THE NANCY GRACE ROMAN SPACE TELESCOPE

Surveys, Science operations and coordination

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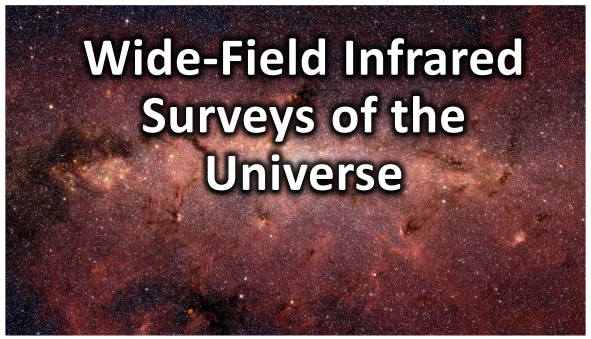
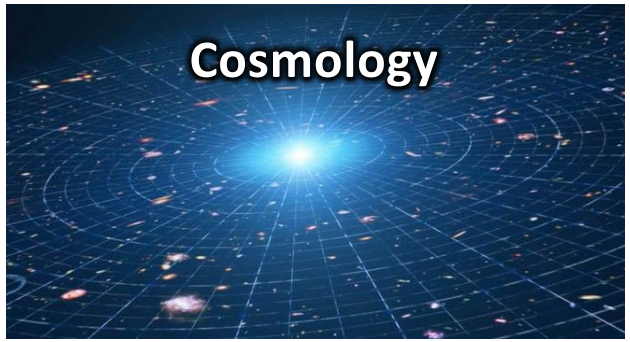
ROMAN SPACE TELESCOPE

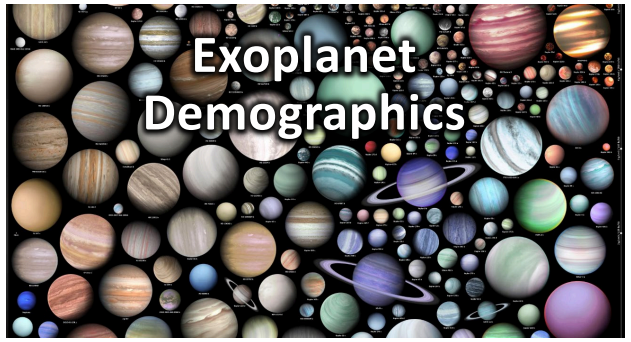
Roman in the Clean Room at Goddard

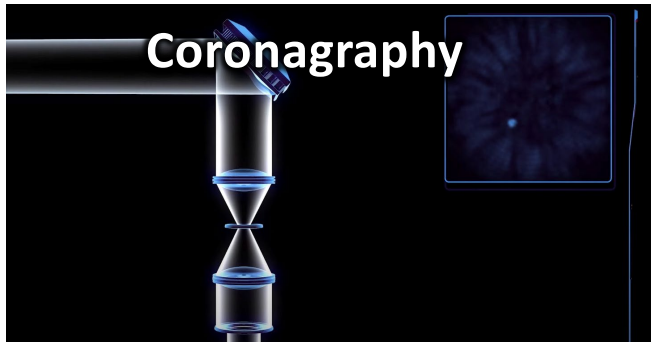
On track for launch in Fall 2026!

Roman Mission Science









- **Cosmology and exoplanet mission objectives drove technical design**
  - Wide field of view, efficient survey observations, ultrastable and precise science observations
- **General Astrophysics addressed in how we implement/execute the mission**
  - Community defined surveys and proposal-driven observing time
- **Roman is a survey mission – every observation will address many science investigations**
  - Emphasize community cooperation/engagement to maximize science return from Roman surveys
- **Roman's large data volume is a defining feature of the mission**
  - Consistent processing to produce high-quality science-ready data
  - Cloud based compute environment to bring users to the data

As-built hardware elements meet all science objectives with margin!

Roman Performance

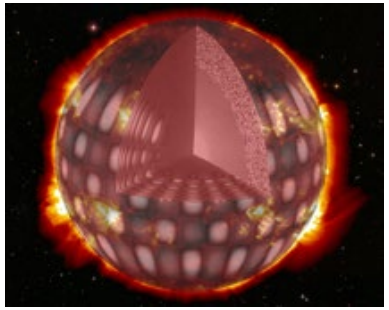
- **Slew and settle times**
  - Updated moment of inertia estimate
  - RWA thermal analysis shows we have margin with wheels operated at full torque
    - 0.54 N-m, as opposed to prior limit of 0.3 N-m.
  - Times in red are based on new estimates of observatory MOI and new power allocations to the reaction wheels

Slew type	Slew angle (deg)	Slew time (s) 6 wheels
Gap Fill	0.025	21.4 ->18.9
Short FoV	0.4	49.3 -> 40.1
Long FoV	0.8	67.4 -> 51.8
2-deg	2.0	98.7 -> 77.8
5-deg	5.0	162 -> 141
10-deg	10.0	267 -> 246
30-deg	30.0	667 -> 646
90-deg	90.0	1865 -1843

- **Throughput**
  - Had been holding 10% margin, but as-built measurements indicate that this is not necessary
- **PSF/wave front error**
  - Preliminary results show that absolute wavefront error is better than prior estimates, more importantly, stability (and thus PSF knowledge) is much better than requirements. Final results expected in a few months.
- **Pixel operability**
  - Requirement is >95%, actual performance is >99%

Roman's Core Community Surveys

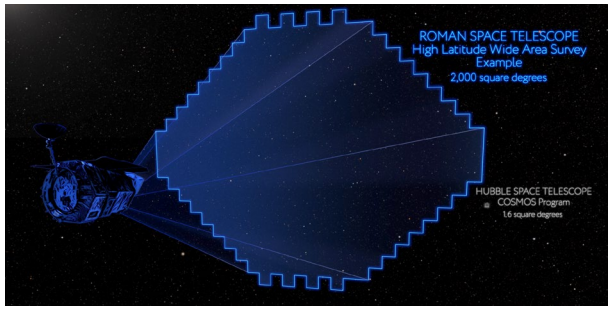
Three ambitious surveys of unprecedented scale to address key questions in Cosmology, Exoplanets and Astrophysics



Galactic Bulge Time Domain Survey: Observe ~2 sq deg towards Galactic bulge every ~15 mins. Monitor >200 million stars to discover exoplanets via the microlensing technique. Exoplanet discovery machine (~100, 000), black hole finder, groundbreaking stellar studies and more

High Latitude Time Domain Survey: Observe ~20 sq deg every ~5 days. Monitor >100, 000 galaxies to detect supernovae (and use these to map expansion history of universe). Will also find tidal disruption events, merging neutron stars, gamma-ray burst afterglows, outbursts from active galaxies and much more

High Latitude Wide Area Survey: >1700 sq deg to measure shape of >100 million galaxies in multiple colors. Precise (spectroscopic) redshifts of >10 million galaxies. Use these to study expansion history and growth of structure in the Universe. Also study everything else in that region of sky.



Observations Enable Roman Mission Objectives

- **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 of deg^2 at high latitudes
    - Enables Type Ia supernova cosmology mission objectives
  - **Galactic Bulge Time Domain Survey**
    - ~<15 min cadence observations over few deg^2 towards galactic bulge
    - Enables exoplanet microlensing mission objectives

Astrophysics with wide-field near-IR surveys

- **Baseline of minimum 25% time allocated to <30 General Astrophysics Surveys**
  - Mostly via peer reviewed proposals and some additional community defined surveys
  - Galactic Plane General Astrophysics survey currently being defined via community process

- **90 days for Coronagraph technology demonstration observations, within first 18 months of mission**

Coronagraph Instrument Observations

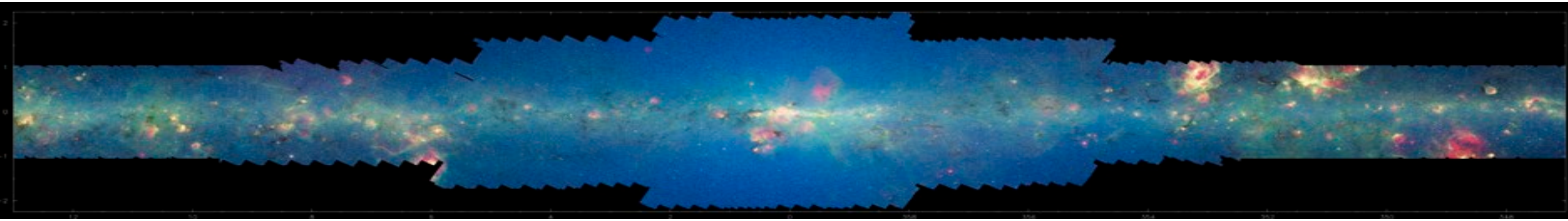
- **Coronagraph has a 3 month observing allocation within the first 18 months post commissioning**
- **Top priority: verify our L1 technical requirement (TTR5)**
  - Expect 2-3 weeks needed (15% - 30% of available time)

- **Remaining time available for expanded technology demonstration and to observe challenging targets**
  - Understanding performance limits helps HWO prep
  - Choose scientifically-interesting targets wherever possible
  - Eg: reflected light Jupiter analogs & exozodi at <10-8 contrast; complement HST/JWST debris disk studies

- **Observing program developed in a collaborative mode / with community input**
  - Community Participation Program (CPP) facilitates community engagement opportunities

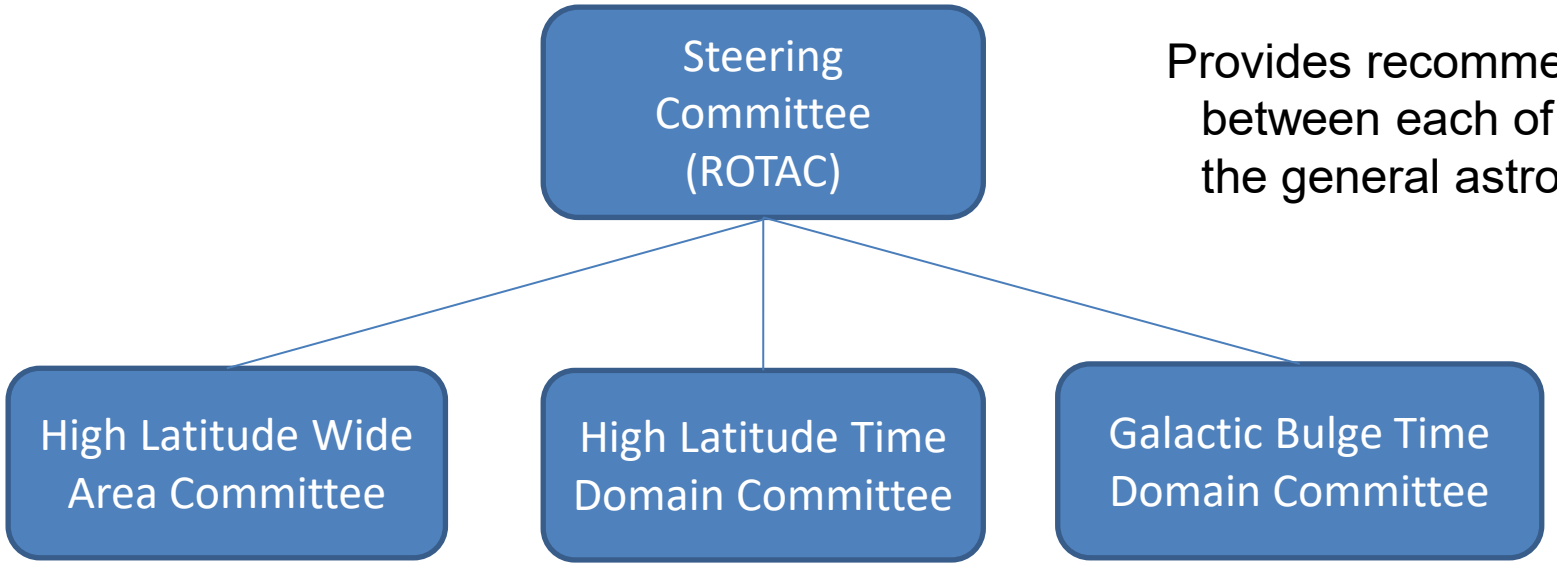
Galactic Plane General Astrophysics Survey

- In 2021 we solicited comments on (a) whether to pre-select a General Astrophysics Survey, and (b) to outline and submit survey concepts that would demonstrably benefit from early definition.
  - Evaluation committee “found that there was sufficient justification to execute an early-definition survey for the Roman telescope”. They recommended that the mission define a survey of the Galactic Plane.
- The Galactic Plane Survey Definition Committee started in September 2024, and is currently working toward generating a survey that would use up to a month of Roman General Astrophysics Survey observing time. Their report is expected in April 2025.
  - It is feasible that this survey could measure multicolor photometry for ***tens-of-billions of stars*** in the Milky Way



Community Survey Definition

- **Tiered committee structure to do the work of recommending survey definitions based on community input**
  - Optimize survey designs for overall science return, while meeting exoplanet and cosmology requirements



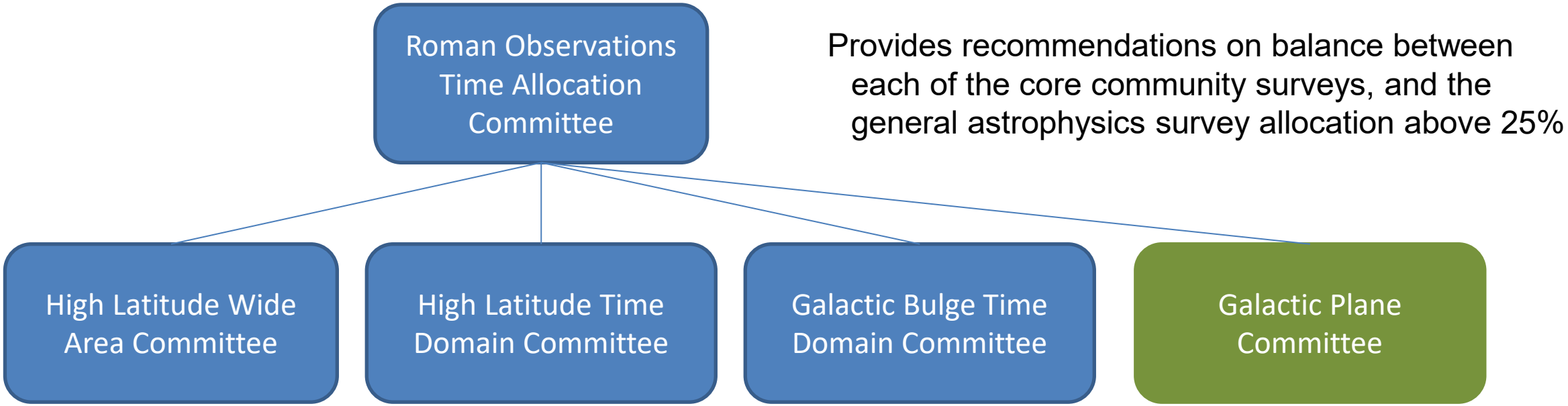
Provides recommendations to Project on balance between each of the core community surveys, and the general astrophysics survey allocation

Evaluate white papers, solicit additional community input, evaluate survey options against science metrics, produce recommendations for survey with options for enhancements/descopes

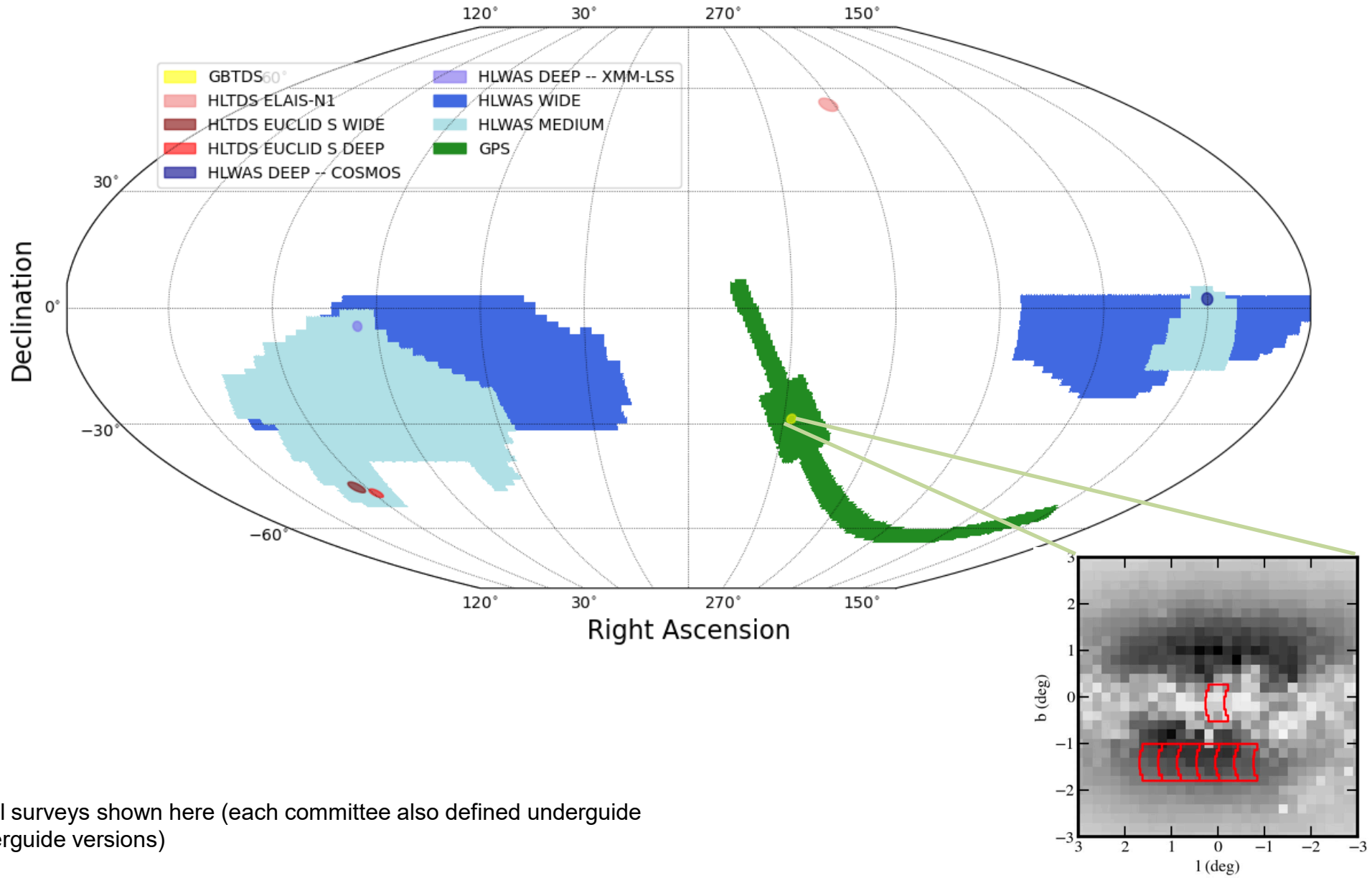
- **Survey committees completed survey designs and submitted reports to ROTAC**
  - Nominal, underguide and overguide options for each survey with associated rationale

Peer process to define and review survey plans

- **Set up and charter a tiered committee structure to do the work of recommending survey definitions based on community input**
  - Added Galactic Plane General Astrophysics Survey to the community process

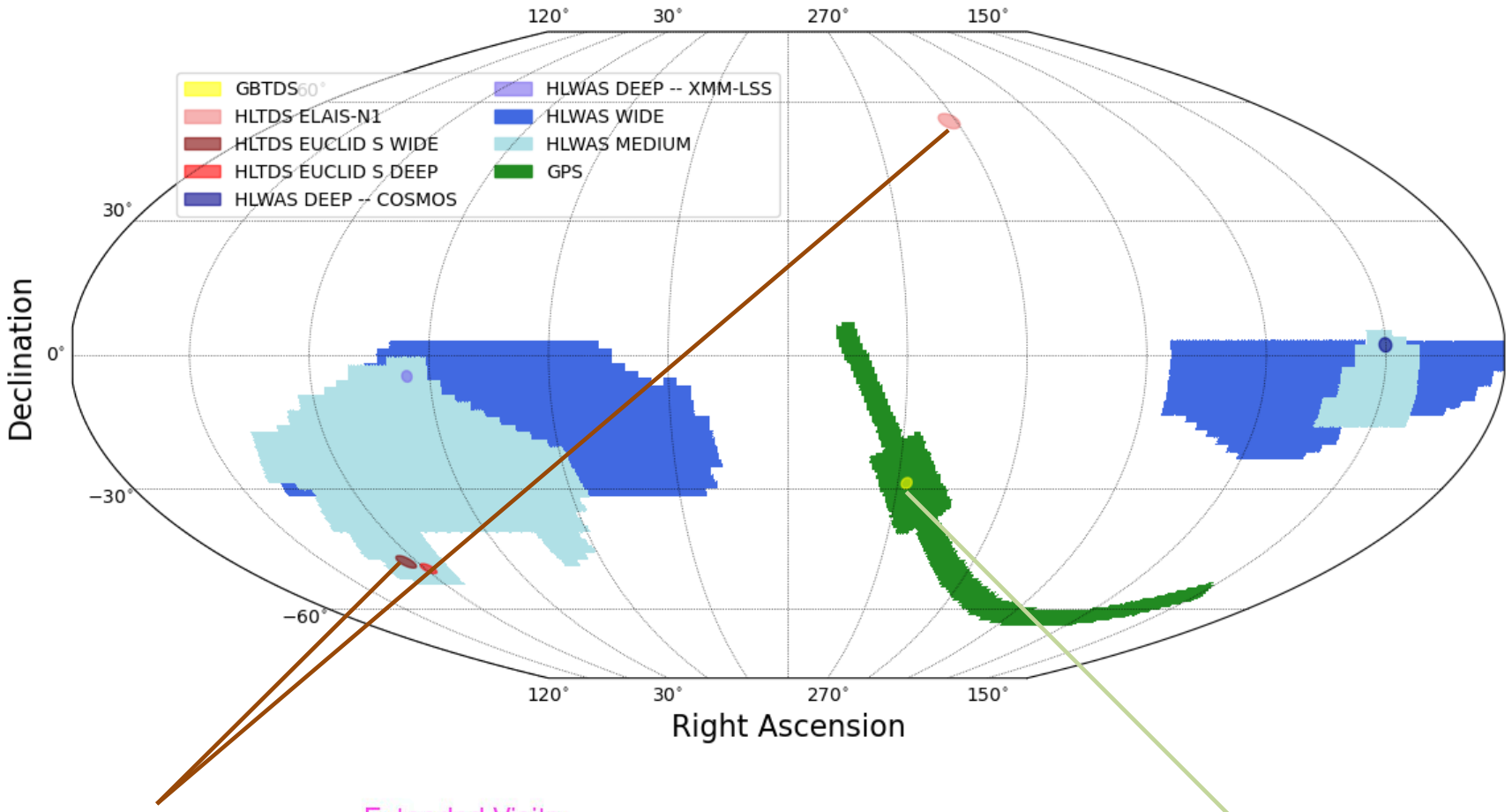


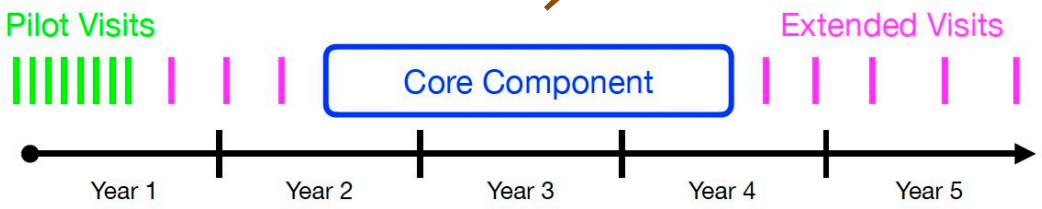
Roman Surveys



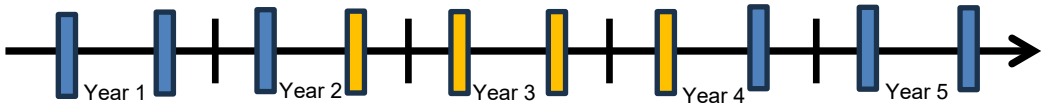
Nominal surveys shown here (each committee also defined underguide and overguide versions)

Roman Surveys – Time Domain





High Latitude Time Domain Survey



Galactic Bulge Time Domain Survey

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Broad Community Participation

Roman Observations Time Allocation Committee

- **Gail Zasowski,** University of Utah (Co-Chair)
- **Saurabh Jha,** Rutgers University (Co-Chair)
- **Laura Chomiuk,** Michigan State University
- **Xiaohui Fan,** University of Arizona
- **Ryan Hickox,** Dartmouth College
- **Dan Huber,** University of Hawaii (Manoa)
- **Eamonn Kerins,** University of Manchester
- **Chip Kobulnicky,** University of Wyoming
- **Tod Lauer,** NOIRLab
- **Masao Sako, University of Pennsylvania**
- **Alice Shapley,** University of California, Los Angeles
- **Denise Stephens,** Brigham Young University
- **David Weinberg,** The Ohio State University
- **Ben Williams,** University of Washington

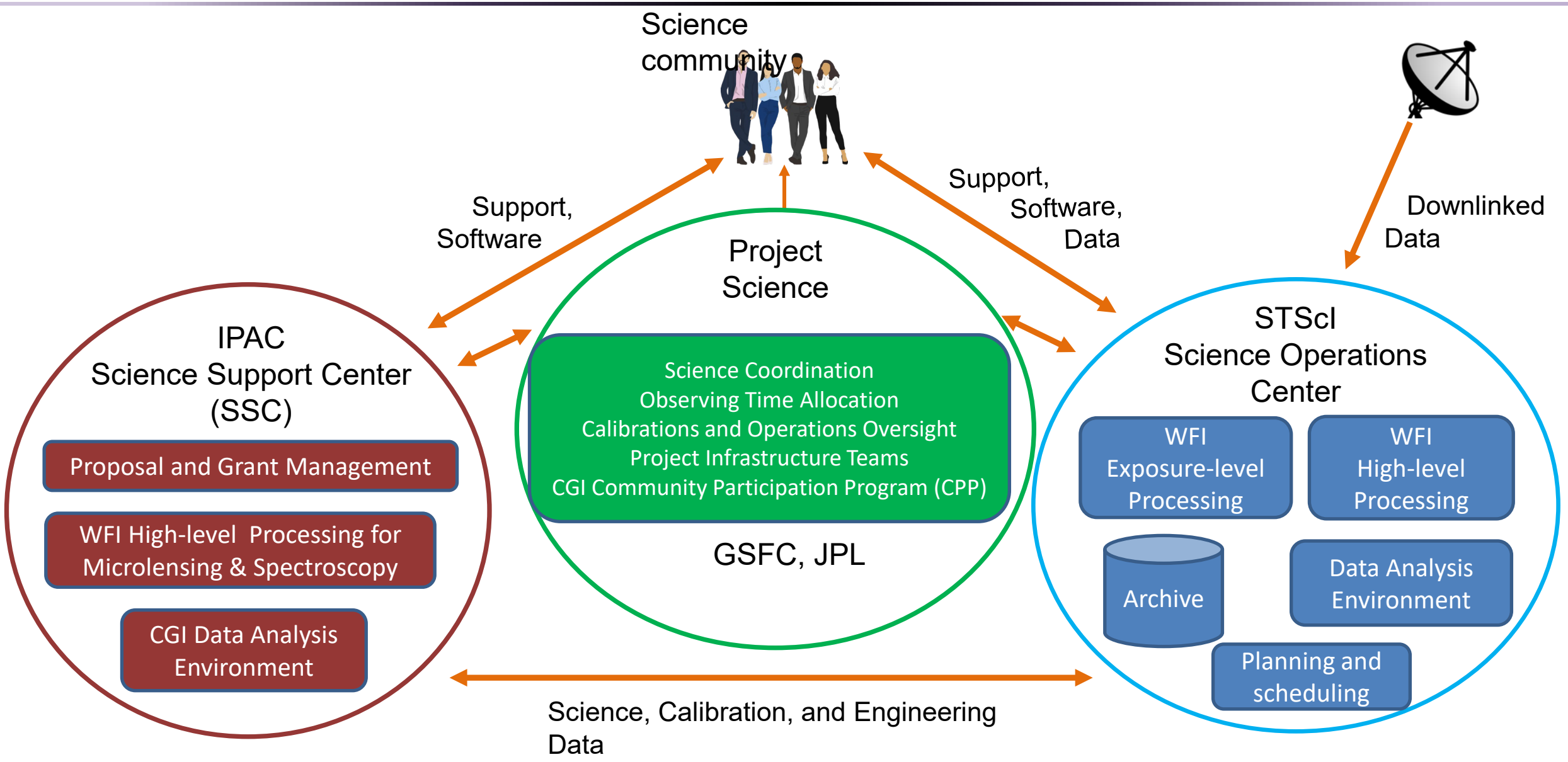
- **Global view of overall observing program**
  - 3 core community surveys – identify synergies/conflicts between the core community surveys
  - Consider science promise of General Astrophysics Survey allocation
- **Make choices between the nominal, underguide and overguide options for each survey (and/or explore additional options for each survey)**
- **Report will be released in April 2025**

What did we achieve?

- **Greatly broadened science input for each survey!**
  - Science pitches, white papers, workshops etc.
- **Survey recommendations include optimizations for astrophysics**
  - E.g., galactic center field, long temporal baseline, wide area tier
- **Considered synergies with other facilities**
  - Help make sure that surveys are complementary, and allow Roman to focus on its strengths
- **Many thanks to all the people who contributed**
  - Pitches, white papers, presentations, simulations/analysis, committees and more!
- **ROTAC is synthesizing the inputs into a recommendation for an overall mission observing plan, and will provide a final report in April 2025**

The draft CCS reports are available, along with committee presentations here:
https://asd.gsfc.nasa.gov/roman/comm_forum/

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 science 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)

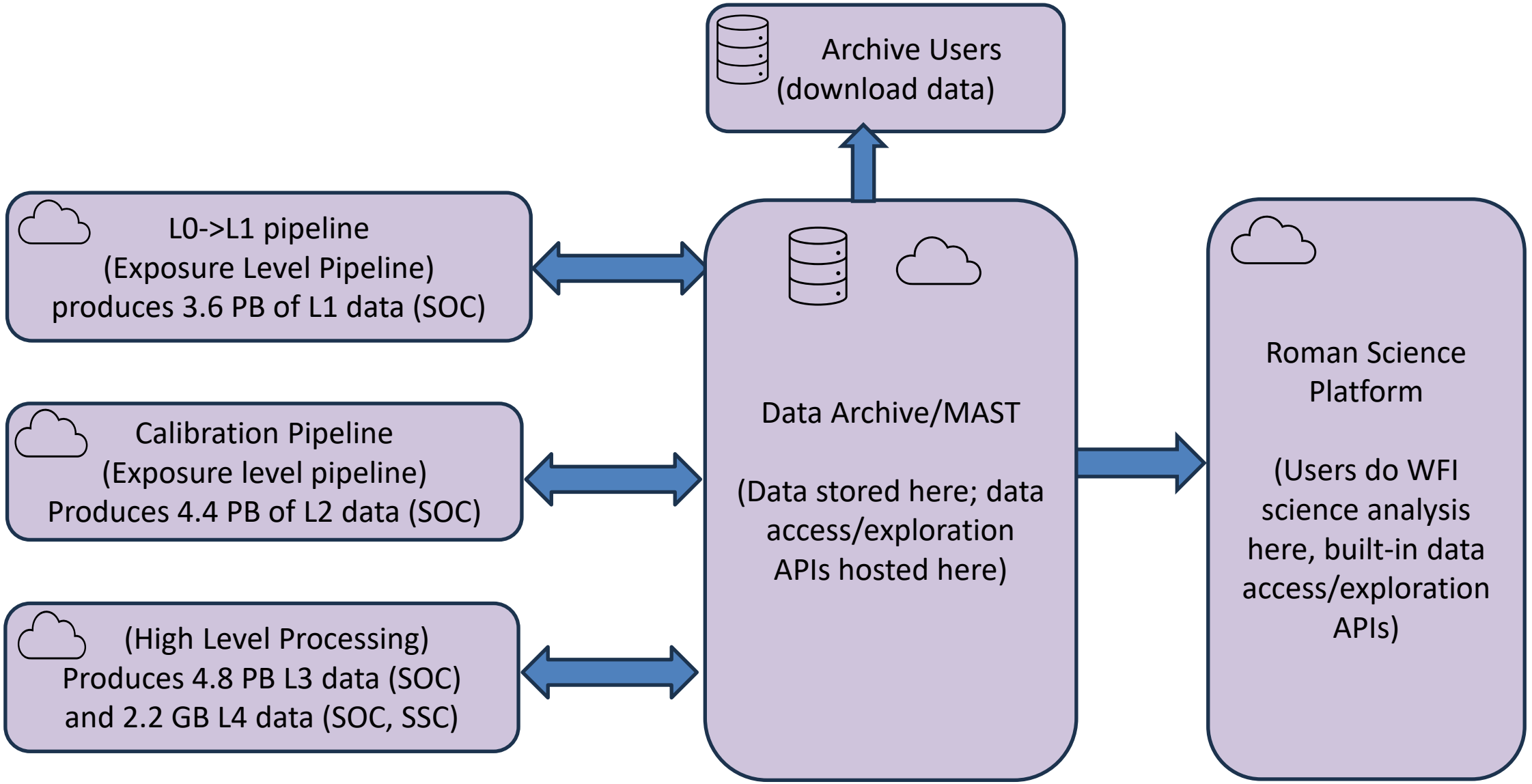
- **Distributed science operations**
  - Leverage the strengths
  - Communication among stakeholders is essential

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

Roman Data Flow



Roman Research Nexus (aka science platform)

- **Roman Research Nexus:** 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. Development of this recently accelerated.

- **Current Status**:
  a. High priority for accelerated development at Roman SOC in STScI.
  b. 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
  c. Developing updated image viewer that is capable of managing Roman's large images with common code stack in both science platform and web-based implementations
  d. Developing 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
  e. Rolling out science platform: first internally, then to Roman science teams, to community at 2025 winter and Summer AAS. Robust resources made available to implement lessons learned

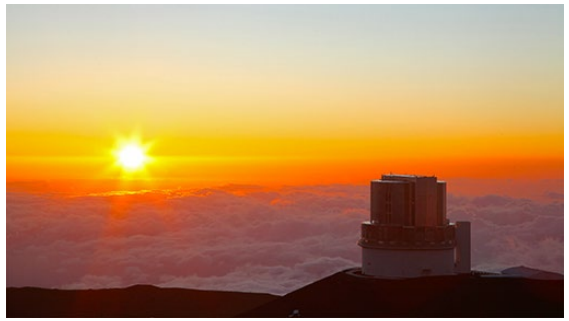
Science Operations Focus Areas

- **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**

Roman and External Synergies

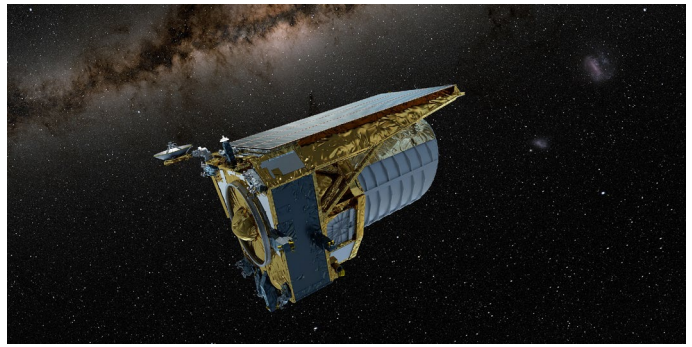
Observations with other facilities act as a multiplier for Roman science

Vera Rubin Observatory: Deep very wide area survey in visible wavebands. Extends Roman observations into the visible band. Roman provides better angular resolution images, which could improve Rubin catalogs. Pathfinder for community definition of surveys at flagship level observatories. Working on identifying datasets of joint interest



Subaru Telescope: Provides wide field optical imaging and spectroscopy. 100 nights available for Roman community as part of agreement with JAXA. Whitepaper call open now, deadline Mar 14. Community workshop in Summer 2025 to discuss selected themes for Subaru observations

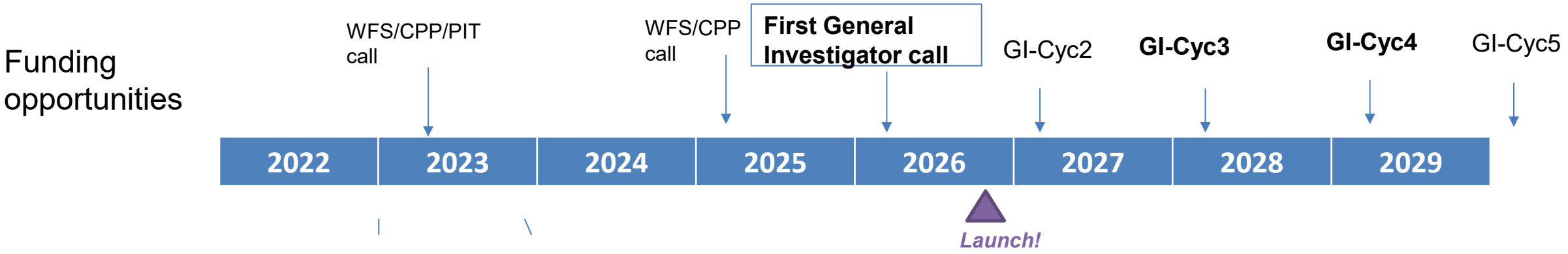
Euclid Mission: Space-based optical/near IR survey telescope. Complementary cosmology surveys. Pathfinder near-IR survey telescope at L2. Lessons learned meeting between Roman and Euclid projects. Euclid precursor observations of Roman Galactic Bulge Time Domain Survey fields will have substantial science return.



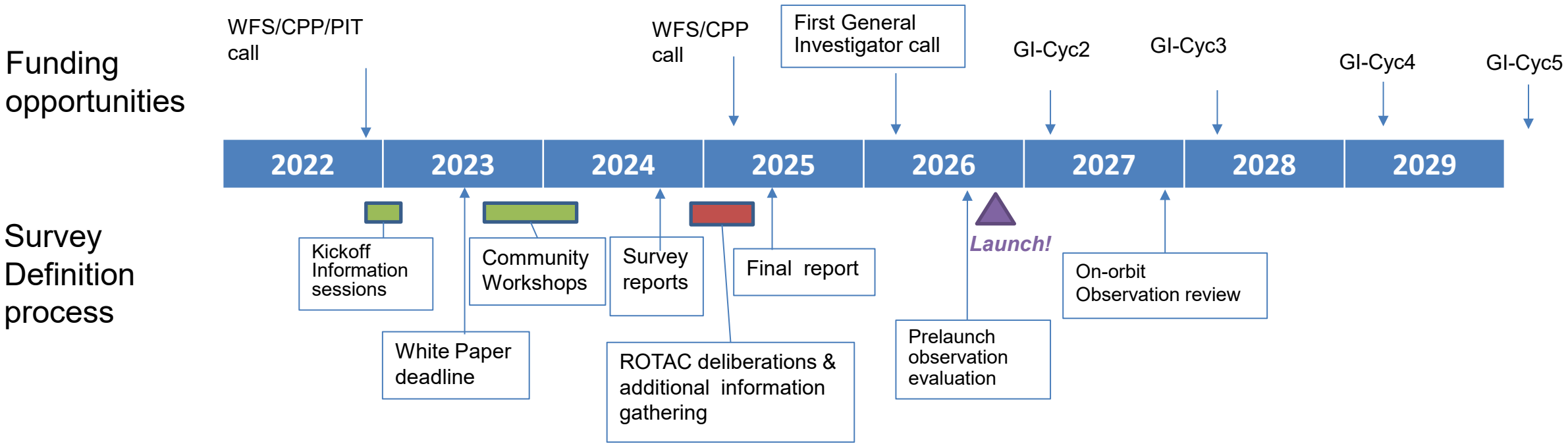
Roman Proposal Opportunities – Annual Opportunities

- **Last call was ROSES call for WFS and CPP (deadline March 6), run by NASA HQ**
  - Results will be announced this summer

- **General Investigator program starts this year**
  - Run by SSC/IPAC
  - First call for General Investigator proposals released in Sept 2025, deadline Feb/March 2026
  - GI program provides resources (funding, computing) for the analysis/exploitation of Roman Surveys (i.e. data driven proposals)
  - Calls bolded below provide an opportunity to propose for general astrophysics surveys
    - Few % of accepted Roman proposals will include observations



The Road Ahead



- **Roman progressing; remains within cost & schedule commitments**
- **For more information**
  - https://roman.gsfc.nasa.gov/engaging_with_Roman.html

Backup

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
  - Implemented lessons learned from JWST on need for close scientist engagement during pipeline development and validation. 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)
  - 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)**
  - Recent transition to make 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 processing to the cloud, this becomes a cost (rather than schedule) saving.

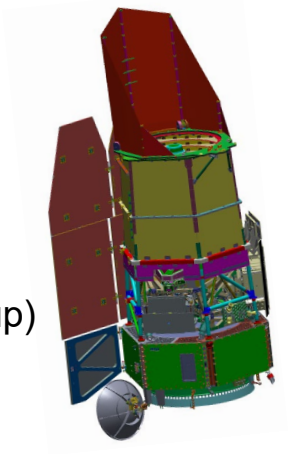
Reprocessing and Data Releases

- **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

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

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 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

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  - 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

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  - 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.

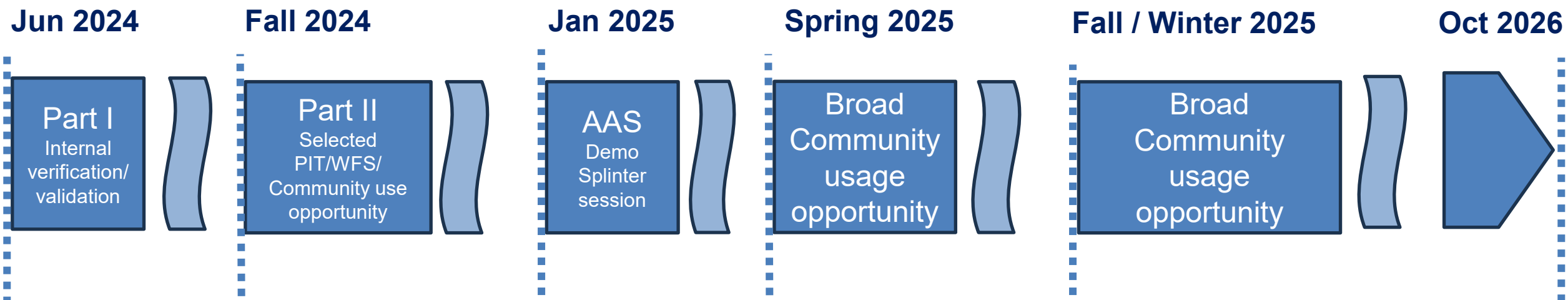
High Level Processing

- **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

Roman Science Platform



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

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

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

Phase I **Phase II** **Phase III**

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