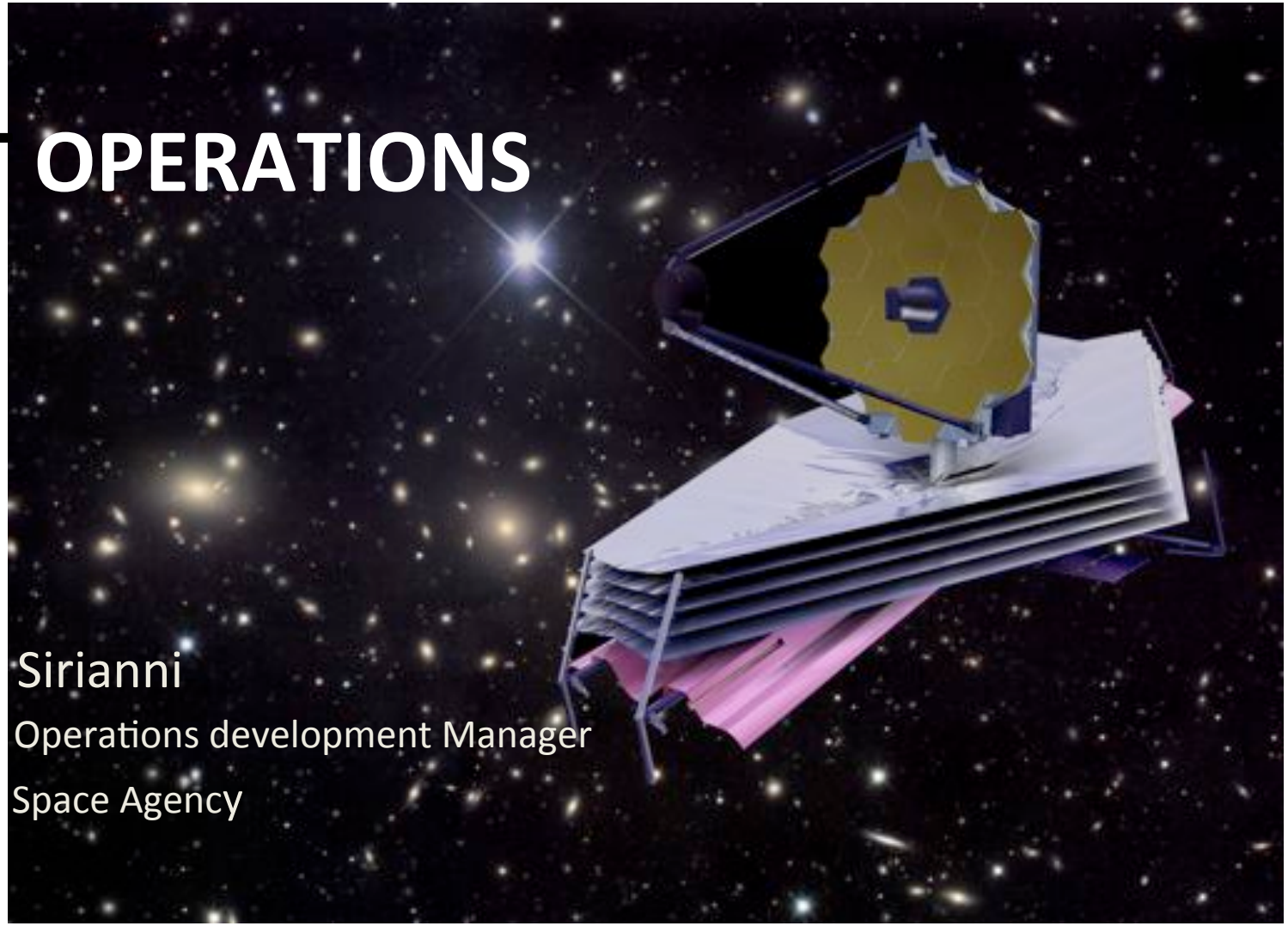
JWST OPERATIONS



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Roma, 09 October 2014

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JWST Operations

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attitude constrains

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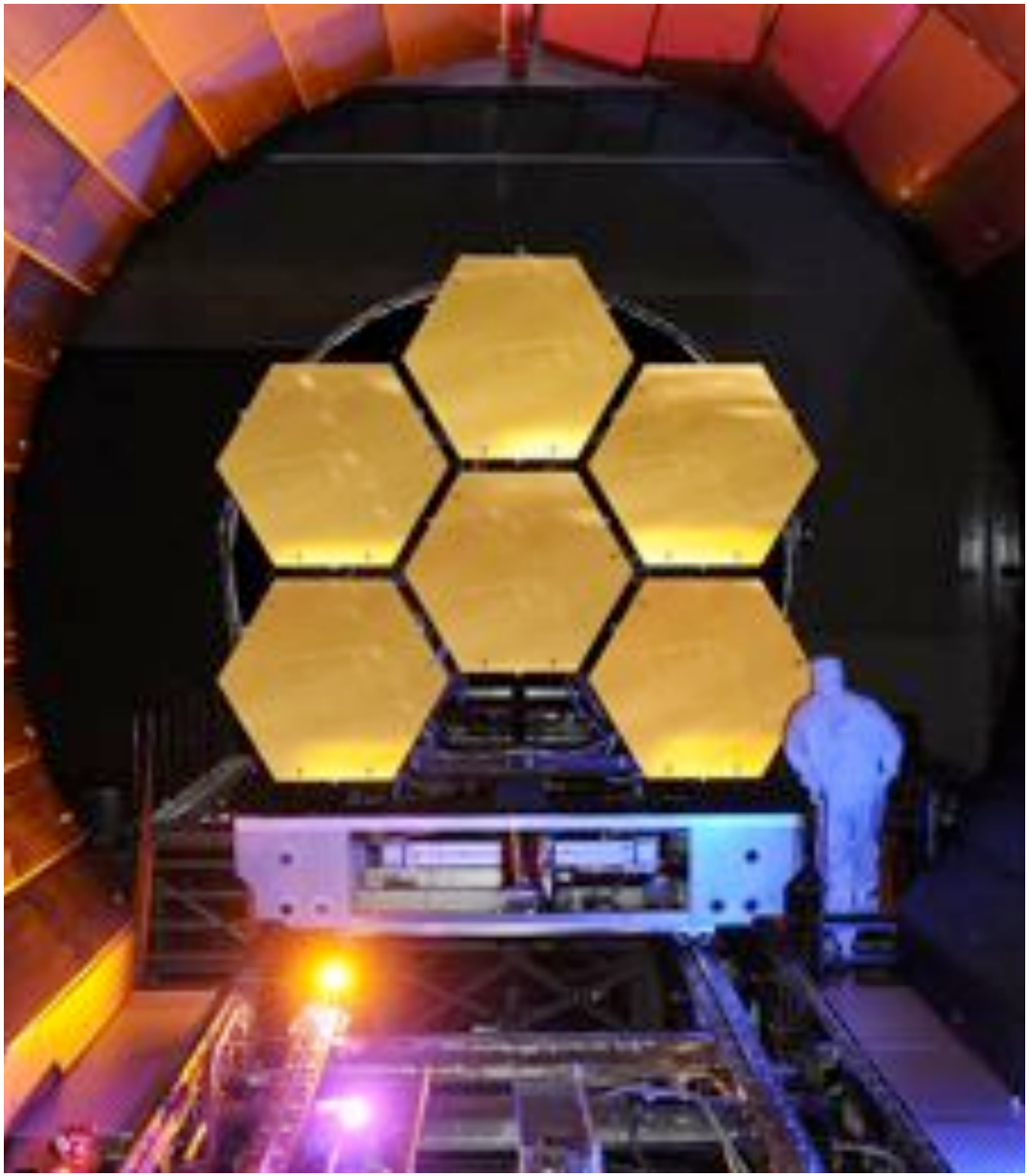
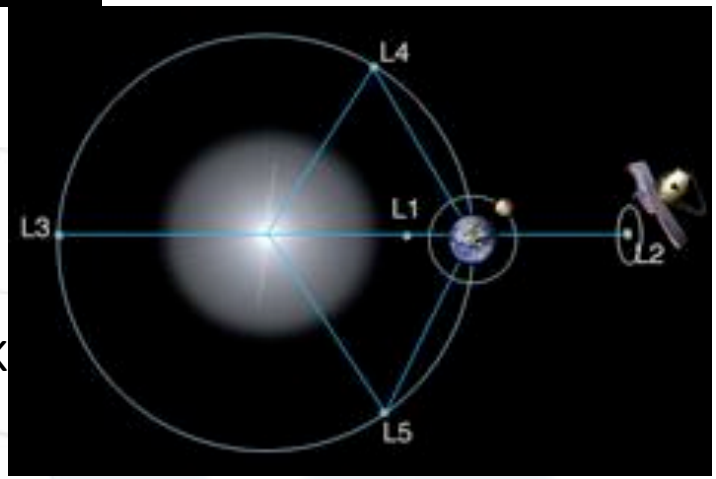


L2



L2 advantages:

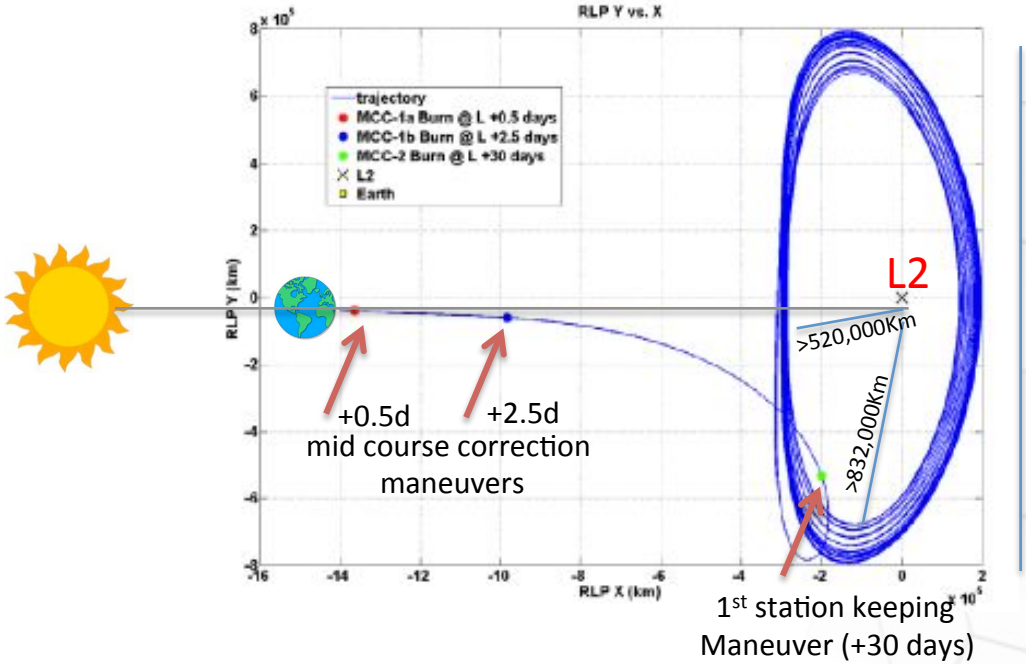
- Same orbital period of the Earth
- Sun+Earth+Moon are always in the same direction
- Nearly constant lightning conditions
- Cold and Stable thermal environment
- Telescope always pointing into deep space (ideal 2.7K heat sink)
- Long continuous visibility windows at ecliptic poles
- Compared to more distance orbits:
  - Easier communication requirements
  - Easier power generation
  - Shorter transfer time and less propulsion required

L2 main disadvantage:

- Saddle point in the gravitational potential -> not a stable orbit

L2 Halo orbit

L2 halo orbit is designed to avoid eclipses of the Sun by The Earth or the Moon which would interrupt power generation by the solar arrays



Halo orbit period is ~ 6 months

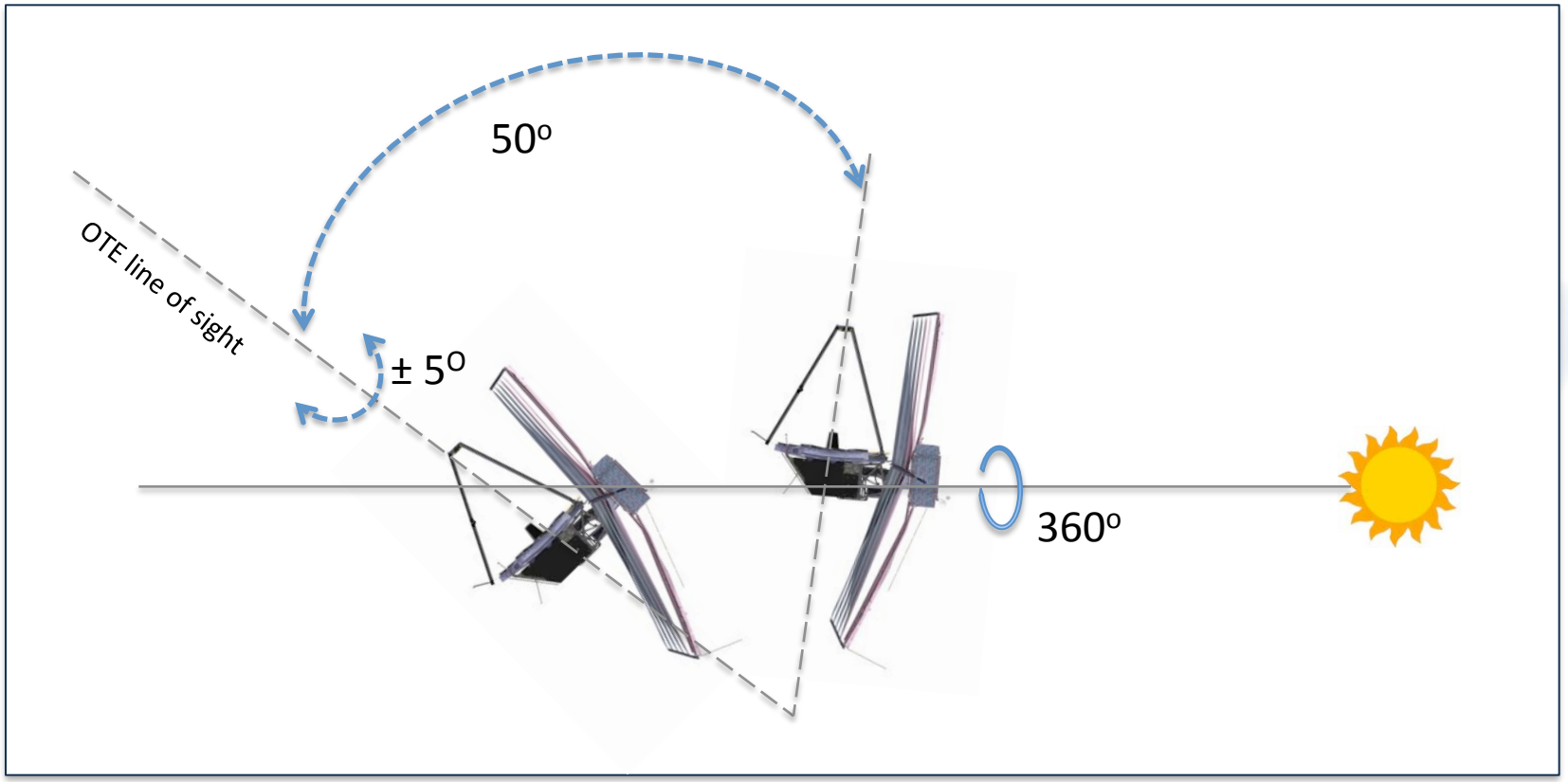
Final details on the orbit depend on launch window

Station keeping required as often as 21-22 days (8x per orbit)

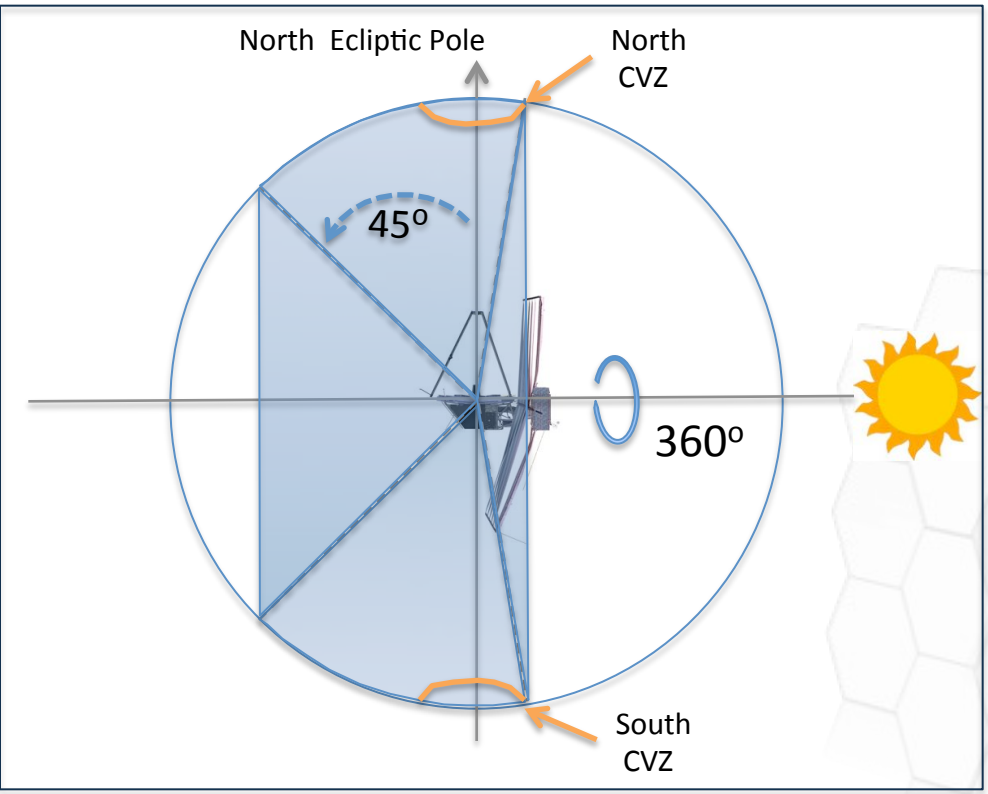
Propellant for 10.5 years of operations

Attitude Constraints

In order to maintain the telescope in the shade of the sun shield the relative attitude of JWST vs Sun is limited between 85 and 135 degrees and the roll around the OTE line of sight is limited to ± 5 degrees

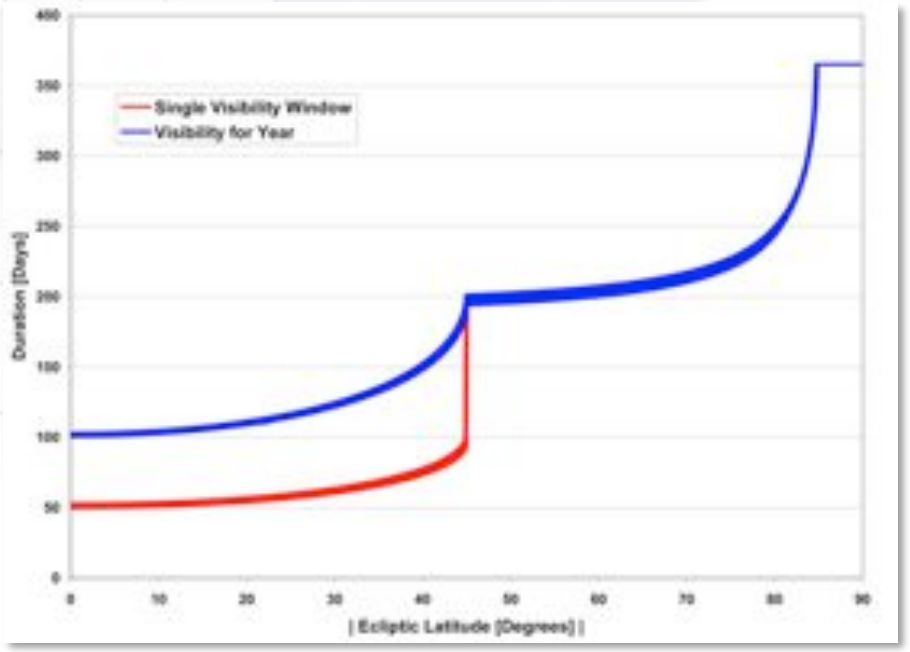


JWST Field of Regard



Instantaneous field of regard (FOR) covers about 45% of the sky (vs 80% of HST)

As JWST orbits the sun the FOR moves across the sky ➔limitation on when a target is visible and for how long:



- Targets in the ecliptic plane (<45º) have two ~ 53-day windows every 6 months with 180º delta roll
- Near the ecliptic pole targets are visible for over half a year
- Targets within 5º of the poles are always visible (CVZ)

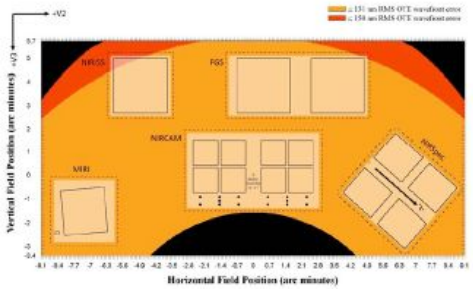
Example of restrictions

- Targets in the ecliptic will have most severe restrictions:

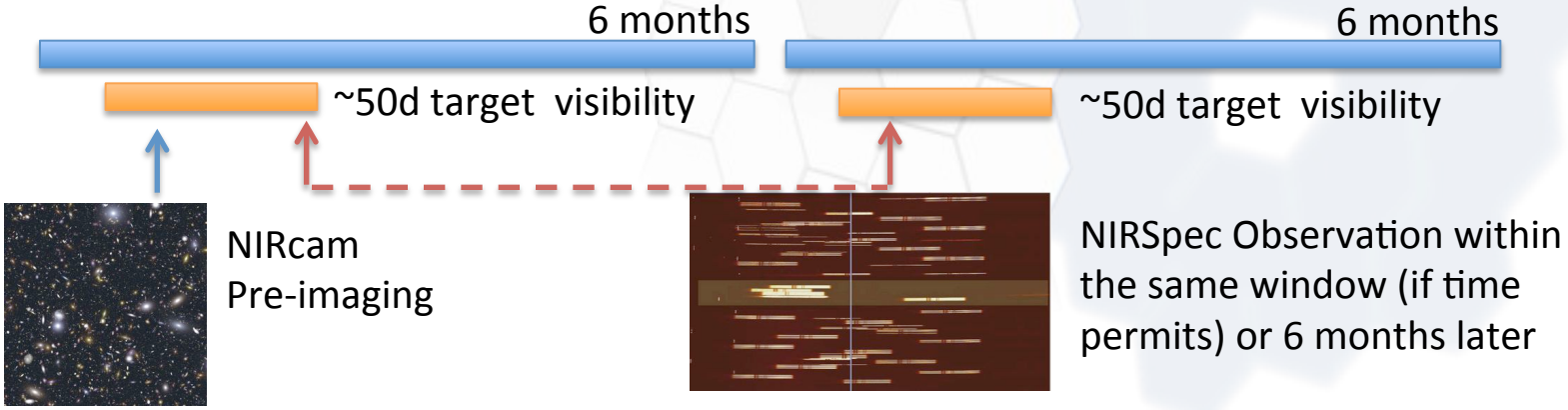
  Allowed orientation for a given FOV

  will be limited by two 10° ranges

  separated by 180°.



- Many NIRSpec MOS observations will require NIRcam pre-imaging (same roll not required but same FOV coverage)



- In addition limited roll range reduces MOS capabilities

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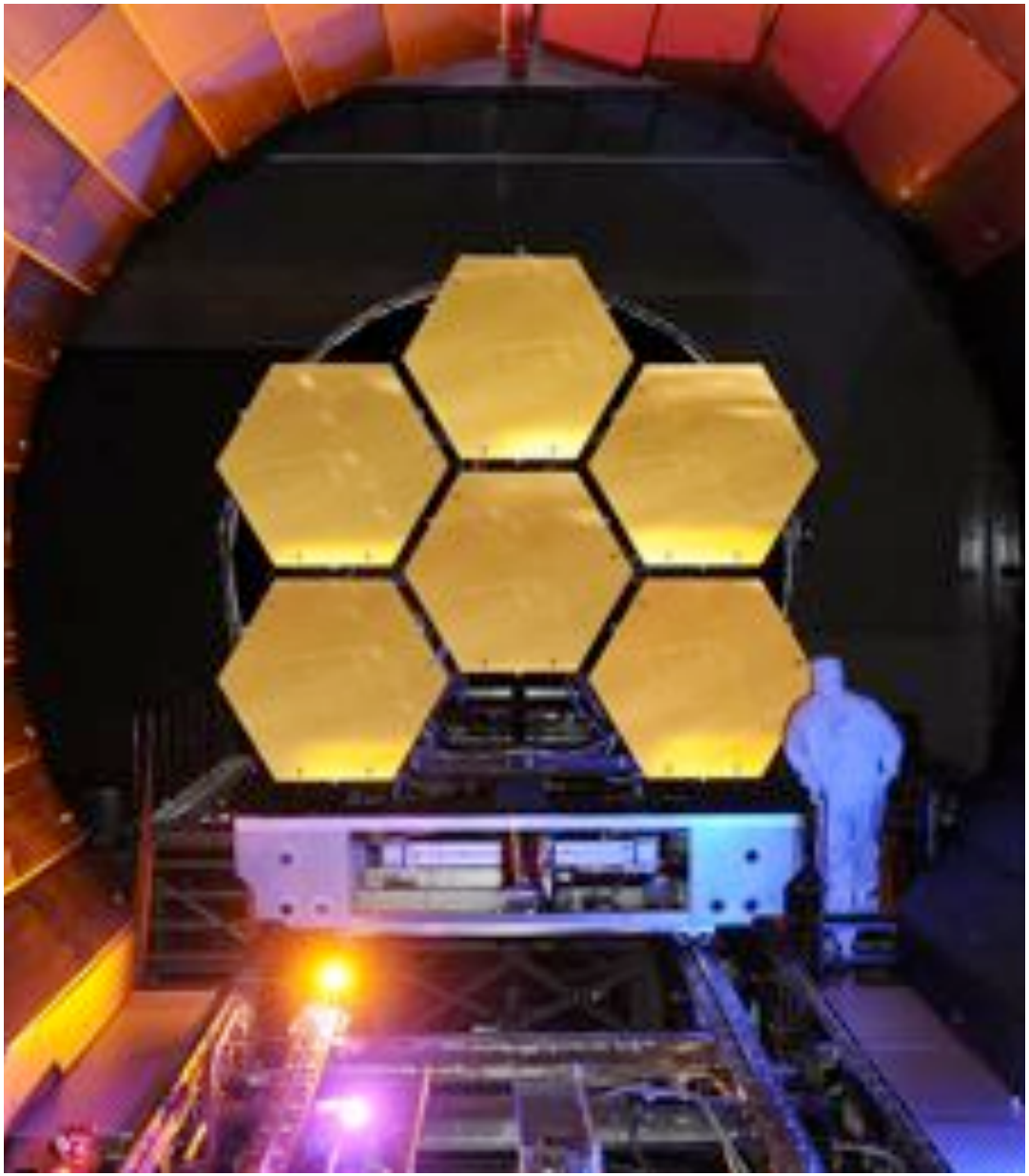
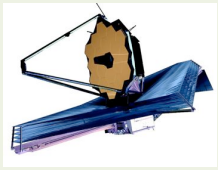


Event Driven Commanding

A fundamental difference with HST is the commanding approach:

Absolute time commanding

Scheduling via sequence of commands with each an absolute start time



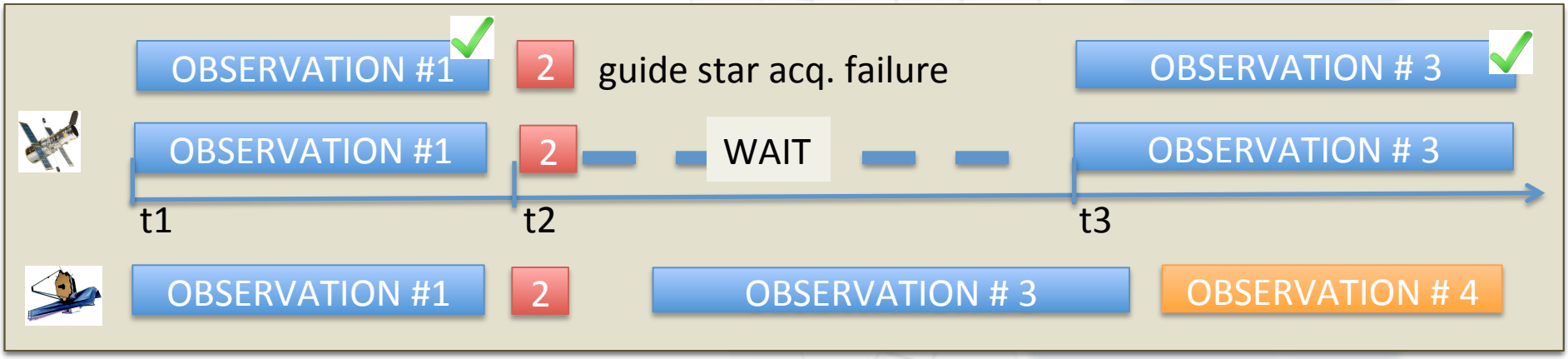
Event Driven commanding

Scheduling via queue of activities that are executed sequentially

- Event driven commanding allow autonomous operations for 7-10 days
- Provided a list of activities, the on-board computer issues commands in real time to the flight software
- Telemetry will tell if a command has been completed and allows to start the next one
- Automatic response to real time error by skipping affected observations

Event driven approach

- Advantages
  - Non need of detailed time-modeling of each command
  - Higher efficiency
    - Autonomous response to real-time events:



    - Minimization of mechanism motion overheads

  - Simplification of on-board scripts (human readable)
  - stress on "test as you fly" philosophy

Event driven approach –cont.

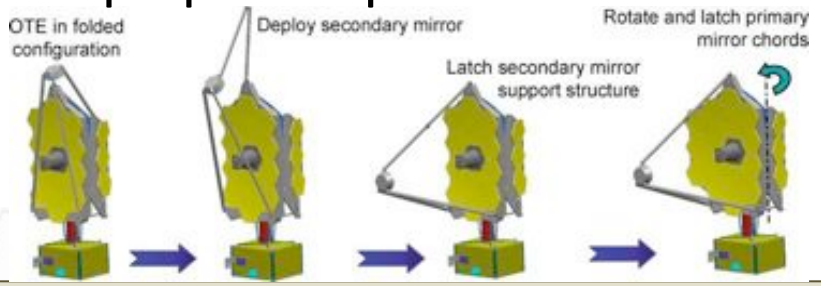
The Observatory will autonomously interrupt execution of the Observation Plan, to perform reaction wheel momentum dumping or antenna pointing

Flight OPS staff will support normal 8-hours / 5 day workweek.
An automated anomaly detection and notification system will notify OPS personnel

Real-time commanding planned only for critical operations: Station-keeping maneuvers, software updates and anomaly recovery

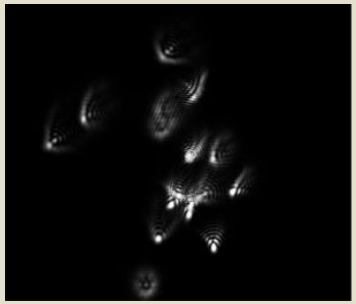
Wavefront Sensing and Control

After the OTE deployment, the telescope point-spread function (PSF) consists of 18 separate, out-of-focus images, one from each primary mirror segment



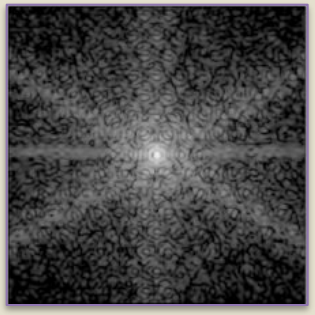
from here

(example of possible 1st light)

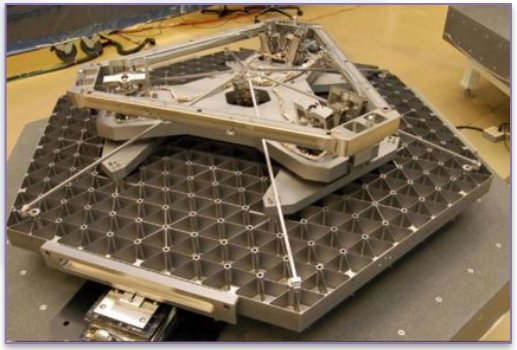


to here

diffraction limited PSF



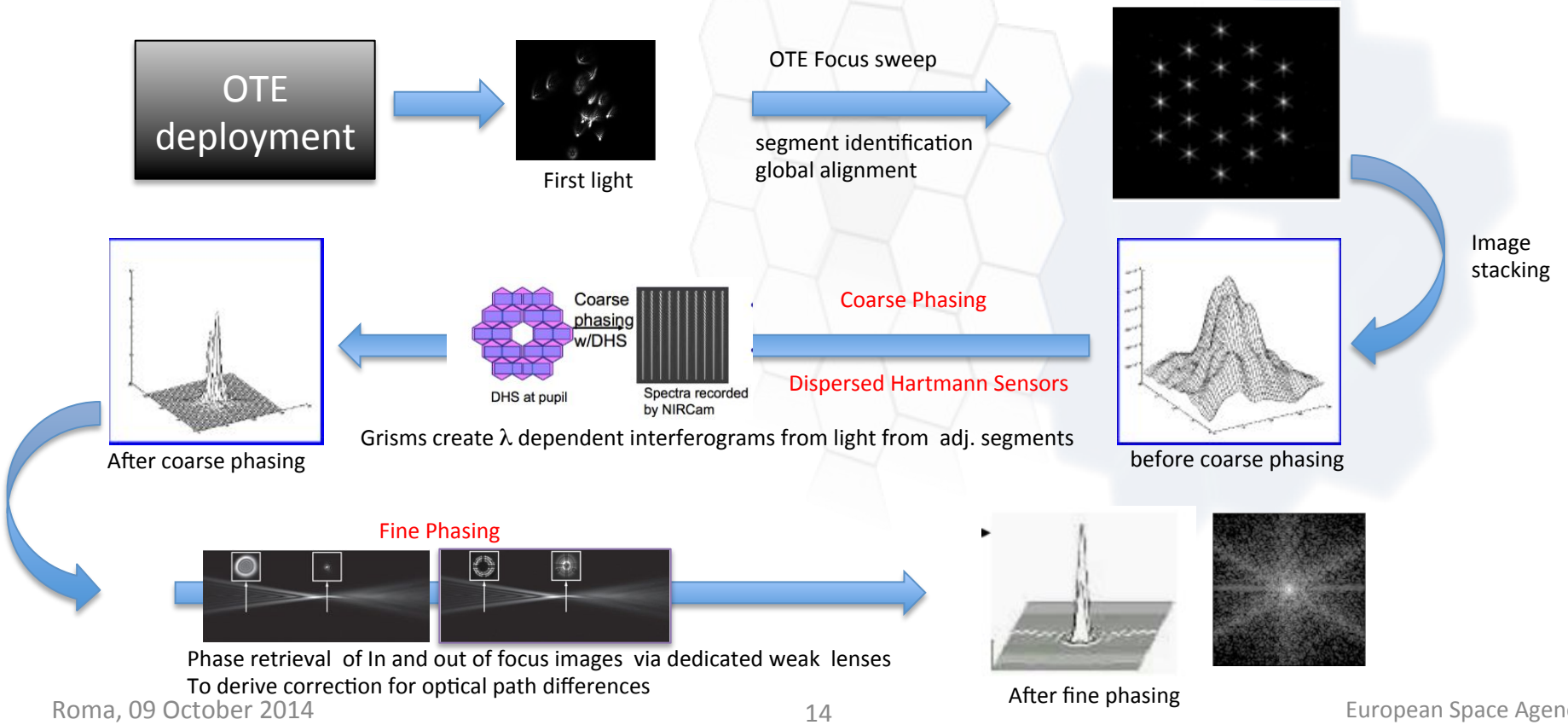
Each one of the 18 segment has 7 controllable degrees of freedom and the secondary mirror has an additional 6 degrees of freedom



WFS&C -2

The mirror segments must be positioned so their wavefronts are phased creating a diffraction-limited 6.6 m telescope, rather than overlapping images from 18 individual 1.3m telescopes

NIRCam will be be the primary instrument to align all 18 primary mirror segments



WFS&C -3

During initial alignment NIRCam Multi field / multi instrument wave front sensing are performed to remove any systematics across the FOV

During operations it will be necessary to periodically monitor and adjust the JWST OTE to maintain the optical quality of the PSF

- NIRCam will be used for monitoring PSF quality up to every 2 days
- Fine phasing will be done observing an isolated bright star
- Wave front sensor scientists at S&OC will analyze/trend data and develop instruction to optimize PSF
- Correction applied as needed (biweekly/monthly)

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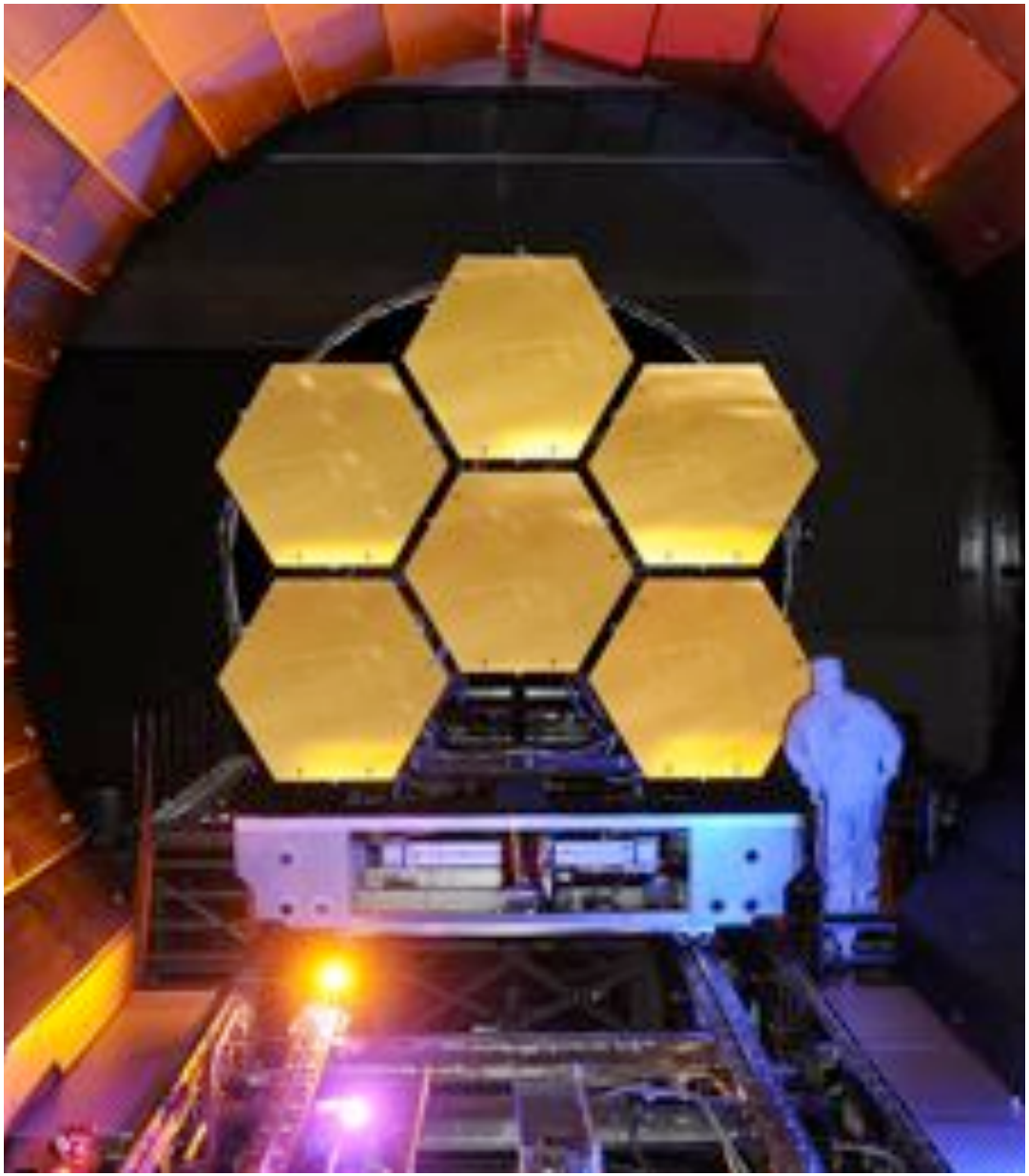
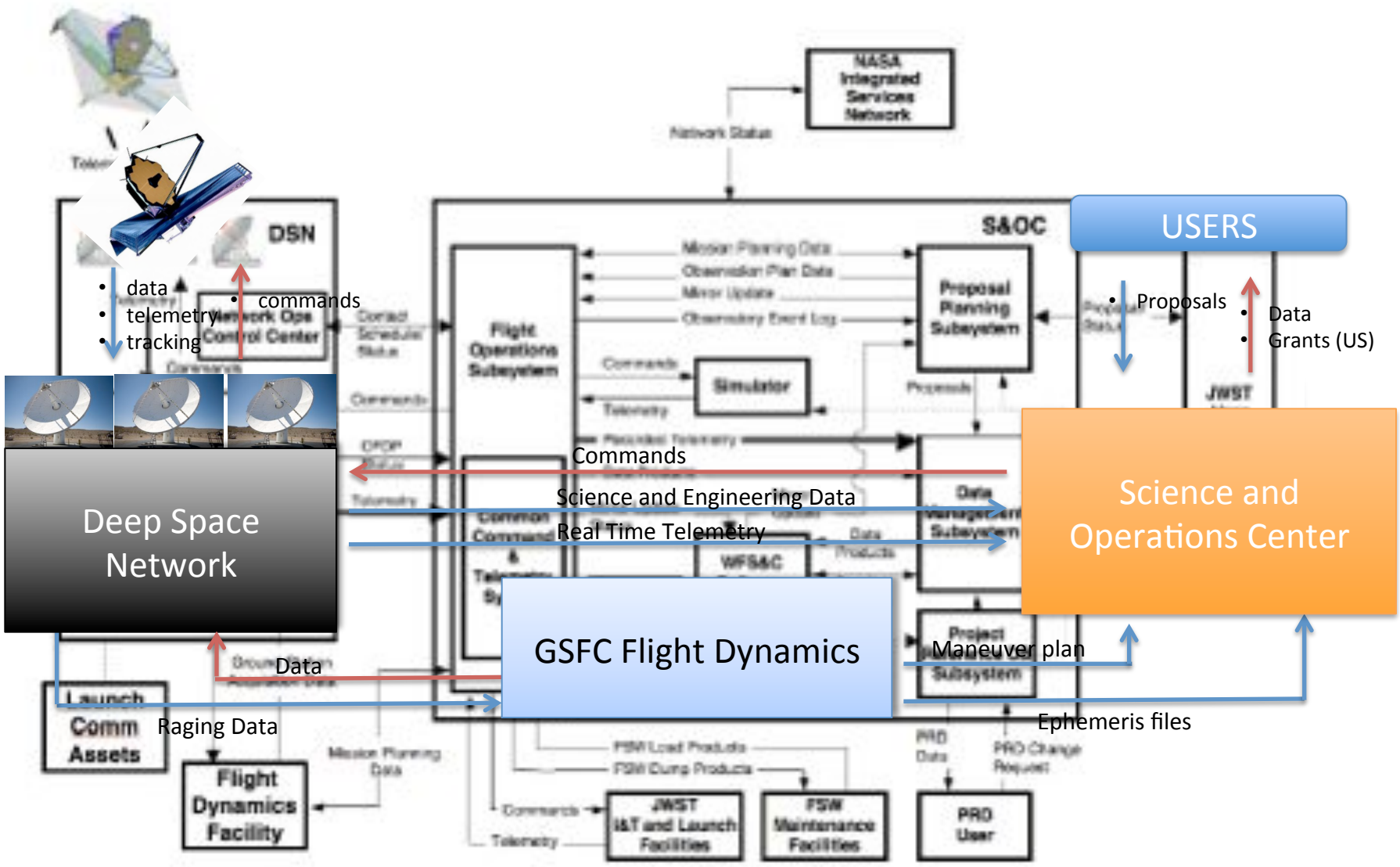
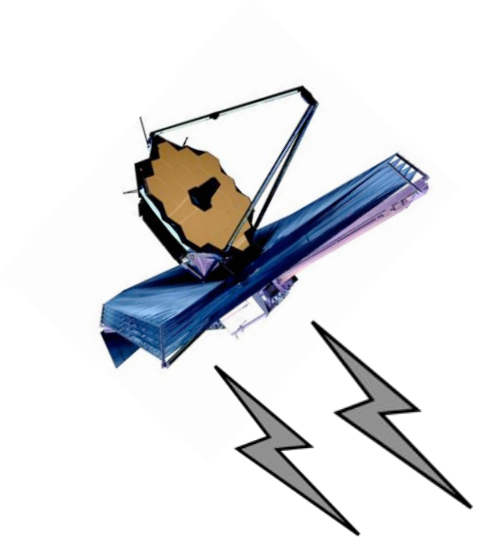


JWST GROUND SEGMENT



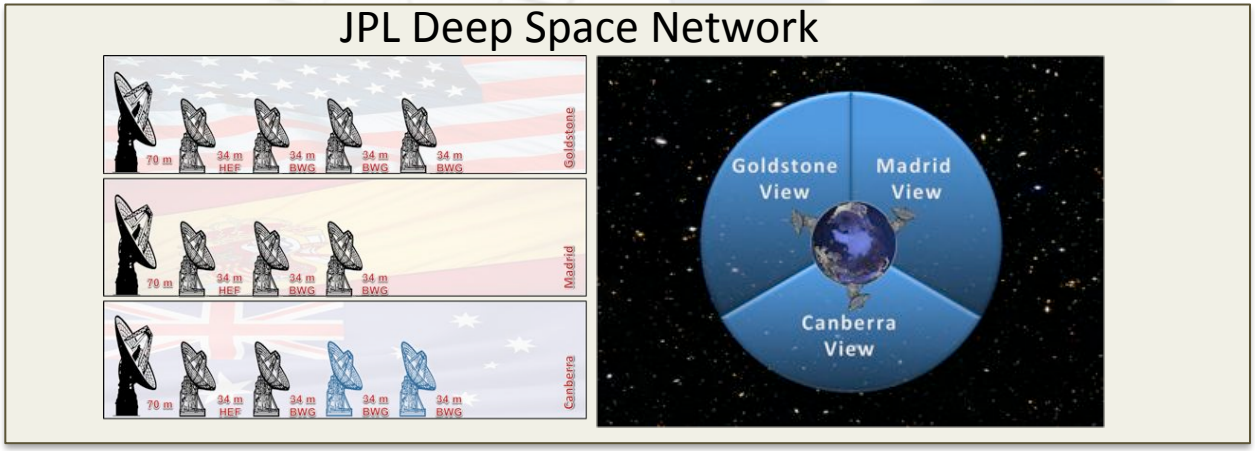
Ground segment - 1

- Deep Space Network is responsible for flight-to-ground communications
- During normal operations 4hr contact every 12 hours
  - Downlink of science and engineering data
  - Dowling of data for orbit determination
  - Uplink of commands
- Up to 458 Gigabits of Science data daily
- Level-0 processing done at DSN level prior to forwarding to S&OC



Low rate S-band up/downlink
For commands, real time telemetry and ranging

High data rage Ka-band downlink
for science and engineering data



Science and Ops Center

The JWST S&OC will be located at the Space Telescope Science Institute (STScI) in Baltimore, MD, and will perform all JWST Ops.

- Launch and commissioning are directed by a Missions Operations Team (MOT) led by NASA and NGAS, with personnel from the S&OC and instrument teams.

- During normal operations S&OC will be responsible for science and mission operations (capture, process, archive, calibrate, and distribute telemetry , science and engineering data)

More in M. Stiavelli's presentation

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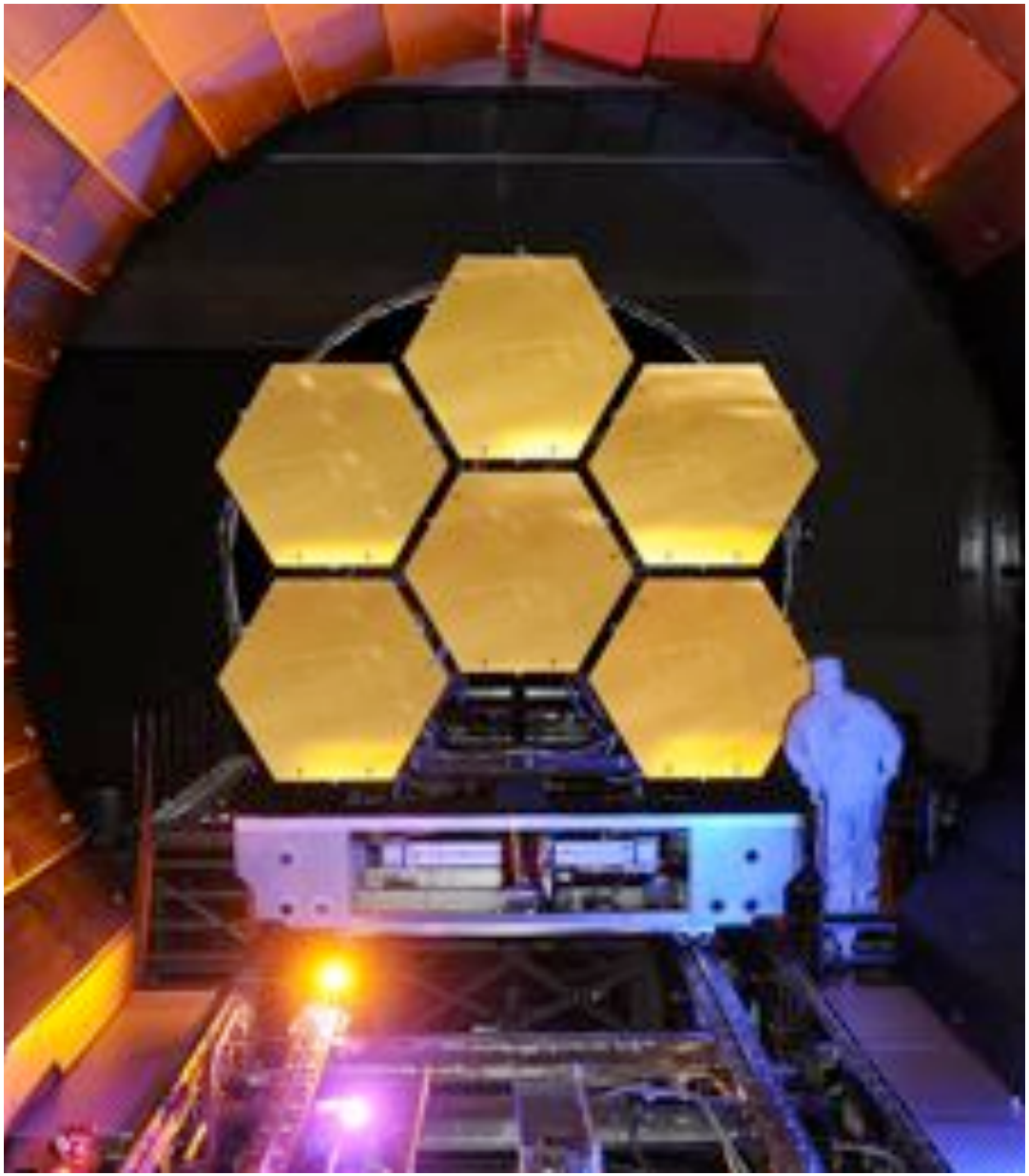
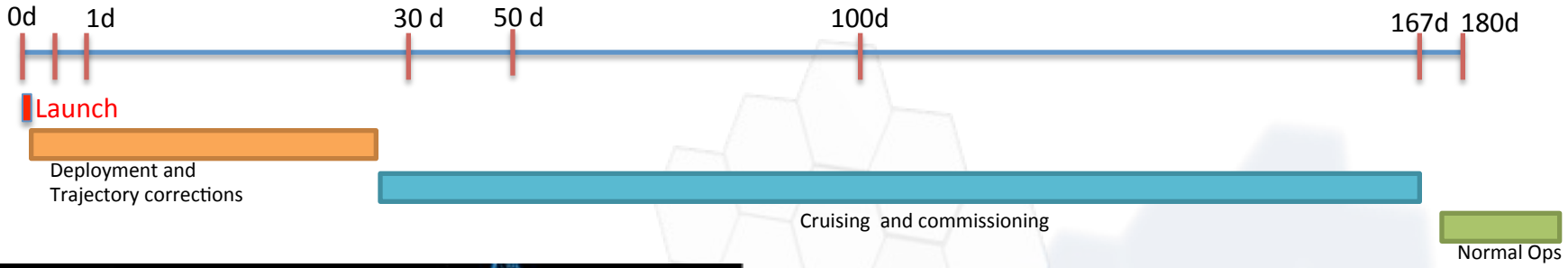
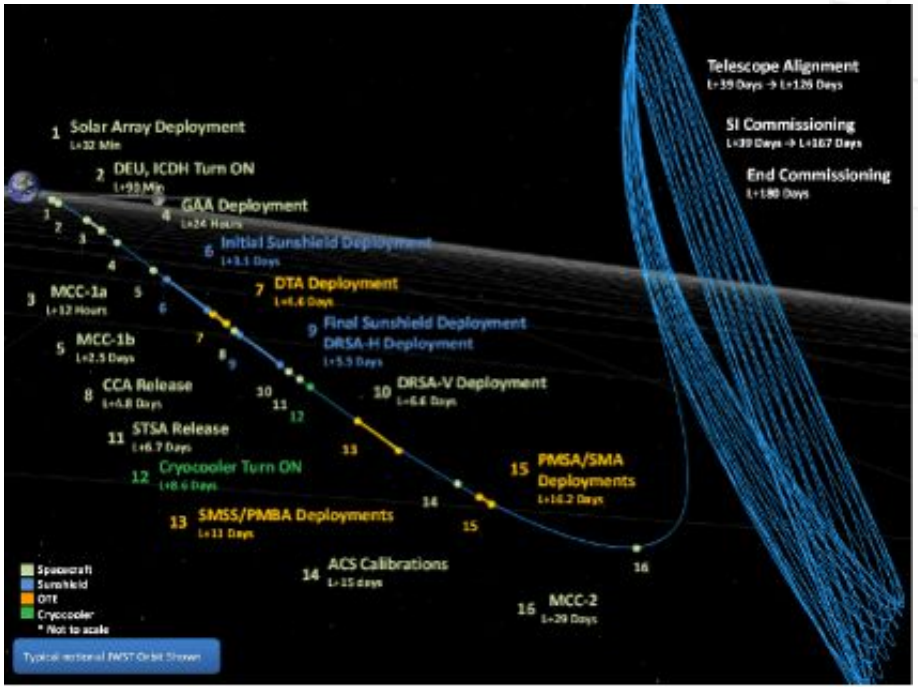


Commissioning

- Starts at liftoff and ends after successful activation, checkout and calibration of the observatory subsystems (including SI) needed to start scientific programs planned for cycle 1





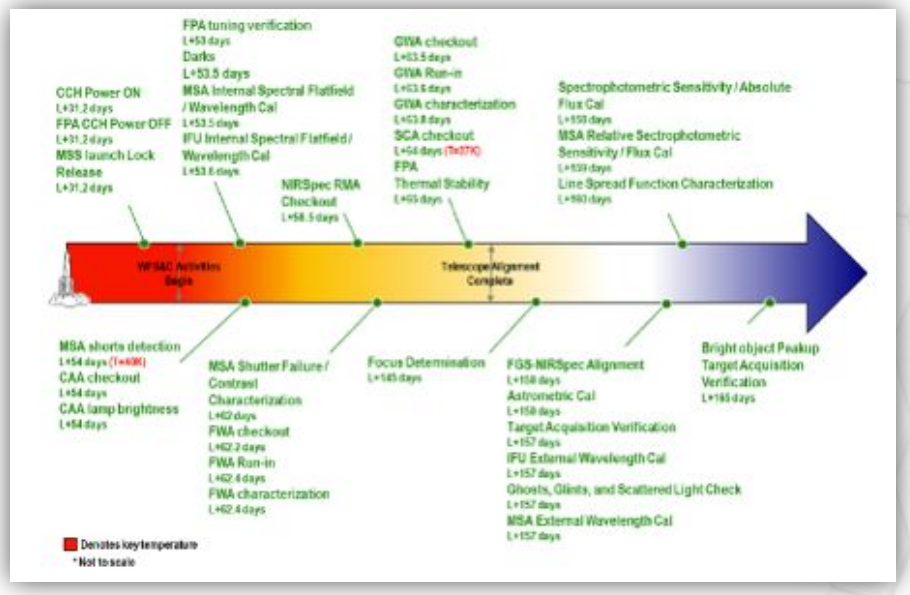
Articulate choreography of activities marked by thermal milestones.

OTE commissioning

- Iterative steps for the optical optimization
  - Wavefront sensing
  - Multi-instrument Multi-Field (MIMF) activities
- Starts in week 5 after
  - OTE thermal stabilization
  - Completion of all deployments
  - NIRCam OA < 80K and passed readiness activities
- Completes in week 19
  - Enables SI internal optics optimization and completion of readiness for science

SI commissioning

Thermal stability requirements and dependencies will dictate timing of each SI test activity



Detail planning on the content/duration/ sequencing is on going

Mission rehearsals and training exercises will start at L-18 months

Commissioning activities will smoothly transition in cycle 1 calibration activities

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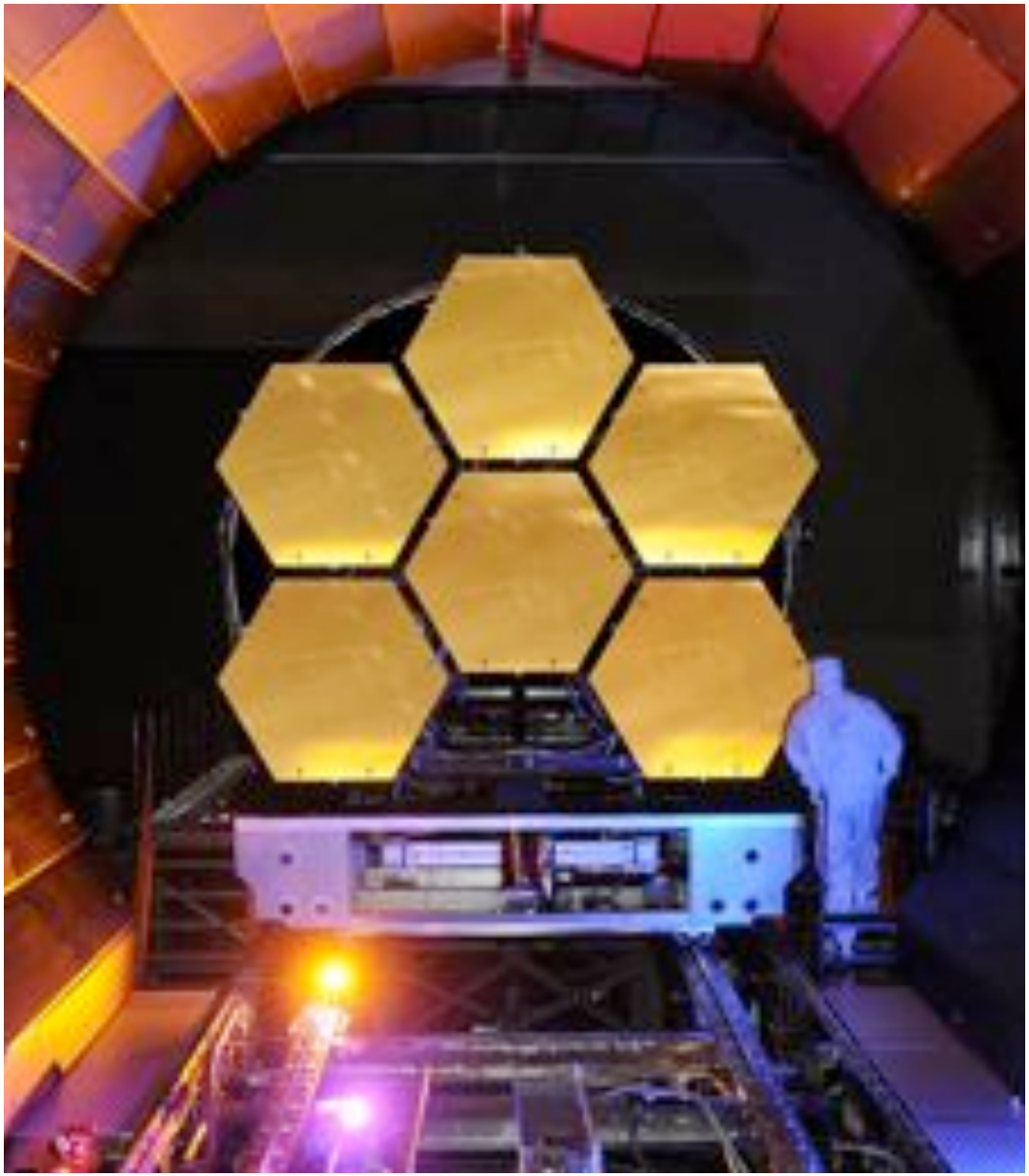

ESA support for JWST OPS

- Ariane V launch system
- ESA Tracking Network ground station in Kenya together with the NASA Space Network will follow the first several hours after launch
- Commissioning
  - Scientist and engineers in support of NIRspec and MIRI commissioning activities will be at S&OC

- Routine Operations Operations

ESA Support to JWST OPS-cont

- Agreement with NASA for 15 ESA staff at S&OC
- Dedicated support (scientists+engineers) to European contributions

- First three members of the ESA JWST Science Operation Team already at the S&OC, four more by next spring – full complement by 2017

ESA Support to JWST OPS-cont

- There will not be a dedicated center in Europe
- Possibility to have a mirror of the JWST archive at ESAC is under discussion
- We plan to have dedicated JWST workshops in ESAC from late 2016
  - Familiarization with JWST capabilities
  - Support with JWST tools
  - Data workshop after launch

Conclusions