Project Status

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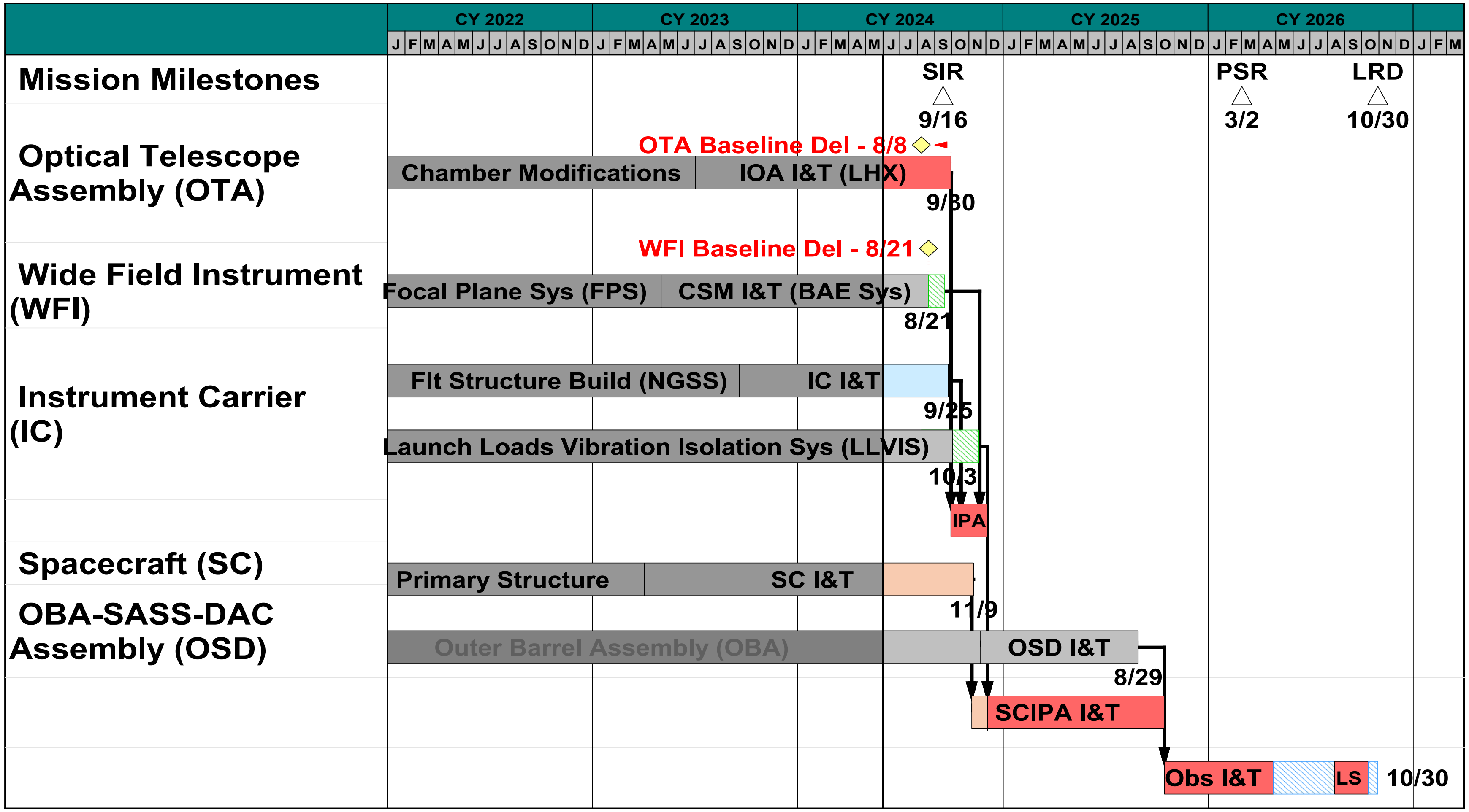
ROMAN SPACE TELESCOPE

Project Schedule

- WFI delivered to Goddard
- Passed system integration review
- Coronagraph Instrument installed in Instrument carrier
- Optical Telescope Assembly delivered to Goddard
- Spacecraft complete
- Spacecraft+payload testing begins Fall 2024
- OBA – SASS – DAC integrated Fall 2025
- Final Observatory testing thereafter



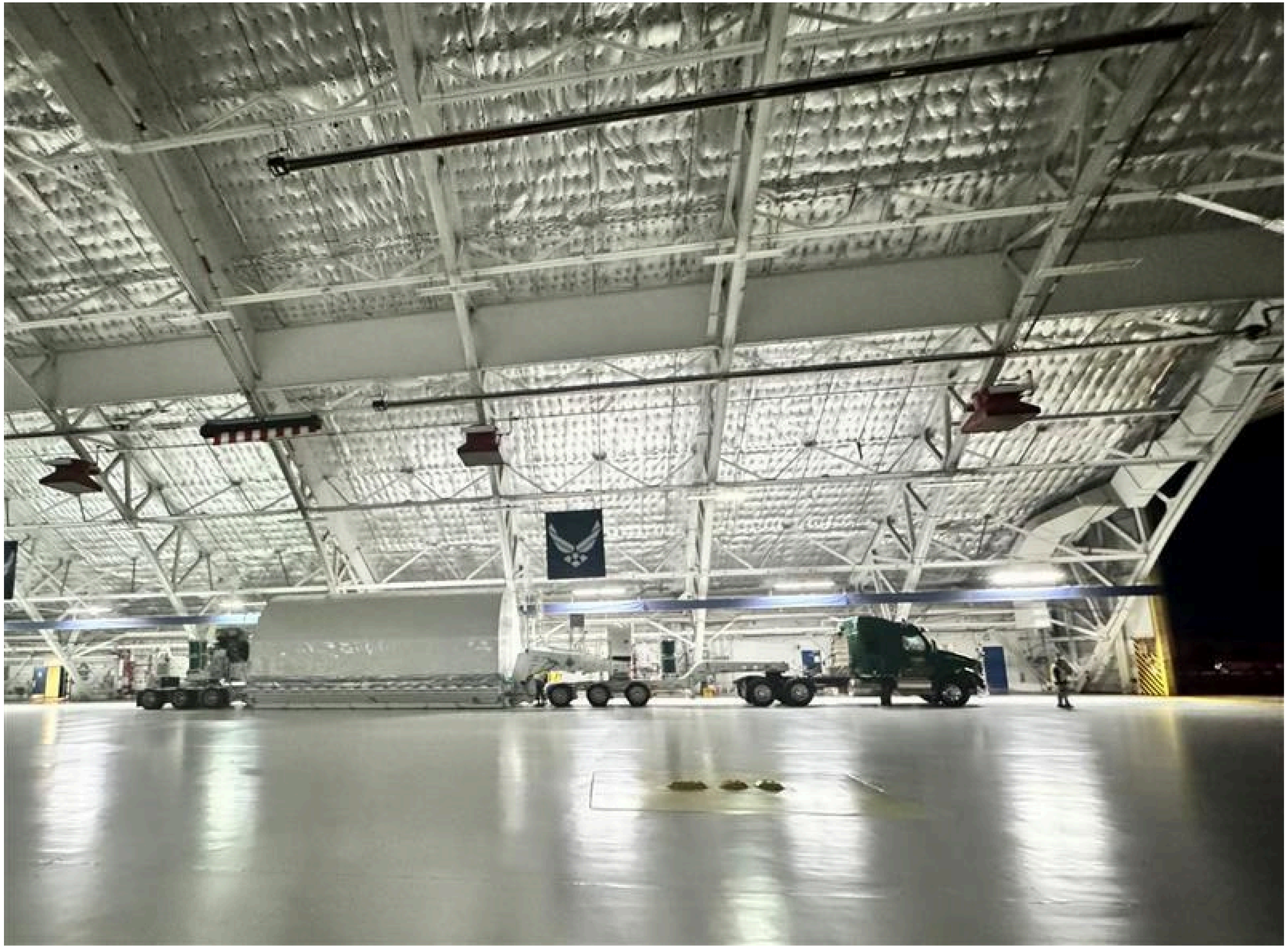
Continuing to work towards launch readiness date of October 2026

Hardware Highlights

- **Telescope at Rochester Airport**

Hardware highlights

- **Telescope at Joint Base Andrews**



Hardware Highlights

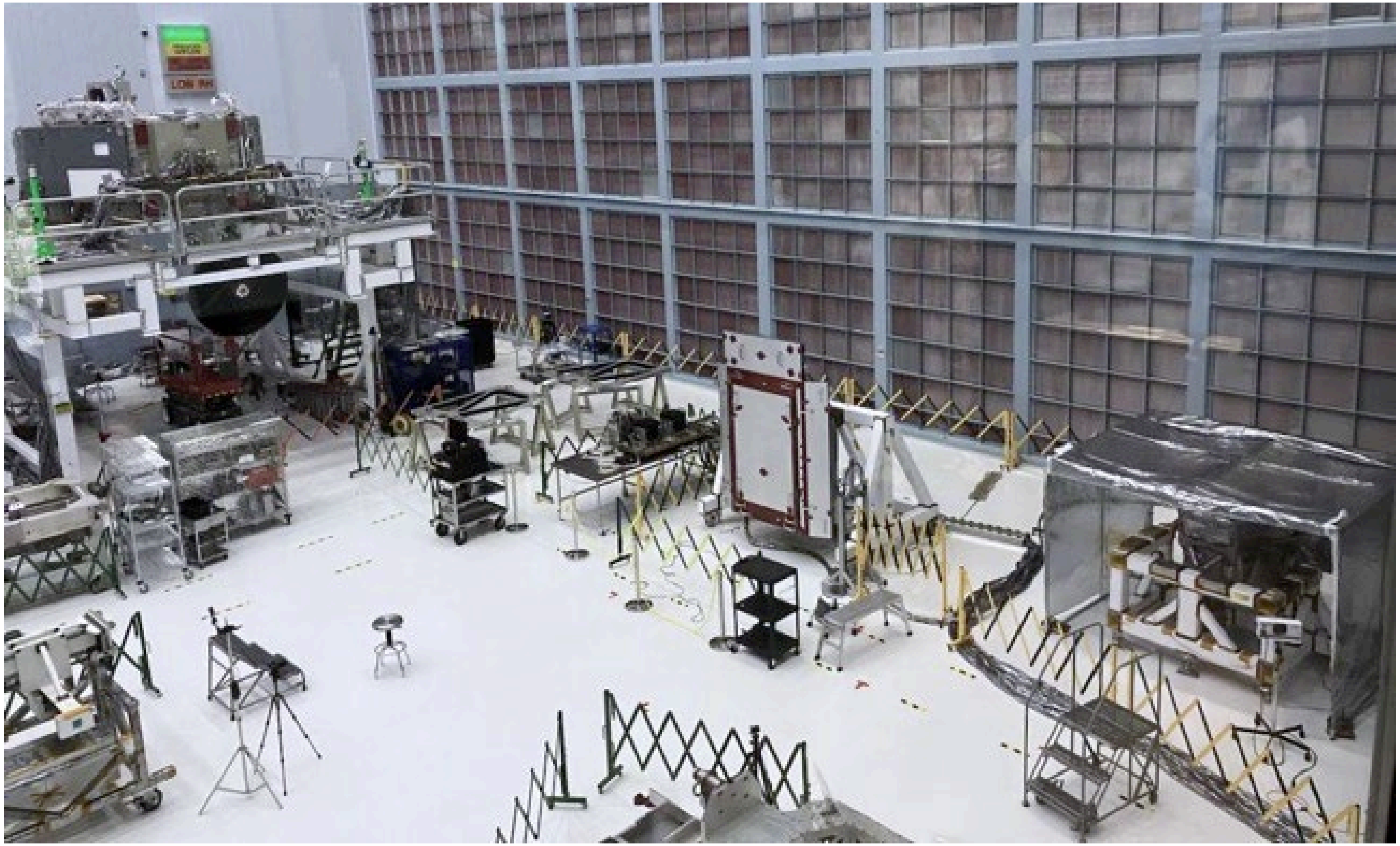
- **Telescope arriving at Goddard this morning**

Hardware Highlights

- **Coronagraph instrument installed into instrument carrier**
  - Completed metrology – confirming successful integration and alignment of Coronagraph Instrument

Hardware Highlights

- **WFI in the SSDIF after integration onto the instrument carrier simulator (center; white protective covers on radiators)**



Roman Topics for APAC meetings

- **This meeting: Ground System/science operations – status on data downlink, pipelines and data processing/reprocessing.**
  - Helpful to get APAC feedback on our plans to engage the community in the use of the science platform
  - Feedback on mechanisms to engage the community on the content of the operational pipelines and how we communicate status

- **March/June meetings: Roman Survey definition –** each of the individual survey committees will have completed their recommendations and reports and we will begin the process of merging the various options into a implementable observation plan. By March, the ROTAC will be partway through their discussions and we should be in a position to present status.

- Other topics: next Roman proposal call (deadline late 1st quarter 2025), plans for the Roman General Investigator program (deadline late 1st quarter 2026), Roman Science Collaboration

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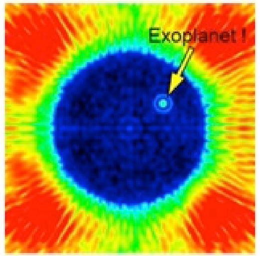
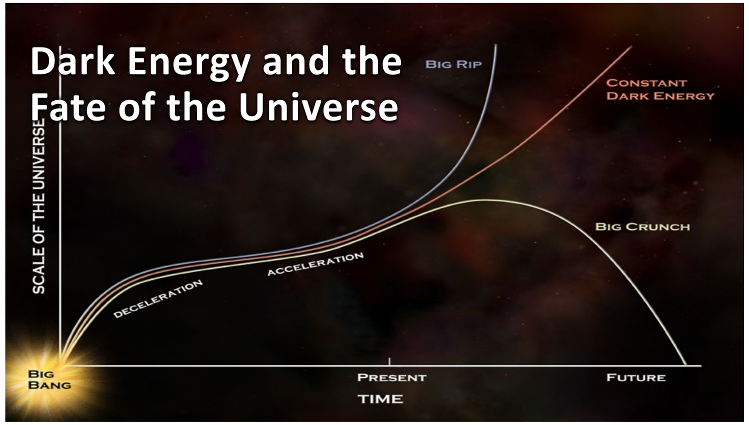
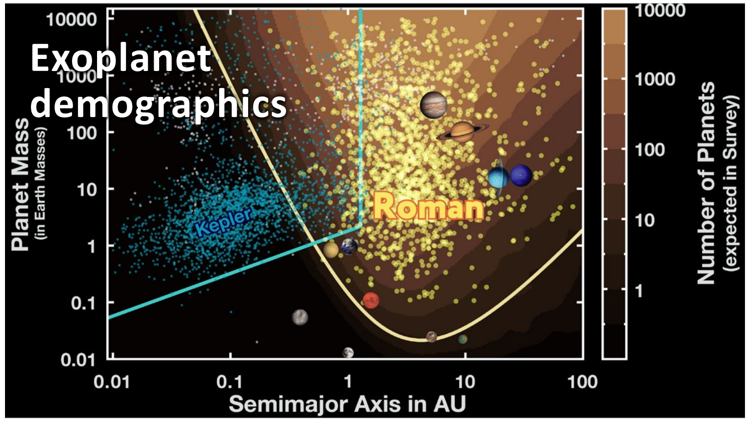
Roman Mission Objectives

- **Wide Field Infrared survey**
  - Imaging and spectroscopy to >26.5 AB mag
- **Expansion history of the Universe**
  - Using supernova, weak lensing and galaxy redshift survey techniques
- **Growth of Structure in the Universe**
  - Weak lensing, redshift space distortions and galaxy cluster techniques
- **Exoplanet Census**
  - Statistical census of exoplanets from outer habitable zone to free floating planets
- **General Astrophysics Surveys**
  - Devote substantial fraction of mission lifetime to peer reviewed program
- **Coronagraph technology demonstration**
  - Demonstrate exoplanet coronagraphy with active wavefront control





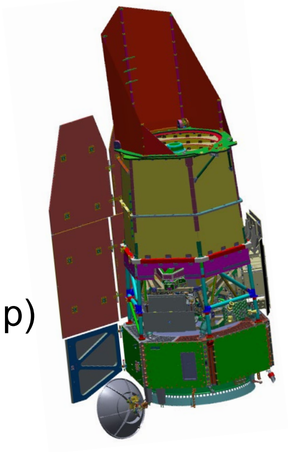


Meeting Mission Objectives

- **Roman hardware is now built, what remains to be optimized are:**
  - Observations strategy (next meeting)
  - Ground system/pipeline/calibration approach (this meeting)

Ground Elements Roles and Responsibilities

- **Ground Stations**
  - S-Band sites – Telemetry, Tracking, and Command
    - Near Space Network - White Sands 1 (WS1)
    - Deep Space Network - Canberra, Madrid, Goldstone
  - Ka-Band sites – Science data downlink, deliver to Cloud
    - Near Space Network - White Sands 1
    - European Space Agency - New Norcia, Cebreros (backup)
    - Japan Aerospace Exploration Agency - Misasa



- **Science Support Center (SSC) at IPAC**
  - WFI Microlensing, grism-prism science data pipeline processing
  - CGI operations and data management
  - Provide Data Analysis Environment for Community Participation Program/CTC
  - Roman proposal review and research awards management
  - Community engagement/outreach

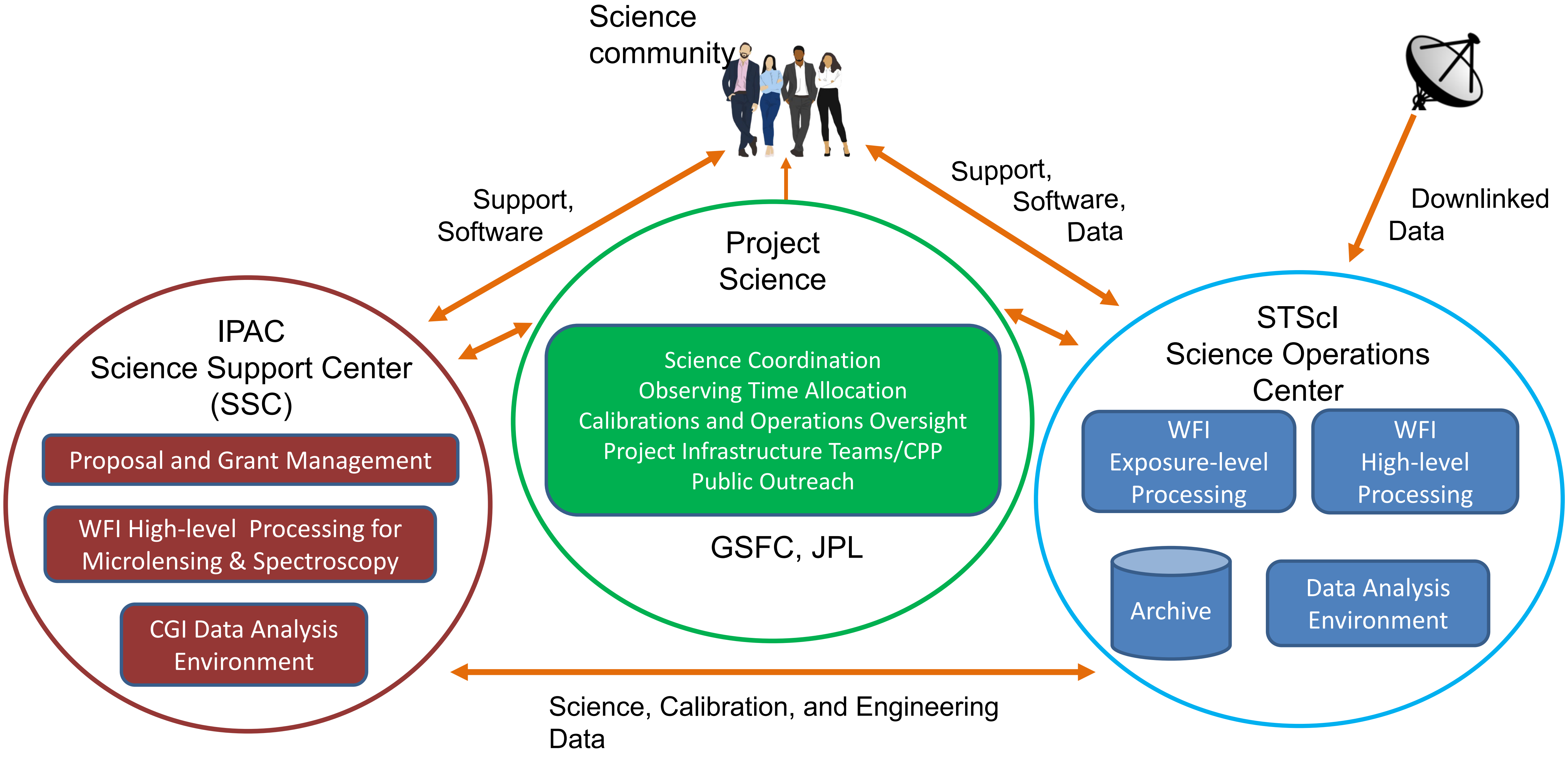
- **Coronagraph Technology Center (CTC) at JPL**
  - CGI data processing in SSC DAE
  - CGI flight software and operational testbed

- **Flight Dynamics Operations Area (FDOA) at GSFC**
  - Orbit determination, navigation, ephemeris products
  - Calibrate thruster performance, track propellant usage
  - Station acquisition data, tracking data evaluation

- **Mission Operations Center (MOC) at GSFC**
  - Observatory telemetry, command, health and safety, performance trending, and anomaly response
  - Observatory science data management
  - Ground station scheduling

- **Science Operations Center (SOC) at STScI**
  - Observation planning and scheduling
  - WFI science data processing pipeline
  - Roman Archive
  - Roman Science Platform
  - Community engagement/outreach

Science Support, Operations, and the Community



What Makes Roman Unique?

- **Roman's large surveys and associated large volumes are the defining feature of the mission**
  - Addressing the challenges in processing / reprocessing, performance choke points, etc., will be critical

- **Simple operations**
  - One instrument with two observing modes (imaging and spectroscopy)
  - Small number of observing programs (3 core community surveys and <30 General Astrophysics Surveys)

- **Most (or all) processing and archives are in the cloud**
  - May encounter challenges with new working model (e.g., resource allocation)

- **Distributed science operations**
  - Leverage the strengths
  - Communication among stakeholders is essential

Distributed Science Operations

- **Two science centers developing operational pipelines**
  - Each center is familiar with different communities
    - Roman community is broad
  - Complementary strengths/experience
    - STScI – experience with NASA flagship missions with similar detectors (and calibration needs, etc.)
    - IPAC – experience with survey missions, many missions, working in distributed science operations
  - Interfaces between science centers forces early communications about nomenclature
  - SSC/IPAC is effectively an early power user of data produced by SOC/STScI calibration pipeline
    - Acts as a pipecleaner on robustness of the L2 data/pipeline, data models, access routines, etc.

- **Project Infrastructure Teams developing pipelines/infrastructure for community use**
  - Focus on enabling science, rather than “owning” science
  - Clean boundaries ensure that no SOC/SSC requirements are dependent on PIT inputs
  - PITs drive detailed evaluation/understanding of calibration pipelines
    - E.g., Weak lensing PIT conducting detailed study of calibration systematics; Supernova PIT driving work on precise flux calibration

Project Infrastructure Teams

Project Infrastructure Teams (PITs) provide comprehensive and sustained support enabling science objectives that require long-term scientific infrastructure development

A. Develop and maintain such infrastructural tools and capabilities as are needed to address the mission objective that is the proposal’s focus;
    - PIT infrastructure focused to a specific science objective, they are not *the* survey teams

B. Support the *Roman* Project and Science Centers (the SSC and the SOC)
    - Science requirements verification
    - Evaluating calibrations, pipeline validation, survey strategies, reprocessed data quality etc

C. Support the community-led science collaboration
    - PITs enable the community to achieve ambitious Roman science objectives

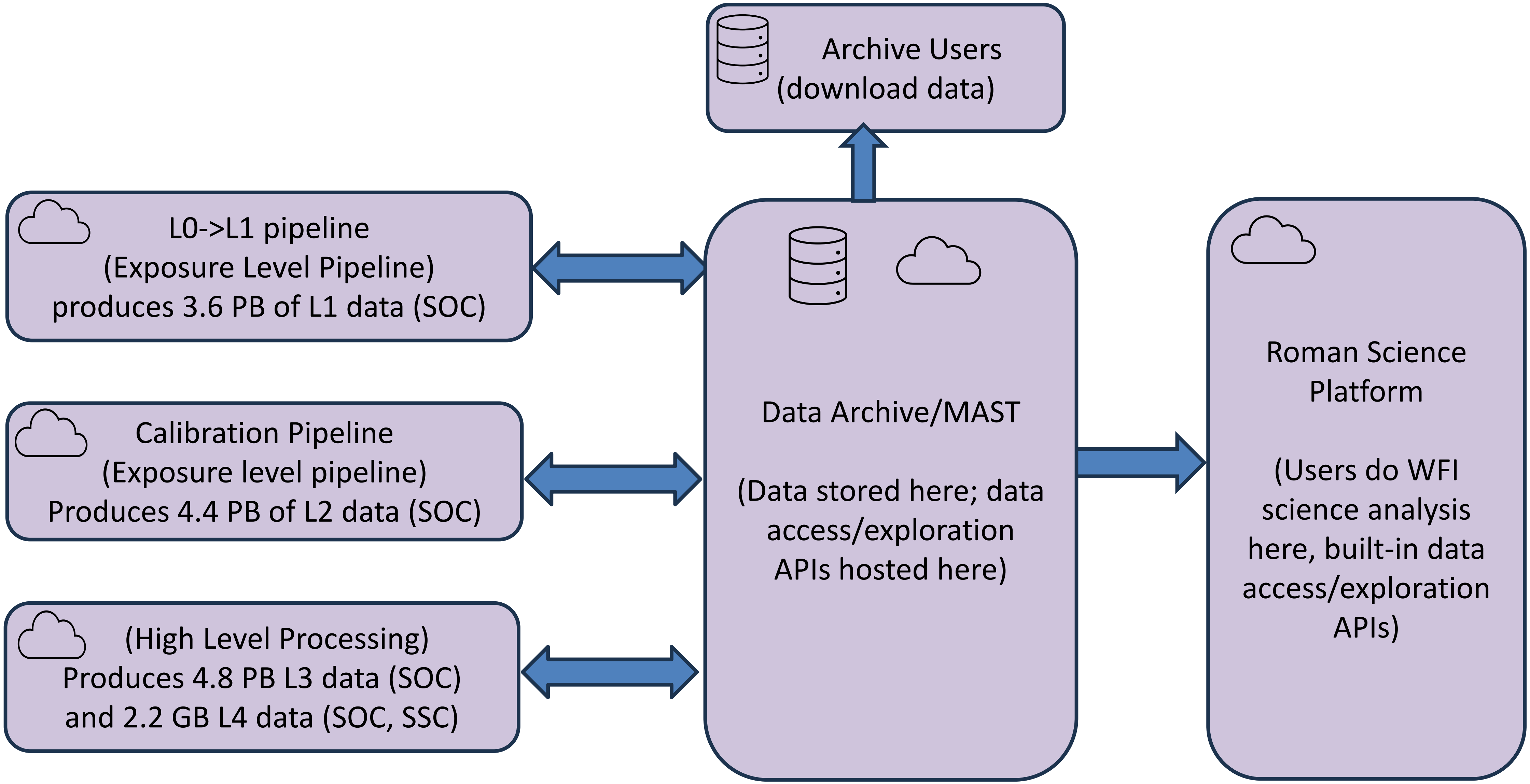
PITs are service oriented; expected to work closely with Project and science centers to ensure that the community can achieve Roman science objectives

WFI Working Groups

- Science Working Group
  - Calibration
  - Software
  - Simulations
  - Photo-Z
  - Time Domain
  - Observation Planning
  - External Synergies
  - Astrometry
  - Software Infrastructure
  - …

- Working groups are a forum for people to work together on topics/methods that cut across science areas
- Where actual work happens
- Brings together PITs, science centers, and project (but open to anyone in the community)
- Report to Project Scientist via the Science working group

Roman Data Flow



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WFI Data Level Reference

Data Level	Description	Comment	
0	**Packetized data as it arrives from the spacecraft**	Level 0 data is identical with raw packetized science telemetry as transmitted from the Observatory and received at the ground stations.	
1	**Uncalibrated "raw" individual Exposures**	Level 1 products are in the form of uncalibrated individual exposures consisting of raw pixel information formatted into the shape of the detectors.	
2	**Calibrated Individual Exposures**	Level 2 data products are corrected for instrument artifacts, with slope fitting, outlier rejection, and other procedures to obtain a true mapping of the scene flux. Calibrated exposures have appropriate astrometric and geometric distortion information attached, and with the exception of grism/prism data, are in units that have known scaling with flux.	
3	**Data Resampled to a Regularized Grid and Combined**	Level 3 products are groups of calibrated exposures resampled to a regularized grid, removing the geometric distortion of the original pixels.	
4	**Derived Data**	Level 4 products are usually focused on sources/objects rather than pixels or celestial coordinates. These can contain traditional data (such as positional, size and shape information) or complex data such as extracted spectra or postage-stamp images of the relevant source from all contributing images.	
5	**Community-Contributed Products**	Community generated data products that can be of arbitrary form and complexity. Encompass any data that is returned to the SOC for archival storage by contributing scientists or groups and may include data that could be described as any of the previous levels.	

Roman Calibration Pipeline Processing

- **Roman's data volume means that the operational pipelines have to produce the products that people need**
  - not feasible for users to generate their own.

- **Make sure the calibration pipeline is well vetted prior to launch**
  - Pipeline implemented early (already available and code is in the public domain)
  - Evaluating (and updating) pipeline using TVAC data already well underway
  - In-depth process for science validation by scientists in Roman Telescope Branch (c.f., witness testing for JWST). Focus on whether pipelines are meeting community needs/expectations in addition to requirements (this isn't a scope increase, but would flag early if we have an issue)
  - STScI scientists lead development "scrums" (this was implemented late in the JWST flow); helps developers stay in touch with science needs
  - Calibration group is long-established forum for discussing calibrations, algorithms, etc., among STScI, IPAC, science teams and project; PITs actively engage and share their analyses and evaluations
  - Calibration Workshops/peer review for in depth discussions

- **Ensure adequate resources to provide quick reprocessing turn around early in mission (and within 6 months later in mission)**
  - Transition to make L0->L2 pipeline cloud capable. This means that we pay for compute when we needed it for reprocessing (so can reprocess more quickly).
  - Computing needs/capability still evolving in good directions. Significant recent work on optimizing code for compute efficiency. By moving L0->L2 processing to the cloud, this becomes a cost (rather than schedule) saving.

High Level Processing

- **Initial implementation for high level processing pipelines at SSC/IPAC is complete**
  - Evaluating algorithms/settings, linking modules together, implementing in the cloud etc
  - VERY close working relationship between developers, IPAC scientists and selected Roman science team members

- **Initial implementation for high level processing pipelines at SOC/STScI scheduled for 2nd quarter 2025**
  - Discussions in software working group attended by SOC, SSC, project science and science community

- **Project Infrastructure teams also developing high level processing pipelines**
  - Slower start than SOC and SSC due to delays in solicitation for teams
  - Very close relationship between relevant PITs and SSC pipeline developers
  - Coordination between PITs and SOC pipelines via science quarterly, dedicated SOC reps to each PIT, and working groups
    - Note that PIT contributions are not a prerequisite for SOC/SSC pipelines/community data products
  - Coordination between PITs and science community via working groups
    - E.g., Time Domain Astrophysics working group

Top Level Coordination of Software / High Level Processing

- **From SOC - PSO tagup October 2022; planning for software group:**
  - **Major topics for FY23**
    - Mosaics, Associations & sky tessellation
    - Photometric redshifts
    - Synthetic photometry (for simulations)
    - Difference imaging
    - Data Releases
    - Basic photometry (including PSF matching)
    - Simulations (idealized & instrument signatures)
  - **Major Topics for FY24**
    - Background estimation
    - PSF photometry & PSF Library
    - Platform Resources & Performance
    - Archive User tools, API, data availability notification, performance
    - PSFs & Astrometry
    - Level 5 products
    - Shape Measurements
  - **Major Topics for FY25**
    - Engineering data relevant for PSFs

Roman Science Platform

- **Roman Science Platform:** Roman's large data volumes mean it will not be feasible for most users to download and process data. Primary interface for the community to access Roman data will be a science platform, hosted in the cloud, with a Roman software environment to make it easy for people to do Roman analysis. Need to make this fast and efficient – i.e., capability beyond current MAST baseline. Need to socialize use of the platform in the community. Development of this stalled for several years.

- **Mitigations**:
  a. Now prioritized at Roman SOC in STScI. Formed "lion" team with membership from both Roman SOC and MAST (eliminated previous siloing and getting the right expertise)
  b. Transitioned to a more rapid development model. Very close coupling between developers and scientists (including project science team representative)
  c. Later start allows incorporation of development progress/lessons learned from other science platforms (e.g. Rubin, Fornax). Separate implementation allows rapid development with timeline focused on Roman's specific needs
  d. Develop updated image viewer that is capable of managing Roman's large images with common code stack in both science platform and web-based implementations
  e. Develop updated database browser to facilitate exploration of Roman's source catalog expected to be more than a factor 50 larger than any other current astronomy source catalog
  f. Staged plan for rolling out science platform: internally, to Roman science teams, to community. Robust resources made available to implement lessons learned

Roman Science Platform

Jun 2024 — Part I: Internal verification/ validation

Fall 2024 — Part II: Selected PIT/WFS/ Community use opportunity

Jan 2025 — AAS: Demo Splinter session

Spring 2025 — Broad Community usage opportunity

Fall / Winter 2025 — Broad Community usage opportunity

Oct 2026

Phase I

Infrastructure:
- Tier definition
- Manage and modify resources allocated to tier
- Team structure: files/resources sharing

Science functionality:
- Simulate, process, visualize, and analyze L1/L2 data - Imaging
- Simulation tools in prep for proposal call
- Community simulated data

Phase II

Infrastructure:
- Tier information received from PSS
- Tier processing resource management
- Archival data retrieval and custom data processing

Science functionality:
- Simulate, process, visualize, and analyze L3 data – Imaging
- Basic spectroscopic capabilities
- APT inputs

Other:
- RSP platform name and graphic identifier

Phase III

Infrastructure:
- Platform overall storage, compute, and data access
- Batch processing (TBD)

Science functionality:
- Additional community simulated data
- Additional spectroscopic capabilities
- Implement community feedback

Other:
- Webinars
- Documentation
- Processes to request resources

Watch items

- **Every Roman user needs to access and analyze data in the cloud**
  - Large volume of data precludes routine downloads of Roman archive
  - We must inform, educate and train the community to use Roman data in this new model, so that it is natural and familiar by launch
    - This will be a major community engagement effort!
- **The calibrations and operational pipelines need to produce what users need**
  - Large data volumes preclude routine reprocessing by users
- **Roman users will make significant use of high level data products from standard pipelines (catalogs, transient alerts, lightcurves, etc.)**
  - Increasing awareness that it is as important for the community to have input into the details of the operational pipelines, as in the definition of the surveys themselves
- **Robust plans for making community/PIT contributed data easily available (especially within the Roman science platform)**
- **Coordination with other observatories (not strictly a requirement), but we'll definitely leave science on the plate if we make choices in our data processing that hampers interoperability with Rubin**

Summary

- **The defining features of a revolutionary survey mission are large data volume and sophisticated data processing and handling needs**
- **We have been proactive in identifying challenges and unique aspects of our system**
  - Implementing mitigations to address areas where performance may not meet community expectations (e.g., image viewer, pipeline extensions)
- **The distributed nature of Roman Science operations greatly reduces risk because we have savvy power users working closely with the system early**

Backup

Reprocessing and Data Releases

- **Roman is a survey mission, with a relatively small number of observing programs (3 core surveys and <30 General Astrophysics Surveys)**
  - This is quite different to JWST, which has a very diverse observing program

- **Roman takes a survey-oriented approach to reprocessing, co-adding, and cataloging different subsets of the data**
  - Prompt processing is performed as the data arrive; may not have the same calibrations/processing across the full survey
    - Data available in the archive as soon as it is processed
  - Data releases will provide the community with coherent, full datasets that are uniformly processed (i.e., this is the output of reprocessing)
    - Cadence of data releases are tied to the cadence of the surveys
    - Entire dataset (for each reprocessing) released simultaneously with a set of documentation
    - PITs will be engaged is assessing data quality while the data release is being constructed

Reprocessing Considerations

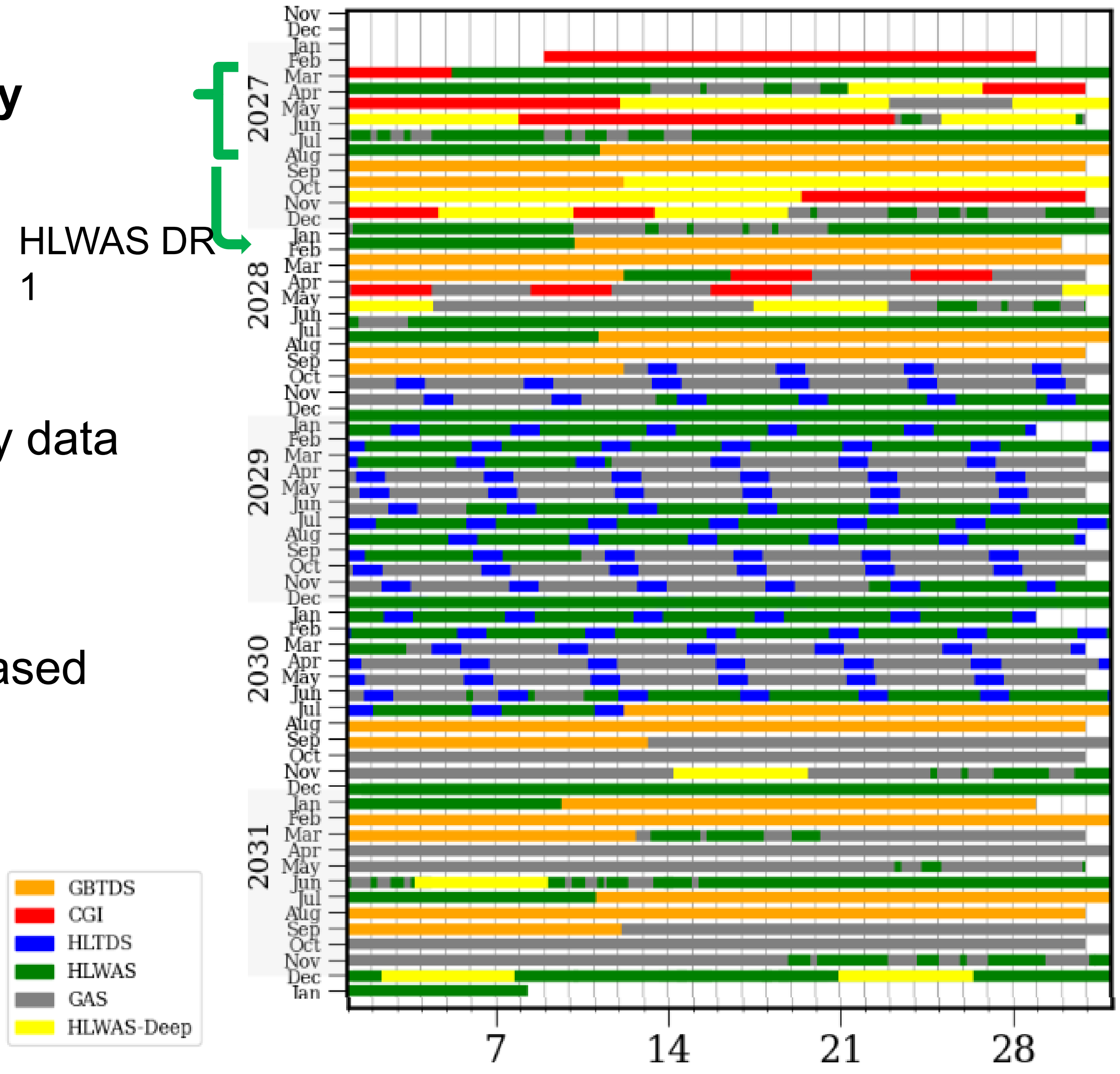
- **Early in the mission (~first year)**
  - Calibration reference files likely to evolve significantly
  - Reprocess small subsets of representative data with each calibration or pipeline change, and make available in the Roman archive
    - Calibration reference fields
    - Few fields of view from each survey
  - The baseline plan is to not reprocess the entire dataset prior to the first data release, but the capability exists to do this if needed

- **Steady State**
  - First major reprocessing will take place for the first data release
    - Requirement is that the data are reprocessed and released within 6 months of receipt of last relevant data
    - Likely released ~1 year after launch (depending on phasing of survey observations)
  - Subsequent reprocessing follows same process
    - Coherent datasets for each release will be identified and uniformly processed

Notional Observing Plan and Reprocessing

Reprocessed data releases will align with key milestones in the planned surveys

HLWAS DR 1



In the notional plan at right

- HLWAS (green) collects the first set of survey data by July 2027 (L+9 mo)
- Reprocessing may take up to the 6-month allocation in requirements
- The first reprocessed data set would be released in January 2028

Roman Observations

- **Three Core Community Surveys address the 2010 Decadal Survey science goals while providing broad scientific power**
  - **High Latitude Wide Area Survey**
    - Wide area multiband survey with slitless spectroscopy
    - Enables weak lensing and galaxy redshift cosmology mission objectives
  - **High Latitude Time Domain Survey**
    - Tiered, multiband time domain observations of 10s deg^2 at high latitudes
    - Enables Type Ia supernova cosmology mission objectives
  - **Galactic Time Domain Survey**
    - ~<15 min cadence observations over few deg^2 towards galactic bulge
    - Enables exoplanet microlensing mission objectives
- **Minimum 25% time allocated to General Astrophysics Surveys**
- **90 days for Coronagraph technology demonstration within first 18 months of mission**