National Aeronautics & Space Administration (NASA)/Goddard Space Flight Center (GSFC)

JAMES WEBB SPACE TELESCOPE (JWST)

Goddard Space Flight Center Systems Engineering Seminar

ISIM Element Environmental Testing and Verification – Running the Gauntlet

For Public Release

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JWST Architecture

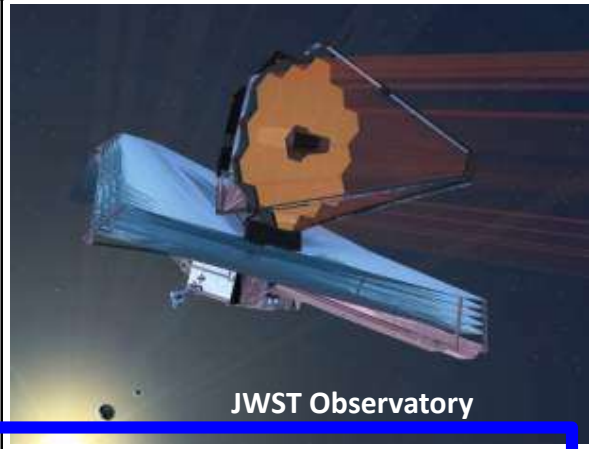
James Webb Space Telescope System

Mission Systems Engineering

Launch Segment

- Launch Vehicle
- Payload Adapter
- Launch Site Services

Observatory Segment



- Optical Telescope Element (OTE)
- Integrated Science Instrument Module (ISIM)
  - NIRCam
  - MIRI
  - NIRSpec
  - FGS
- OTIS – Integrated OTE & ISIM
- Spacecraft Element (SE)
  - Spacecraft Bus
  - Sunshield

Ground Segment

- Science and Operations Center (SOC)
- Institutional Systems
- Common Systems

Provided by NASA/GSFC
Provided by NGAS
Provided by STScI
Provided by ESA
Provided by CSA

JWST Observatory Segment Partitions

Observatory Segment

Integrated Science Instrument Module

- **Near-Infrared Camera**
- **Near-Infrared Spectrograph**
- **Mid-Infrared Instrument**
- **Fine Guidance Sensor/ NIRISS**
- ISIM Structure Subsystem
- Thermal Control Subsystem
- ISIM Command & Data Handling Electronics
- ISIM Remote Services Unit
- ISIM Flight Software
- ISIM Electronics Compartment
- ISIM Harness
- MIRI Shield
- Operations Scripts Subsystem
- ISIM Harness Radiator

Optical Telescope Element

- Primary Mirror Subsystem
- Secondary Mirror Subsystem
- Aft Optics Subsystem
- OTE Electronics Subsystem
- Thermal Management Subsystem
- Deployment Tower Subsystem
- Wavefront Sensing & Control Subsystem

Spacecraft Element

- Sunshield Subsystem
- Structure and Mechanisms Subsystem
- Thermal Control Subsystem
- Electrical Power Subsystem
- Propulsion Subsystem
- Attitude Control Subsystem
- Command and Data Handling Subsystem
- Communications Subsystem
- Flight Software
- Electrical Harness
- MIRI Cooling System

Segment Element ▪ Subsystem

JWST Observatory Segment Partners Roles

Mission Project Management

Mission Systems Engineering

Observatory Performance & Programmatics | **Observatory I&T** | **Observatory Systems Engineering**

Spacecraft

- S/C Bus
- Sunshield
- Observatory FSW

Optical Telescope Element

OTIS

ISIM

ISIM Management, Systems, & Science

ICDH | IRSU | FSW | Structure | IEC | Thermal | OSS | MIRI Shield

ISIM Enclosure | OTE Simulator | Harness | I&T | Harness Radiator

NIRSpec

- Optics Assy.
- Instrument Control Electronics
- Instrument FSW
- Detector Subsystem & FSW
- Microshutter Subsystem & FSW

NIRCam

- Optics Assy.
- Instrument Control Electronics
- Instrument FSW
- Detector Sub-system
- Wavefront Sensing Elements

MIRI

- Management, Systems Engineering
- Optics System
- Instrument Control Electronics
- Instrument FSW
- Detector Subsystem
- Cooling System

FGS/TF

- Optics Assy.
- Instrument Control Electronics
- Instrument FSW
- Detector Subsystem

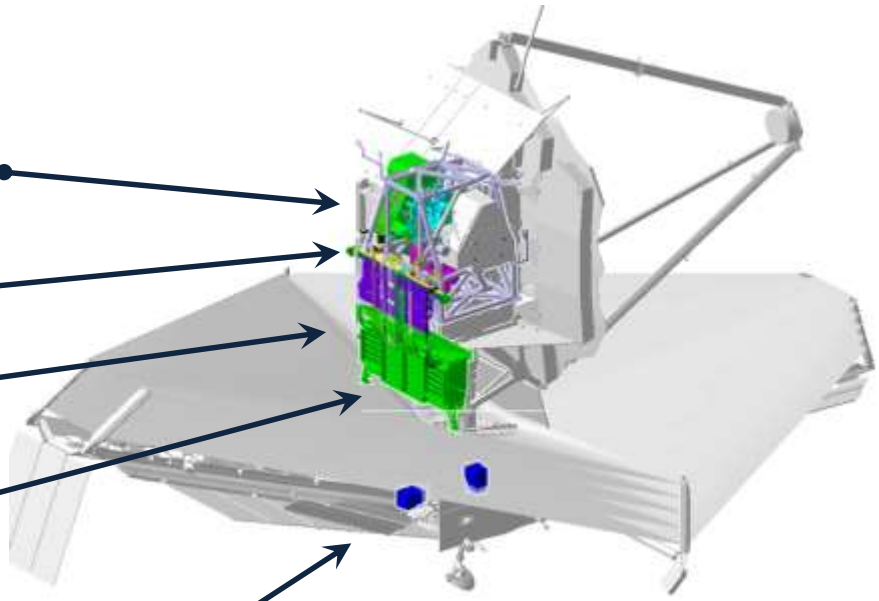
LEGEND	
NG Team	GSFC
STScI	ESA
CSA	JPL
ESA/EC	U of Az

Integrated Science Instrument Module

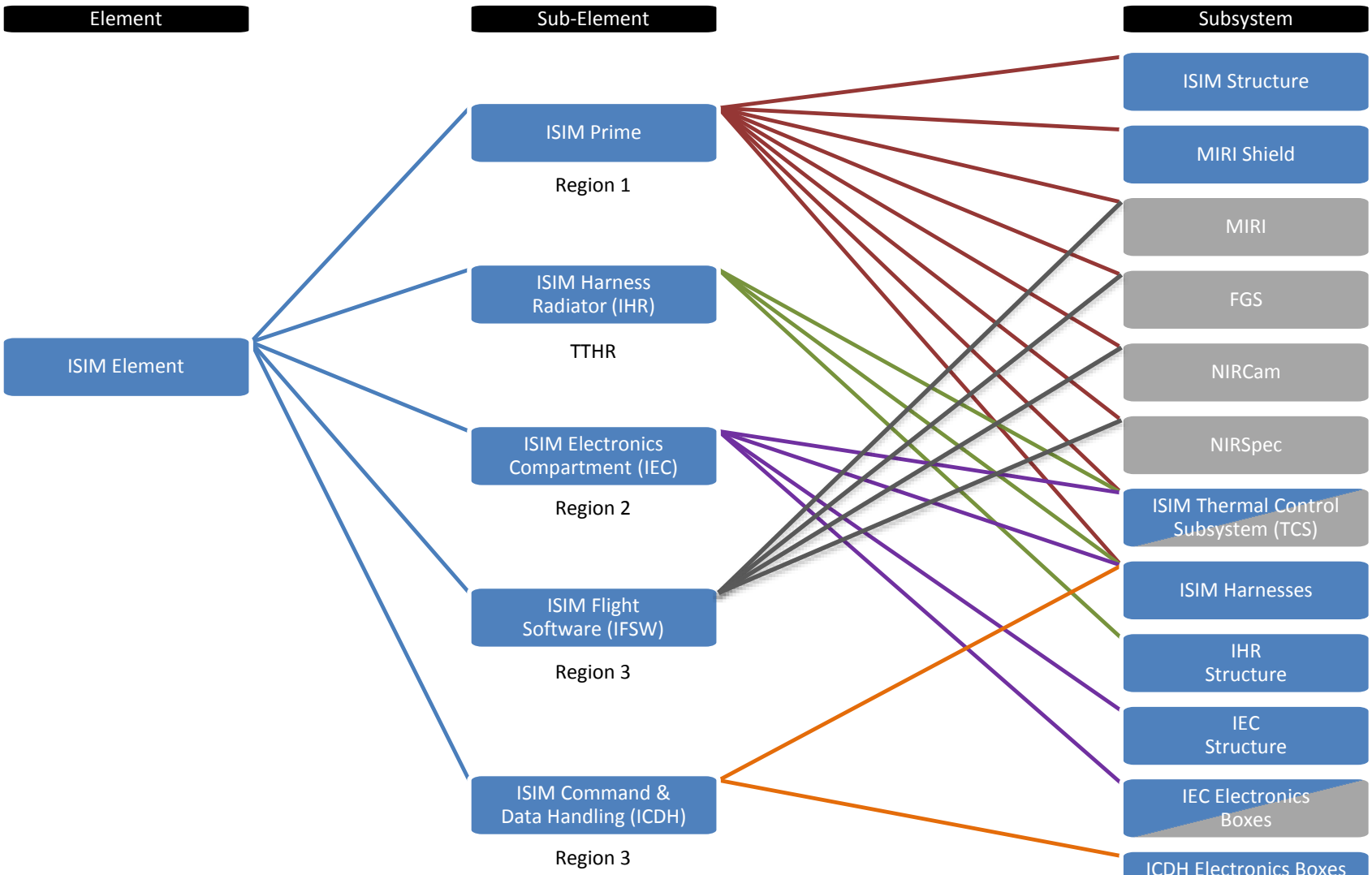
ISIM is one of three elements that together make up the JWST space vehicle

- Approximately 1.4 metric tons, ~20% of JWST by mass

- The ISIM system consists of:
  - Five sensor systems
    - MIRI, NIRCam, NIRSpec, NIRISS, FGS
  - Nine instrument support systems:
    - Optical metering structure system
    - Electrical Harness System
    - Harness Radiator System
    - ISIM Electronics Compartment (IEC)
    - Cryogenic Thermal Control System
    - Command and Data Handling System (ICDH)
    - ISIM Remote Services Unit (IRSU)
    - Flight Software System
    - Operations Scripts System



ISIM Element
Hierarchy

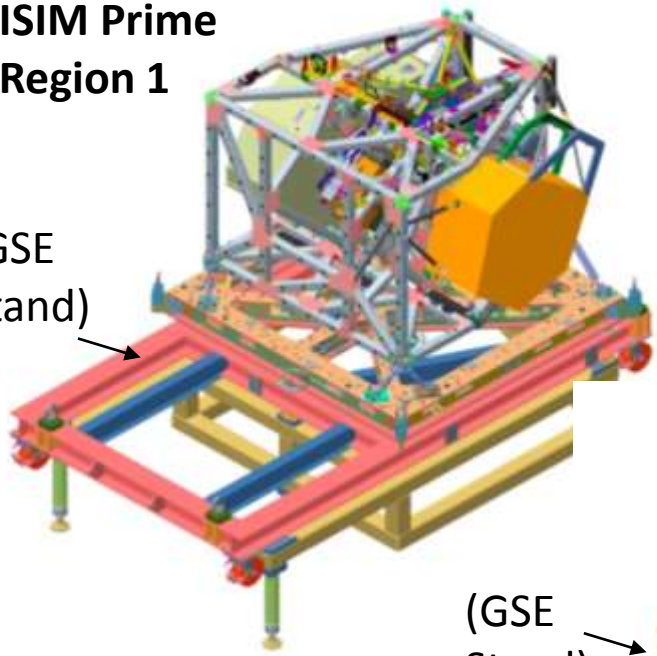


ISIM Element at Delivery to OTIS

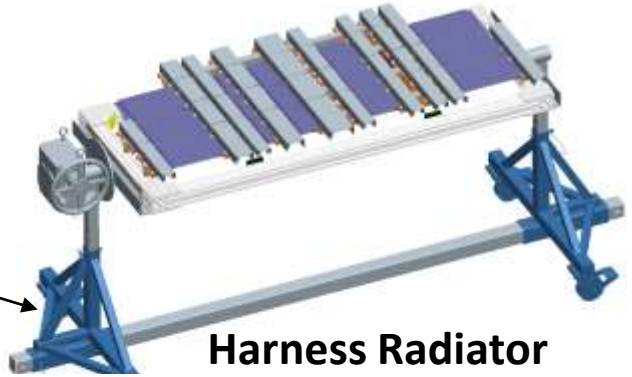
- ISIM Hardware
  - ISIM Prime, IEC, and HR are delivered to OTIS for integration
  - ICDH Delivered to the Spacecraft (Northrop Grumman)

ISIM Prime Region 1

(GSE Stand)

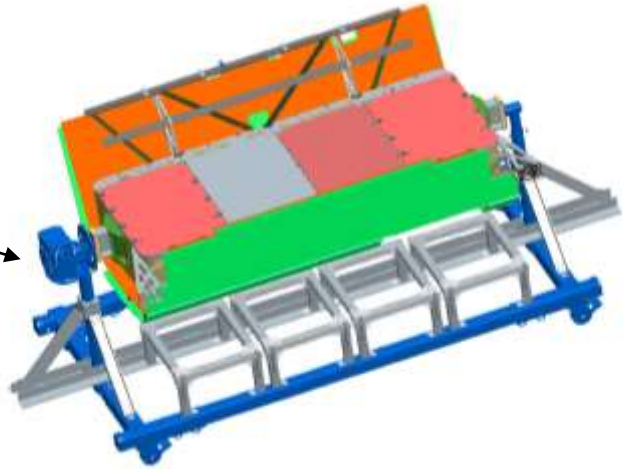


(GSE Stand)



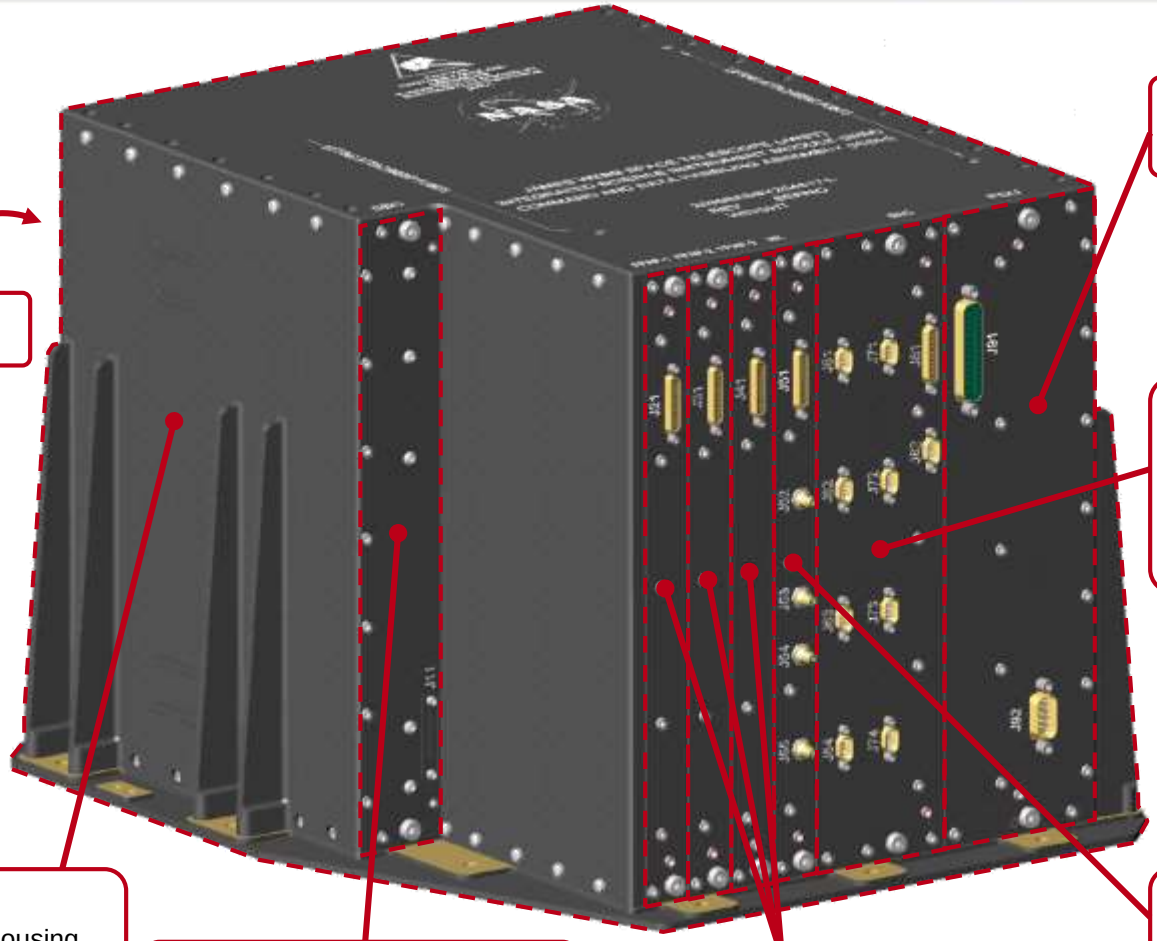
Harness Radiator (Thermal Trans Region)

(GSE Stand)



ISIM Electronics Compartment Region 2

ICDH Overview – Region 3/Spacecraft



Backplane (not shown)

Power Distribution Unit (PDU)

Bus Interface Card (BIC)
- NIRCam, NIRSpec, MIRI FPEs, SSR & FPAP SpaceWire Interfaces
- Science Data Storage Formatting

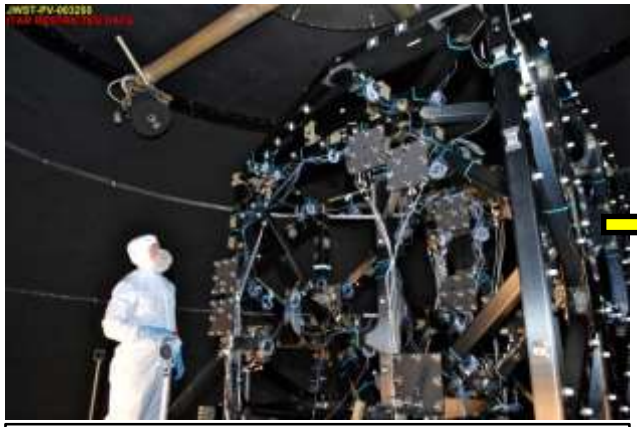
Chassis
- Provides mechanical housing and some radiation shielding for assemblies

Single Board Computer (SBC)
- Hosts ISIM Flight Software

Focal Plane Array Processors (FPAP)
- Simultaneous Science Data Processing

Housekeeping (HKI) Card
- S/C and ICE 1553B Interfaces
- ICDH Temperature and Voltage Monitoring

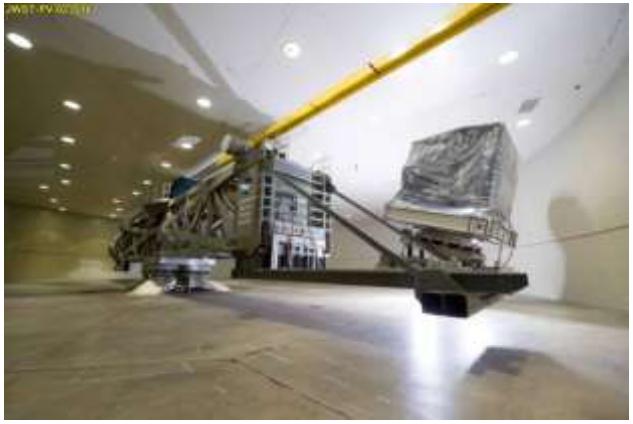
ISIM Structure – Qualification Tests

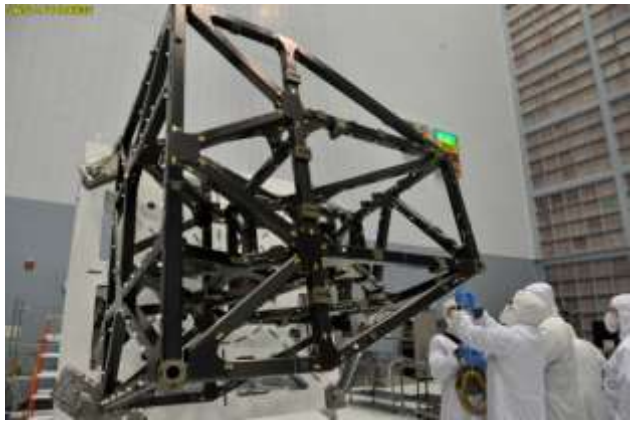


Optical Stability - Cryoset Test
2010

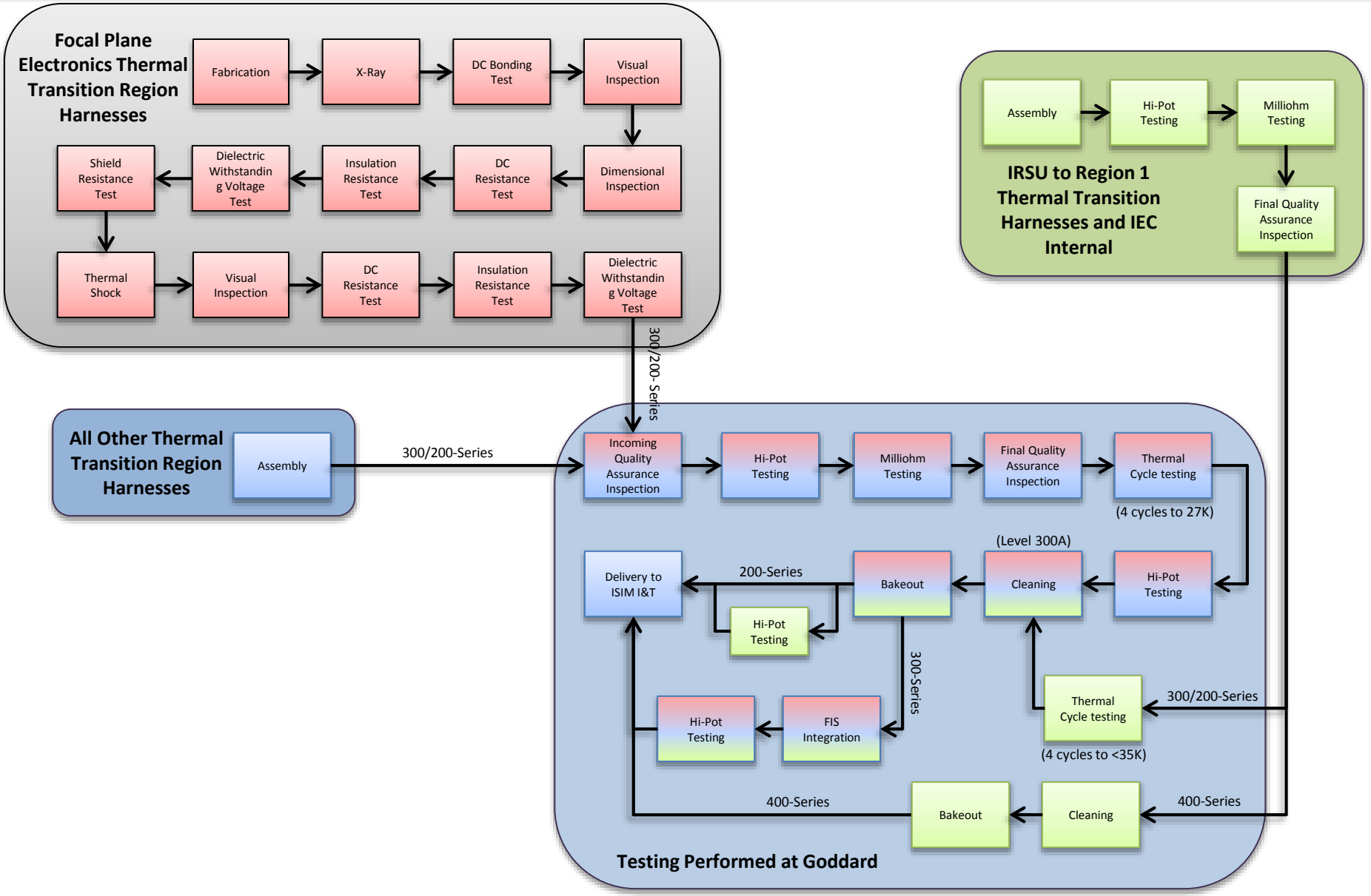
Cryogenic Strength Test - Cryoproof Test
2011

Modal Survey
2011





ISIM Harness Test Flow



IRSU Testing at Box Level

Board Test Flow

PCU, ITCE, MSC

Physical Verification → Functional Verification Test → Thermal Cycles (PCU & MSC)

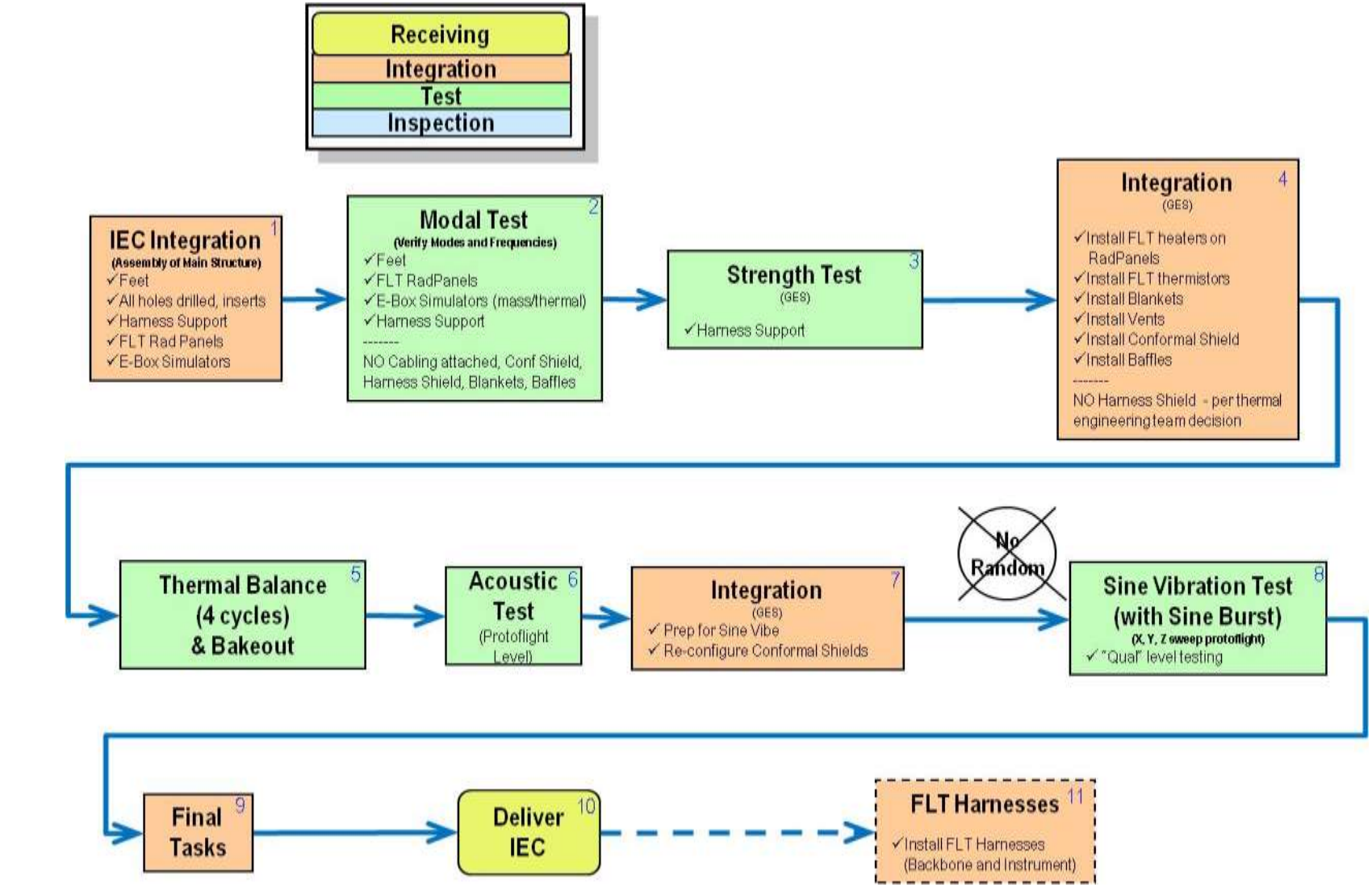
IRSU Box Test Flow

Preliminary Mechanical/ Electrical Integration → Functional Verification Tests → EMI/EMC Testing per the ISIM plan → Conformal Coating → Final Mechanical/ Electrical Integration → Functional Verification Tests → Vibration Testing – Protoflight Levels → Functional Verification Tests → Thermal Vac - 4 Cycles - Protoflight Levels → Functional Verification Tests → Completion of Burn-In For 200 hours → Functional Verification Tests → Box Mod → Mech/Elec Integration → Functional Verification Tests → Workmanship Vibe → 1 Cycle TVAC → Functional Verification Tests

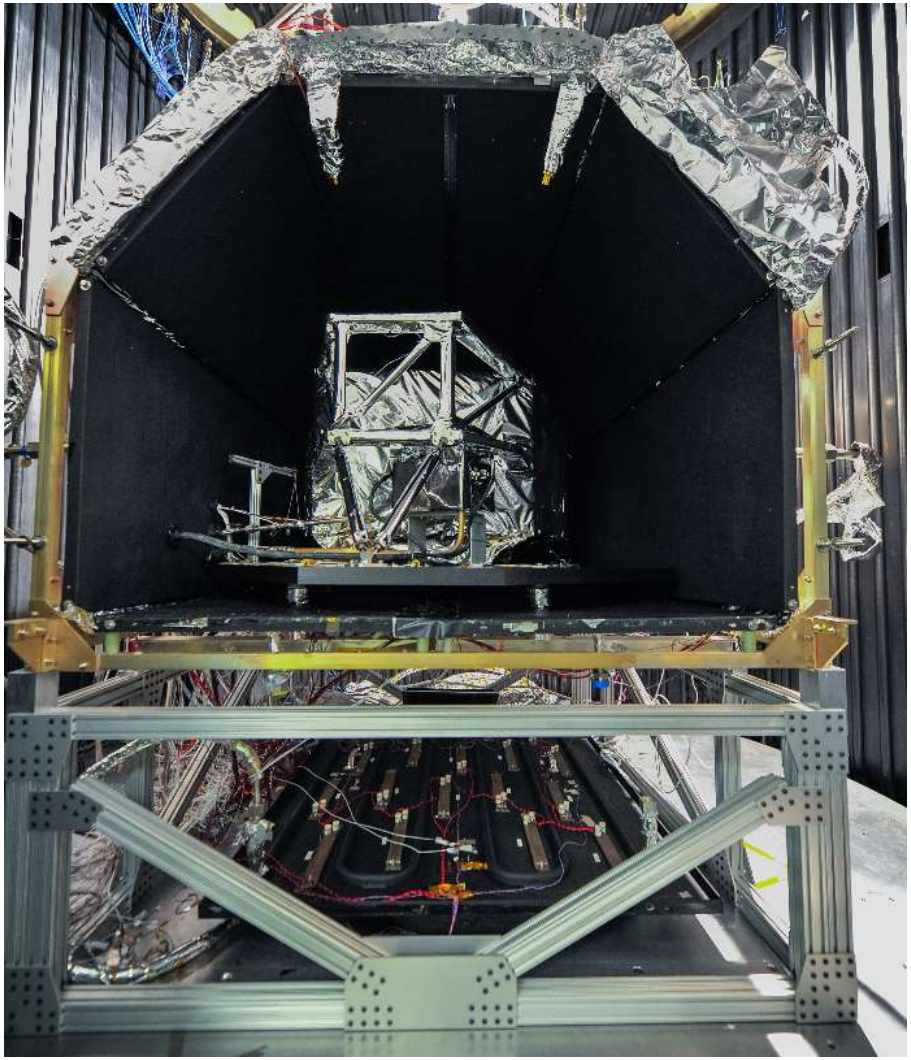
ISIM Test Flow

Delivery to ISIM → CV1RR

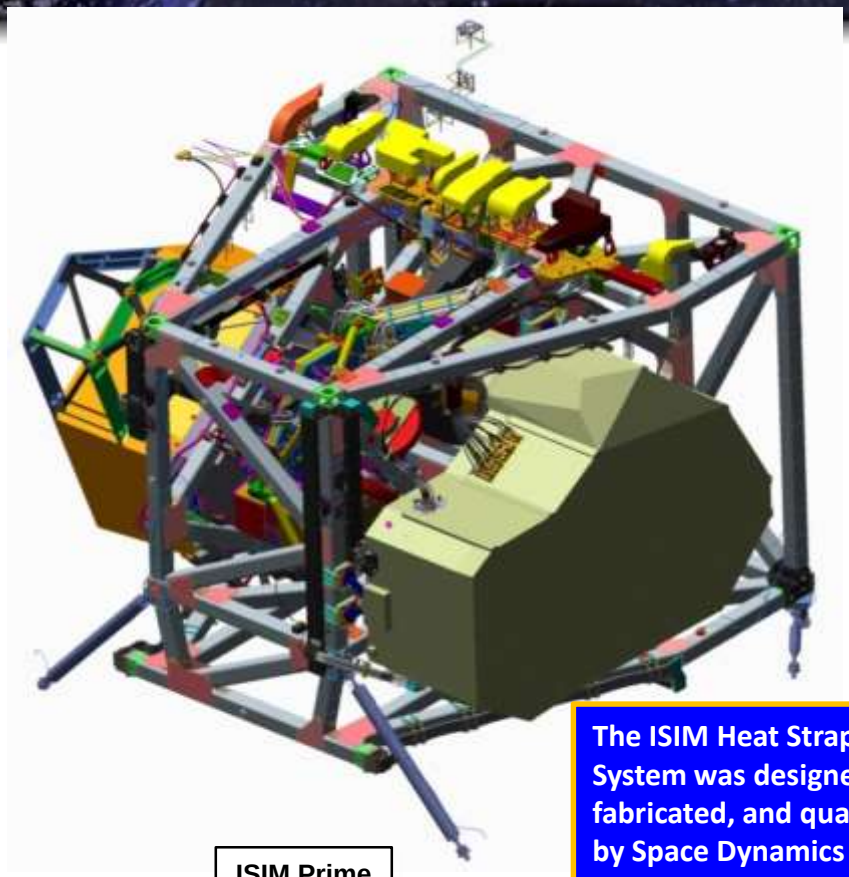
IEC Integration & TEST Plan



MIRI Shield in Facility 238 / Doghouse in TV/TB Test



ISIM utilizes aluminum heat straps for coupling to its radiators

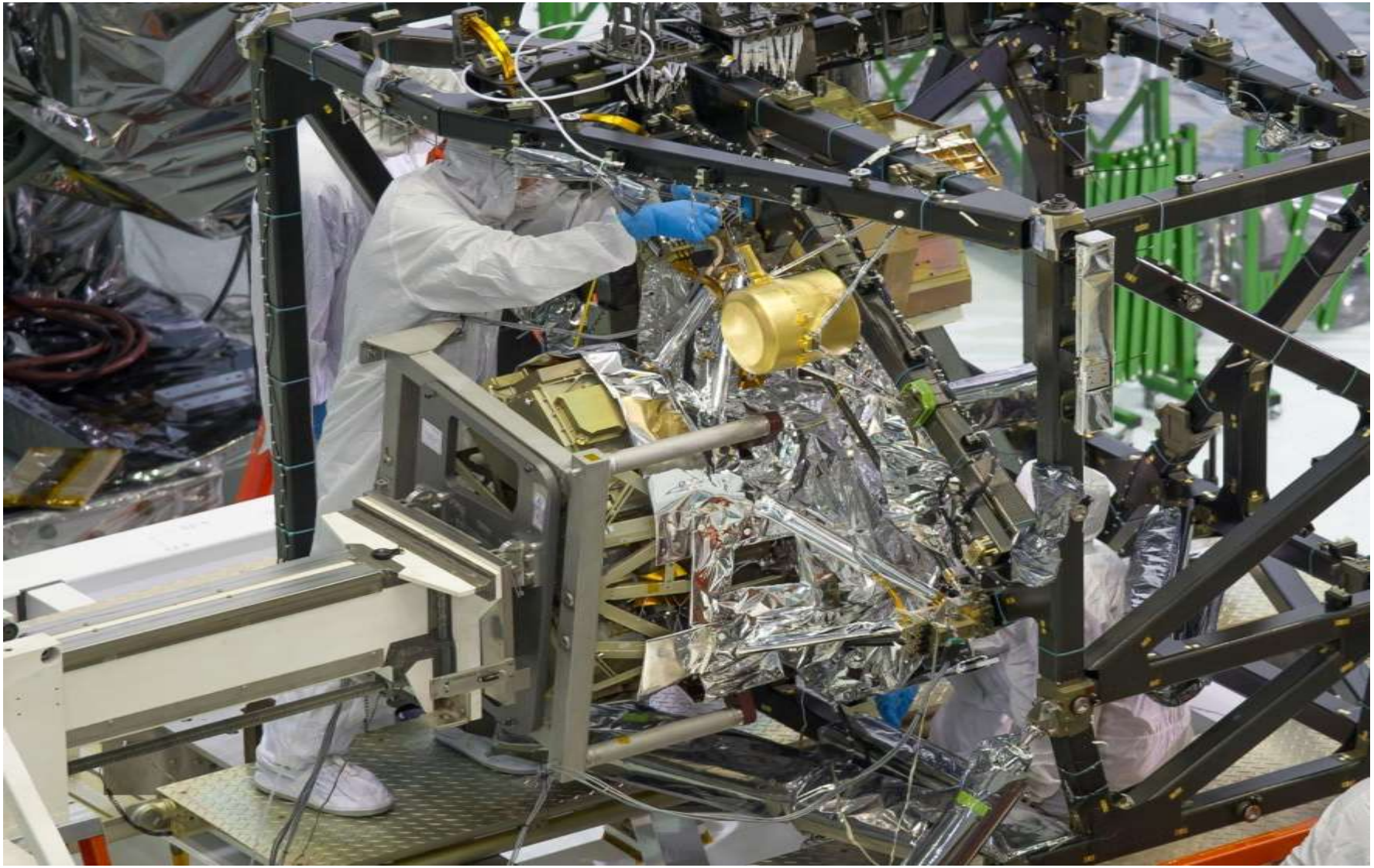


ISIM Prime

The ISIM Heat Strap System was designed, fabricated, and qualified by Space Dynamics Laboratory.

The straps create a thermal path between the sensors and the radiator panels that provide their passive cryogenic cooling

MIRI Integration – Delivered September 2012

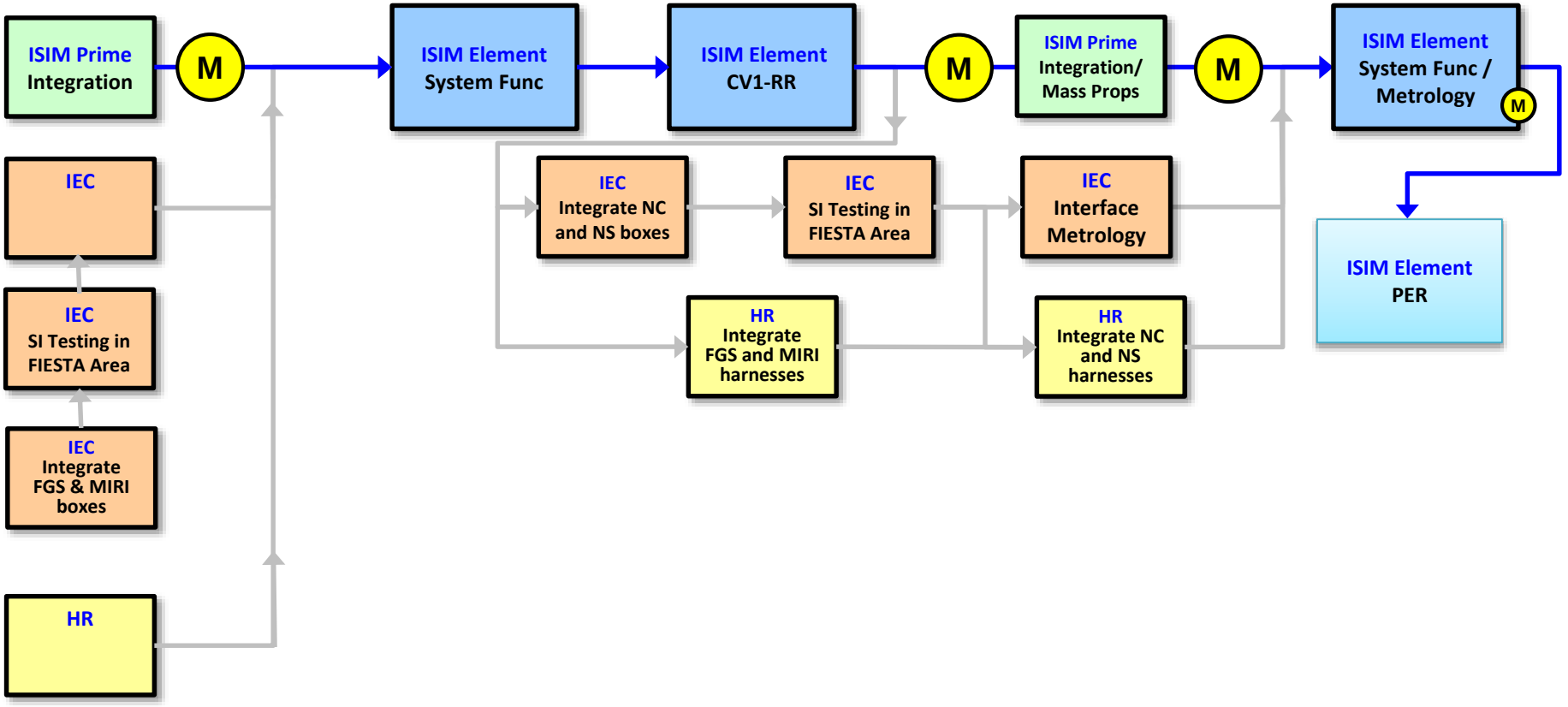


MIRI Shield Integration

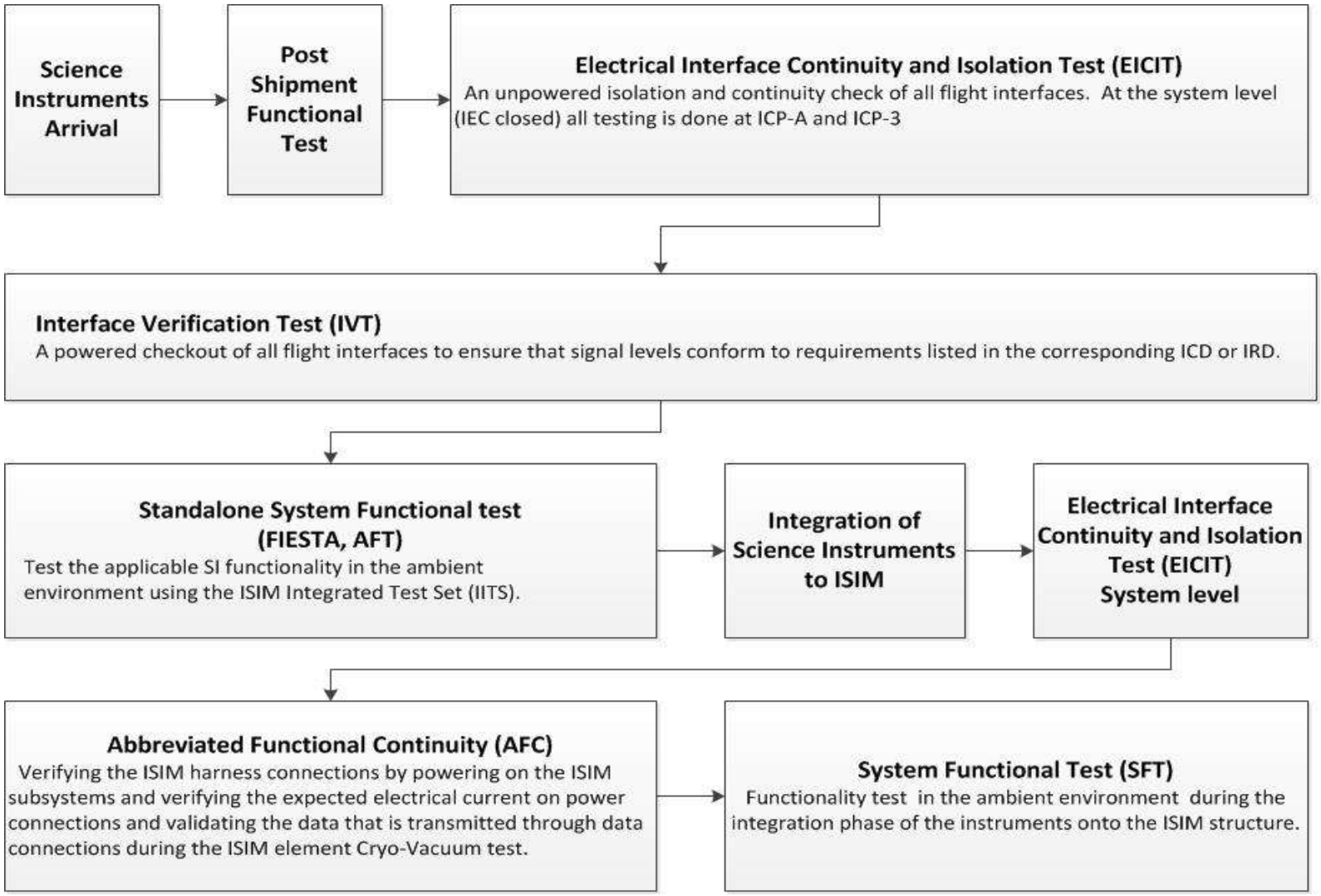
FGS Integration – Delivered December 2012

ISIM Integration and Risk Reduction Tests

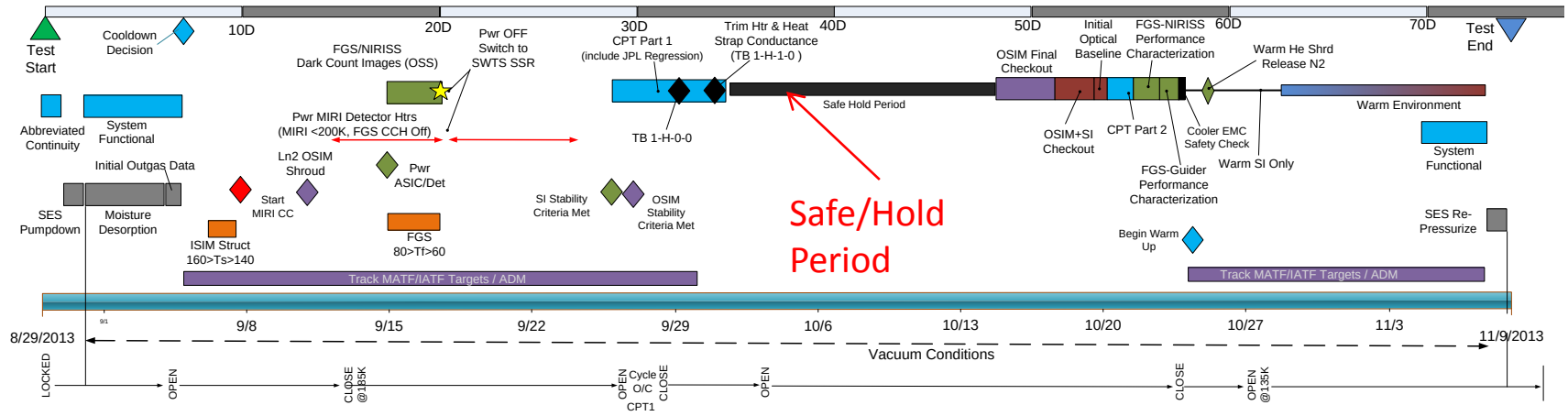
- Prior to the ISIM level Pre-Environmental Review (PER), integration and risk reduction tests were performed
  - Accommodated staggered SI delivery
  - FGS + MIRI in first wave
  - NIRCam and NIRSpec in second wave

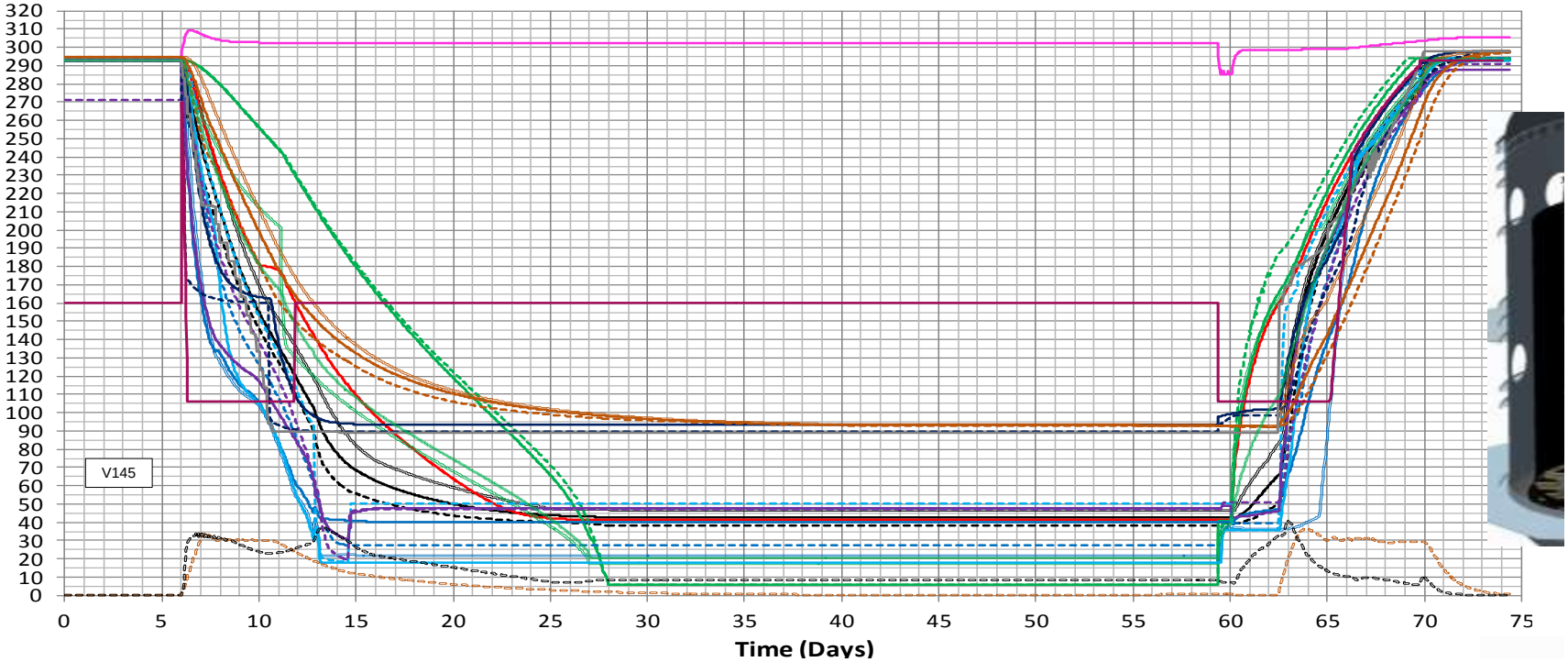


ISIM Electrical Tests Flow



Achieved CV1 RR Timeline



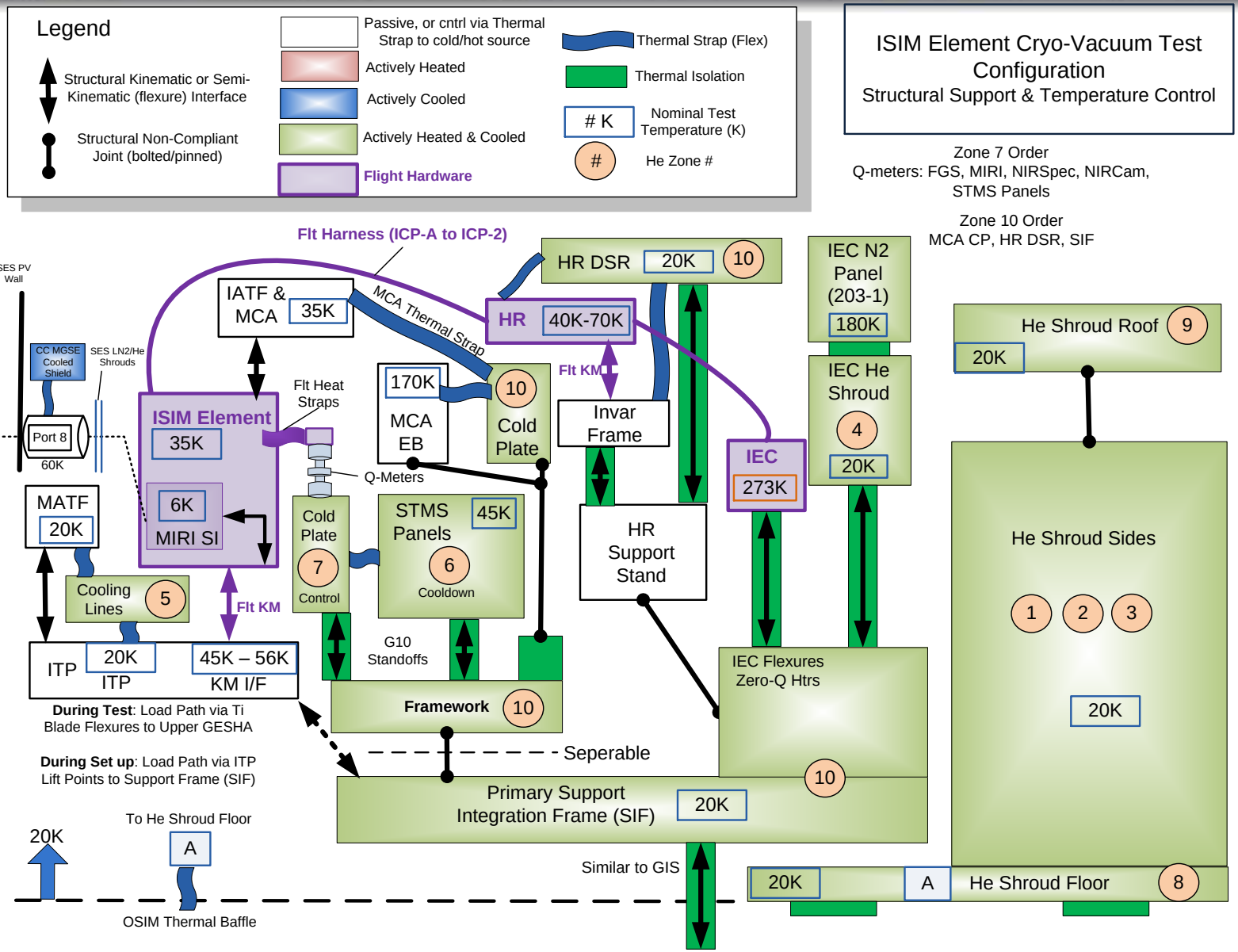


Top Level Goals of CV1-RR Very Well Satisfied

Will march through the objectives, as presented at the CV1-RR Test Design Review:

- The fundamental purpose of ISIM CV1-RR was, through this early exercise of the ISIM CV test hardware and procedures, to maximize the likelihood that the subsequent ISIM verification tests, CV2 and CV3, will run effectively and efficiently (i.e., as the name of the test implies, to reduce the risk that they won't)
- Hence, in broad terms, the primary objectives of CV1-RR were:
  - To demonstrate that the test configuration, which includes large amounts of new GSE, is able to support the test requirements of the ISIM verification program (identify any necessary fixes to hardware before CV2) − highly successful; despite issues with He shroud and spacecraft simulators, we could have run a successful verification test
  - By dry-running critical test procedures, to learn how to most efficiently formulate and execute them and to analyze the results (identify any necessary improvements to procedures before CV2) − also successful and extremely productive; learned a huge amount about test scripts, data flow, optical test procedures that will enable us to improve the execution of CV2 and CV3

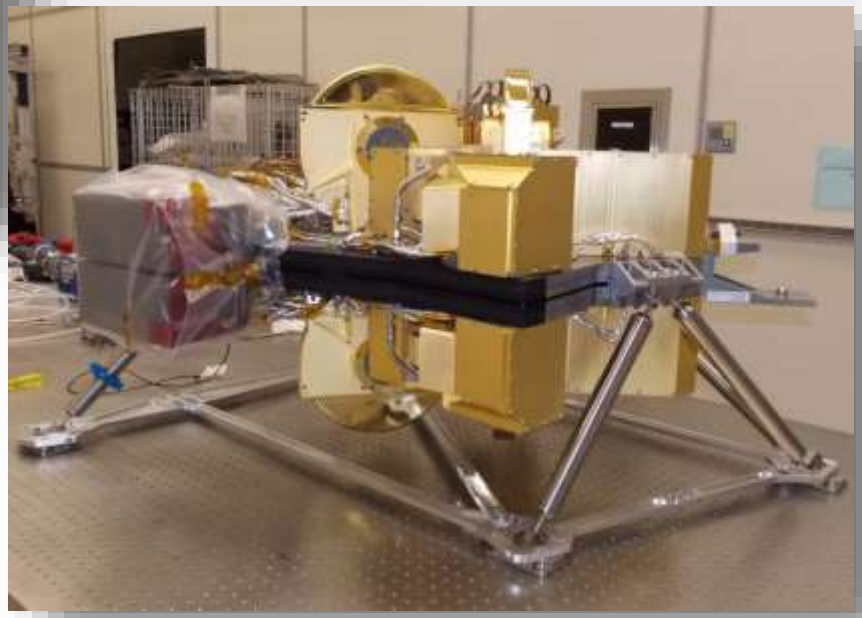
ISIM CV Test Configuration – He Zones



NIRSpec Arrival in the SSDIF, September 2013

NIRCam Delivery and Detector Replacement

- Flight NIRCam delivered to ISIM I&T September 18, 2013
- New NIRCam flight detectors **installed** November 19 2013…**10 months early**!



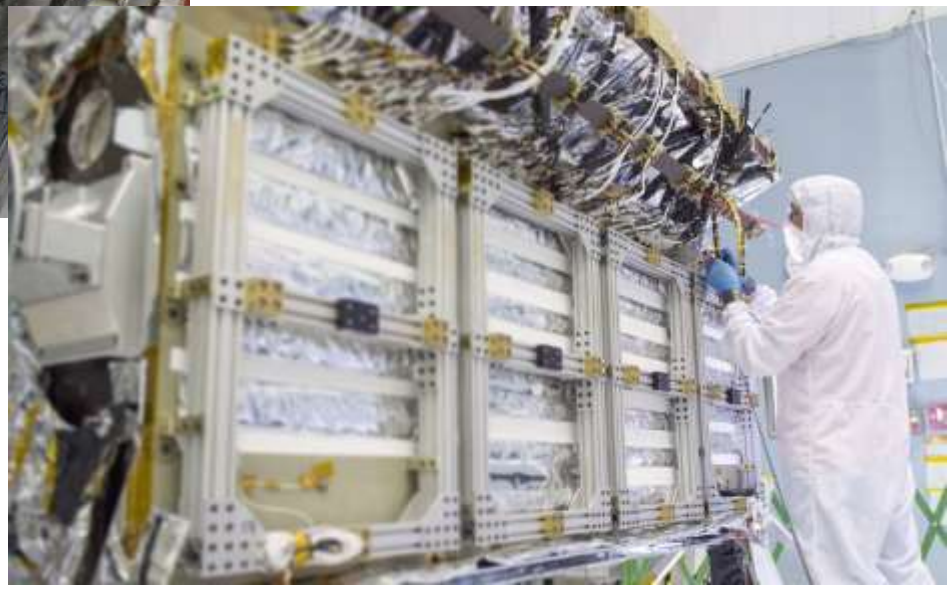
NIRCam Integration to ISIM

IEC Mechanical & Electrical Integration

Thermal Transition Harness Integration

ISIM Overview – ISIM SubElements

ISIM Prime



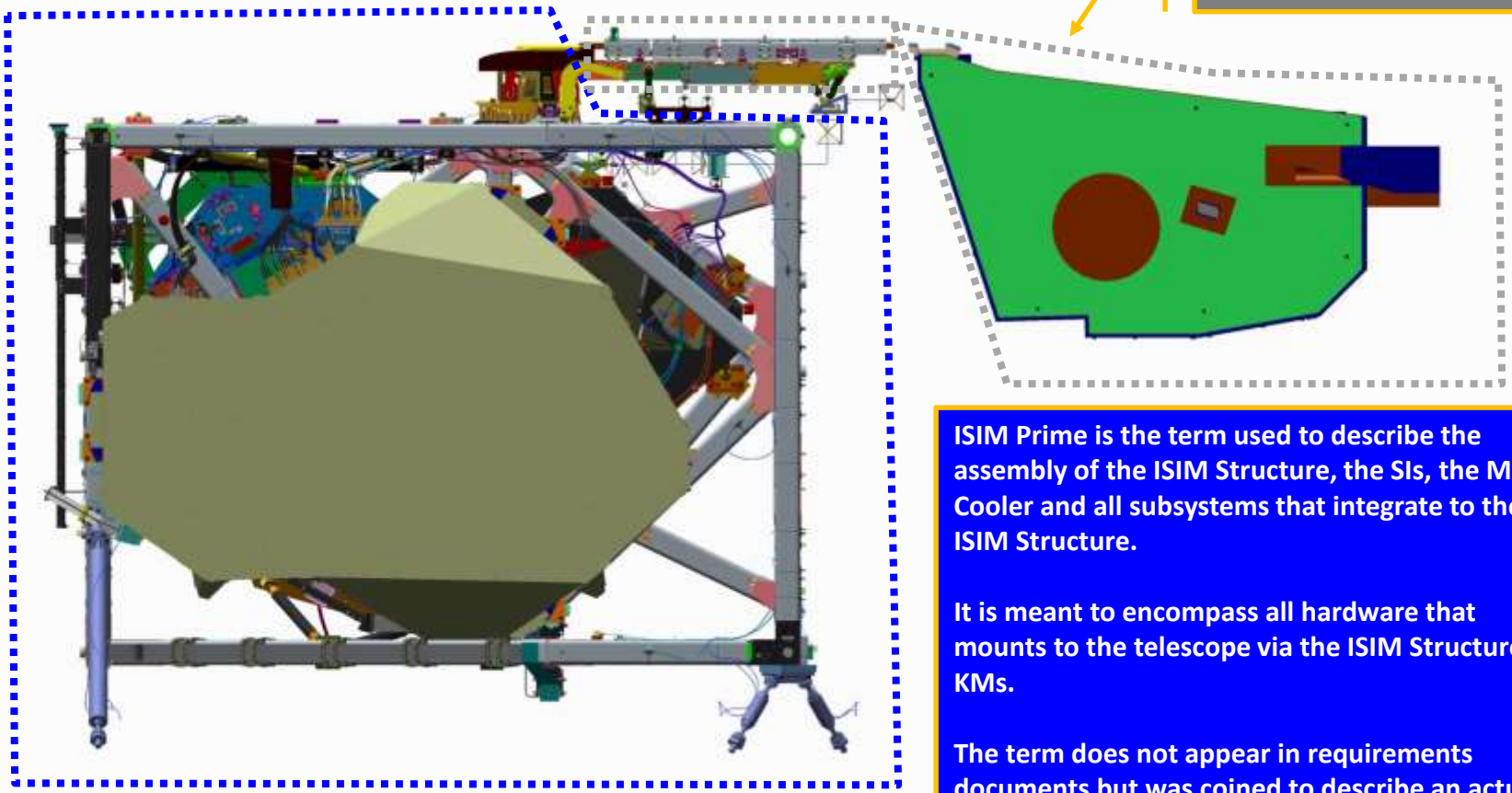
ISIM Electronics Compartment

JWST Overview - ISIM Element

ISIM Prime

ISIM Harness Radiator

ISIM Electronics Compartment



ISIM Prime is the term used to describe the assembly of the ISIM Structure, the SIs, the MIRI Cooler and all subsystems that integrate to the ISIM Structure.

It is meant to encompass all hardware that mounts to the telescope via the ISIM Structure KMs.

The term does not appear in requirements documents but was coined to describe an actual piece of assembled hardware that gets delivered as an entity. ISIM Prime is not just the ISIM Structure, nor is it ISIM Element (Prime + HR + IEC + ICDH), nor is it the R1 hardware.

ISIM Prime Mass Properties

Objective of Test

- Provide information used to calculate the mass of ISIM Prime.
- Provide information used to calculate the CG of ISIM Prime.

Level of Test

- n/a

Test Facility / View of Test

- NASA GSFC B29 SSDIF

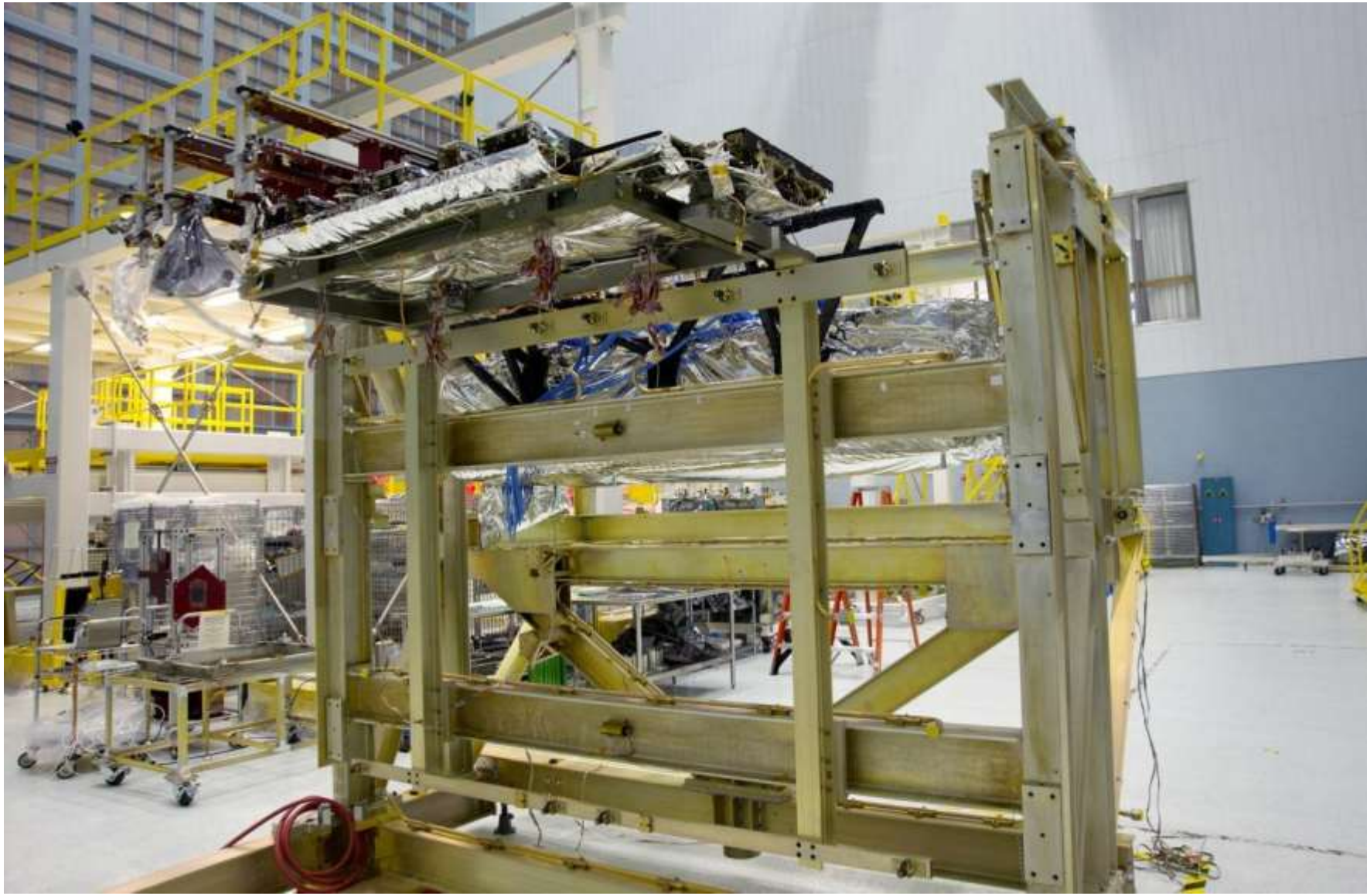
Known Deviations from Flight Configuration

- Flight ISIM Structure Kinematic mounts cannot be part of the measurement
- GSE HSA is on ISIM Prime for the measurement
- 4x Non-Flight CFMPs (Corner Fitting Metrology Plates) are still integrated on various -V3 corner fittings
- 15x Non-flight metrology nests are still integrated to ISIM Prime for this measurement
- 15x Non-flight metrology retention bands are integrated to non-flight metrology nests on ISIM Prime
- 4x Non-flight metrology nests are integrated FGS
- 4x Non-flight metrology retention bands are integrated to non-flight metrology nests are integrated FGS
- Some protective padding was on ISIM Prime for this operation
- 4x Non-flight lift-blocks & shackles were integrated to ISIM Prime (they are needed to enable the lift itself)
- Non-flight ICP-A blanket is integrated to ISIM Prime (this represents a flight blanket that the OTE team is going use so it isn't part of ISIM Prime mass)
- Traveling ground was hanging from ISIM Prime
- Traveling purge was hanging from ISIM Prime
- RTG saddle connection (cable ties currently used vs machined pieces to be used on flight)
- No MIRI cooler line AFTER the line field joint at cooler line location 4.

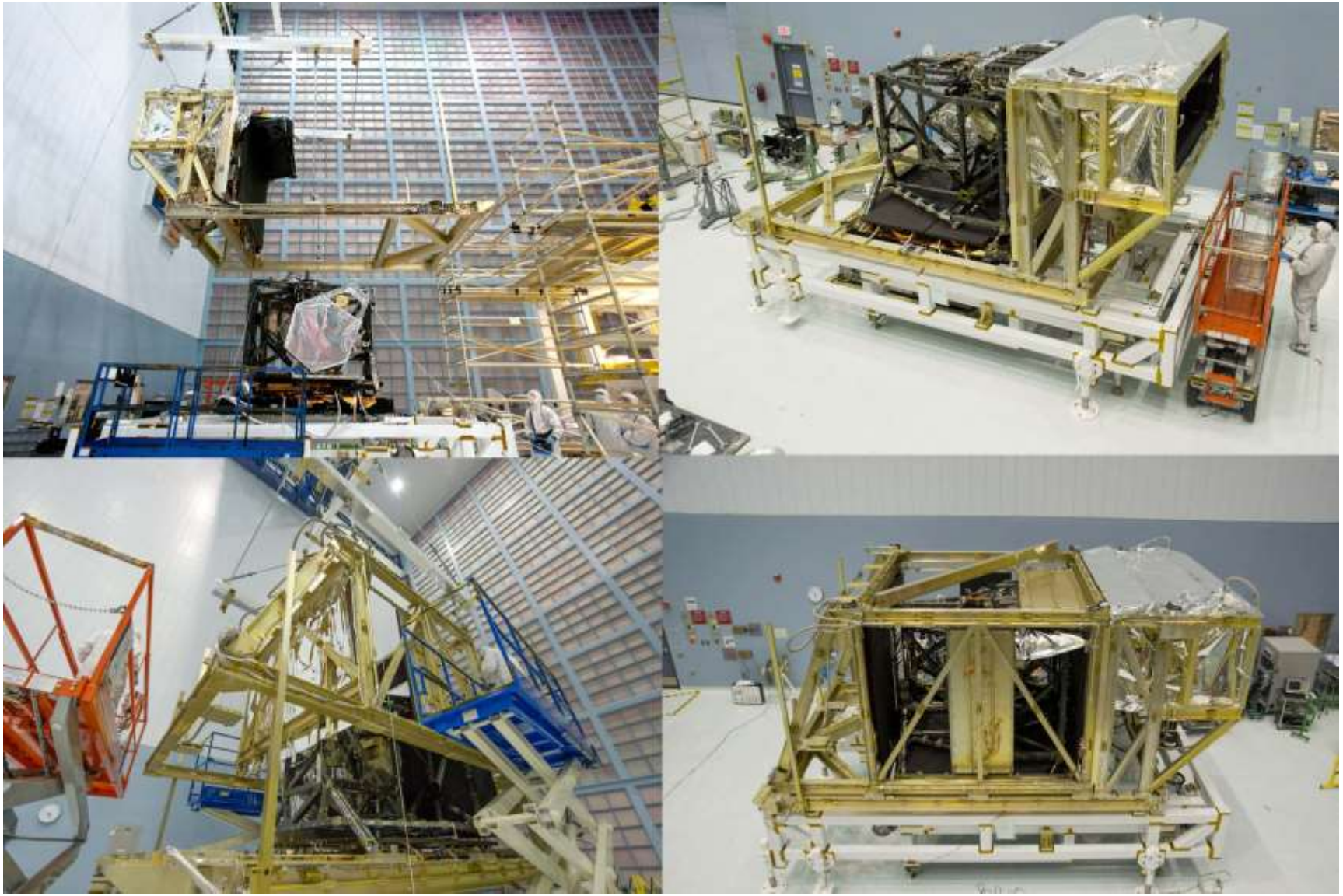
Plans, Procedures, and WOAs

- ISIM Prime Mass Properties Test Plan, JWST-PLAN-020889
- ISIM handling WOA, JWST-WOA-005903

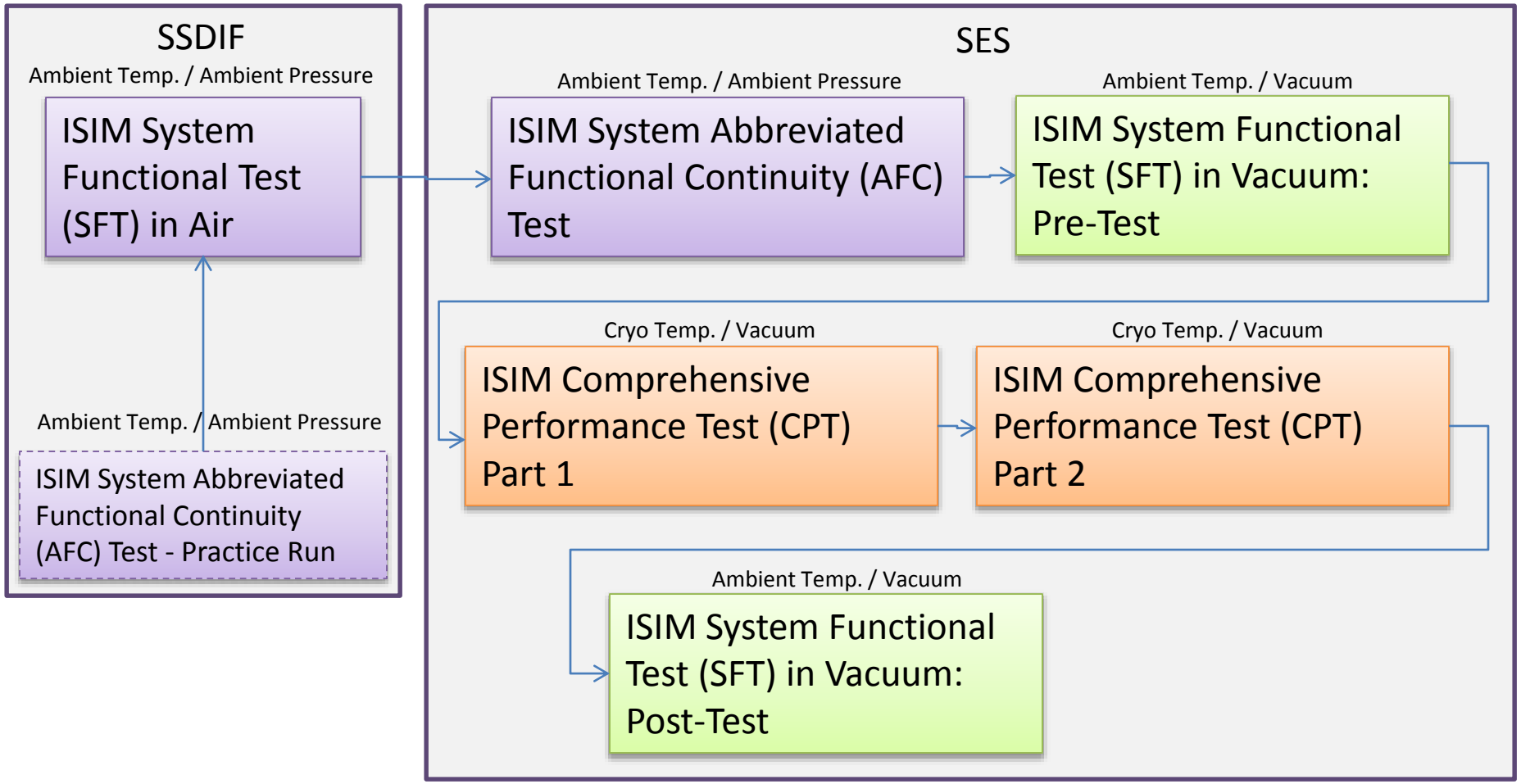
Harness Radiator and IEC Integrated to the SIF



ISIM Element and SIF Build Up

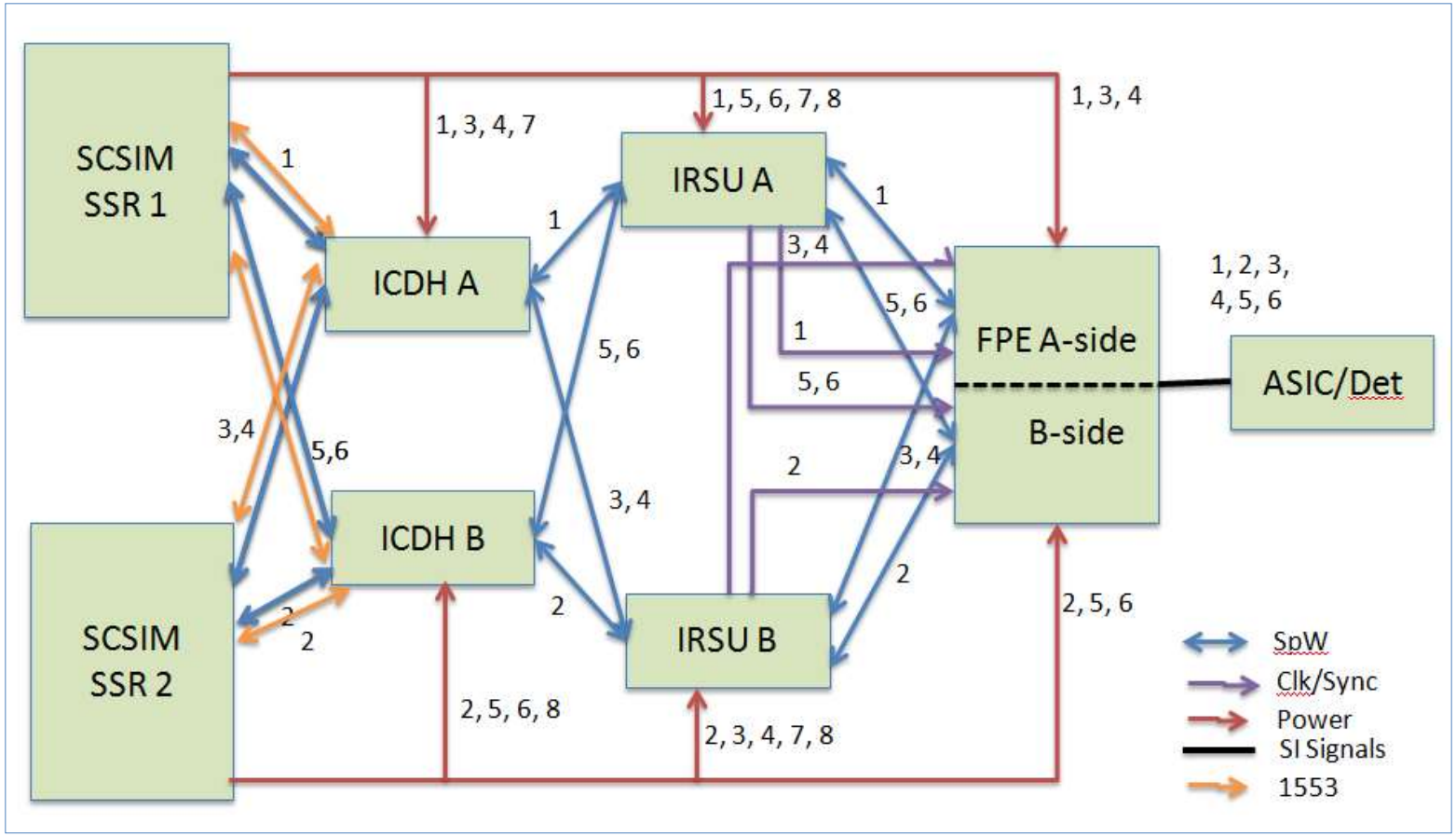


ISIM Integrated Functional and Performance Test Flow



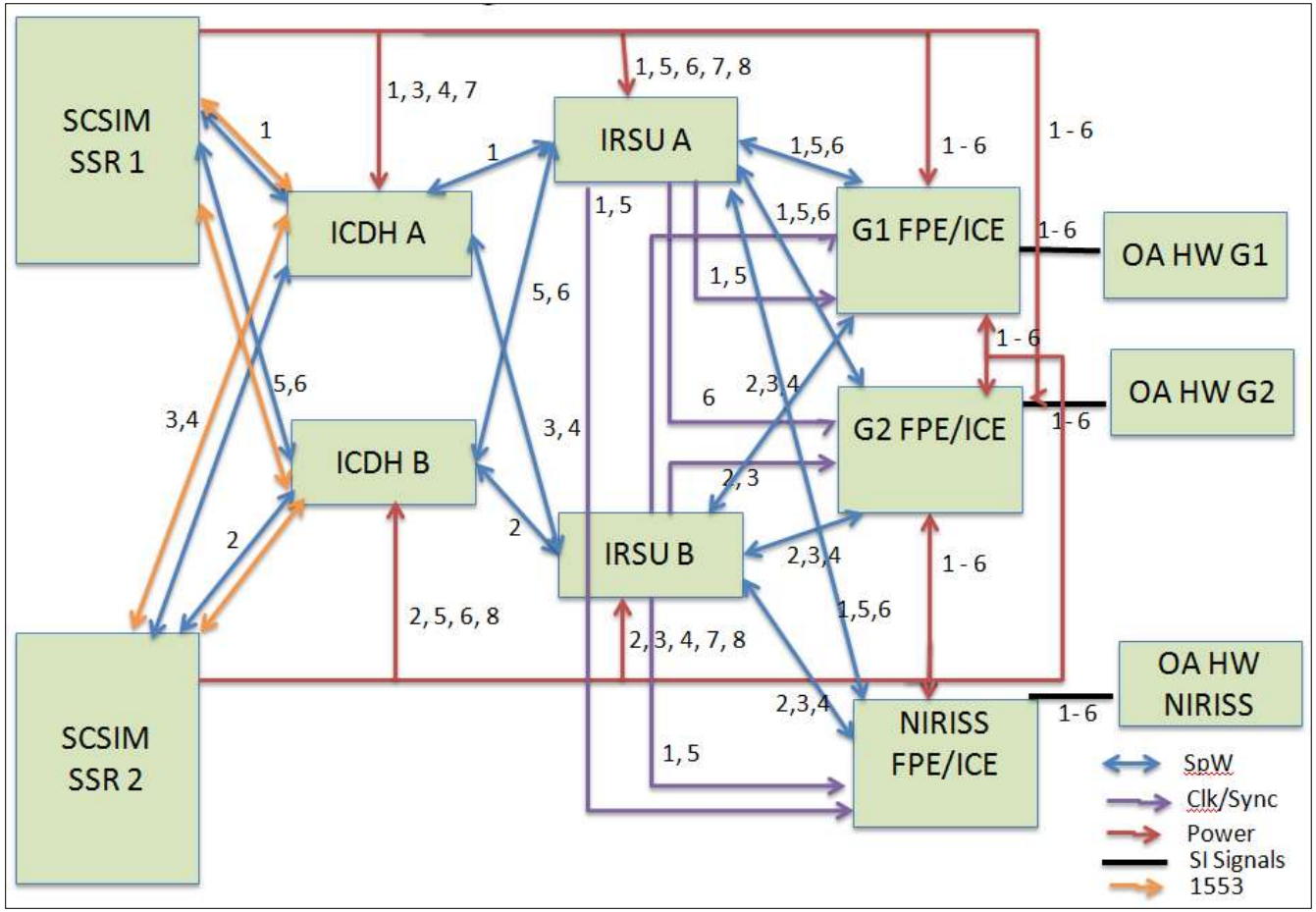
Signal Continuity / Component Operability

FPE Configurations – excluding FGS/NIRISS



Signal Continuity / Component Operability

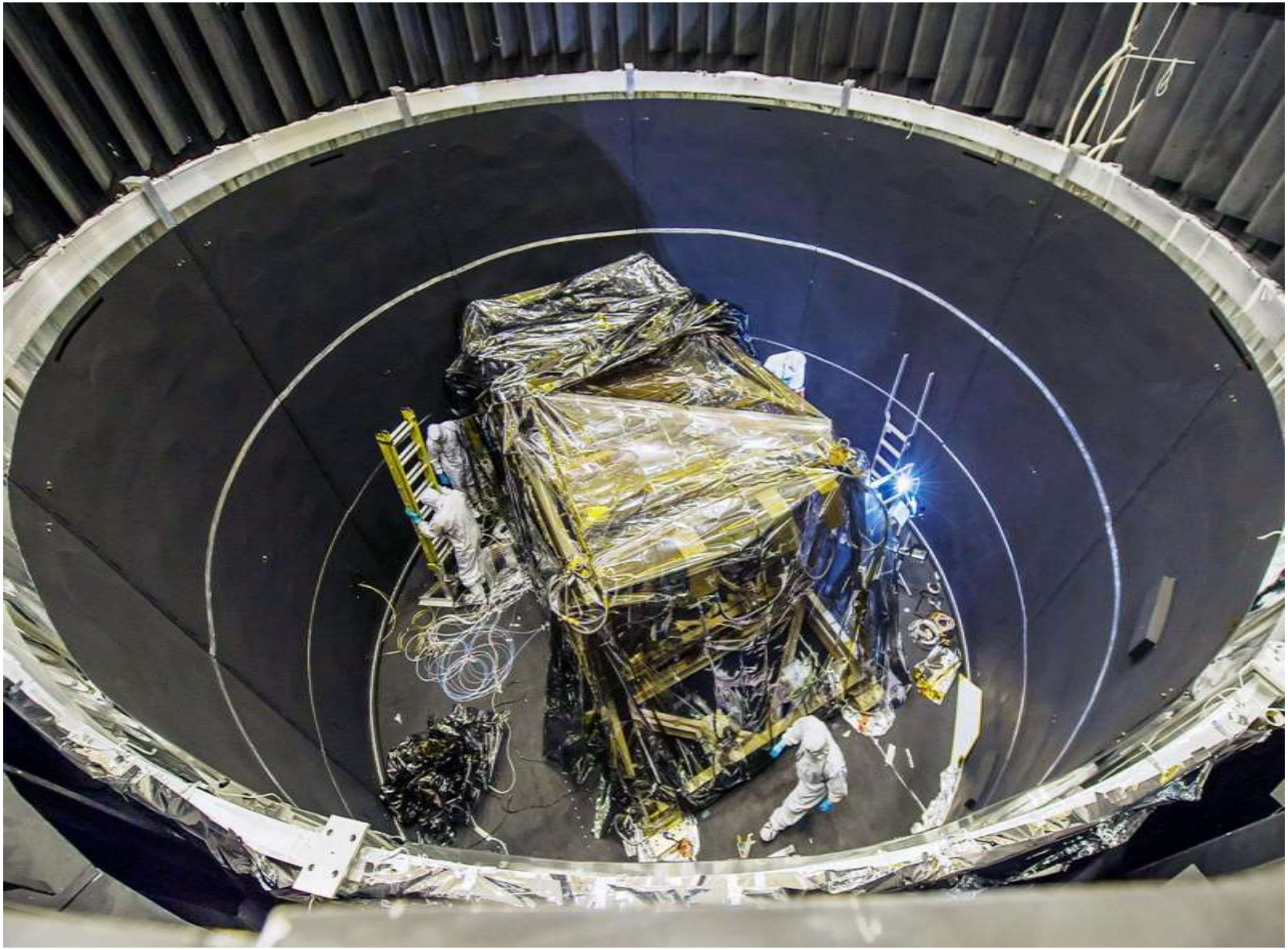
FPE/ICE Configurations – FGS/NIRISS



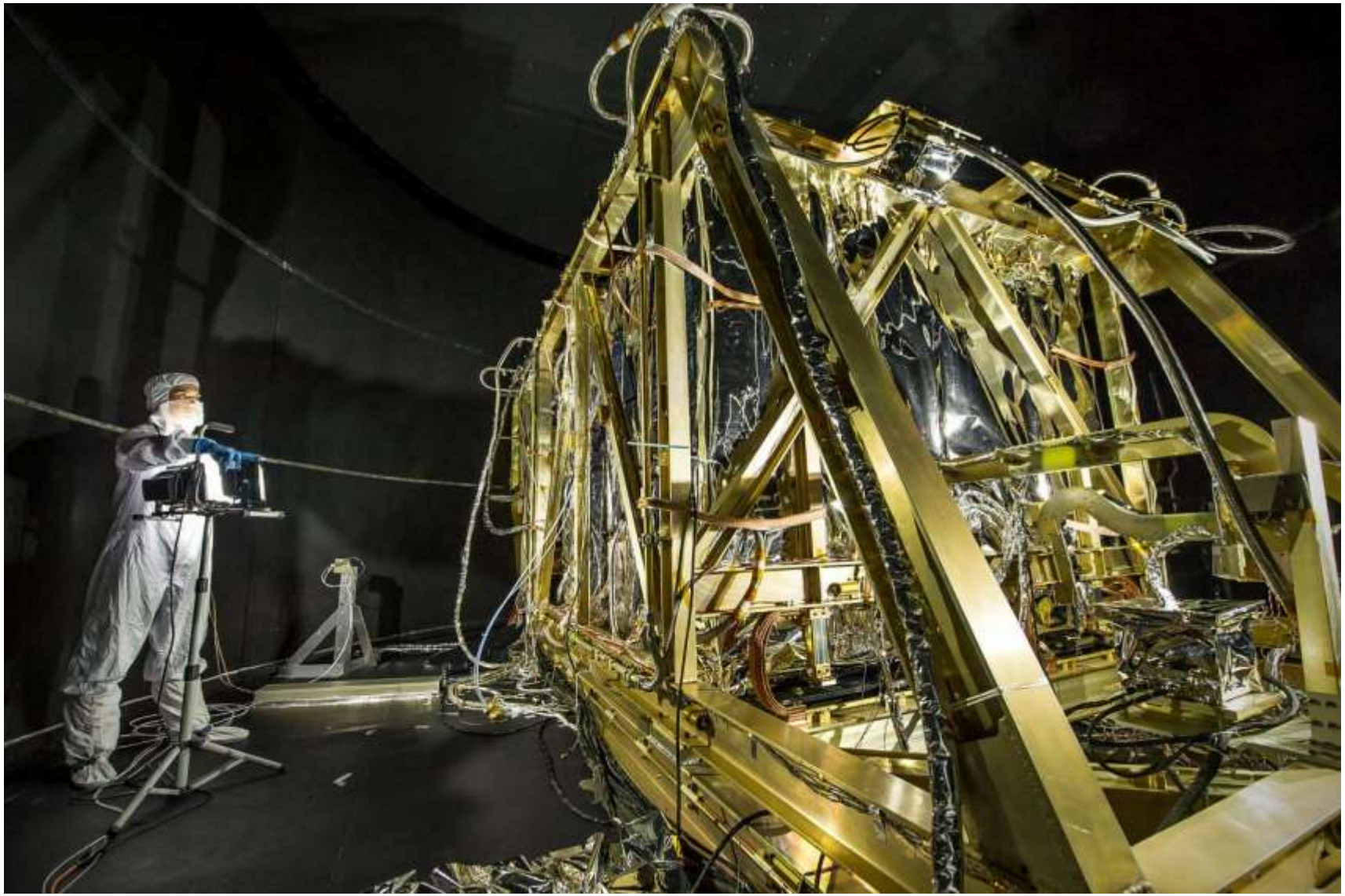
ISIM Element Just Prior to Move to the SES

ISIM Element Being Lowered in the SES

ISIM Element in SES

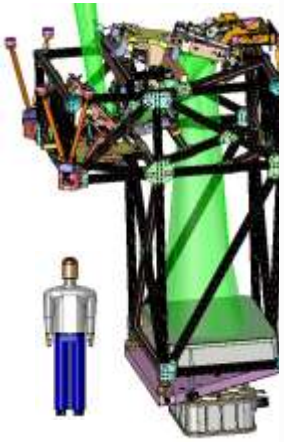


ISIM Element in SES Just Prior to Pump Down August 2013



ISIM Cryo-Vacuum Test Configuration

GHe Shroud



OTE Simulator (OSIM)

Cryocooler GSE

Vacuum Shell (9m diam x 13m tall)

GHe Shroud, 20K

IEC (inside, 293K)

ISIM (inside, 43K)

SES Integration Fixture with sTMS

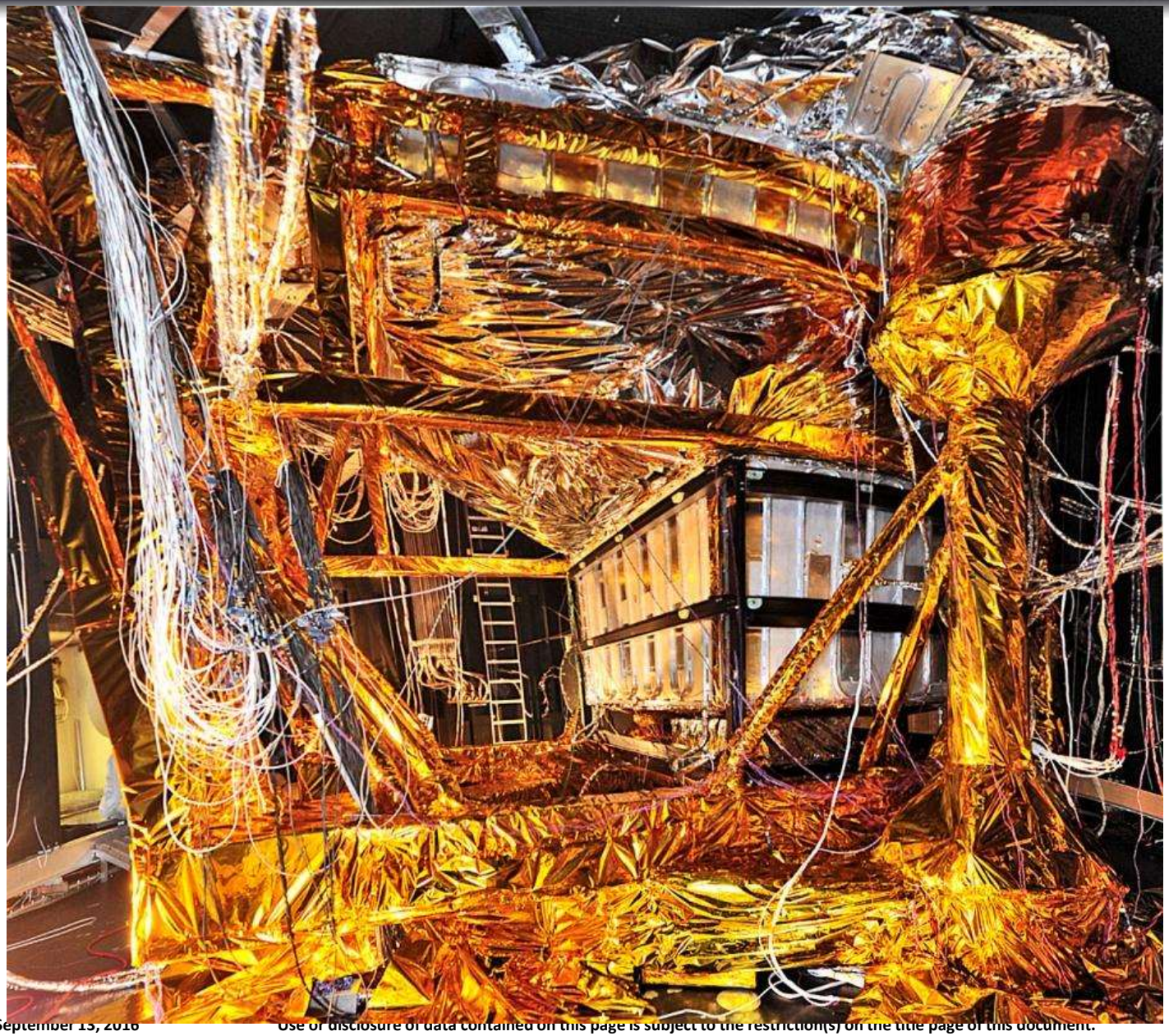
N2 Shroud

Vibration Isolators (not used)

OSIM (inside cryopanels, 100K)

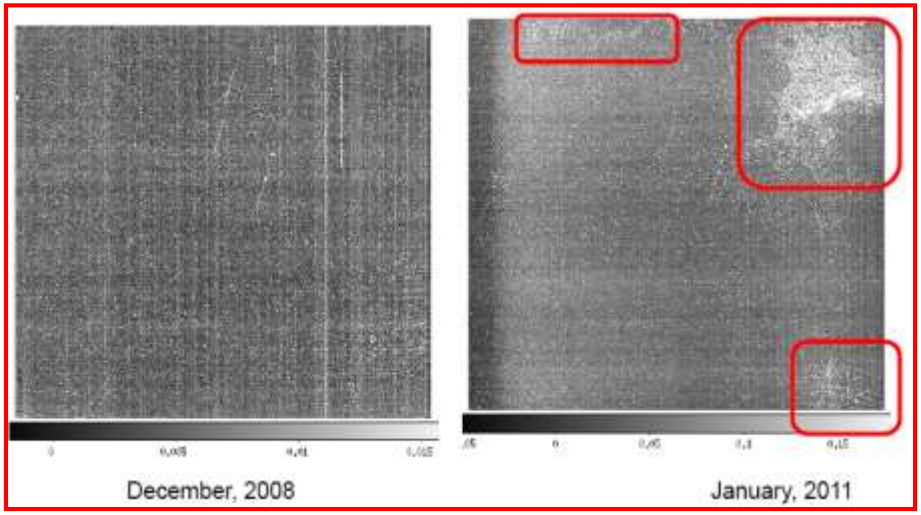
OSIM Into the SES for Cryo Calibration

OSIM in the SES



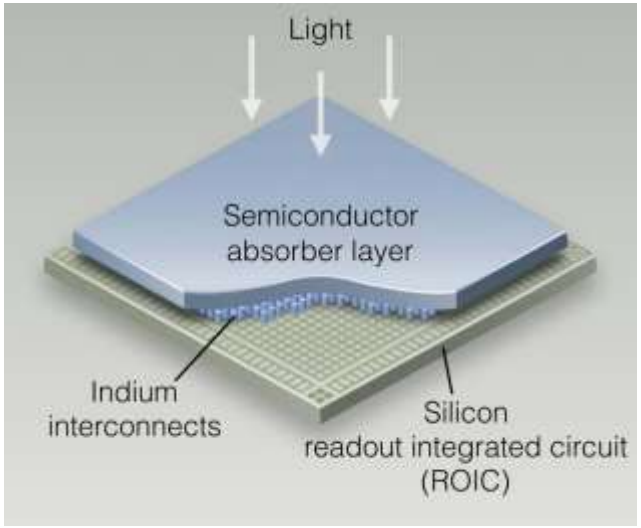
Detector Degradation – The issue

- In January 2011 NIRCam reported that their 5µm cutoff detector arrays had degraded over a two year period.
- Degradation was a significant increase in hot pixels (high dark current).



- Nature of degraded pixels is an “RC” response with a high residual dark current.
- All JWST flight 5µm cutoff detectors and at least two flight 2.5µm cutoff detector appear to be degrading.

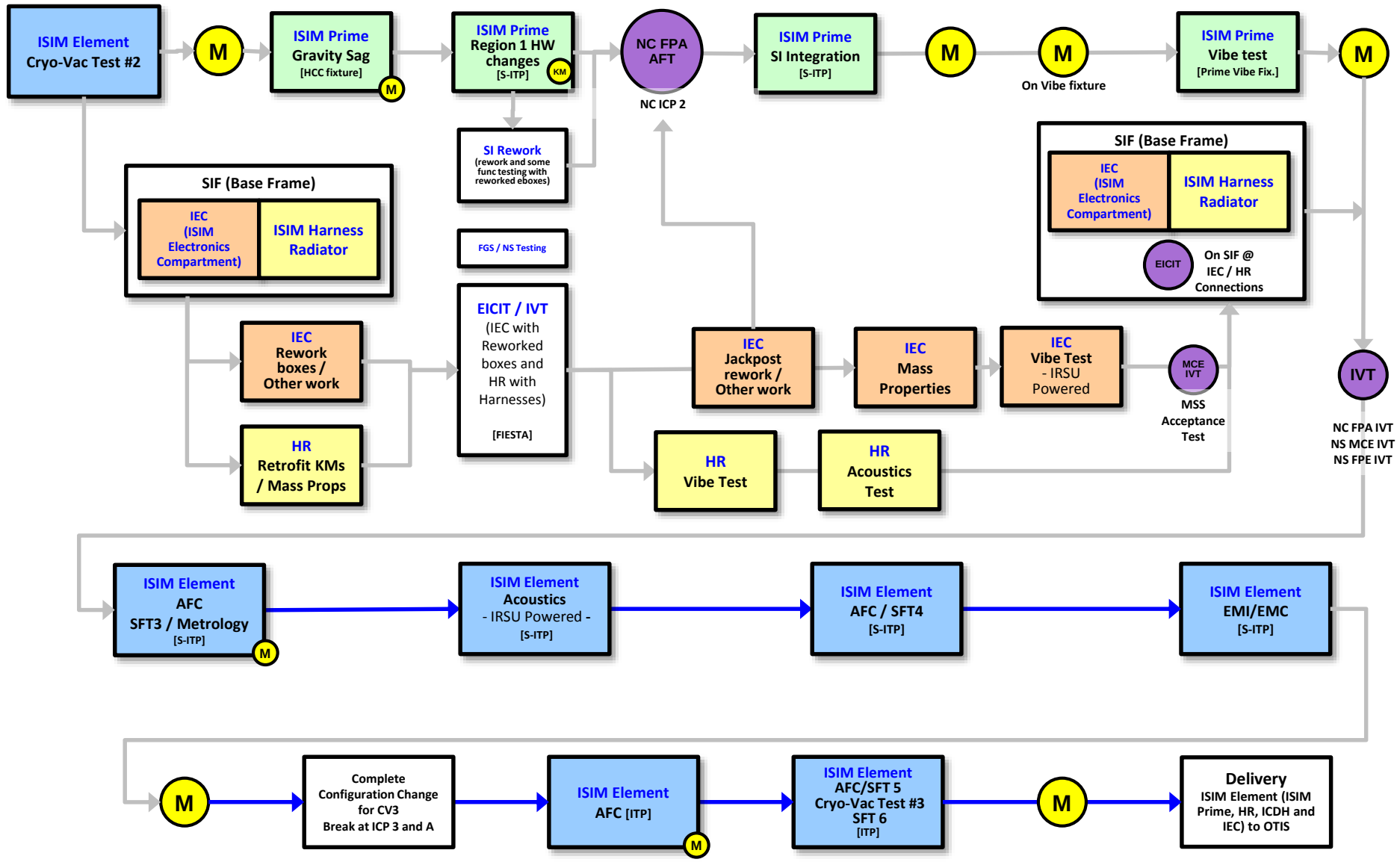
Table 1: HgCdTe sensors in the JWST ISIM			
Instrument	Agency	Quantity: 5 um cut-off	Quantity: 2.5 um cut-off
NIRCam	NASA	2	8
NIRSpec	ESA	2	NA
FGS-TF	CSA	1	NA
FGS-Guider	CSA	2	NA



ISIM Element I&T Flow

- Ideally, the hardware within the three components would not be changed from the start of CV2 through the conclusion of CV3 and only the three components would be mated and demated for various tests.
- Reality is that some hardware will need to be changed after CV2 and *before* mechanical environmental, EMI/EMC, and cryo-vac performance testing
- At the PER, we presented:
  - What are we going to do?
  - What are the risks?
  - How are the risks mitigated?
- CV3 - This test will verified the ISIM System in its final configuration after environmental exposure and provided the post-environmental performance verification test
- All hardware changes between CV2 and CV3 were fully verified

ISIM Element Environmental Testing



ISIM CV2 Design

Minimum Test for ISIM CV2:

Activity verifies requirement(s) requiring the comparison of **pre- and post-environmental** tests

Activity provides data used to close previous PRs and **PFRs**

Activity provides **basic health and safety** reducing the risk of finding a problem that could have a large impact if not found until the next test phase

All other objectives are prioritized:

Higher Priority

Activity provides continued **Model Validation** data for system and subsystem items

Activity verifies requirement(s) and is time critical to obtain a performance or functional assessment to **reduce risk** of finding an issue late/CV3.

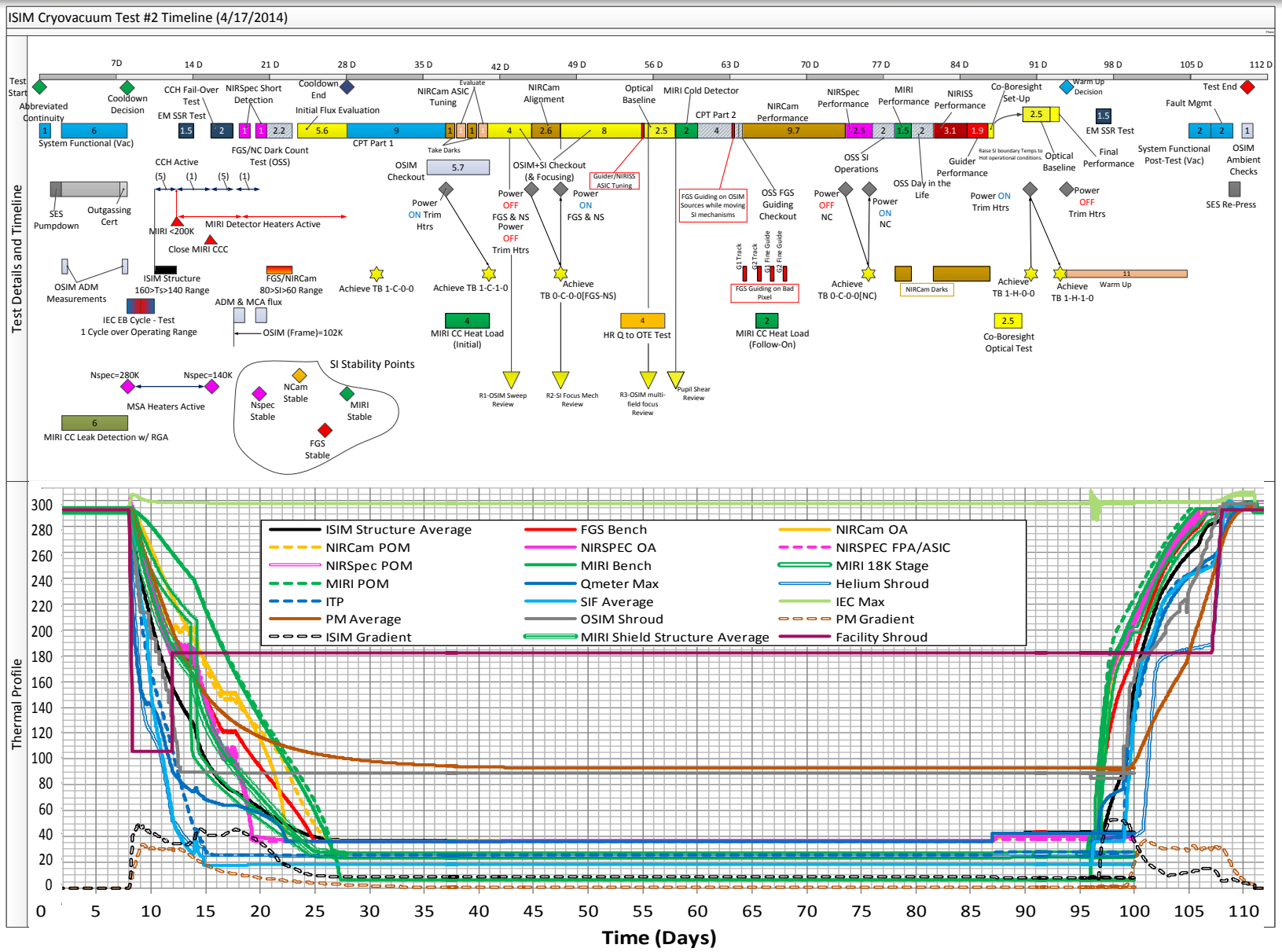
Activity verifies requirement(s) and leads to a **subsystem's final verification**

Lower Priority

Activity verifies requirement(s) and is straightforward to perform in CV2, AND does not need to be repeated in CV3 - doing it now takes it off the table

Activity provides data for calibration of science data; if not obtained in CV2, becomes High priority for CV3.

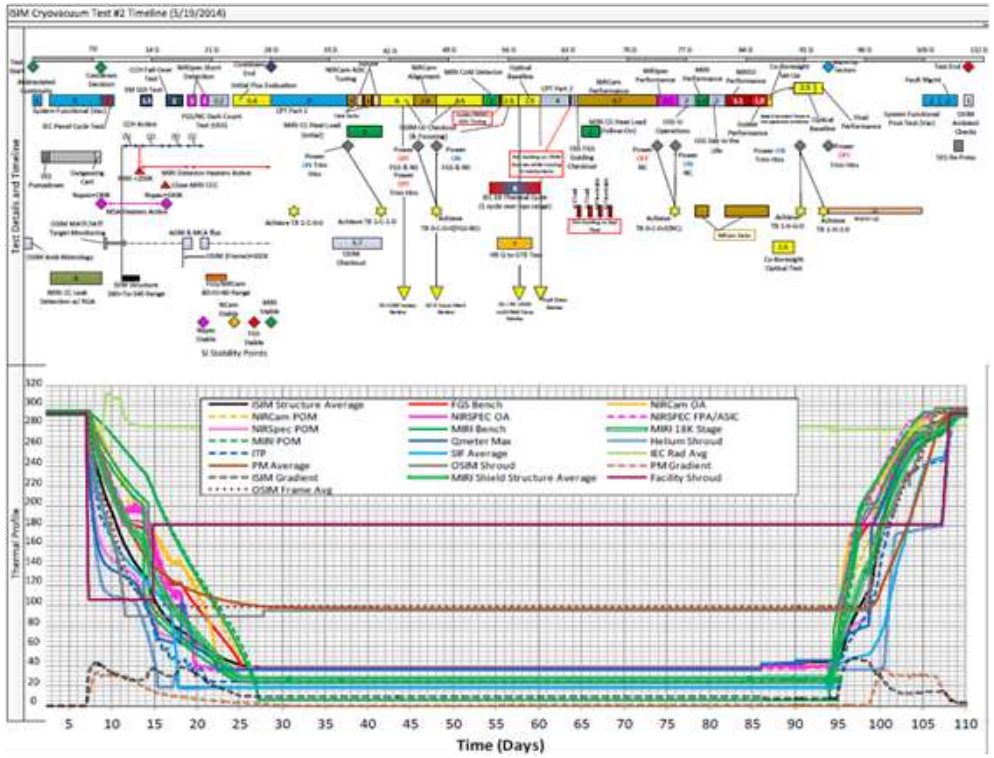
ISIM Cryo-Vacuum Test 2 Timeline



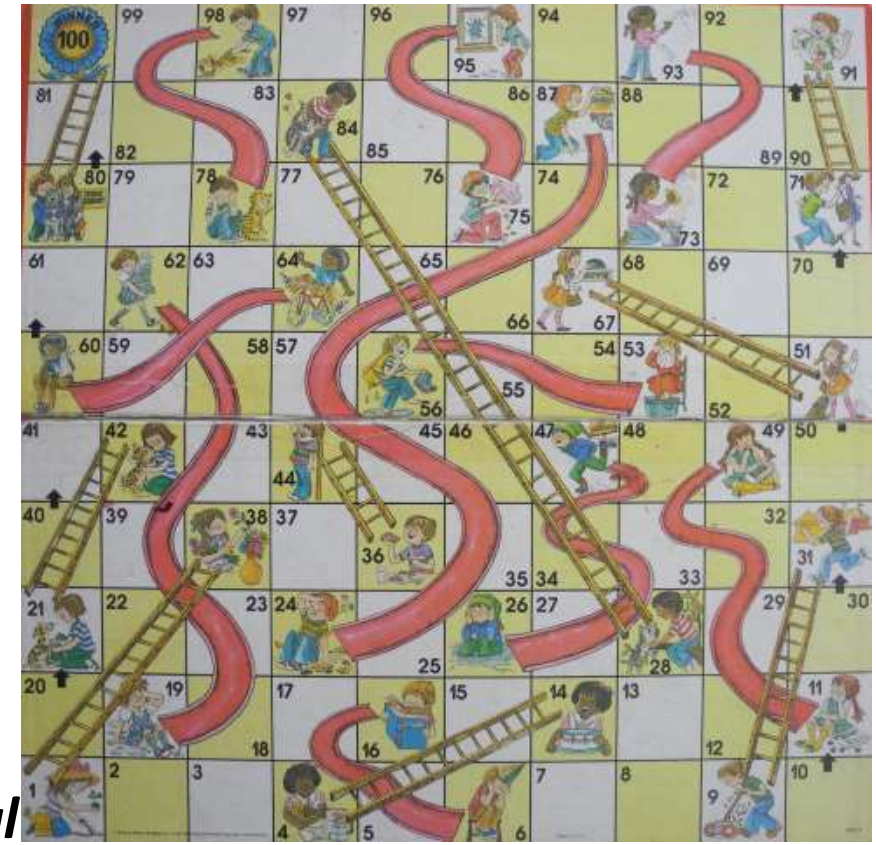
ISIM Cryo-Vacuum Test 2 Procedure List

Numb	Procedure (Current Rev)	Procedure Name	Baseline Plan	Notes
1	JWST-PROC-022529	ISIM Element Cryo-Vacuum Test #2	Note (1)	[was 016116]
2	JWST-PROC-016387	JWST ISIM Long System Functional Test (Air)	Note (1)	[was 016393]
3	JWST-PROC-016353	ISIM Long System Functional Test in Vacuum (Pre-Test)	Note (1)	[was 016394]
4	JWST-PROC-016358	ISIM Long System Functional Test in Vacuum (Post-Test)	Note (1)	[was 021887]
5	JWST-PROC-016395	ISIM Comprehensive Performance Test Part 1	Revise/release existing	Revise to RevA
6	JWST-PROC-016497	ISIM Comprehensive Performance Test Part 2	Revise/release existing	Revise to RevA
7	JWST-PROC-016249	JWST ISIM System Abbreviated Functional Continuity (AFC) Test Procedure	Revise/release existing	Revise to RevC
8	JWST-PROC-016302	OSIM Final Checkout Test Procedure	Revise/release existing	Revise to RevA
9	JWST-PROC-016304	OSIM Initial Flux Evaluation Procedure	New procedure	
10	JWST-PROC-016305	JWST CV2 OSIM & SI Checkout Test Procedure	Note (1)	[was 016313]
11	JWST-PROC-016307	NIRCam Optical Alignment Test Procedure ISIM Cryo-Vacuum Test 2	New procedure	
12	JWST-PROC-016344	JWST SIDECAR ASIC and SCA Tuning Procedure	Note (1)	[was 016314]
13	JWST-PROC-016346	NIRSpec MCA Short Detection Test Procedure	New procedure	
14	JWST-PROC-023678	FGS-NIRISS Performance Characterization Test Procedure, ISIM Cryo-Vacuum Test 2	Note (1)	[was 016434]
15	JWST-PROC-016360	MIRI Cryo-Cooler Heat Load Verification Test in CV2	New procedure	
16	JWST-PROC-016306	ISIM Optical Baseline Procedure	Note (1)	[was 016434]
17	JWST-PROC-016308	NIRCam Performance Characterization Test Procedure	New procedure	[was 016433]
18	JWST-PROC-016318	NIRSpec Performance Characterization Test Procedure	New procedure	
19	JWST-PROC-016309	MIRI Performance Characterization Test Procedure, ISIM Cryo-Vacuum Test 2	Note (1)	[was 016447]
20	JWST-PROC-023679	FGS-Guider Performance Characterization Test Procedure, ISIM Cryo-Vacuum Test 2	Note (1)	[was 016435]
21	JWST-PROC-016335	JWST ISIM Co-Boresight Test Procedure	New procedure	
22	JWST-PROC-021687	MIRI Cryo-Cooler MIRI Detector Lower Temperature Test Procedure	New procedure	M. Ressler/JPL A. Glasse / EC
23	JWST-PROC-016340	Warm Dark Cryo-2 Test Procedure	Note (1)	[was 016315]
24	JWST-PROC-016341	GS&O/OSS SI Characterization Test Procedure	Note (1)	[was 016317]
25	JWST-PROC-016343	Cryo-2 Day in the Life Procedure	Note (1)	[was 016273]
26	JWST-PROC-016361	OSS FGS Guiding Checkout	New procedure	
27	JWST-PROC-TBD	JWST ISIM Ambient Fault Management Test	Note (1)	[was 016494]

CV2 Planned vs Actual Test Flow:



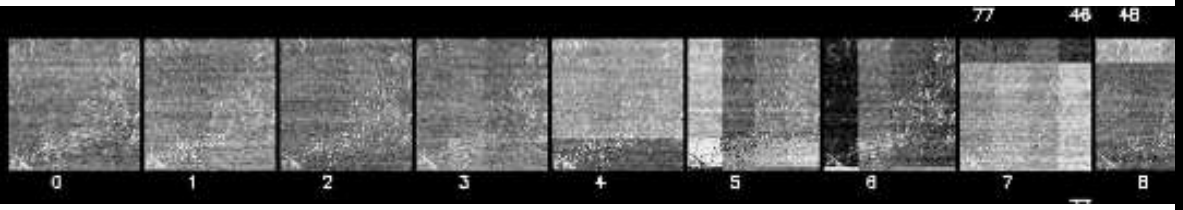
CV2 Planned

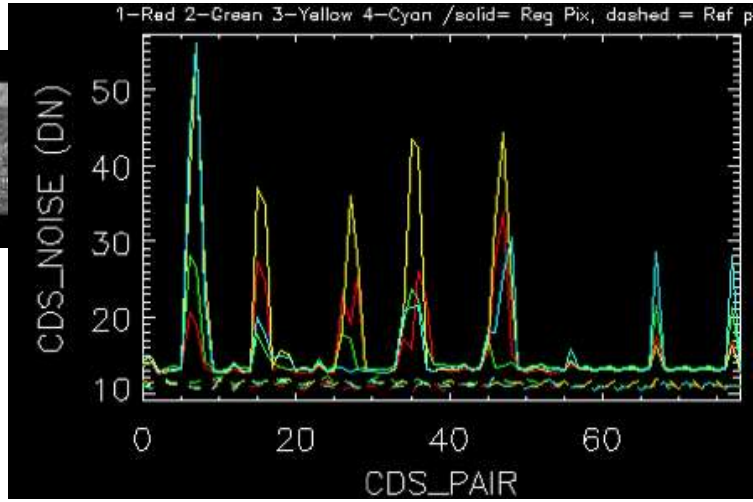


CV2 Actual

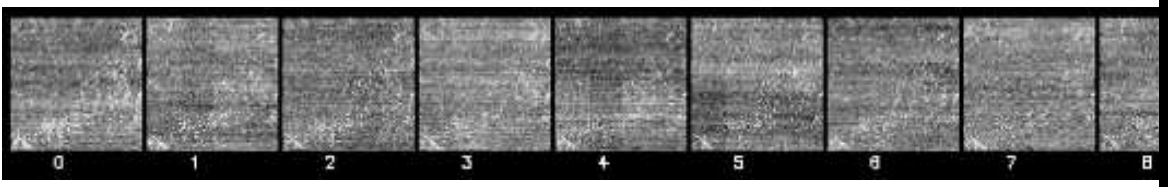
Parallel observations – Data Scramble

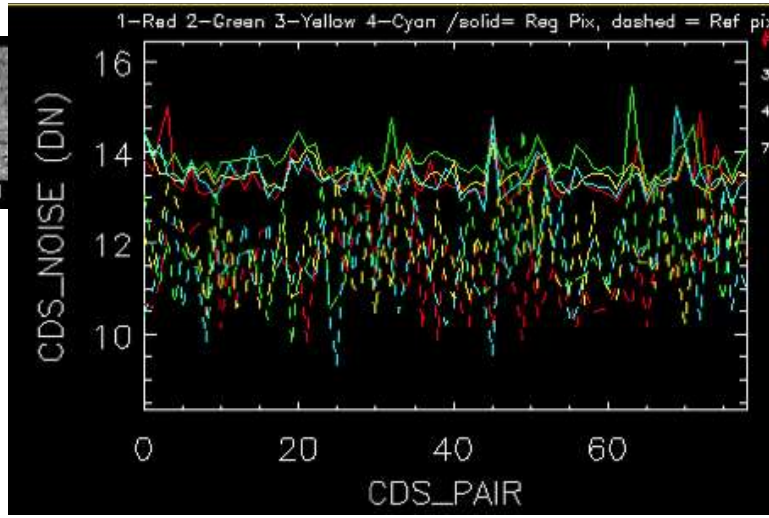
- SCRAMBLED INTEGRATION



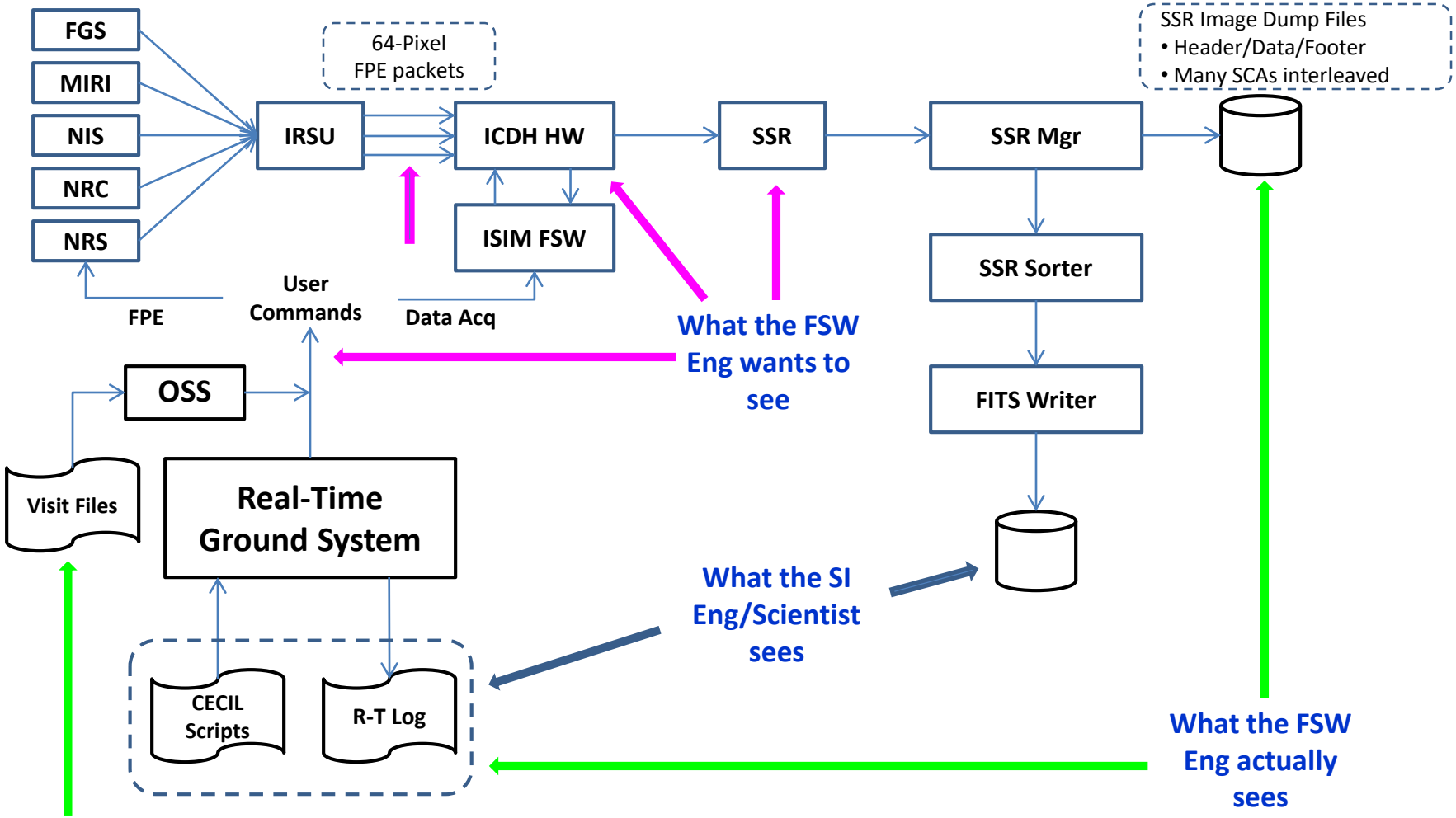


- REGULAR INTEGRATION





Data Scrambling Context



CV2 Test Summary

- CV2 started on June 16, 2014 with Abbreviated Functional Continuity Test
- Facility issues (power and chilled water) and the SuROM anomaly (during CPT Part 1 Test) early in the test flow triggered a re-arrangement of the CV2 timeline
  - The higher priority tests from each of the SI Performance Characterization Test Procedures were moved earlier in the flow, before the CPT Part 2 Test.
  - The lower priority tests (science calibrations) were left to the end of the cold operating temperature plateau.
- All tests at the cold operating temperature were completed by 9/14. The transition to the hot operating temperature started on 9/15 and the Co-Boresight Test was performed.

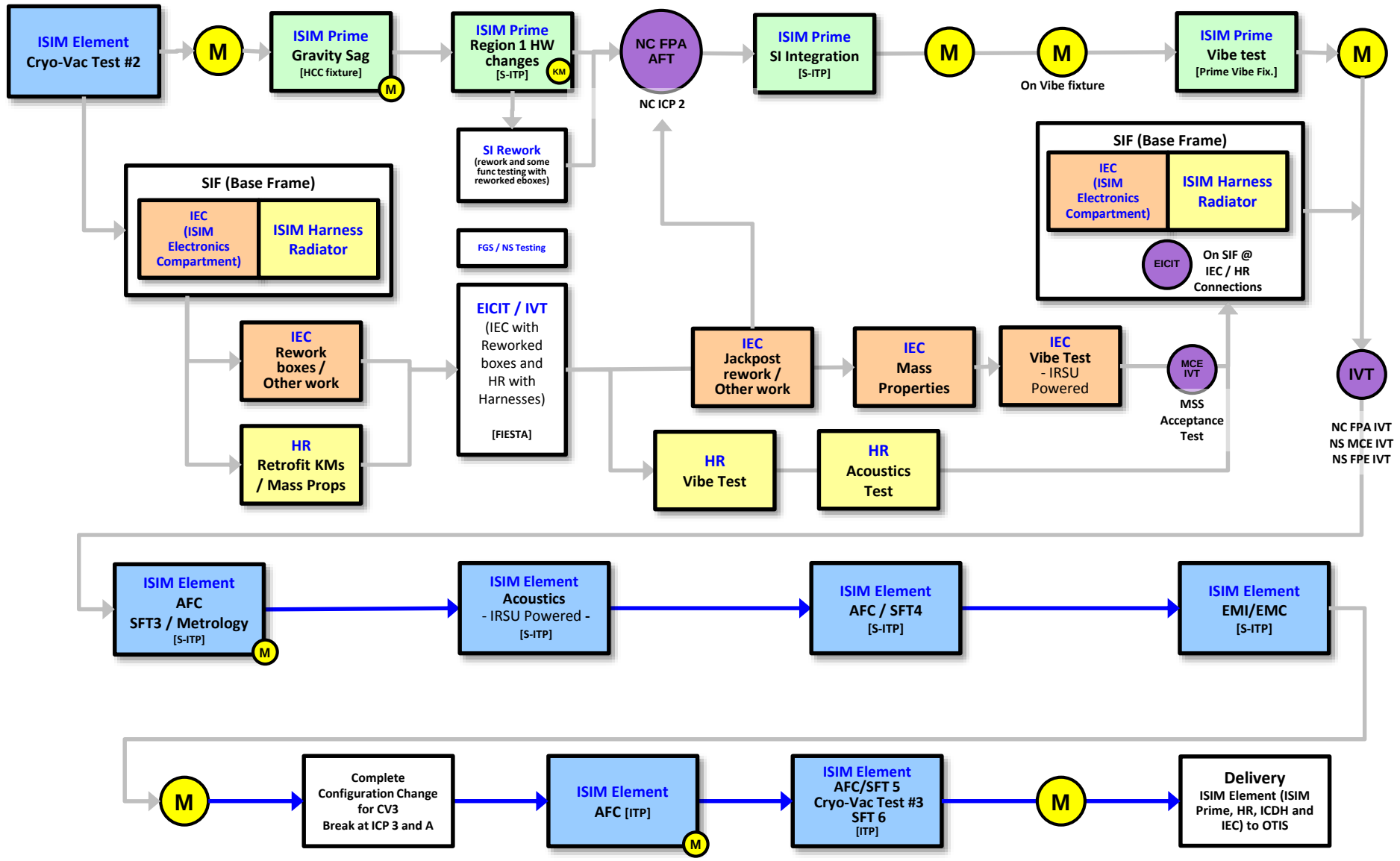
Warm-Up Decision Point Success Criteria

Collected all needed data

- Best focus with analysis uncertainty estimates for all SI's
- First cut at (OSIM + SI) WFE and first cut back-out of SI-only WFE for the MIMF field points, plus ISIM_1 (NIRSpec fixed slit)
- Uncertainties: variation in WFE determined by each analyst (all SI's) and comparison to the variation at the end of CV1RR for MIRI, FGS and NIRISS
- First cut at (OSIM + SI) WFE and first cut back-out of SI-only WFE over the full fields of NIRCam and MIRI
  - Uncertainties: variation in WFE determined by each analyst (for NIRCam) and comparison to the variation at the end of CV1RR for MIRI
- CV-environment pupil shear for each SI and comparison to results from CV1RR where available
  - First cut at on-orbit pupil shear for each SI
- CV-environment FOV/boresight for each SI and comparison to results from CV1RR where available
  - First cut at on-orbit FOV/boresight for each SI (*PFR on NIRCam LW B*)
- Check of Co-boresight data quality
  - (We will only have time to confirm that the data quantity and quality is sufficient to perform the analysis relevant to co-boresight requirements)
- ISIM Balance #3 (TB 1H10) is with SI's ON, trim heaters ON
  - Fraction of heat at SI that gets to radiator end;
  - Strap end-to-end thermal conductance
- ISIM Balance #4 (TB 1H00) is with SI's ON, trim heaters OFF, to determine:
  - Fraction of heat at SI that gets to radiator end;
  - Strap end-to-end thermal conductance
- PFR Investigations complete
- Data quality and completeness and is sufficient for any "Problems" that required additional data
- Summary of departure from expectation

All required testing was accomplished in CV2 before warm-up

ISIM Element Environmental Testing



ISIM Prime Gravity Sag Test

Objective of Test

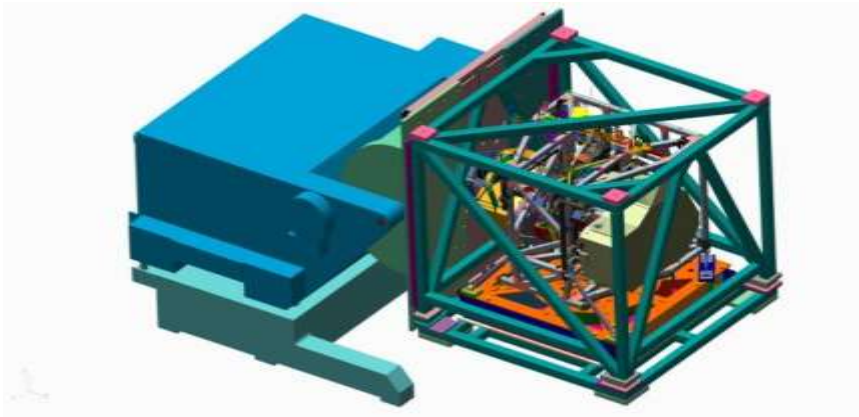
- Measure distortions (information) of the ISIM Structure and exterior targets on the SIs with ISIM Prime in a +V1 and –V1 orientation.
- The measurements taken during the test are used to validate the analytical gravity sag modeling (because we can't measure anything internal during the gravity test)
- Use the analytical modeling to do on-orbit predictions based on ground testing

Level of Test

- n/a

Test Facility / View of Test

- NASA GSFC, Building 29 SSDIF



Known Deviations from Flight Configuration

- Flight MIRI Shield will not be present (so that MIRI metrology targets can be seen)
- GSE HSA may still be integrated to ISIM Prime as opposed to the flight HSA
- GSE metrology targets are installed for this operation
- MIRI Cooler Line supports are not flight
- MIRI Cooler Line will be replaced with one that comes with the flight HSA
- RTG saddle connection (cable ties vs machined piece)
- Non-bonded OTIS accel mounts not on
- Flight ICP-A Micrometeoroid shields will not be present

Plans, Procedures, and WOAs

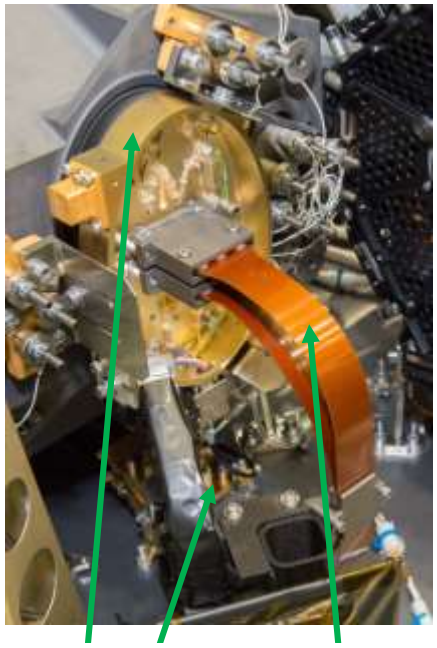
- ISIM Prime Gravity Release Test Plan, JWST-PLAN-021021
- ISIM Prime Metrology Procedure, JWST-PROC-018065

ISIM Gravity Sag Test

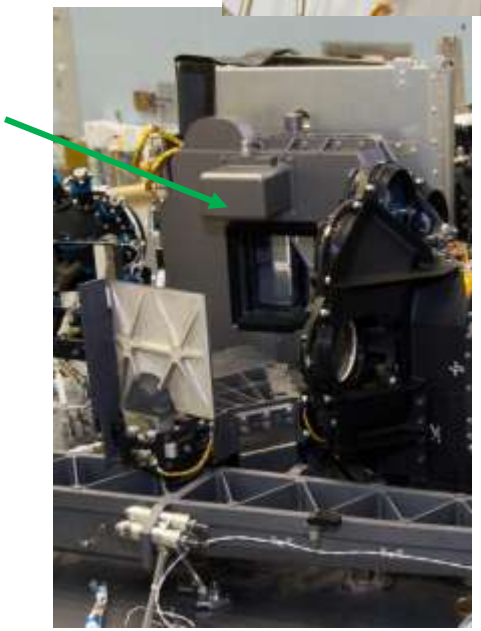
NIRSpec Major HW Changes after CV#2

- Detector Subsystem changeout
- MSA FM2 + MCE repair
- OA cover replacement

NIRSpec with closed OA cover
January 28th 2015



FPA, ASICs and harness



MSA FM2

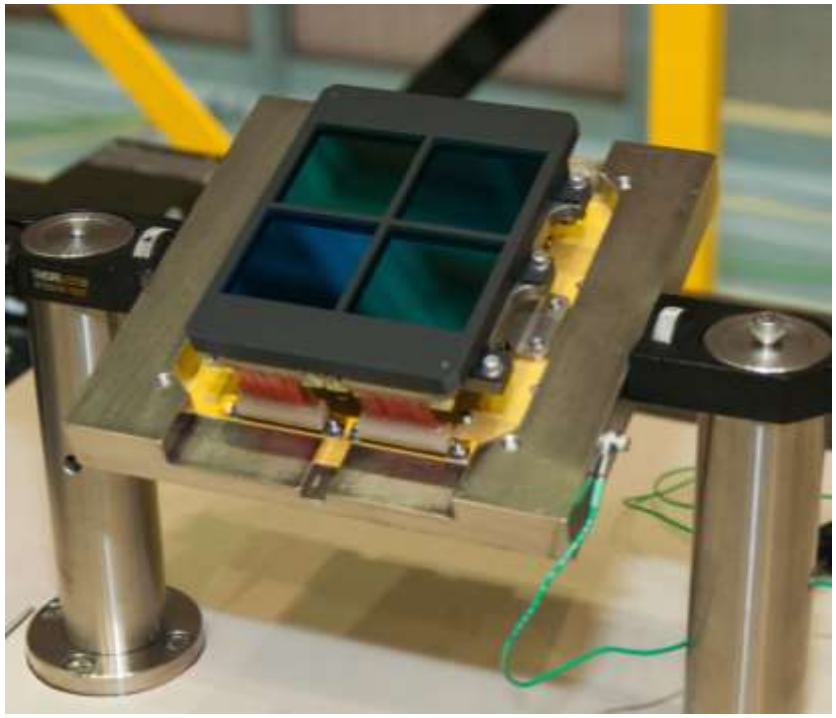
OA cover

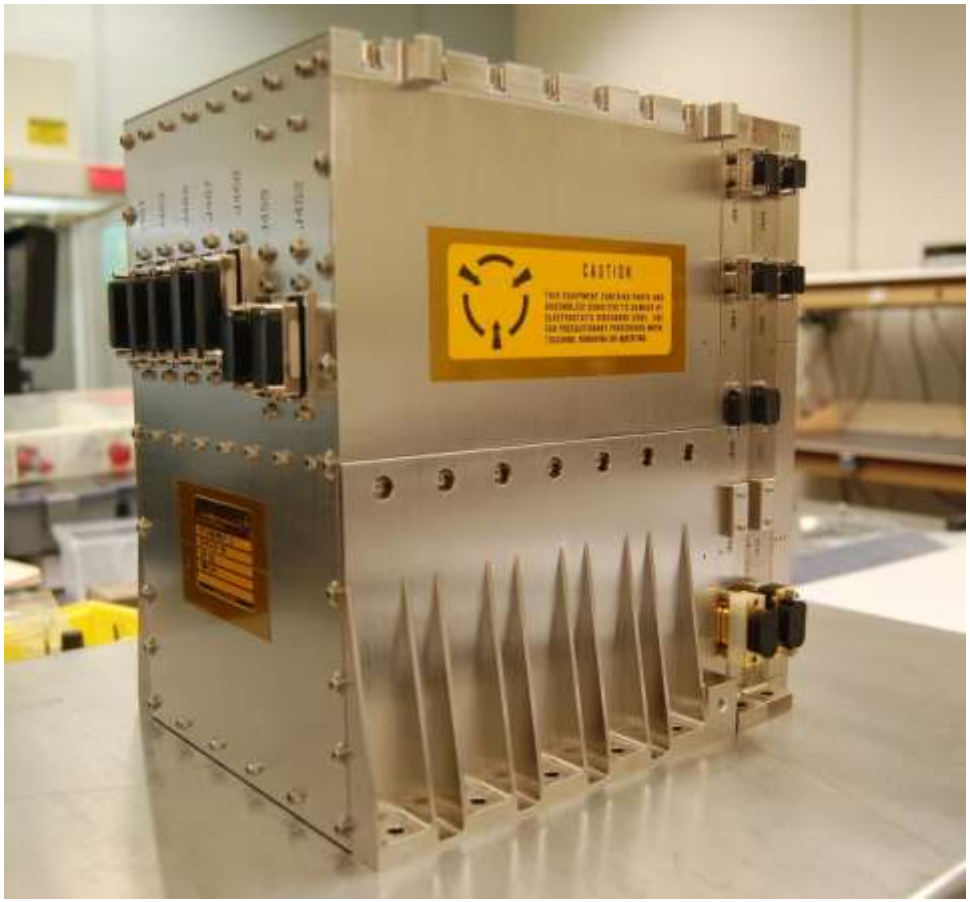
Successful FGS “Halftime Show” at GSFC

- Detector Subsystem change out
- Motor Replacement
- Grism replacement
- Harness rework
- FPGA Change

NIRCam Post CV2 Changes

- Three changed SCAs due to vibe issues
- All FPA masks were replaced
- FPE boxes each had a board replaced due to a capacitor failure that could propagate and take down an entire FPE box





MIRI Timeline of Hardware Changes

2011 2012 2013 2014 PER 2015 2016 PSR 2017

Integration and Testing

- FPS delivered to OA
- OBA delivered to ISIM
- CV1RR
- CV2
- ISIM Env. Testing
- CV3

MIRI Optical Module

1. Replace MIRI OM Top MLI
2. Remove OM strain gauge connectors
3. PR JWST-WOA-006409-005
   - Restrain accelerometer harness

Legend

- Planned Work (presented at PER)
- New Work (response to PR/PFR)

MIRI Focal Plane Harnesses

4. PFR-135
   - Loss of MIRI Imager exposures
     - ➢ Replace Imager flight harness with Imager spare
5. PFR-163
   - Unusable MIRI Imager exposures
     - ➢ Replace Imager flight harness with LW spare

MIRI Focal Plane Electronics

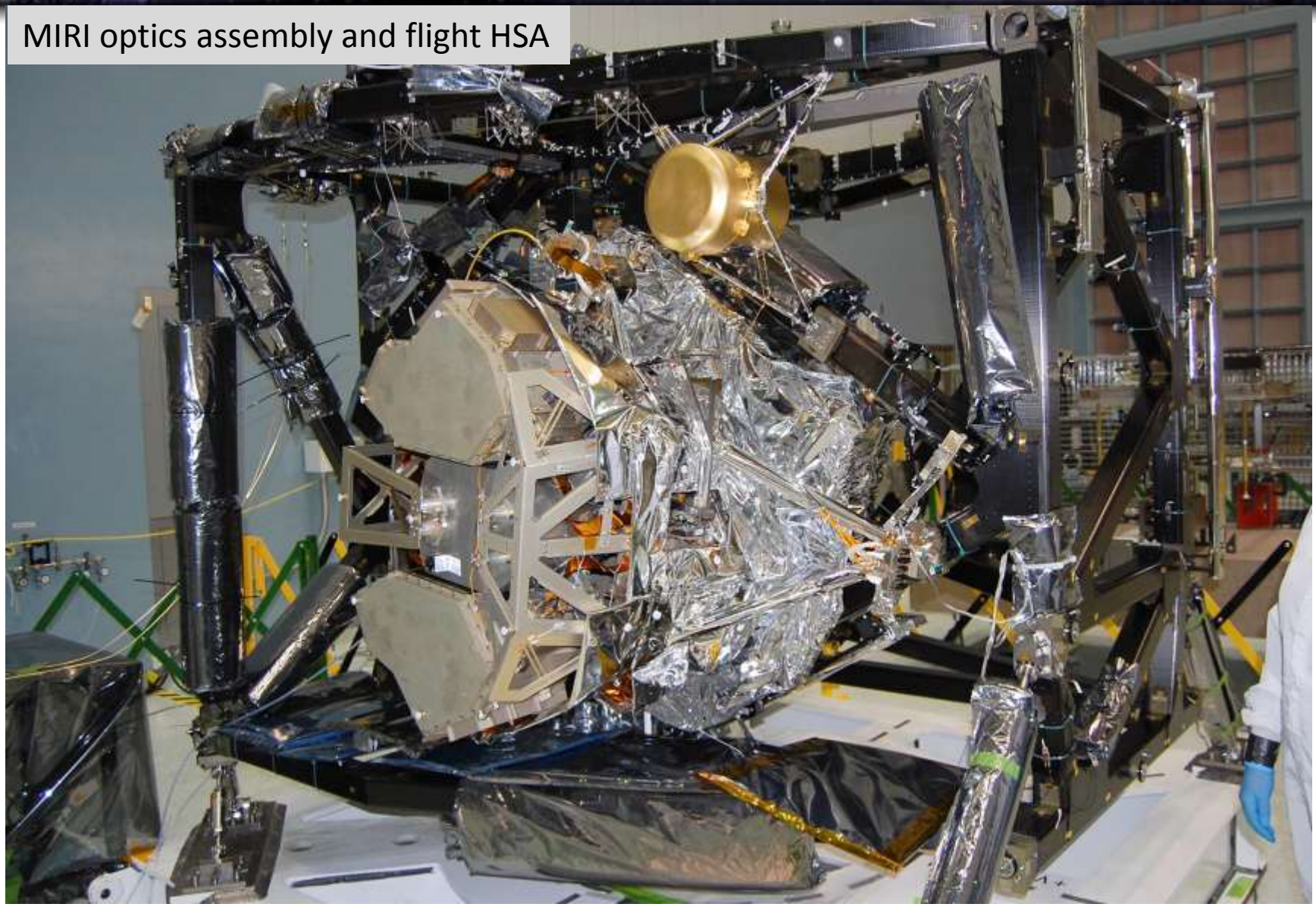
6. Known Issues at FPS delivery to OA
   - Corrupted detector frames
   - Temp sensor idiosyncrasies
6. PFR-124
   - FPE ground path anomaly
6. FPE Retrofit
7. PFR-164
   - Command Failure
   - Temp Sensor Anomaly
   - FPM Anneal Errors
7. **Open Work**
   - FPE Repair recommended by PFR-164 ARB

ISIM Heat strap issue is the ISIM critical path

- NIRCam heat strap performance during CV-2 was in spec but out of family WRT the other instruments
  - This anomaly prompted a check of the strap joint fastener torques
  - Lose bolts were found
  - Subsequent examination revealed lose bolts throughout the heat strap system
    - Since lose fasteners were found everywhere, they may not explain the anomalous NIRCam strap performance
- Several separate issues are raised by the above observations:
  1. Loss of mechanical preload due to design flaws / failed components
  2. Loss of mechanical preload due to long term material creep
  3. Loss of thermal conductivity due to workmanship issues at strap to end-block interface

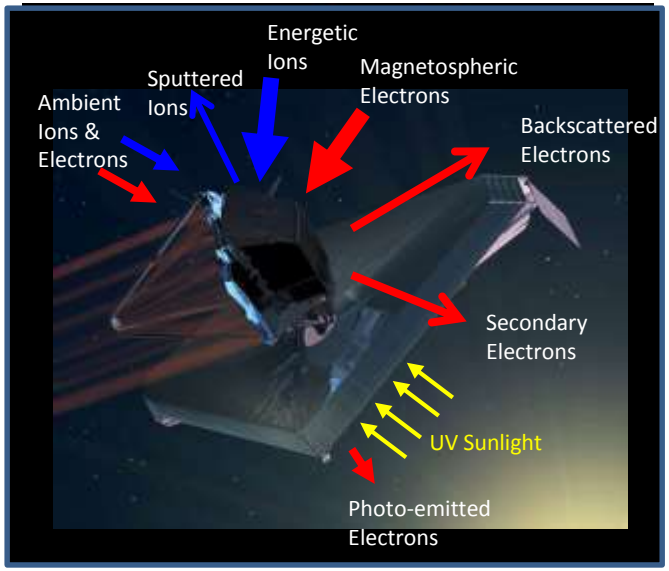
Heat strap work paces installation of the MIRI thermal shield

MIRI optics assembly and flight HSA



Space Charging

- L2 Environment
  - Defined in JWST Environmental Specification, EV1-0074
    - Initial definition early in JWST program indicated relatively benign environment
    - Newer model, L2 - Charged Particle Environment (L2-CPE), Model Released in 2004 shows significantly higher electron fluxes at high energies than the previous LRAD model
- Concern
  - Lots of charged particles at L2
  - Exposed dielectrics can collect particles and build up large potentials (charging a capacitor)
  - When potential reaches the dielectric breakdown voltage of the material, potentially damaging discharges can occur
  - ~1/3 of all spacecraft failures and anomalies due to the space environment result from plasma-induced charging
  - Primary concern are the Region 2-1 harnesses



Solar panel damaged by localized charging event

Space Charging and Micrometeoroid Risk

Space Charging

- Insure all harnesses can withstand the induced current from such a discharge
  - Added black Kapton XC tape to Microshutter and MIRI FPHs
  - All harnesses have black Kapton Jackets
    - Finite resistance between jacket and shell offers bleed path for surface charge

Micrometeoroid Protection

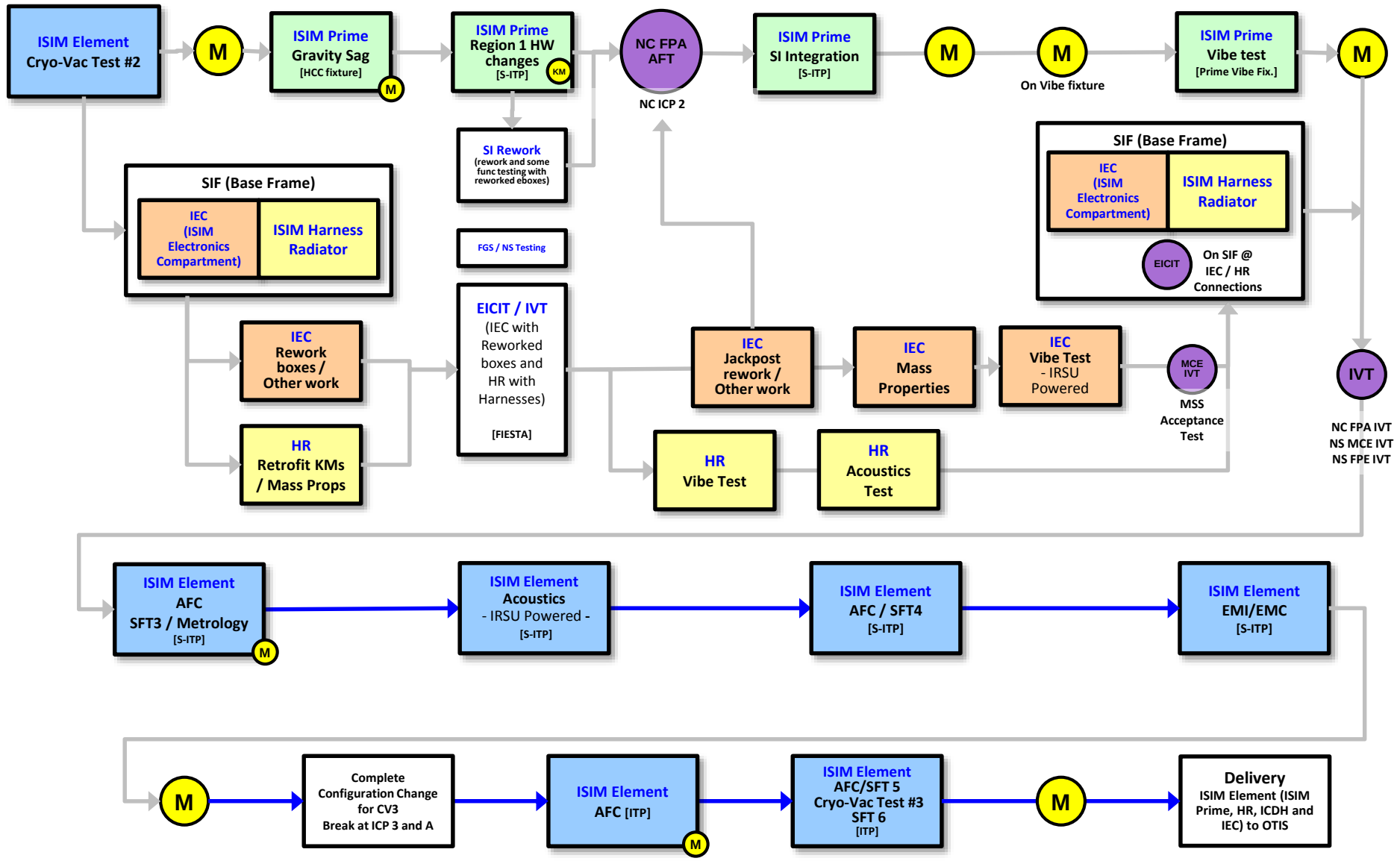
- MSS Shielding Added:
  - MIRI FPE harness between harness radiator and diagonal BSF beam
  - MIRI FPE harness between diagonal BSF beam and ICP-A
  - MIRI FPE harness inboard from ICP-A, i.e., interior to the ISIM enclosure (also a new request from me)
  - NIRSpec FPE harness between the harness radiator and BSF diagonal beam or inboard from ICP-A
  - Harnesses also shielded by blanketing between ICP-2 and the HR
- **All harnesses meet the POS requirements of ISIM-1557.**
  - JWST-RPT-029291, “ISIM Harness Meteoroid-Environment Probability of Success”

ISIM Prime Successfully reintegrated after changes

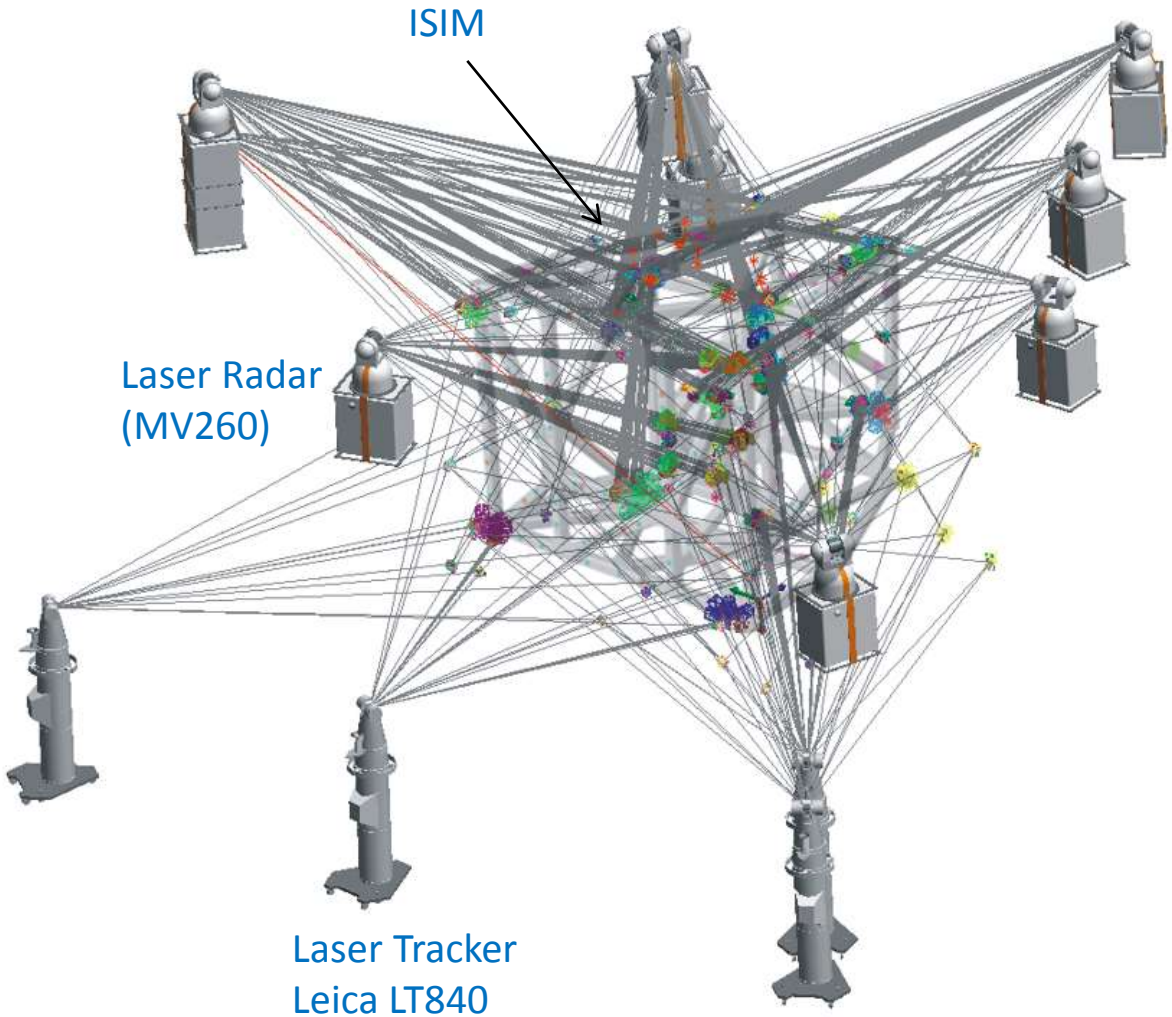
ISIM Prime: April 2015

ISIM Integration and NIRSpec Team

ISIM Element Environmental Testing

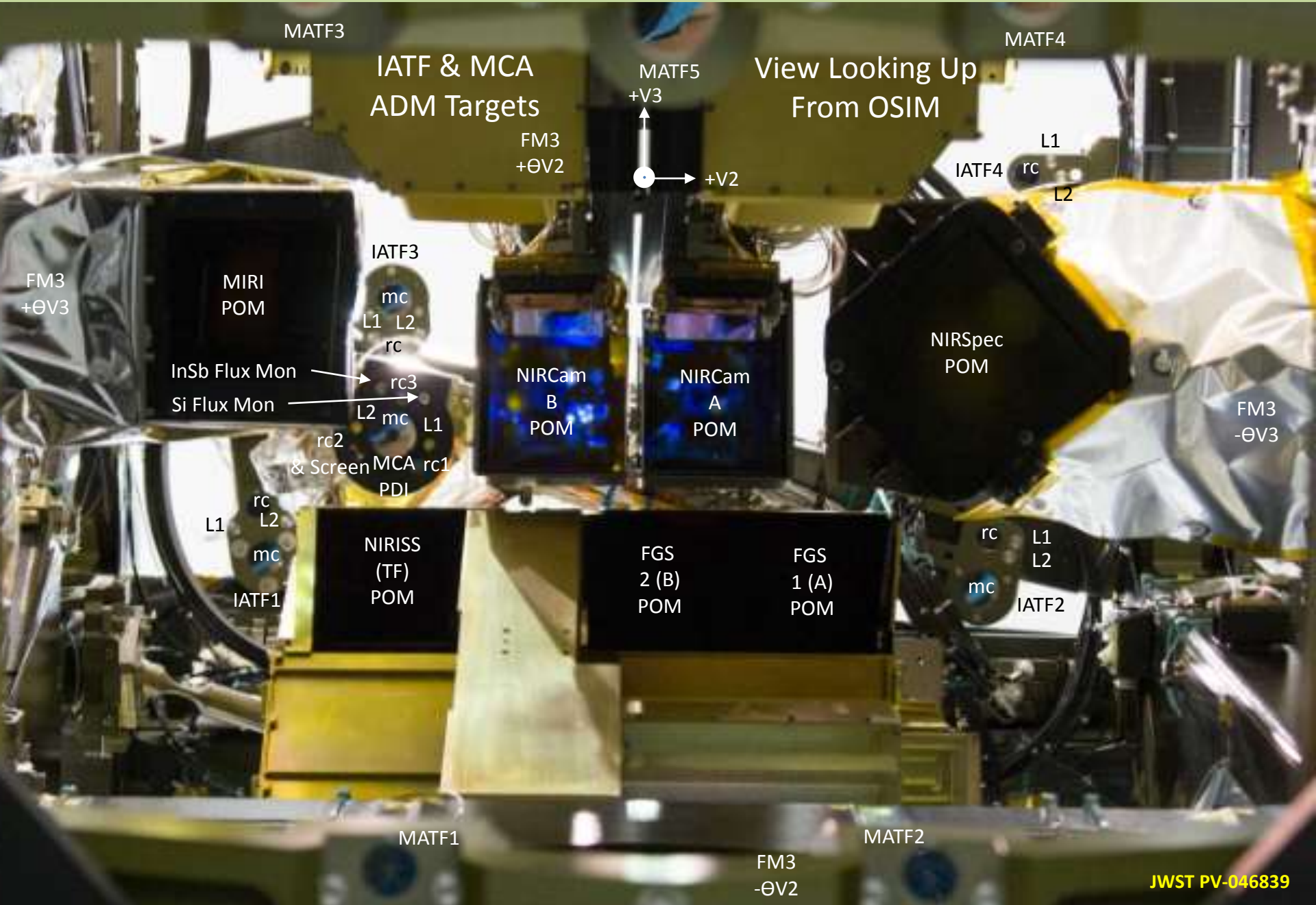


Goddard ISIM Metrology Survey



- Stations Used:
  - 9 Laser Radar (LR) stations
  - 4 Laser Tracker (LT) stations
- Duration of all measurements ~10 days
- ~23,000 LR points measured (enhanced metrology mode)
- ~200 LT points (spatial trigger mode)

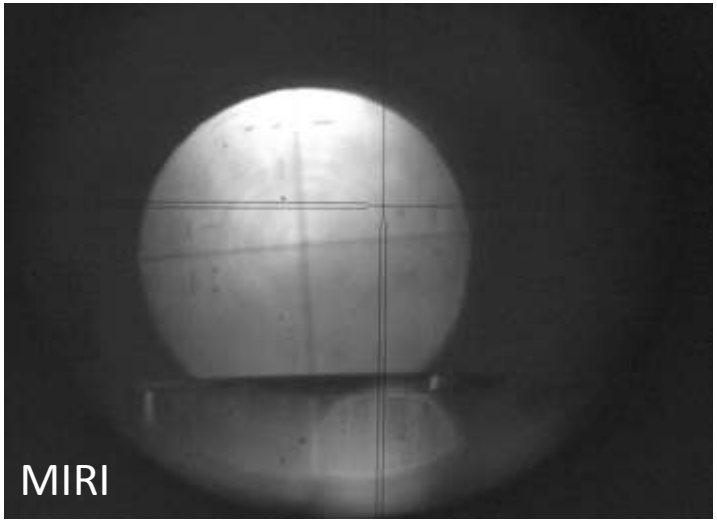
CV2 ISIM, MATF, IATF Test Configuration

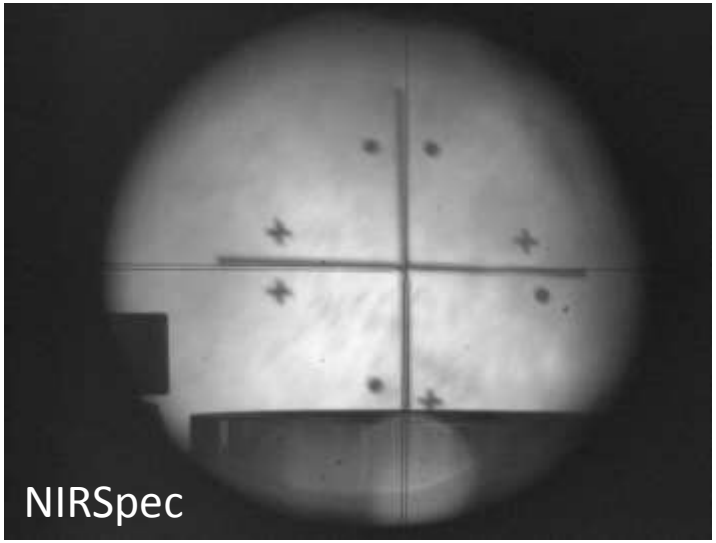


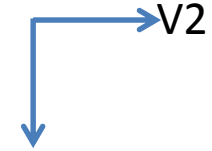
JWST PV-046839

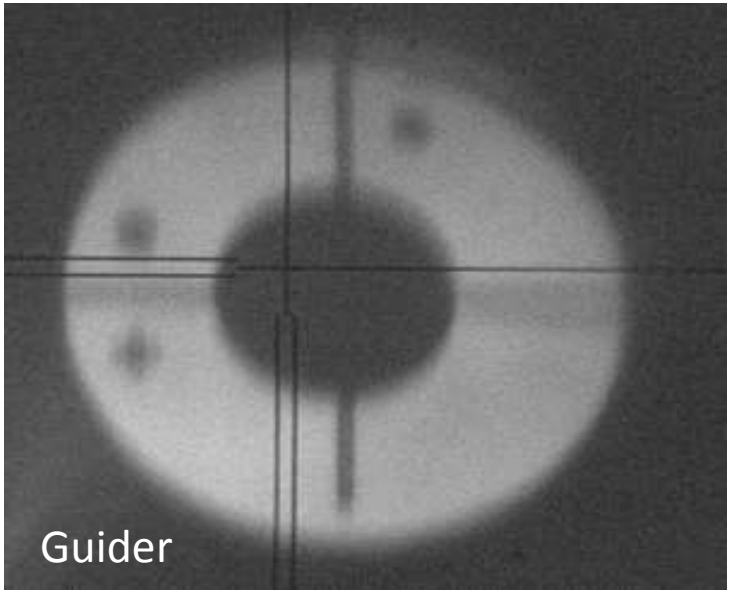
Science Instrument pupil alignment reference (PAR)

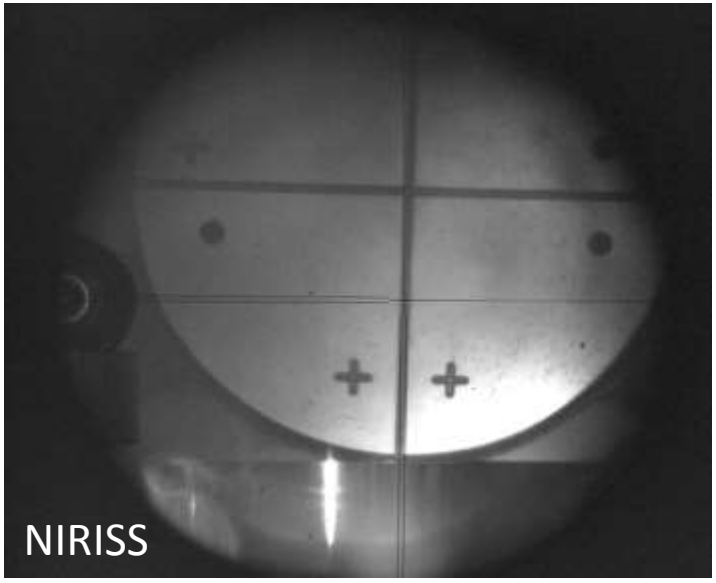
PARs are used at ambient to trend pupil changes, not calculate absolute pupil alignment





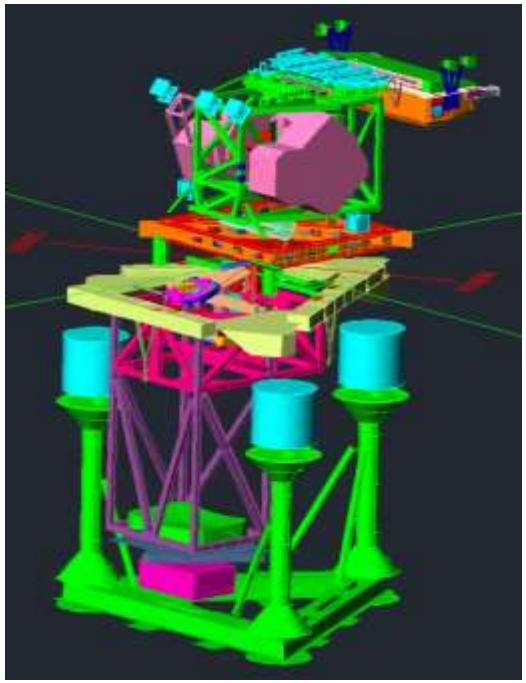




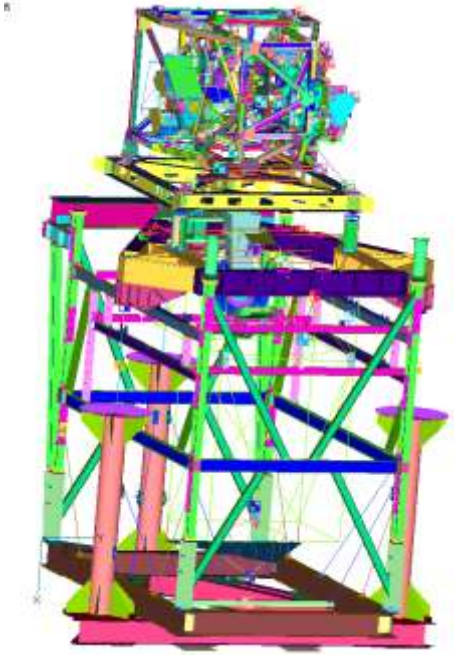


STOP Models

Thermal Model
Model Format : Thermal Desktop



Structural Model
Model Format: NASTRAN



Optical Models
Model Format: Code V, LOM*

NIRCam Short Wavelength Channel

MIRI Imager Mode

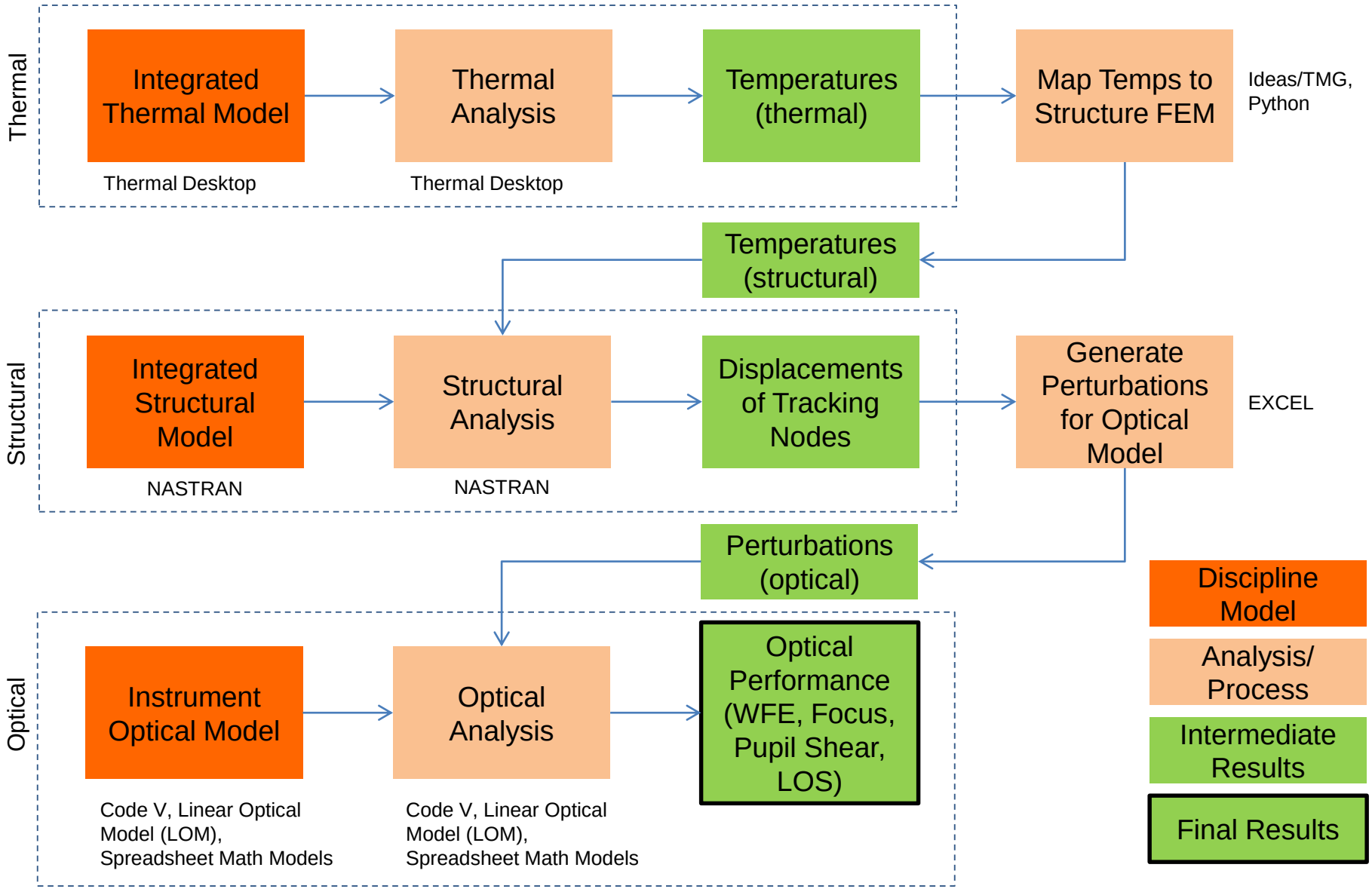
NIRSpec Camera Imaging Mode

Fine Guider Channel A

OSIM

*LOM – Linear Optical Model developed in-house by GSFC optical analysis team.

STOP Analysis Process

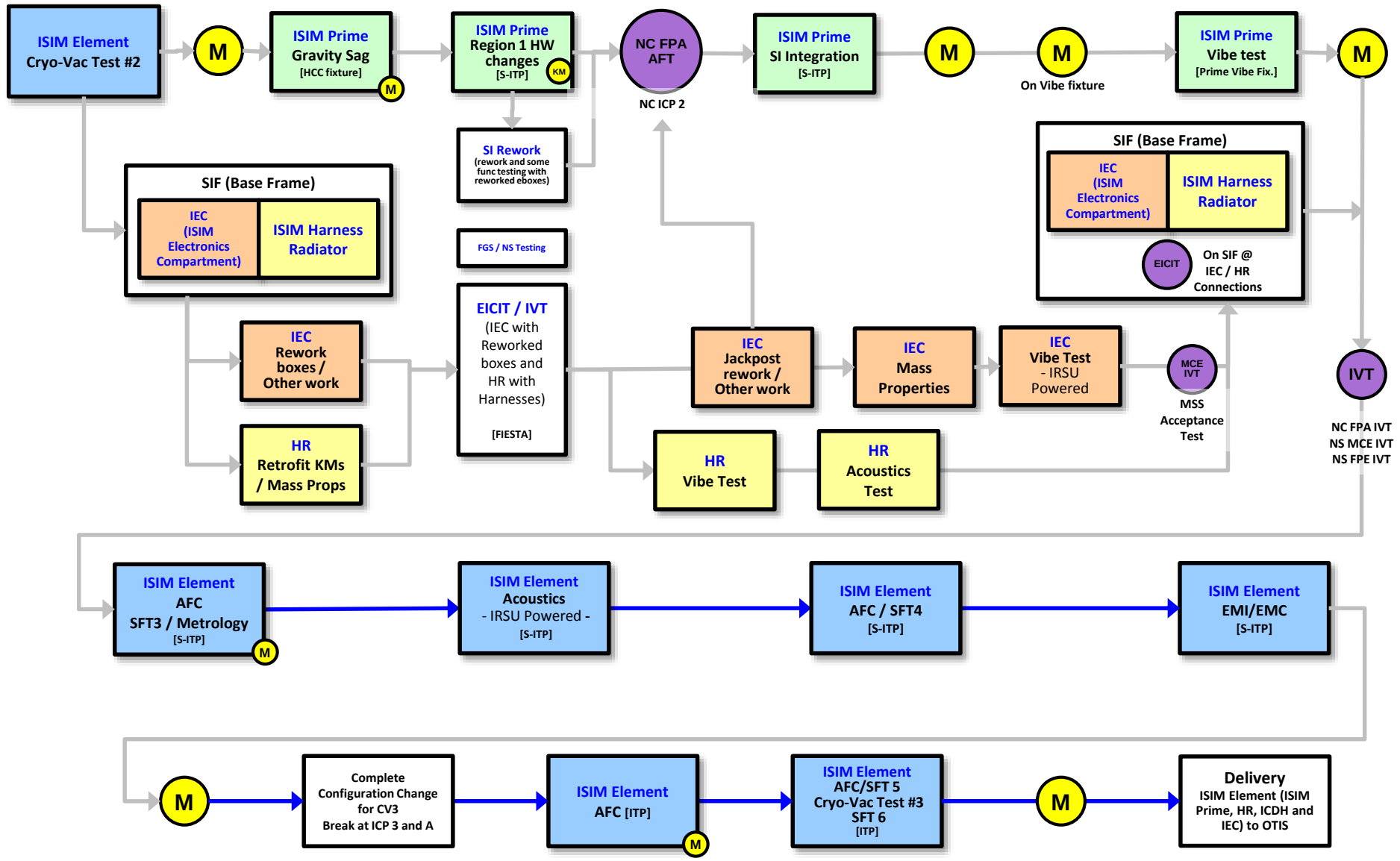


Load Cases and Analysis Objectives

Analysis Case			TD results wrt	Analysis Objectives				
				Test System Budget Assessment			Products for ISIM Alignment	Products for SI Optical Performance Predictions
Load Case		Analysis Case Description		Cooldown Alignment	Cryo Stability	CB Stability		
SES Cooldown	CV2 Cold	Cooldown from ambient to the CV2 Thermal Cold Balance.	U-GESHA/OSIM IF Centroid	X				
SES Thermal Stability	CV2 Hot - CV2 Cold	Thermal overdrive case for SES CB stability assessment.	Ref A			X		
	CV2 Hot [-2.0K MGSE, -0.1K OSIM, 0.0K ISIM] - CV2 Hot	Test system stability cases for SES stability assessment. Bounding temperature perturbations based on thermal stability requirments are applied to OSIM and ISIM MGSE (four cases).	Ref A / Ref B		X	X		
	CV2 Hot [-2.0K MGSE, +0.1K OSIM, 0.0K ISIM] - CV2 Hot		Ref A / Ref B		X	X		
	CV2 Hot [+2.0K MGSE, -0.1K OSIM, 0.0K ISIM] - CV2 Hot		Ref A / Ref B		X	X		
	CV2 Hot [+2.0K MGSE, +0.1K OSIM, 0.0K ISIM] - CV2 Hot		Ref A / Ref B		X	X		
Thermal Variation	OnOrbit(Hot) - CV2(Cold)	Difference between On-Orbit(Hot) and CV2(Cold).	Ref A / Ref BCG					X
Gravity Sag	Gravity in +V1 (CV2 config in SES)	Gravity distortion (1 G in +V1) for CV Baseline (CV2/3) configuration in SES.	Ref A / Ref BCG				X	X
	Gravity in +V1 (CV2 config in SSDIF)	Gravity distortion (1 G in +V1) for CV Baseline (CV2/3) configuration on ITS.	Ref A / Ref BCG				X	
	Gravity in +V1 (ITP I/F Deformation Effect)	Difference in gravity sag distortion results between CV2 and On-orbit configurations.	Ref A / Ref BCG					X
KM Adjustment	KM Adjustability (CV2 config)	Rigid body change due to KM adjustments.*	Ref A / Ref BCG	X			X	X
On Orbit Operational Stability	On-Orbit **Short** Term Stability (10,000 sec)	Thermal distortion change from a predicted On-orbit thermal drift during a 10,000 sec period.	Ref A					X
	On-Orbit **Mid** Term Stability (24 hrs)	Thermal distortion change from a predicted On-orbit thermal drift during a 24 hour period.	Ref A					X
	On-Orbit **Long** Term Stability (14 days)	Thermal distortion change from a predicted On-orbit thermal drift during a 14 day period.	Ref A					X
	On-Orbit **Short** Term Stability (0.10 K)	Thermal distortion change due to a 0.10 K drift from On-orbit (Hot).	Ref A					X
	On-Orbit **Mid** Term Stability (0.25 K)	Thermal distortion change due to a 0.25 K drift from On-orbit (Hot).	Ref A					X
	On-Orbit **Long** Term Stability (0.5 K)	Thermal distortion change due to a 0.5 K drift from On-orbit (Hot).	Ref A					X

Note: Table lists primary load cases ran. Additional load cases were ran for studies and benchmarking.

ISIM Element Environmental Testing



IEC Mass Properties

Objective of Test

- Provide a measured mass of the IEC
- Provide information used to calculate the final delivered mass and CG of the IEC

Level of Test

- n/a

Test Facility / View of Test

- NASA GSFC, Building 29, SSDIF

Known Deviations from Flight Configuration

- FLIGHT DITCE box is not present for this measurement.
- The flight lock NEA are not present for this test.
- The flight on-orbit flexures are not present for this test
- Flight baffles may not be present depending on timing of measurement (if tied to vibe test handling, the will be present)
- Note that the Towel bar harness supports should be present for this test but have not been delivered yet

Plans, Procedures, and WOAs

- ISIM IEC Mass Properties Test Plan

IEC Vibration Test

Objective of Test

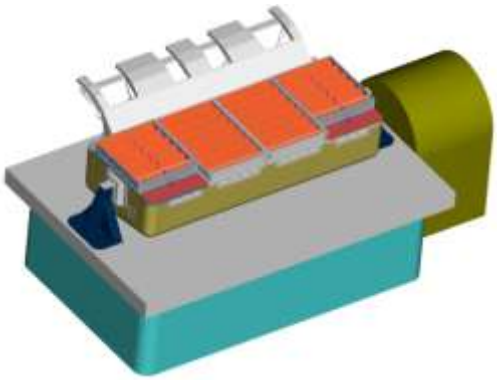
- Verify minimum workmanship standards have been met by subjecting the IEC to the low frequency structural dynamic spectrum of the launch environment
- Provide data for FEM verification

Level of Test

- Protoflight (5-100 Hz)

Test Facility / View of Test

- NASA GSFC, Building 7, Rm 028



Known Deviations from Flight Configuration

- FLIGHT DITCE box is not present for this test
  - Mass sim is used
- The flight lock NEA are not present for this test
- The flight on-orbit flexures are not present for this test
- No flight harnesses are connected to EXTERIOR of IEC (HR end or OTE end)
  - We may need to use a harness sim on ICP-2 end to load towel bar and connector (harness with no pins)

Plans, Procedures, and WOAs

- ISIM Element Level IEC Vibe Test Plan
- Facility test procedure based on plan

Harness Radiator Mass Properties

Objective of Test

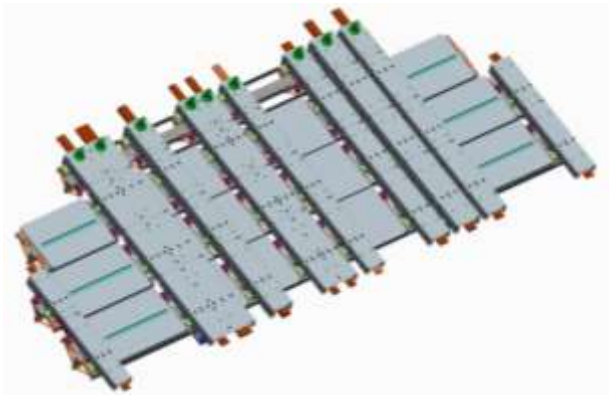
- Provide a measured mass of the IEC
- Provide information used to calculate the final delivered mass and CG of the IEC

Level of Test

- n/a

Test Facility / View of Test

- NASA GSFC, B29 SSDIF



Known Deviations from Flight Configuration

- The HR can NOT be picked up and weighed as an assembly because it is required to be assembled to a flight or GSE frame – otherwise, the HR doesn't exist as an assembly.
    - At the ISIM level, the GSE frame is so heavy (made of invar for CTE reasons) that it swamps the mass of the HR and would make a measurement unreliable.
- Measurements
    - During the HR kinematic mount retrofit – set for post CV2 – the HR team will measure as many individual components or subassemblies as possible and we will compare that to the CAD estimates/predictions.
    - We will use that info to make a CAD prediction for the full HR mass, CG, and MOI and we will use a monte carlo analysis using the measurement tolerances to put a bounding box on the mass and CG.

Plans, Procedures, and WOAs

- ISIM Harness Radiator KM Retrofit WOA

Harness Radiator Vibe Test

Objective of Test

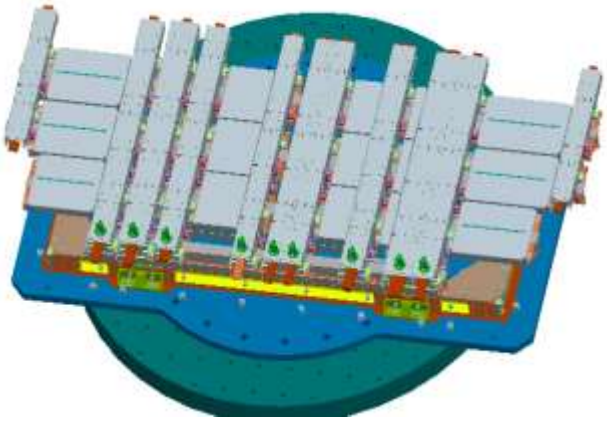
- Strength test
- Verify minimum workmanship standards have been met by subjecting the HR to the low frequency structural dynamic spectrum of the launch environment
- Provide data for FEM verification

Level of Test

- Protoflight (5-100 Hz)

Test Facility / View of Test

- NASA GSFC, Building 7, Rm 028 (MB-C 220 #1 Shaker)



Known Deviations from Flight Configuration

- Flight harnesses are replaced by mass simulators
- Added the flight harnesses to this test configuration based on feedback at the PER.
    - Required unique GSE to deal with free connector ends.

Plans, Procedures, and WOAs

- ISIM Harness Radiator Vibe Test Plan
- Facility test procedure based on plan

Harness Radiator Acoustics Test

Objective of Test

- Verify the ability to survive the launch acoustic environment and to demonstrate acceptable workmanship

Level of Test

- Protoflight

Test Facility / View of Test

- NASA GSFC, Building 10

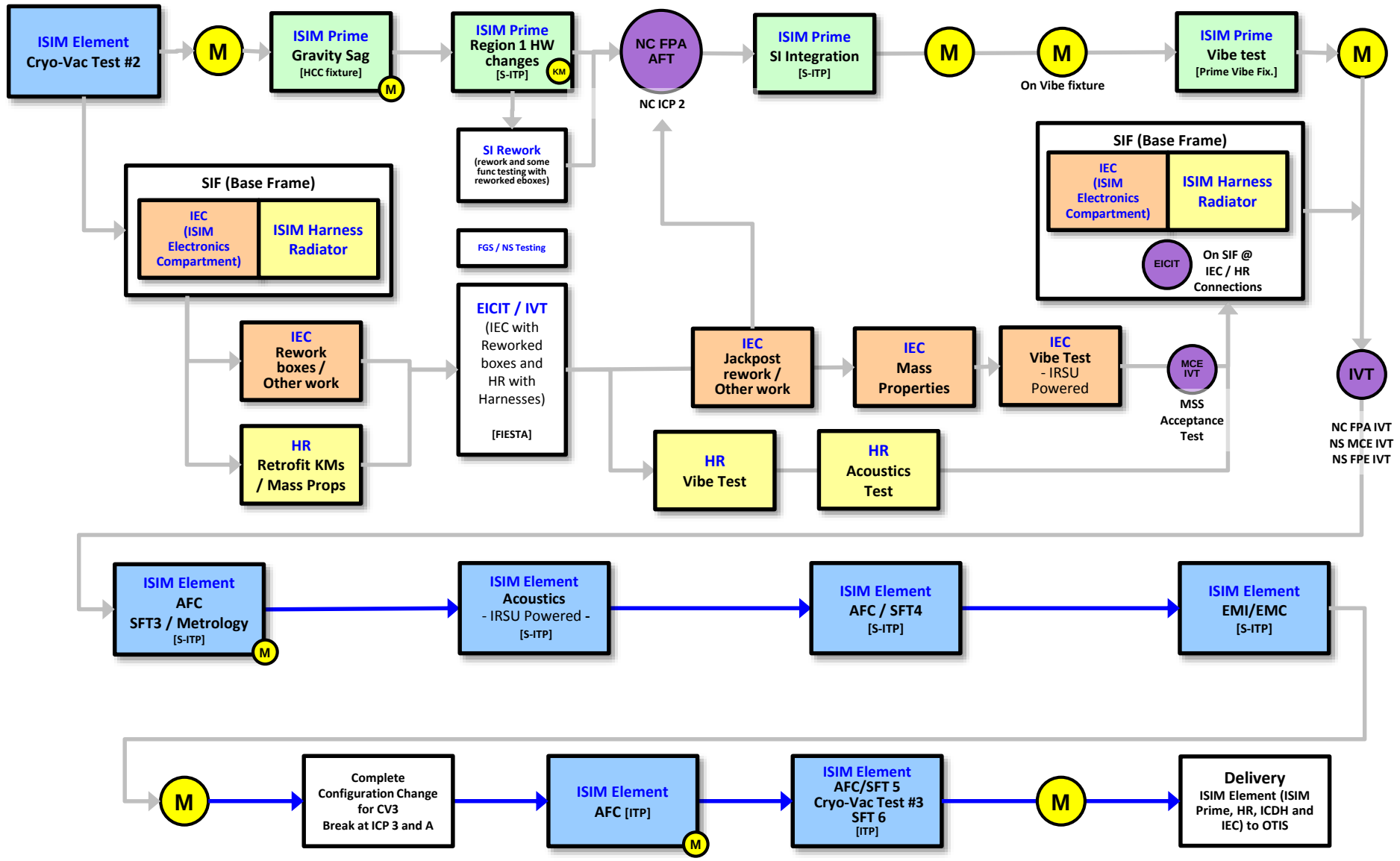
Known Deviations from Flight Configuration

- Flight harnesses are replaced by mass simulators
- Added the flight harnesses to this test configuration based on feedback at the PER.
    - Required unique GSE to deal with free connector ends.

Plans, Procedures, and WOAs

- ISIM Harness Radiator Acoustics Test Plan
- Facility test procedure based on plan

ISIM Element Environmental Testing



ISIM Prime Vibe Test

Objective of Test

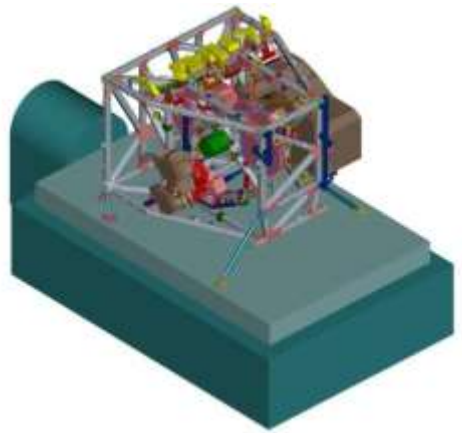
- Verify minimum workmanship standards have been met by subjecting the ISIM Prime to the low frequency structural dynamic spectrum of the launch environment
- Provide data for FEM verification

Level of Test

- Protoflight (5 - 100 Hz)

Test Facility / View of Test

- NASA GSFC, Building 7, 028 (MB-C 220 #1 Shaker)



Known Deviations from Flight Configuration

- Flight and GSE purge lines are tied off to ISIM Structure because there is no purge panel (part of STMS for CV testing and part of OTE for flight) available during this test
- 2x non-flight CFMPs (corner fitting metrology plates) will be in integrated at the time of this test
- Flight cooler line ends at cooler line location 4. A GSE line will be added from cooler line location 4a through 1 to properly load line supports 1, 2, 3, and 4a.
- ICP-A : Harnesses are attached on ISIM side but no harnesses are attached to the HR side
- MIRI and NS FPE harness supports (located between ICP-A and HR) will not have harnesses attached because these harnesses are not present unless ISIM Element (not just Prime) is assembled.
- Harnesses that go to T-ICP-1 (on OTE) will be tied off to FGS ICP-A since the OTE is not present.

Plans, Procedures, and WOAs

- ISIM Prime Vibe Test Plan, JWST-PLAN-020896
- Facility test procedure based on plan

ISIM Element Acoustics Test

Objective of Test

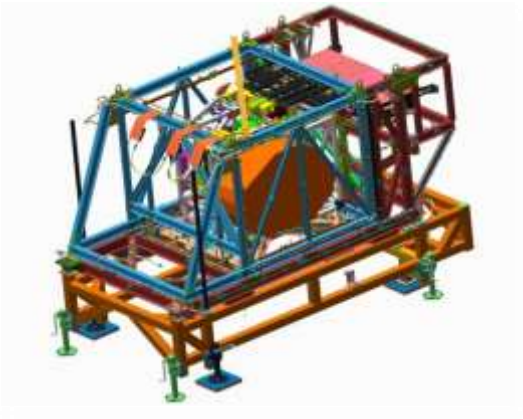
- Verify the ability to survive the launch acoustic environment and to demonstrate acceptable workmanship

Level of Test

- Protoflight (note Risk under review on next slide)

Test Facility / View of Test

- NASA GSFC, Building 10 Acoustics Chamber



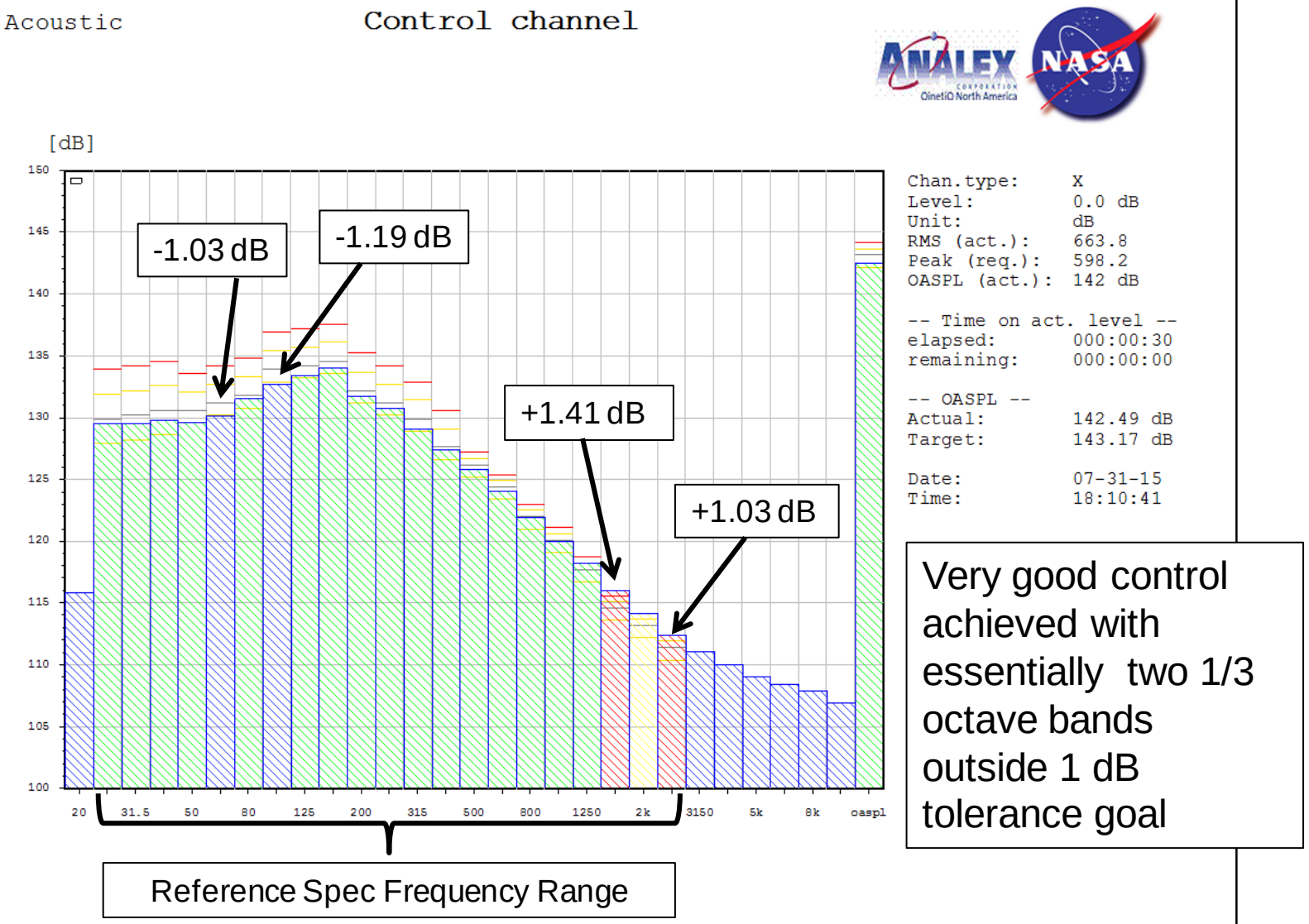
Known Deviations from Flight Configuration

- The ISIM Prime has 4x Non-Flight CFMPs (Corner Fitting Metrology Plates) are still integrated on various -V3 corner fittings
- The IEC DITCE box is not present for this test.
- The IEC V2 vents are not present for this test.
- The IEC flight baffles (4x) are not present for this test.
- The IEC inner and outer conformal shields are not present for this test.
- The IEC flight lock NEA are not present for this test.
- The IEC flight on-orbit flexures are not present for this test
- The ISIM Prime, HR and IEC are mounted to the SIF as opposed to the composite Backplane.
- The IEC mounts to the SIF (SES Integration Fixture) are GSE mounts, not flight launch locks
- A GSE purge panel is used to support purge lines (on STMS Frame)
- Flight cooler line on ISIM Prime ends at cooler line location 4. A GSE line will be added from cooler line location 4a through 1 to properly load line supports 1, 2, 3, and 4a.

Plans, Procedures, and WOAs

- ISIM Element Acoustics Test Plan, JWST-PLAN-021019

ISIM Element Acoustic Control vs. Spec



Very good control achieved with essentially two 1/3 octave bands outside 1 dB tolerance goal

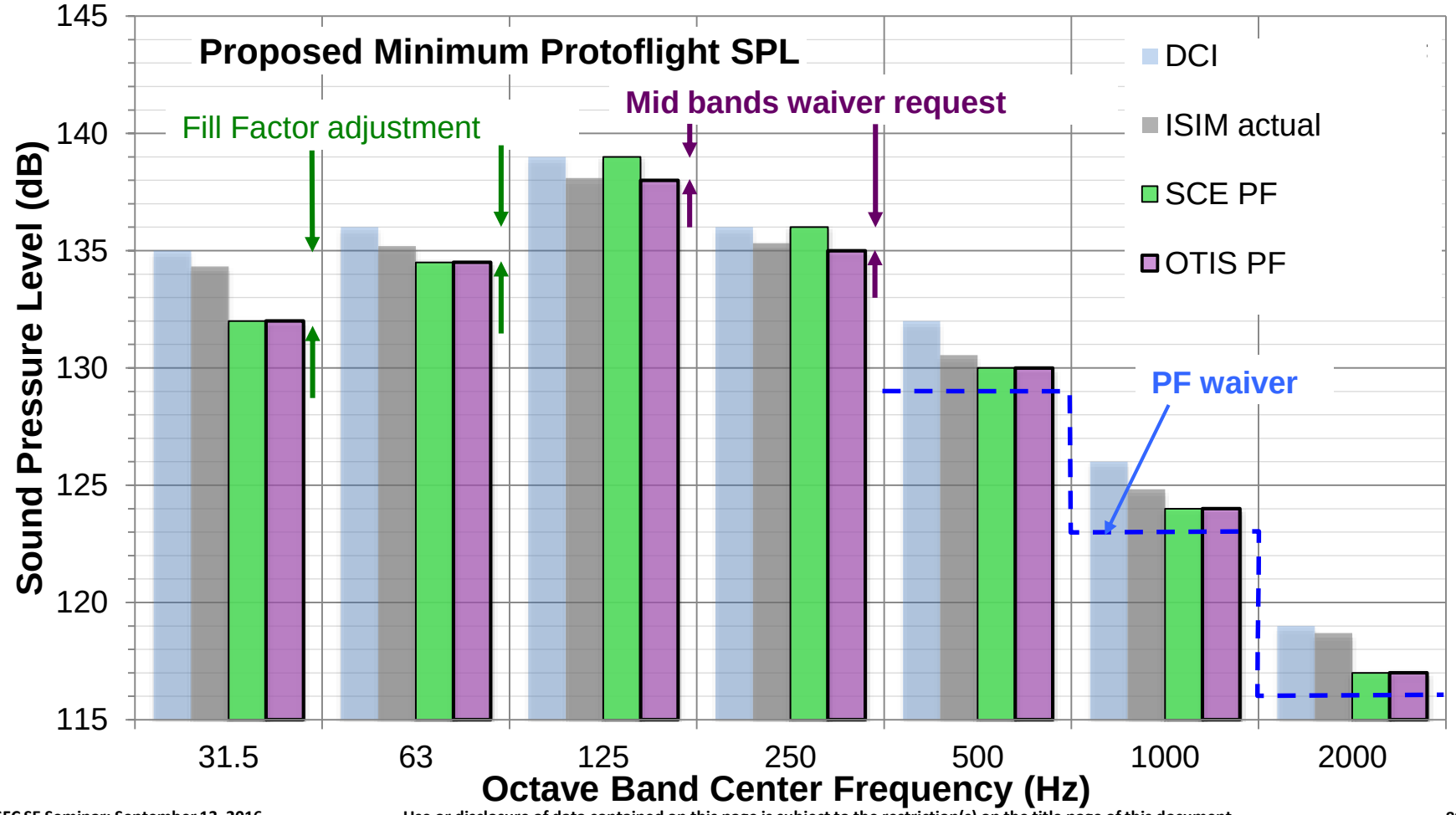
MSA Performance and Trending

NIRSpec Microshutter ➔ Black "dots" are failed-closed/plugged shutters.

Minor increase failed closed shutters observed after ISIM Protoflight level Acoustics

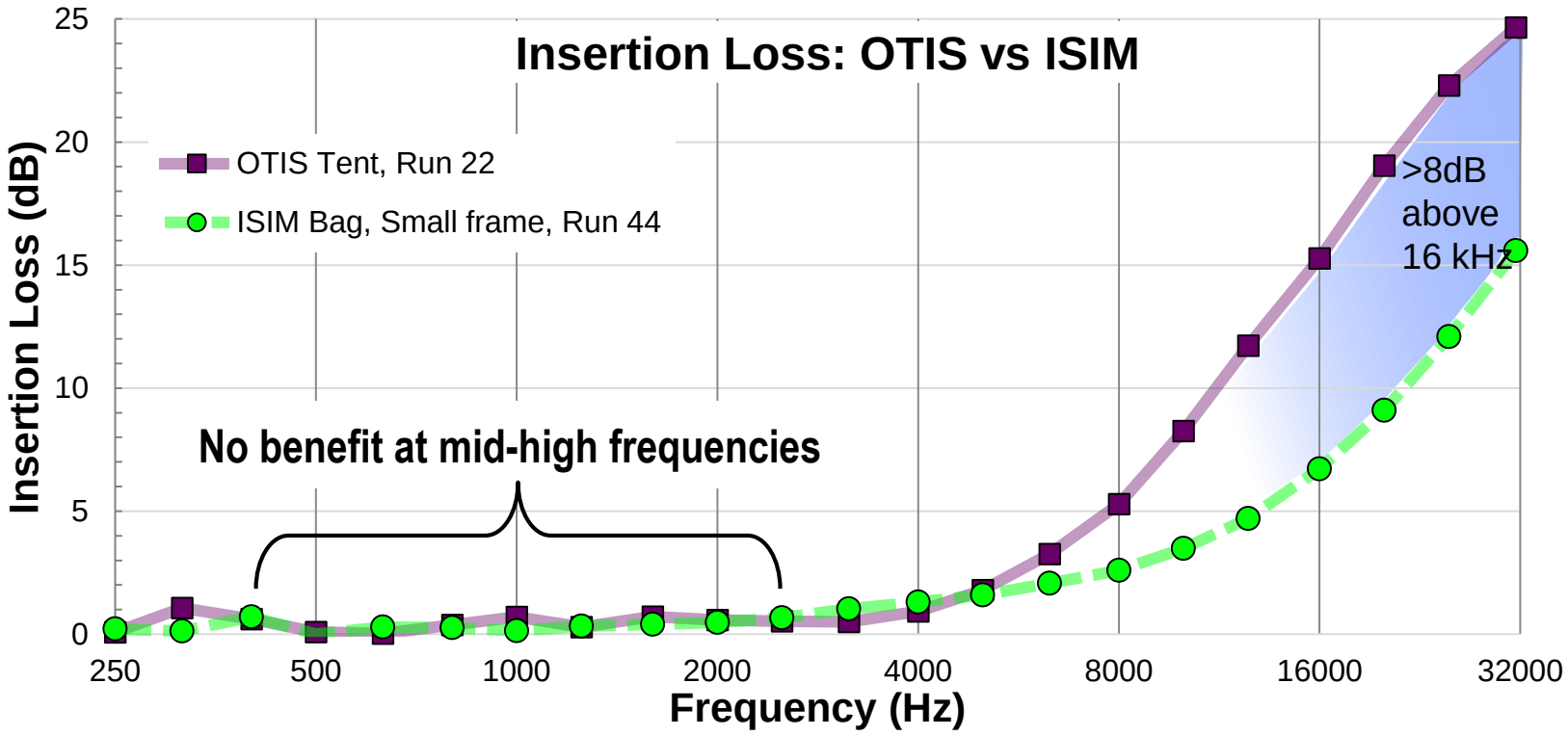
Protoflight Acoustic Test Levels for OTIS

- Will control chamber to +/- 1 dB to meet AE's minimum spec level (purple bar level) and uniformity requirements
  - Demonstrated tolerance and uniformity during Tent Frame Dry Run Test



Insertion Loss Improvement Help MSA's (OTIS)

- OTIS tent configuration: notably more attenuation @ high frequencies critical to MSA's
  - Geometry and material choice included and demonstrated improvement
  - Microphone quantity, type, placement not equivalent, but minor uncertainty compared to insertion loss improvement over original contamination bag from ISIM vibe test
  - No appreciable change in attenuation within specified octave bands (31.5 - 2 kHz)



ISIM Element EMI/ EMC Test

Objective of Test

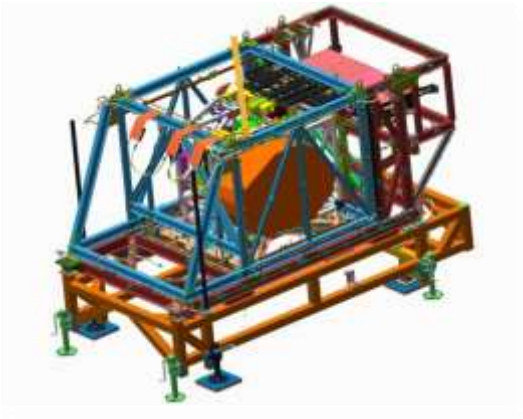
- Radiated Emissions Testing
- Radiated Susceptibility Testing
- Conducted Emission (limited)

Level of Test

- *Charts with test details follows*

Test Facility / View of Test

- NASA GSFC, Building 7, N115 (Anechoic Chamber)



Known Deviations from Flight Configuration

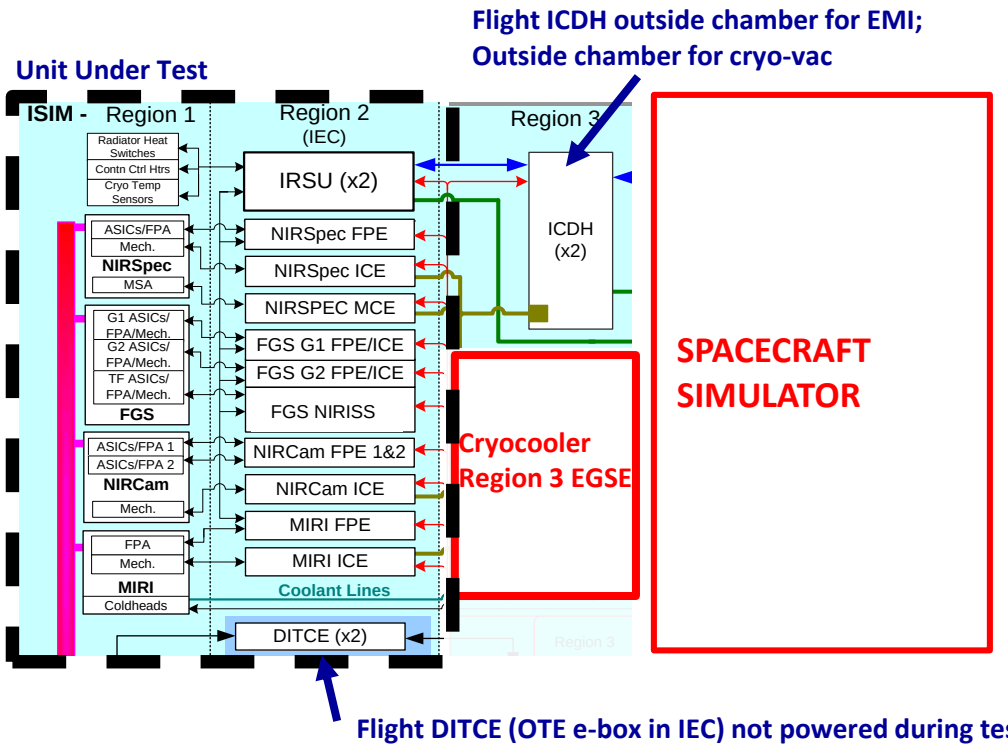
- The ISIM Prime has 4x Non-Flight CFMPs (Corner Fitting Metrology Plates) are still integrated on various -V3 corner fittings
- The IEC DITCE box is not present for this test.
- The IEC V2 vents are not present for this test.
- The IEC flight baffles (4x) are not present for this test.
- The IEC inner and outer conformal shields are not present for this test.
- The IEC flight lock NEA are not present for this test.
- The IEC flight on-orbit flexures are not present for this test
- The ISIM Prime, HR and IEC are mounted to the SIF as opposed to the composite Backplane.
- The IEC mounts to the SIF (SES Integration Fixture) are GSE mounts, not flight launch locks
- A GSE purge panel is used to support purge lines (on STMS Frame)
- Flight cooler line on ISIM Prime ends at cooler line location 4. A GSE line will be added from cooler line location 4a through 1 to properly load line supports 1, 2, 3, and 4a.

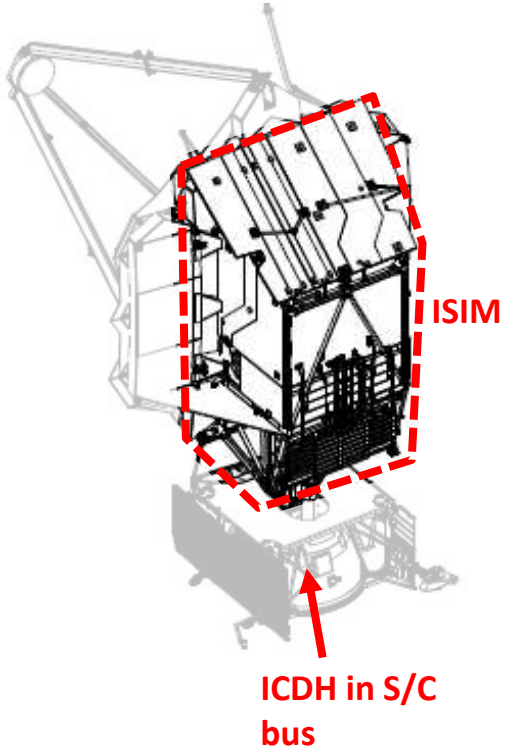
Plans, Procedures, and WOAs

- JWST/ ISIM EMI/ EMC Control Plan
- JWST/ ISIM EMI EMC Test Procedure

ISIM Level EMI/EMC Tests

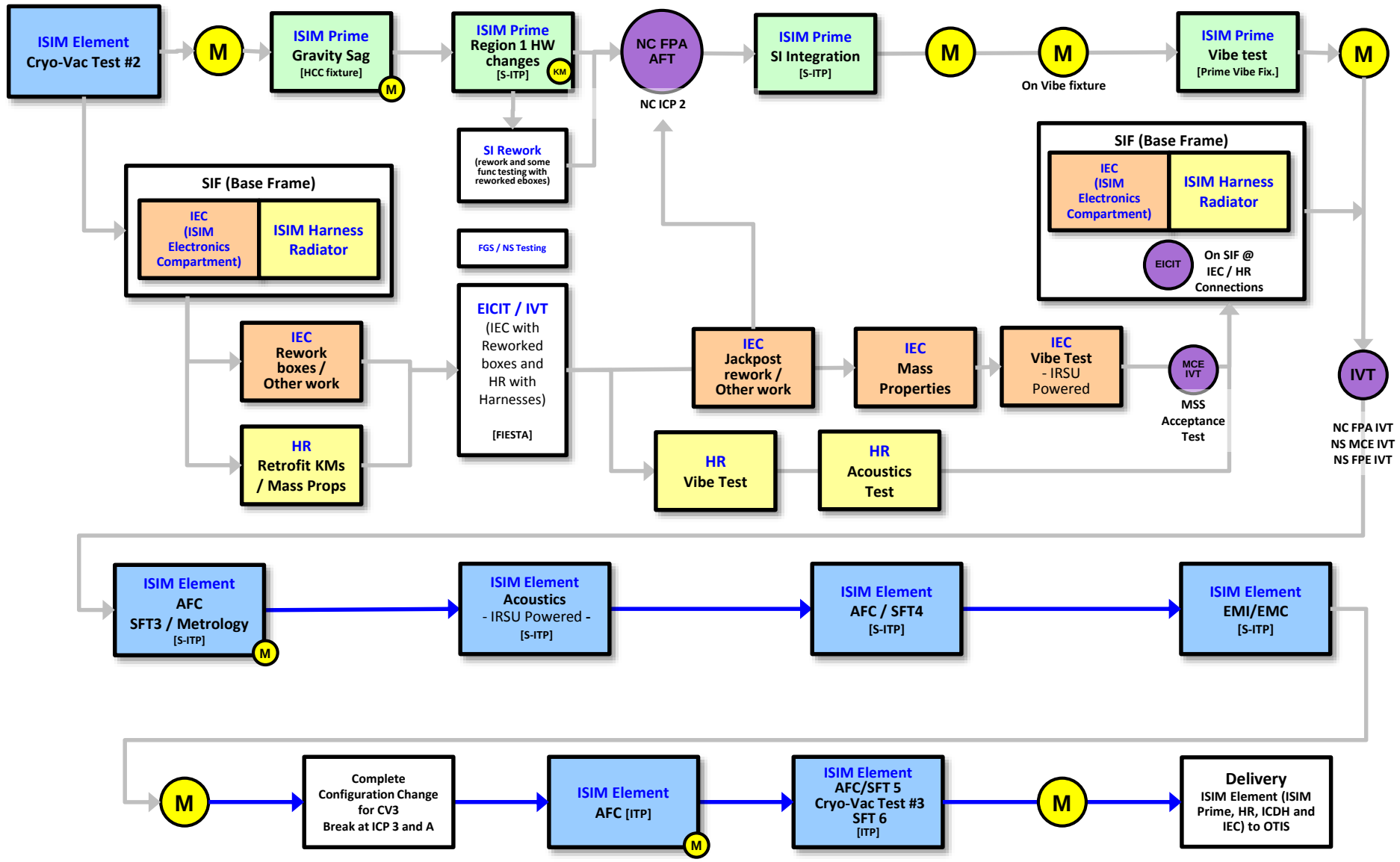
- **Test plan defined in ISIM EMC Control Plan, JWST-PLAN-004633, section 3.3 – All Successfully Executed!**
  - Conducted tests (power subsystem compatibility)
  - Radiated tests (communications subsystem compatibility)
  - Self-compatibility/crosstalk





ISIM EMI Test Team

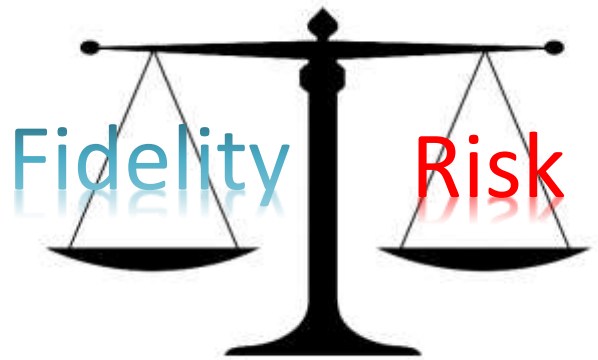
ISIM Element Environmental Testing



ISIM CV3 Design/Timeline Decisions

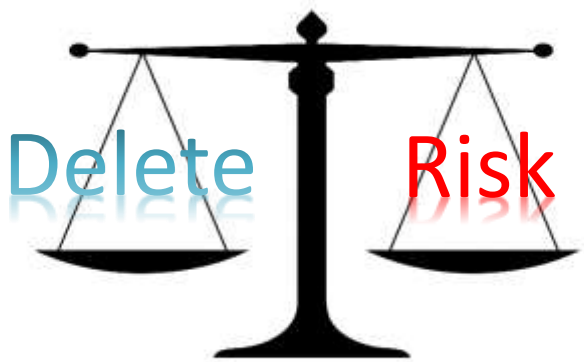
Highest Priority for ISIM CV3:

- Activity provides **basic health and safety** reducing the risk of finding a problem that could have a large impact if not found until the next test phase
- Activity verifies requirement(s) requiring the comparison of **pre- and post-environmental** tests
- Activity provides data used to close previous PRs and **PFRs**



All other objectives are prioritized based on the consequence of deletion:

- **ISIM level or subsystem's final verification**
- Activity provides continued **Model Validation** data for system and subsystem items
- Activity provides **data for calibration** of on-orbit science data.
- Activity verifies requirement(s) **reduce risk** of finding an issue at OTIS level tests.
- **operational planning** / observing mode previews



As-Run CV3 Timeline

Path from Requirements to Data Collection

Identifier	Object Text	I	A	D	T	Responsible Org	Preliminary	Provisional	Full	ISIM Repeat	Verification Description/Notes	Verification Plan(s)	Verification Reference(s)
IOS-IR-5798	On-orbit, after articulation of the NIRCam pupil adjustment mechanism, the pupil shear error in the Module A and B NIRCam channel with respect to the Optomechanical Reference Plane A, due to the ISIM Element shall not exceed 1.8%.		A		T	ISIM		ISIM-TST-20200 ISIM-TST-21201 ISIM-TST-20401	ISIM-ANA-10004		Full verification by Optical analysis with CV test input; verifcation description in optical verification plan.	JWST-PLAN-018335 JWST-PLAN-009738	
IOS-IR-5799	Excluding the NIRCam channel, the on-orbit, instrument pupil shear error with respect to the A Reference caused by the ISIM Element shall not exceed 3.1%.		A		T	ISIM	ISIM-ANA-10004	ISIM-TST-20401 ISIM-TST-21201 ISIM-TST-20200	ISIM-ANA-10006		Verification will be through combination of optical measurements from ISIM CV test, STOP analysis predictions, and finally optical analysis to combine these inputs. ISIM STOP Analysis Plan will provide a description of analysis process used to generate analytical	JWST-PRES-012494 (JWST ISIM CDR Integrated Modeling Presentation)	

1. Verification Matrix

2. Optical Performance Verification Plan

6.12 PCF 3.1 – ISIM PUPIL SHEAR AND CLOCKING

⇐Previous PCF Next PCF⇒

Requirements Addressed

DOORS ID	Requirement Title
IOS-IR-5798	On-Orbit ISIM NIRCam Channel Pupil Shear
IOS-IR-5799	On-Orbit ISIM Element Pupil Shear – Excluding NIRCam
IOS-IR-5790	ISIM Contribution to Pupil Clocking

Imaging Configuration Overview

IMAGING CONFIGURATION OVERVIEW

Instrument	Pupil (P) / Filter (F) / Grating (G)	OSIM Source	OSIM Pupil	Field Point	Comment	CV2 Test Procedure
NIRCam A/B PIL	P: Imaging F: F187N	SC	PAR #1	PIL Center		Initial Optical Baseline
NIRCam A/B PIL	P: Imaging F: F187N	SC	Ha Dis			
NIRCam A/B PIL	P: PAPPA F: F187N	Very bright SC				
NIRCam A/B + OSIM PIM	P: PAPPA F: F187N	LD064	Open	Center	PAR imaging	Initial Optical Baseline
NIRCam A/B + OSIM PIM	P: PAPPA F: F187N	LD064	PAR #1	Center	PAR imaging	Initial Optical Baseline
MIRI Imaging	F: FLENS	LD155	PAR #2	MIRIM PAL	(OTESKY_AM -7.2466, -1.5991)	Initial Optical Baseline
MIRI Imaging	F: FLENS	LD155	Hartmann-Distortion	MIRIM PAL	(OTESKY_AM -7.2466, -1.5991)	Initial Optical Baseline
MIRI	F: FLENS	LD155	Tricont	MIRIM	(OTESKY_AM	Initial Optical

3. CV Test Procedure

4. Initial Optical Baseline Test Procedure

Requirements Addressed in OTP 3.1 (OTP3.1.*)

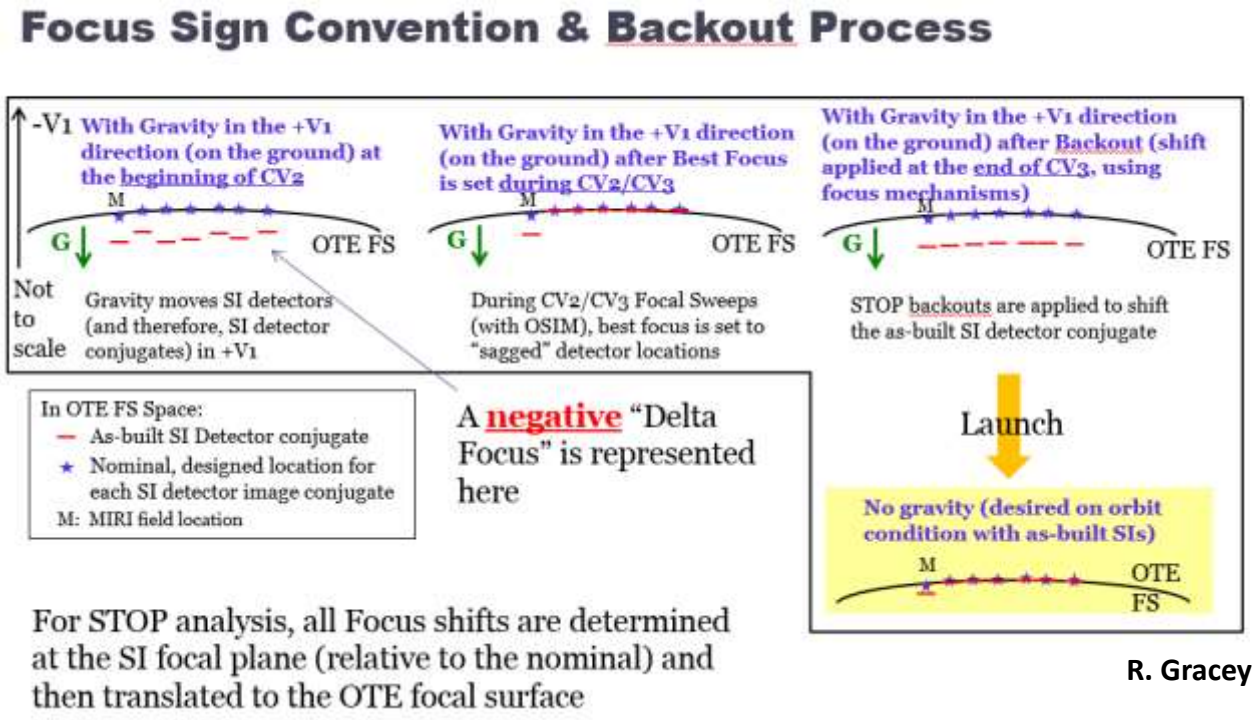
DOORS ID	Requirement Title
IOS-IR-5798	On-Orbit ISIM NIRCam Channel Pupil Shear
IOS-IR-5799	On-Orbit ISIM Element Pupil Shear – Excluding NIRCam
IOS-IR-5790	ISIM Contribution to Pupil Clocking
IOS-IR-5801	ISIM Element NIRCam Pupil Adjustment Range
IOS-IR-5804	Active Pupil Shear Accommodation

5. OTP Tracking Spreadsheet

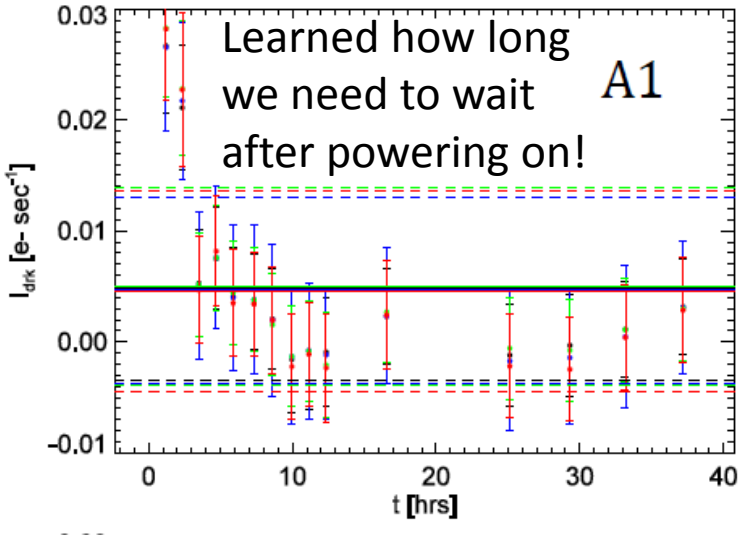
Test Name	OTPnumber	OTPname
Initial Optical Baseline - Focus and Image Quality - NIRCam B SW	0.4.2.NC.B.SW.I	OTP0.4.2.NC.B.SW.I
Initial Optical Baseline - Focus and Image Quality - NIRCam B LW	0.4.2.NC.B.LW.I	OTP0.4.2.NC.B.LW.I
Initial Optical Baseline - Pupil Alignment Check - MIRI PAR	3.1.MR.I	OTP3.1.MR.I
Initial Optical Baseline - Pupil Alignment Check - NIRISS PAR	3.1.NR.I	OTP3.1.NR.I
Initial Optical Baseline - Pupil Alignment Check - FGS PAR	3.1.FG.I	OTP3.1.FG.I
Initial Optical Baseline - Pupil Alignment Check - NIRSpec PAR	3.1.NS.I	OTP3.1.NS.I
Initial Optical Baseline - Pupil Alignment Check - NIRCam A PAR	3.1.NC.A.I	OTP3.1.NC.A.I
Initial Optical Baseline - Pupil Alignment Check - NIRCam B PAR	3.1.NC.B.I	OTP3.1.NC.B.I

Final Alignment Offset Using SI Mechanisms for Best Performance On-Orbit

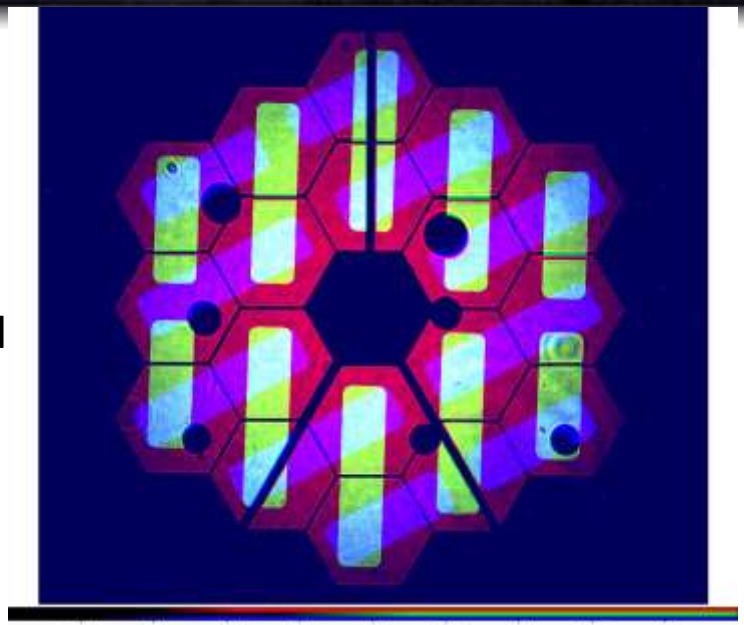
- Offsets generated via Structural, Thermal, Optical Performance (STOP) modeling
- Offsets implemented for focus for NIRCam, NIRSpec, Guider, and NIRISS (and pupil shear for NIRCam)
- Reference: ISIM CV2 & CV3 STOP: Ground to On-Orbit Gravity and Thermal Cases, JWST-PRES-027671, R. Gracey

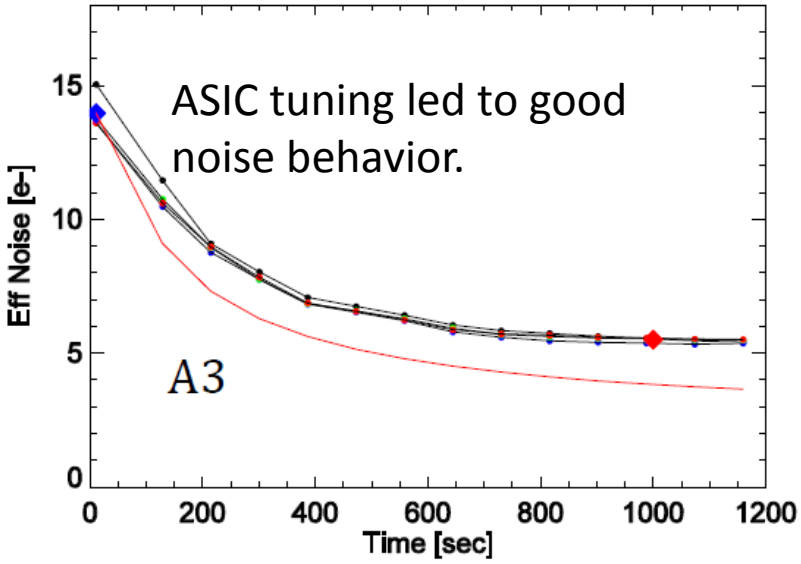


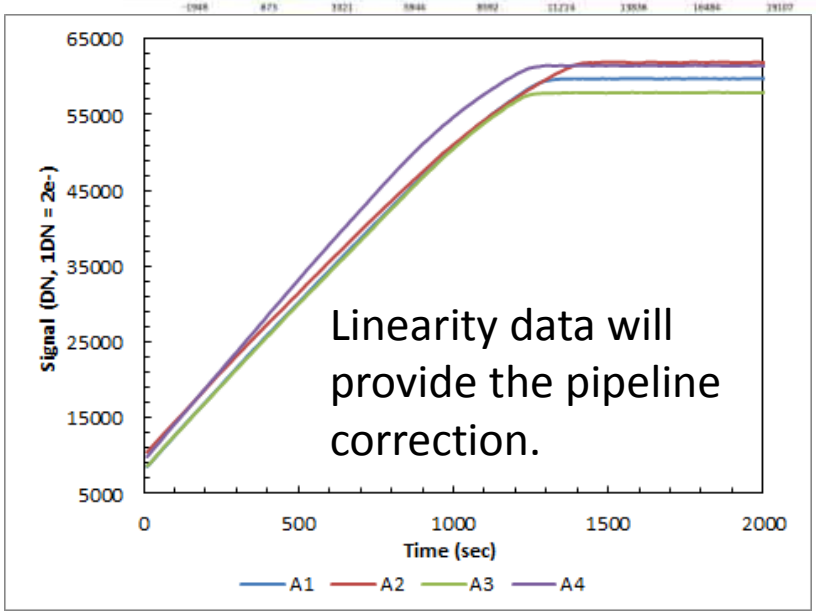
Sample NIRCam CV3 Results



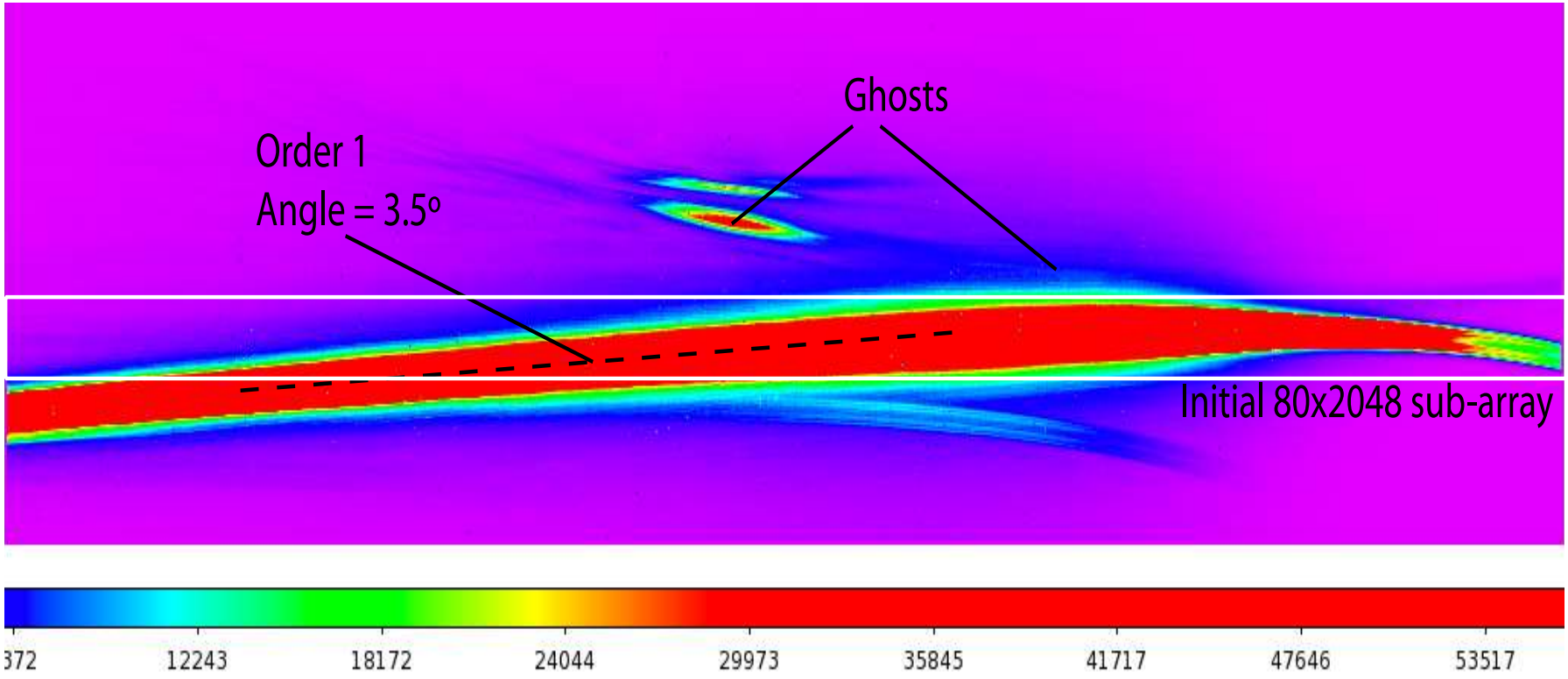
Mod B DHS alignment – wheel zero points repeated well from CV2.



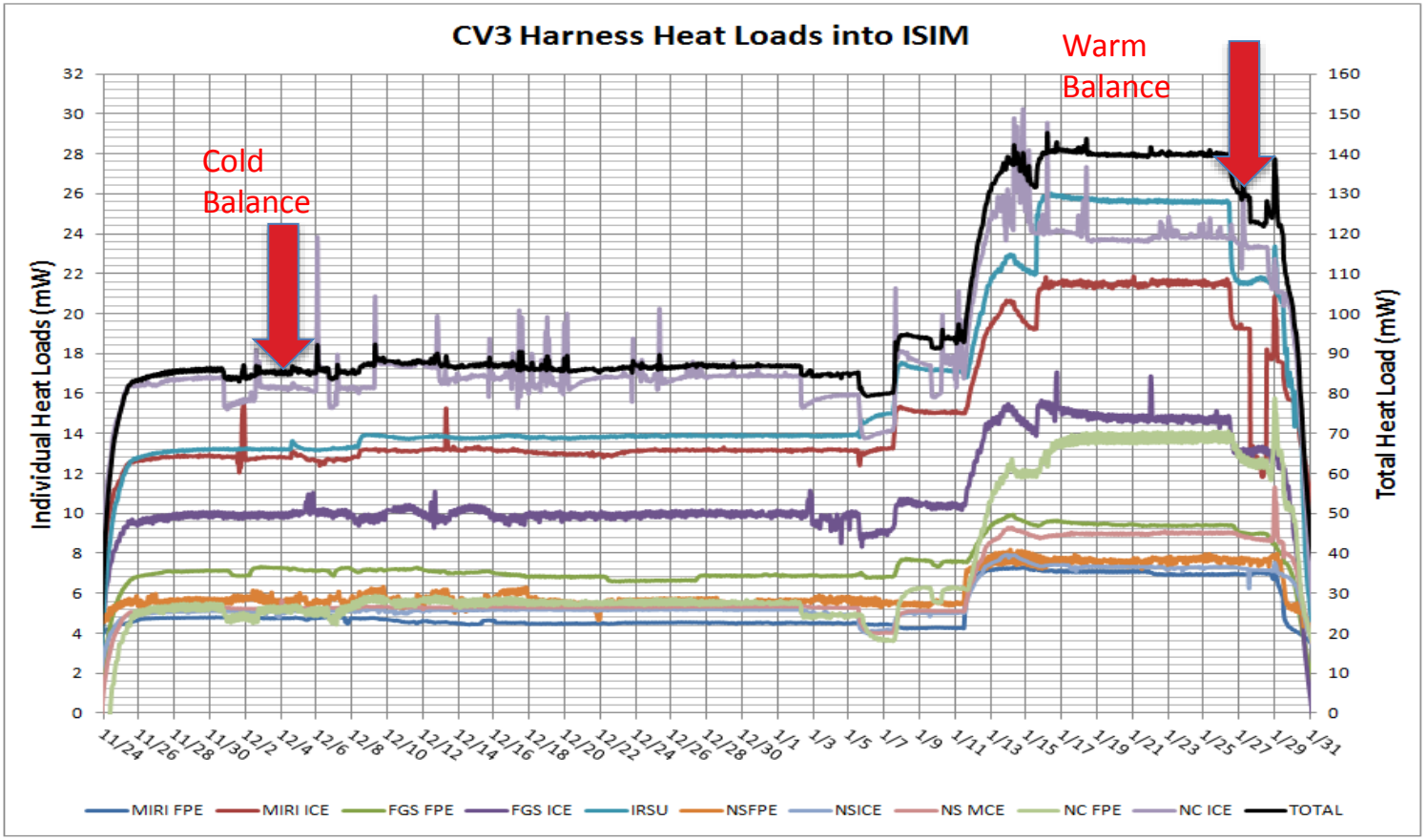




Ghost with the NIRISS SOSS Mode



Harness Thermal Loads into ISIM in CV3



ISIM CV3 Summary

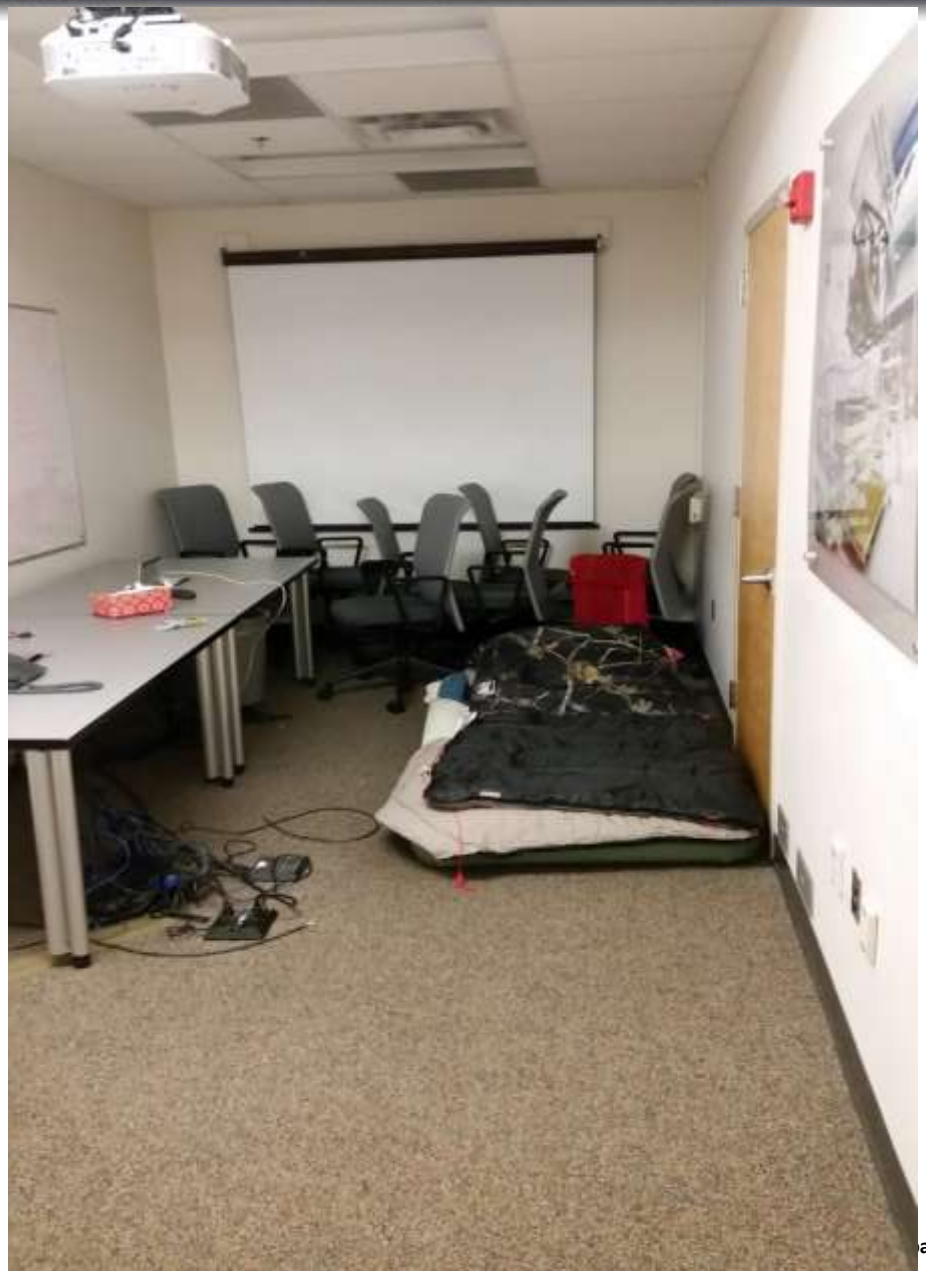
- The CV3 test has run phenomenally well. We will have run for 110 days from start of AFC (Ambient Functional Checkout) before chamber pump-down to door opening post test – almost on track with original 104 days prediction
- Completed all planned activities as well as additional requests at cold operational temperatures and started the warm up to ambient on Thursday, January 28th
  - 214 PRs written to date (compared to 407 in CV2) – 133 of them are ready for closure
  - Nearly all software/ops related, no hardware related issues other than the known MIRI FPE
  - ZERO PFRs!
- Opened the chamber door Saturday, the 13th of February 2016
- Only one significant event during the test….

- *Fantastic support from the ISIM test team, Code 549 facilities team and Code 200 facilities team….*

  THANK YOU ALL!

The Blizzard of 2016

http://www.theatlantic.com/science/archive/2016/02/snowed-in-at-nasa/433959/



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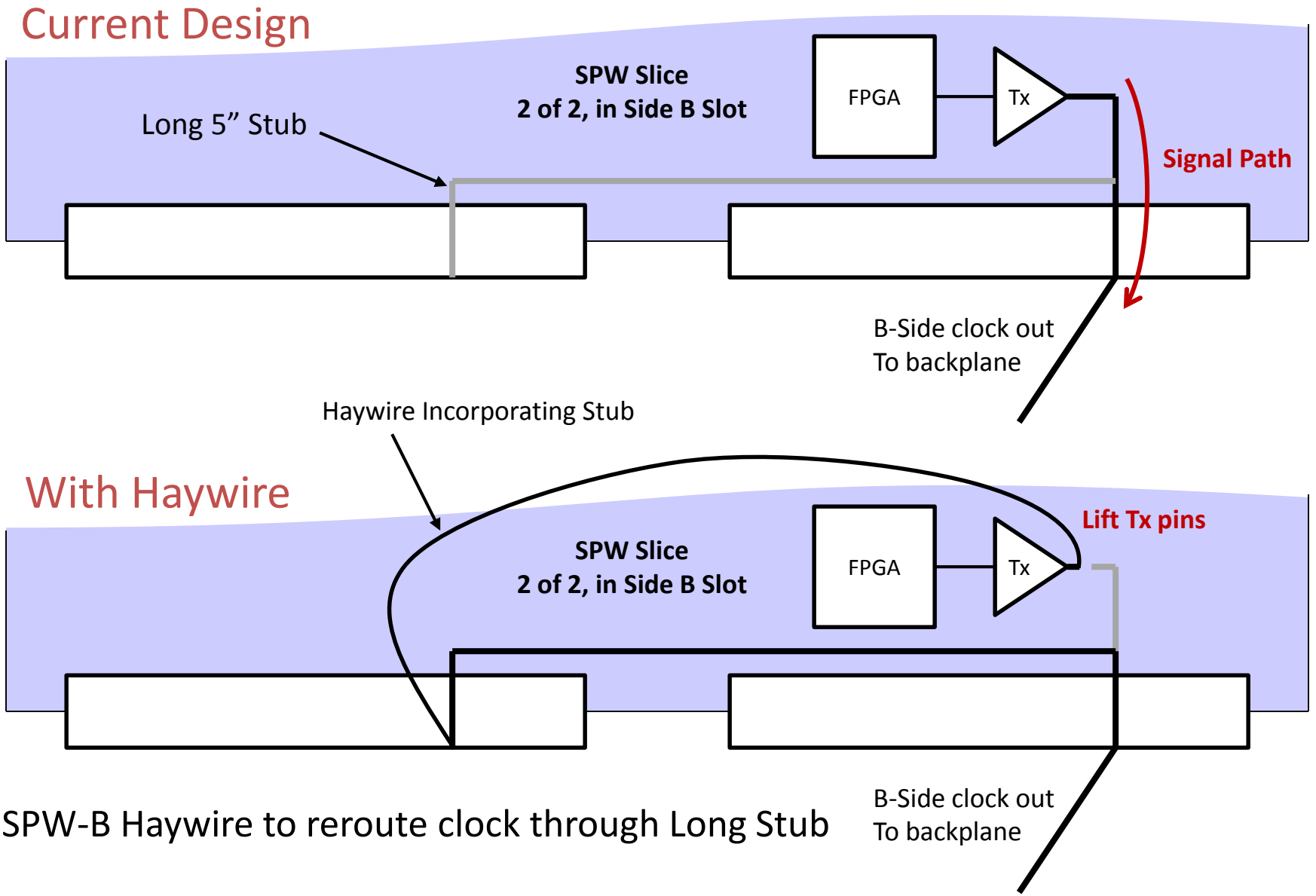
MIRI FPE Design Problem & Solution



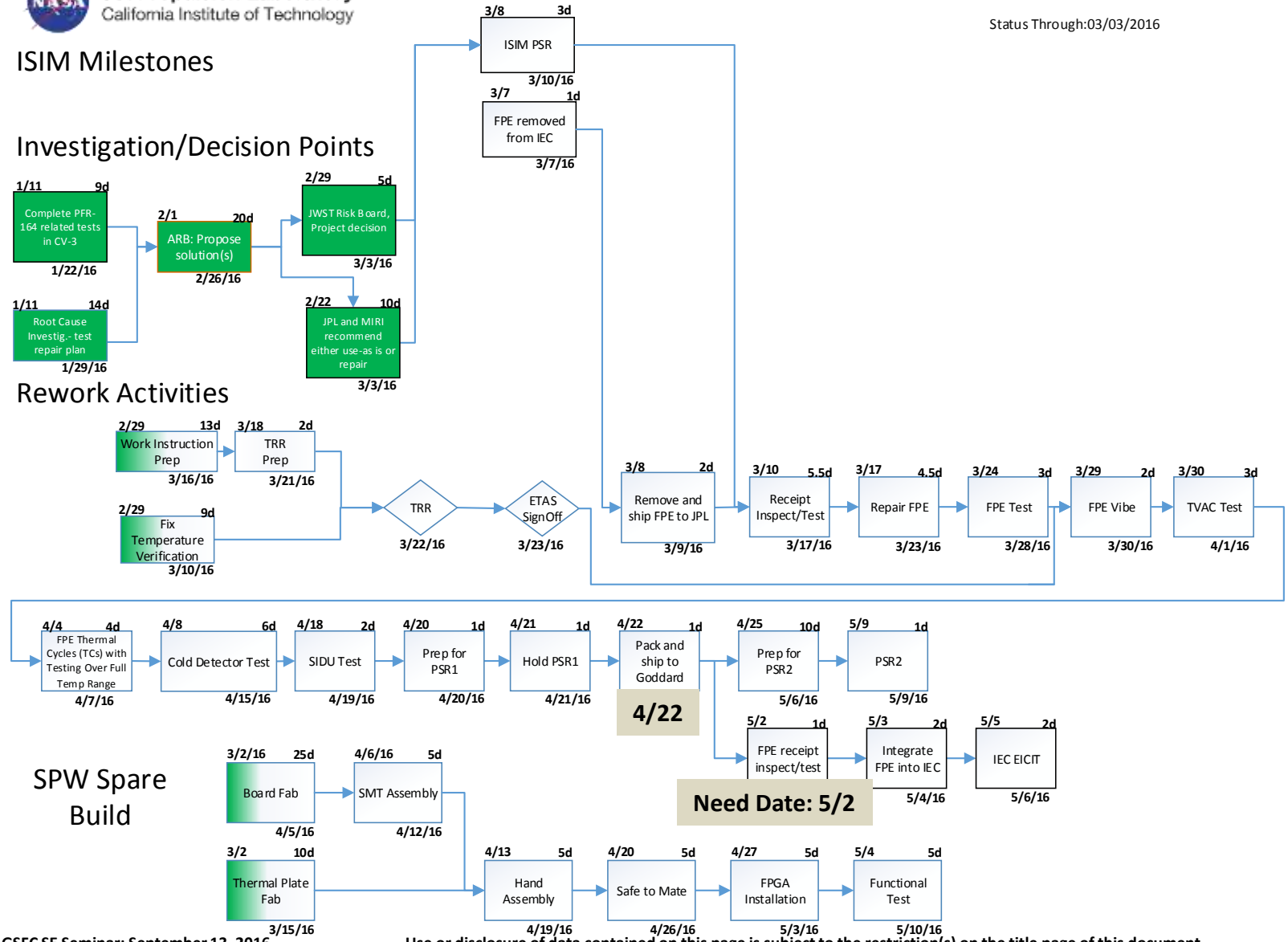
SPW-B Haywire to reroute clock through Long Stub

FPE Repair and Test Plan

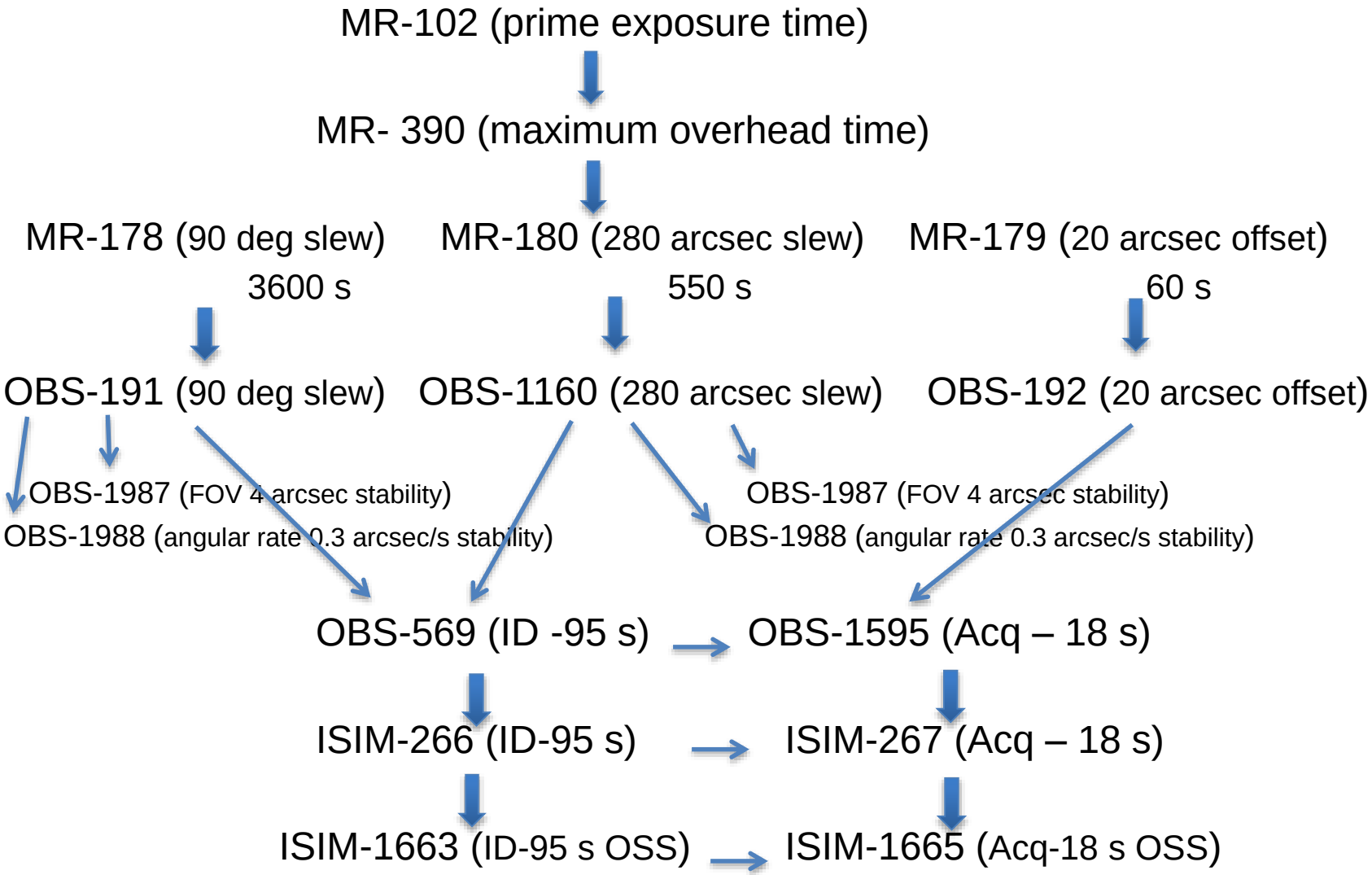
Jet Propulsion Laboratory
California Institute of Technology

MIRI FPE PFR 58524 Draft Path Forward Schedule

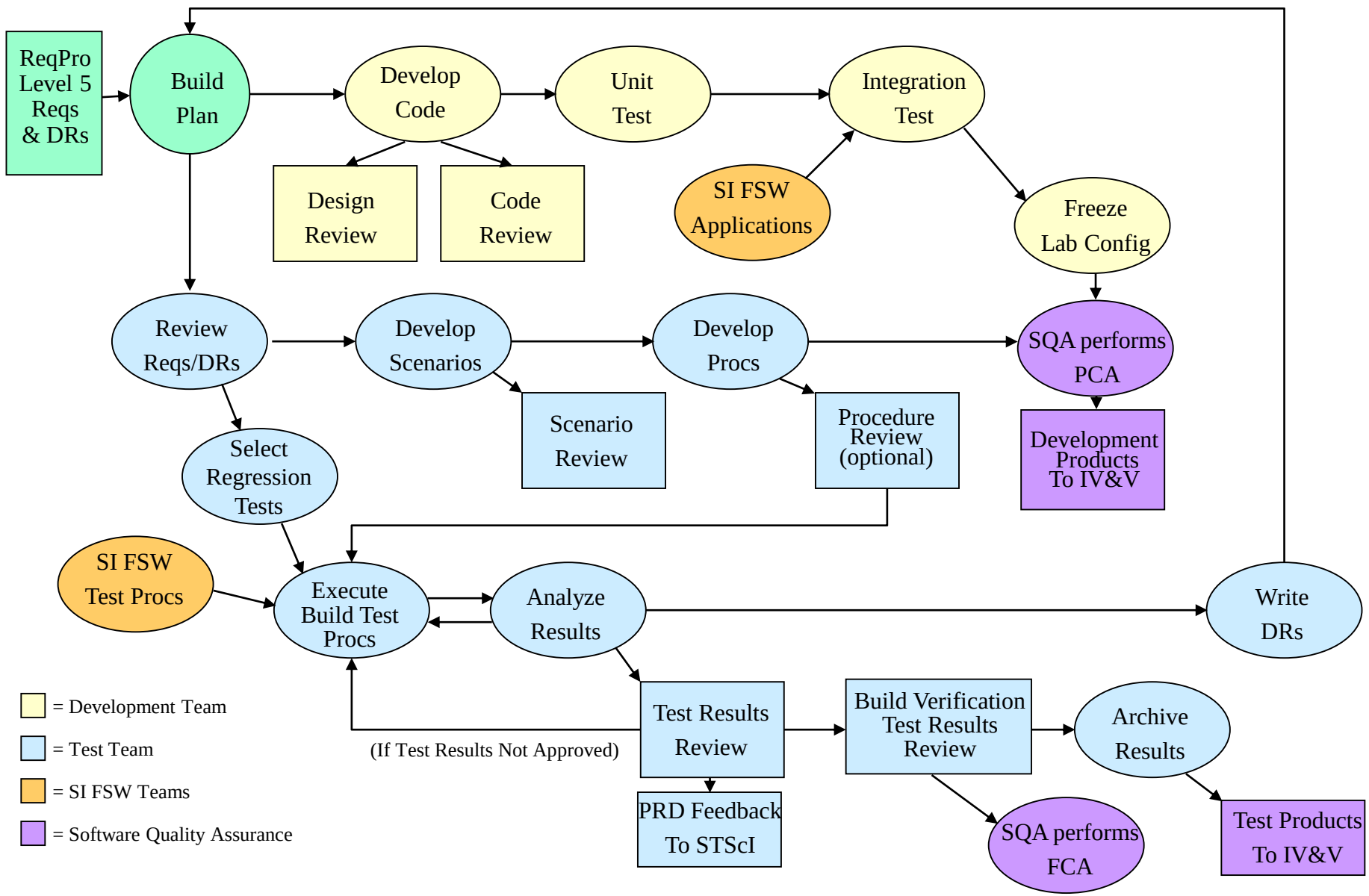
Status Through:03/03/2016



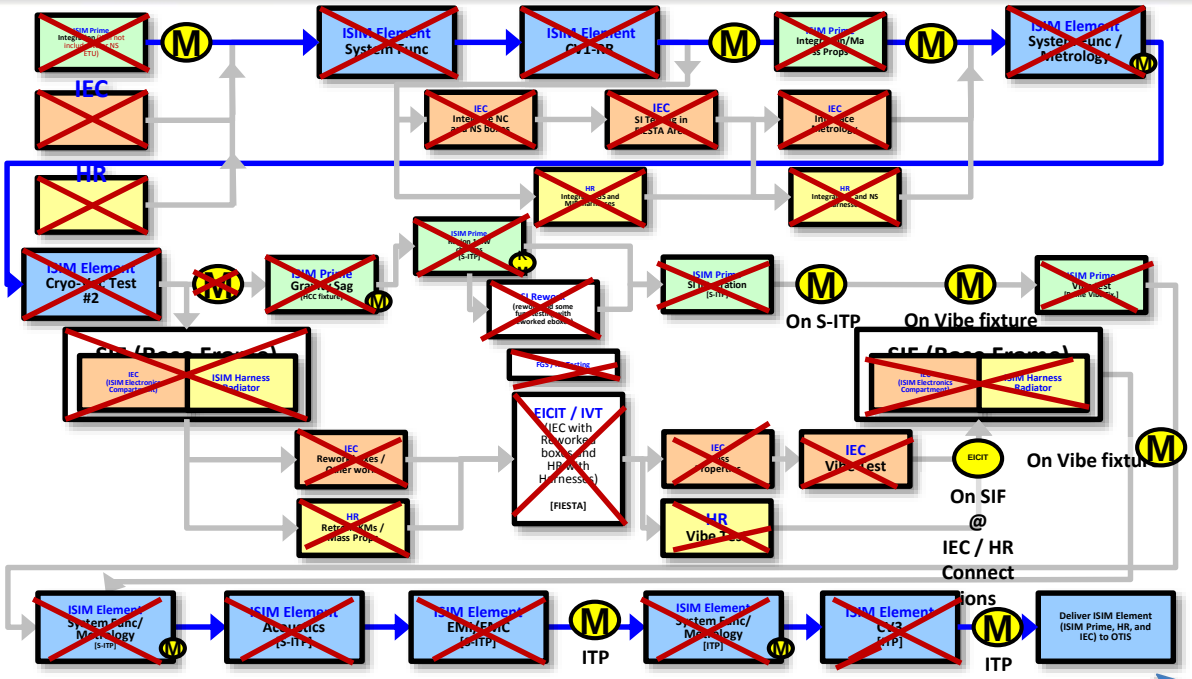
ID Timing – Requirements Flow Down
(ISIM-266, ISIM-1663)



Build Development and Test Process



ISIM I&T Flow



Deliver ISIM Element (ISIM Prime, HR, and IEC) to OTIS!!!

Timing of ISIM Element PSR

- Although this is a “Pre-Shipment Review” we do not “ship” ISIM. It is programmatically “handed over” to the OTIS team for integration with the OTE.
  - Many of the key OTIS integration leads are also the ISIM leads.
  - The OTIS “System Integration Review” is next week.
  - Therefore, we will not go into many of the details of the “Post-Delivery Integration”

- The KEY entrance criteria from GSFC-STD_1001A:
  - **The successful completion of all verification activities of any associated flight systems.**

- The **ISIM element has completed the last verification activity**, which was ISIM Cryo-Vacuum Test 3 (CV3) and the Post-Test System Functional (SFT-6).

ISIM PSR Preparation Mantra

We must seek serenity to accept
the documentation we cannot complete by PSR,
the courage to complete the documentation we can,

And wisdom to know the difference.

ISIM Lessons Learned

- ISIM I&T was conducted over approximately 4 years, which was a test of everyone's endurance as we all missed holidays, birthdays, anniversaries. Over the span of the project, together we experienced births, raised our children, experienced the aging of our parents, celebrated as coworkers retired and suffered through the loss of members of our team. We made it through the most difficult and complex integration and test program ever planned at GSFC. All of this and we successfully navigated numerous hardware changes, a 17-day government shutdown and a record-setting blizzard in the middle of our performance test.

- **The most important lesson learned through the ISIM program is the value of experience as a team. That lesson is being implemented by using the experienced teams from ISIM to move forward and support ISIM in the OTIS level integration and test efforts.**
  - Also, the operations team has gained invaluable experience by being integrated during both the Science Instrument Performance testing and ISIM level Functional and Performance testing.

ISIM Team

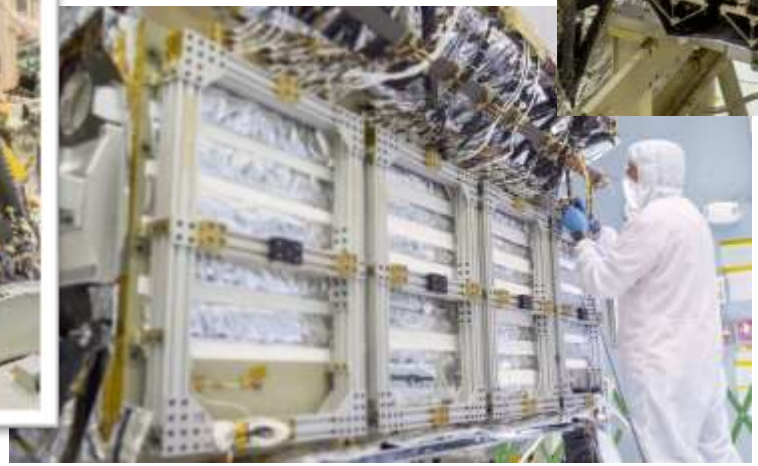
- GSFC
  - Management, Systems Engineering, & Science
  - ISIM C&DH Electronics/Software, including Remote Services Unit
  - ISIM Structure, IEC, and Thermal Control Subsystem
  - ISIM-level I&T, GS&O I&T support
  - NIRSpec Micro-Shutter and Detector Subsystems
- European Space Agency/European Consortium with Airbus
  - NIRSpec Instrument
  - MIRI OBA (Optical Bench Assembly)
- Canadian Space Agency with Honeywell
  - FGS/NIRISS
- University of Arizona with Lockheed Martin
  - NIRCam Instrument
- JPL
  - MIRI Management & Systems Engineering
  - MIRI Detector Subsystem, Cooler, and Flight Software
- JWST Prime Contractor Team (NG, Ball, ITT, ATK)
  - ISIM Thermal Management System (enclosure) & GSE for ISIM I&T
  - Spacecraft Simulator
- Space Telescope Science Institute
  - Instrument Support for Flight and Science Operations

JWST Overview - OTIS

OTE

OTIS = Optical Telescope Element + Integrated Science Instrument Module

ISIM



Last View of ISIM Prime before Integration