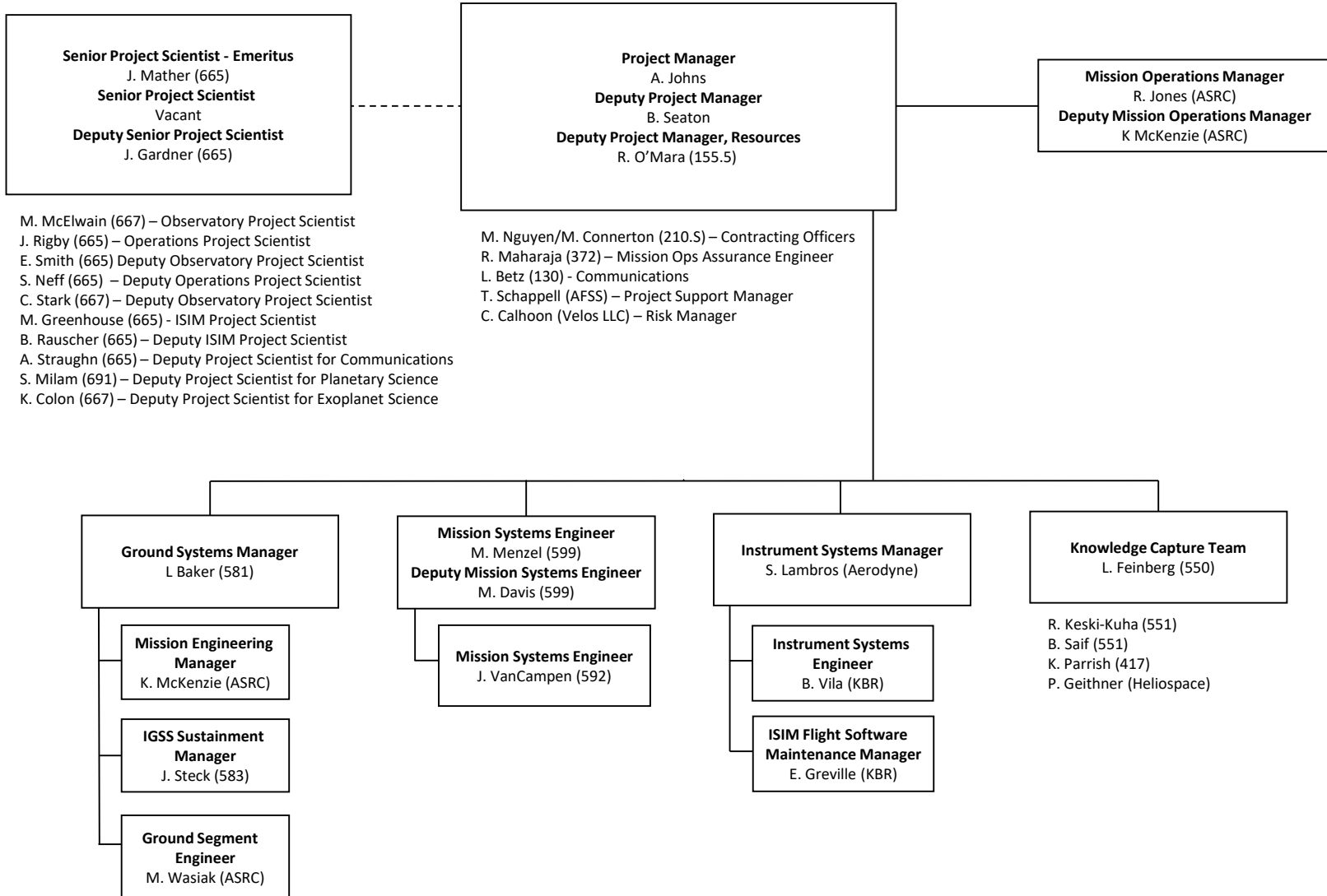


- **The Neutral**

- The JWST Project/GSFC/Code 443 has transitioned to the JWST Operations Project/GSFC/Code 443
  - Personnel/organization changes, new reporting chain to GSFC and NASA HQ, office relocations



# JWST Operations Project – Code 443





# Since the August 2022 JSTUC Meeting...

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## ● The Not So Good

### ■ MIRI Grating Wheel Anomaly

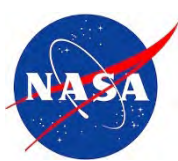
- On August 24, 2022, a commanded move of MIRI Grating Wheel-14 failed and MIRI was put into its safe mode by onboard fault management.
- An Anomaly Review Board was formed to investigate the problem and the MIRI Medium Resolution Spectroscopy science mode was made unavailable.
- Will be covered in MIRI Update presentation

### ■ The December from Heck

- A series of five anomalies occurred over the period December 7-22, 2022.
- Anomalies and path forward covered in following four charts.

### ■ NIRISS FPGA Anomaly

- On January 15, 2023, NIRISS experienced a communications delay within the instrument, causing the flight software to timeout.
- NIRISS was flagged as unavailable for science during investigation into cause of anomaly, ultimately thought to be a radiation event affecting the Spacewire FPGA within NIRISS.
- Will be covered in NIRISS Update presentation



# Summary of December 2022 Anomalies/M. Menzel

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- **There was a series of on-orbit anomalies during December 2022 that resulted in unusual JWST down time.**
  - The series started on December 7, 2022 with the last anomaly occurring on December 22, 2022
  - The anomaly descriptions, causes and remediations are shown on the following chart.
- **The anomaly causes were quickly identified and addressed.**
  - Two of the anomalies were easily solved by using a previous operations “Checklist” used during commissioning that was updated from its original form.
  - One was the result of unforeseen consequences of the initial remedy of the first anomaly
  - The final was a more “routine” anomaly caused by a faint but acceptable Guide Star and a nearby hot pixel.
- **These instances illustrated a need for an assessment of the system to changes in the ground and or flight segments, and the sufficiency of existing processes to evaluate the impact of such proposed changes.**
- **A working group led by Mission Systems Engineering was established to:**
  - Perform a detailed process evaluation of more susceptible flight processes, in particular the interactions between the Attitude Control System (ACS), the Fine Guidance Sensor (FGS), the Telescope Actuator Drive Unit (ADU), the Orbit Script Subsystem (OSS), On-Orbit Plan (OP) and the science instrument Flight Software (FSW)
  - Assess the way software patches and builds are evaluated and tested
  - Conduct trades and formulate recommendations for improvements or risk reduction.



# Anomaly Specifics (1 of 2)/M. Menzel



Date	Anomaly Description	Cause	Remediation / Result
12/7/22	<ul style="list-style-type: none"> <li>During its slew to station keeping (SK) intermediate attitude for SCAT thruster cool-down, the observatory aborted and went into SAFE HAVEN Mode.</li> <li>Slew was planned while out of ground contact. Upon ground contact the observatory was found in SAFE HAVEN.</li> </ul>	<ul style="list-style-type: none"> <li>Series of failed observations left the observatory in a mode that blocked Start Tracker Assembly (STA) data from the ACS ~ 3 hours.</li> <li>The ACS used Inertial Reference Units (IRUs) to propagate attitude and drift error built up.</li> <li>When the observatory began its SK slew, STA data was re-engaged and the error between STA attitude and propagated attitude exceeded the limit tripping SAFE HAVEN entry.</li> </ul>	<ul style="list-style-type: none"> <li>In order to remedy leaving the observatory in STA data-blocking mode after a failed visit, a SW patch was tested and uploaded using a "ZERO_SAM" command that eliminates block.</li> <li>Patch OSS 8.5.0.1 was tested and successfully uploaded on 12/14/22 for SK on 12/15/22</li> </ul>
12/14/22	<ul style="list-style-type: none"> <li>During real time operations uploaded OSS 8.5.0.1 with the ZERO_SAM command, AND performed ADU memory dump for a "stuck bit".</li> <li>An A_04 error was detected that put the observatory into an inertial pointing mode (IPM)</li> </ul>	<ul style="list-style-type: none"> <li>The ZERO_SAM command expected the ADU to be in an FSM Mode. But the memory dump left the ADU in OPERATE Mode.</li> <li>ADU Mode discrepancy caused the error and put the observatory in IPM.</li> </ul>	<ul style="list-style-type: none"> <li>Station keeping Maneuver #16 was delayed.</li> <li>Cross check list was re-established to make sure that configuration errors such ADU FSM versus OPERATE Mode were avoided.</li> </ul>
12/18/22	<ul style="list-style-type: none"> <li>During a COARSE visit consisting of a slew and FGS internal calibration the ZERO_SAM from OSS 8.5.0.1 was initiated.</li> <li>The ZERO_SAM was not completed in the 30 min, exceeding time limit resulting in an RTS-63 response putting the observatory in IPM.</li> </ul>	<ul style="list-style-type: none"> <li>Coarse visits such as Real Time Visits, SK visits, etc run the risk of inducing a ZERO_SAM that takes the observatory to the attitude of previous guided visit. The slew to that location took longer than 30 minutes, and that tripped the response.</li> </ul>	<ul style="list-style-type: none"> <li>Patch OSS 8.5.0.1 with the ZERO-SAM command was removed to further understand all such collateral effects.</li> <li>With ZERO_SAM removed, Ops Team tried to avoid Ops with high risk of gaps that result in STA to IRU errors due to drift.</li> </ul>
12/18/22	<ul style="list-style-type: none"> <li>Following recovery from RTS-63, the OP was started. The first visit was a Wavefront Sensing visit and the ADU was transitioned into CMU Mode while the ADU Command and Sensor Processing were still enabled.</li> <li>ACS required ADU to be FSM Mode. Since it was in CMU Mode A0_4 error was triggered and the observatory entered IPM.</li> </ul>	<ul style="list-style-type: none"> <li>This was the first on-orbit recovery from RTS-63 in this specific configuration, and clean-up activities were missed.</li> </ul>	<ul style="list-style-type: none"> <li>Approved path forward for transition from a real time visit to OSS control now requires a checklist derived from a previous checklist used for such transitions during commissioning.</li> </ul>

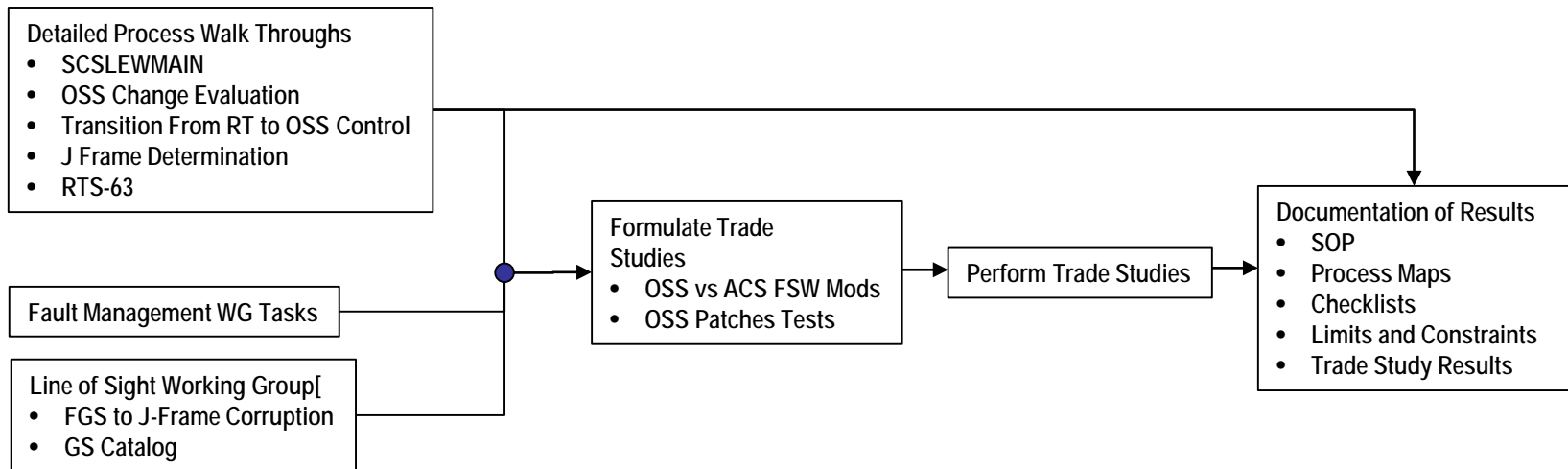




# Anomaly Specifics (2 of 2)/M. Menzel



Date	Anomaly Description	Cause	Remediation / Result
12/22/22	<ul style="list-style-type: none"><li>A real time engineering visit was successfully completed and control was transitioned back to the OSS.</li><li>The first visit failed Guide Star (GS) acquisition and a second visit timed out on its first science dither, following a single science exposure.</li><li>This dither was an FSM SAM (&lt;0.06 arcsec).</li><li>Settle time was longer than 60 sec, triggered RTS-63 putting the observatory in IPM.</li></ul>	<ul style="list-style-type: none"><li>Data indicated the GS was acceptable but very close to the lower brightness limit</li></ul>	<ul style="list-style-type: none"><li>The Anomaly Management Board approved recovery, and called for a re-evaluation of GS limits and long term responses.</li><li>The Line of Sight Working Group will be evaluating, and will coordinate with the Anomaly Working Group.</li></ul>



- **The Working Group Plan shown above, performs the following:**
  - Evaluates deficiencies and or risks associated with the processes involved in the December Anomalies via detailed walk-throughs.
  - Based on these evaluations trades are defined and performed. Two likely areas for such trades:
    - Functional interfaces between the OSS and ACS FSW
    - OSS Patch Testing and r Impacts Assessment
- **The existing Fault Management and Line of Sight Working are already addressing aspects of these issues and so the Anomaly Working will coordinate with these groups.**
- **The Groups' recommendations are expected to be completed in the April 2023 timeframe.**



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# QUESTIONS?