The Roman Space Telescope Observatory Build, Test and Verification Status

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ABSTRACT

The Nancy Grace Roman Space Telescope ("Roman") was prioritized by the 2010 Decadal Survey in Astronomy and Astrophysics and is NASA's next astrophysics flagship observatory. Launching no earlier than 2026, it will conduct several wide field and time domain surveys, as well as conduct an exoplanet census. Roman's large field of view, agile survey capabilities, and excellent stability enable these objectives, yet present unique engineering and test challenges. The Roman Observatory comprises a Spacecraft and the Integrated Payload Assembly (IPA), the latter of which includes the Optical Telescope Assembly (OTA), the primary science Wide Field Instrument, a technology demonstration Coronagraph Instrument, and the Instrument Carrier, which meters the OTA to each instrument. The Spacecraft supports the IPA and includes the Bus, Solar Array Sun Shield, Outer Barrel Assembly, and Deployable Aperture Cover. It provides all required power, command handling, attitude control, communications, data storage, and stable thermal control functions as well as shading and straylight protection across the entire field of regard. This paper presents the Observatory as it begins integration and test, as well as describes key test and verification activities.

Keywords: Roman Space Telescope, Space Observatory, Astrophysics, Infrared Missions

1. INTRODUCTION AND SCIENCE MOTIVATION

The Roman Space Telescope (Roman)[1,2] is NASA's next flagship mission responding to the 2010 National Research Council New Worlds, New Horizons (NWNH) Astronomy and Astrophysics Decadal Survey.[3] It was the top priority recommendation in the large space mission category. Roman is dedicated to answering questions about dark energy and exoplanet exploration, and includes a substantial General Observer program to enable astrophysics programs. The mission also includes the Coronagraph Instrument (CGI) to demonstrate and advance the state of the art of coronagraph technology.

The expansion of the universe is accelerating and Roman is designed to answer two specific questions in cosmology: is this acceleration driven by a new energy component or by a deviation of general relativity on large cosmological scales? If there is a new energy component is the energy density of this component constant in space and time or has it evolved along with the universe? Roman is conceived from the ground up as a survey mission to answer these questions.

Dark energy drives the expansion history of the universe and is imprinted on the structure of the universe. The small perturbations in the cosmic microwave background (CMB) gave rise to the structure we see today (galaxies, clusters of galaxies, and large scale structure) and the growth of this structure was governed by dark energy. Roman will measure the expansion history and growth of structure via multiple independent techniques:

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- Type Ia Supernovae: Roman will find and characterize thousands of Type 1a Supernovae allowing us to measure the expansion rate of the universe. Using the combination of the SNIa luminosity function and redshift measurements will enable the direct evaluation of the distance-redshift relation from redshift 0.2 to 1.7 and higher.
- Baryon Acoustic Oscillations: Roman will map out the positions of and distances to millions of galaxies in our local universe. The distribution of energy and matter in the early universe is encoded in the perturbations observed in Cosmic Microwave Background (CMB) radiation. Mapping the spatial distribution of galaxies over cosmological time will reveal the role that dark energy has played in defining the large-scale structures observed in the universe today. Roman will perform a census of the baryons in the local universe over a large area of sky from z=1-to-2, which is enabled by the observatory's unique design and orbit about the second Lagrange point.
- Redshift Space Distortions: The measurement of the three dimensional galaxy distribution gives a handle on the growth of structure in the universe. The imprint of local velocities on galaxies is due to the large scale flows due to large scale structure (and an additional random component). By measuring the overall difference between the redshift and real space measurements we can add a lever arm in measuring the effect of dark energy on structure formation.
- Weak Gravitational Lensing: The measurement of shear of galaxies will provide a measurement of the clustering of matter between the observer and the lensed galaxies. These measurements give a handle on the understanding of the expansion history of the universe that can be compared to the SN1a and BAO measurements.

Understanding the distribution of exoplanet masses and orbital distances allows us to understand the evolution of planets in general. Roman will advance this study in two ways:

- Study the demographics of planets via the Galactic Bulge Survey
- Provide a detailed characterization of nearby exoplanets via the CGI technology demonstration.

Roman will complete the statistical census of planetary systems begun by Kepler. It is sensitive to analogs of all of the planets in our Solar System with the mass of Mars or greater. Roman will complete a survey of planets with separations from the outer habitable zone to free floating planets.

2. MISSION AND OBSERVATORY DESCRIPTION

Roman is designed to execute highly efficient surveys[4] and to provide the necessary data to answer the questions posed in §1. Roman's spacecraft (§2.1) provides a very stable platform with low jitter and the capability to slew and settle efficiently. The Instrument Carrier (IC, §2.1) holds the instruments in alignment with the telescope and provides thermal and mechanical isolation from the spacecraft. The Optical Telescope Assembly (OTA, §2.2) includes a large 2.4 m diameter mirror and focuses the light into the two instruments. The Wide Field Instrument (WFI, §2.3) allows the wide field imaging and multi object spectroscopic abilities to do the surveys. The roman coronagraph instrument (CGI, §2.4) will be the first coronagraph in space with active wavefront control and will demonstrate the on-orbit coronagraphy capabilities needed for the next generation of missions. Throughout the process, significant attention was given to understanding the observatory and the instruments in terms of systematic errors and characterization of the full system, especially on the optical performance (see, for example, §3.1). The Roman mission will be in a quasi-halo orbit at L2 providing thermal stability and year-round observing. The mission is in integration and test (§3) and will launch no later than 2026 (§5)

To accomplish these science goals of understanding dark energy and exoplanets, several key surveys have been identified. While these surveys have a specific science goal in mind, the general astrophysics capability of these data sets will also be very impactful. The design of the Roman observatory enables efficient NIR surveys, typically 1000 times faster than Hubble depending on the nature of the survey. The information on the surveys discussed below are notional and are currently being reconsidered through a community process. More

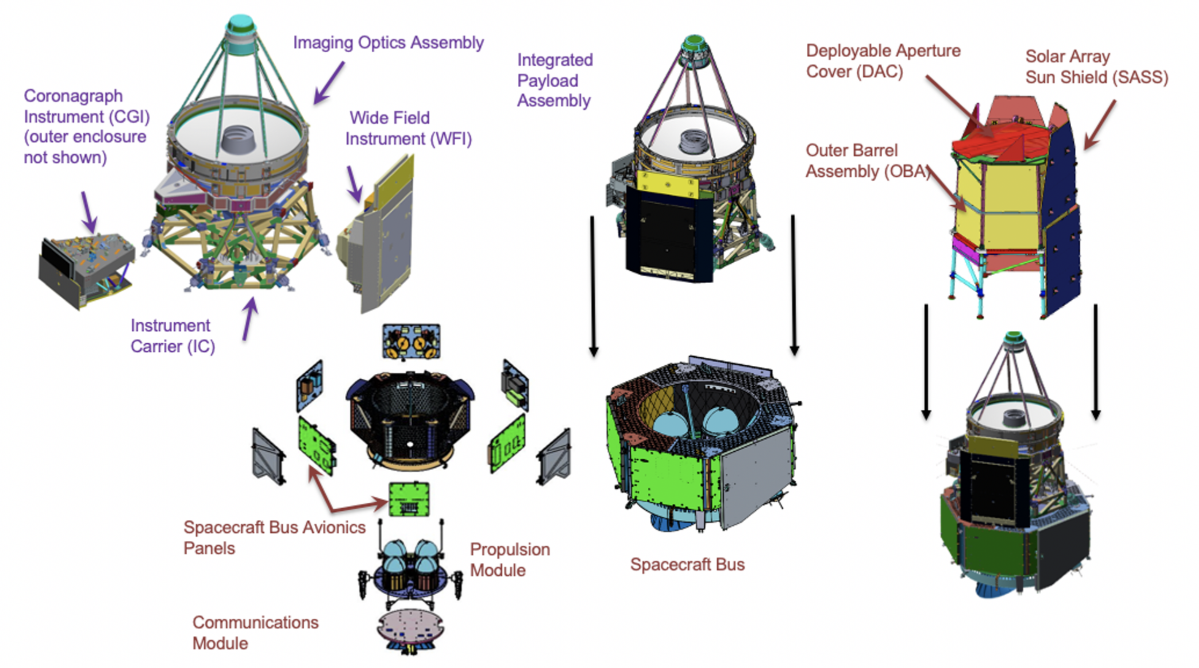

Figure 1. This diagram of the Roman Observatory shows its major components. The mission is designed from the ground up to exectue efficient surveys to answer outstanding questions about dark energy and exoplanets.

information on this process and Roman's core community surveys can be found at `https://roman.gsfc.nasa.gov/science/core_community_survey_definition.html`.

- High Latitude Wide Area Survey: Aimed at the science goals of BAO, Redshift Space Distortions, and Weak lensing, this 1.5-year survey will cover approximately 2,000 square degrees of the sky with imaging in the NIR bands: F106 (Y), F129 (J), F158 (H), and F184, with a depth of roughly $J = 26.7$ AB, and low-resolution (grism) spectroscopy (15 million sources at redshift 1.1 to 2.8).
- High Latitude Time Domain Survey: Aimed at finding and characterizing Type 1a Supernova, this 0.5 year survey includes both imaging and slitless spectroscopy. The preliminary survey design includes two tiers: wide and deep at a high cadence.
- Galactic Bulge Time Domain Survey: Aimed at finding and characterizing planets, this 1.15 year survey is intended to observe multiple fields in the Milky Way's bulge. The preliminary survey design included high-cadence (every ~ 15 minutes) imaging of these fields over six contiguous 72-day seasons. This design is expected to create highly sampled light curves of 56 million stars brighter than $H = 21.6$ (AB). This sample is expected to yield the discovery of over 2000 bound planets in the range 0.1–1,000 Earth masses and orbital major axes from 0.03 to 30 AU through their microlensing signature. In addition, the survey is expected to enable the detection of about 20,000 giant planets in short-period orbits from their transit signature.

2.1 Spacecraft and Instrument Carrier

The Spacecraft portion of the Roman Observatory consists of the Spacecraft bus, the Star Tracker (ST)/Inertial Reference Unit (IRU) assembly, and the Outer Barrel Assembly (OBA), Solar Array Sun Shield (SASS), and Deployable Aperture Cover (DAC) assembly.

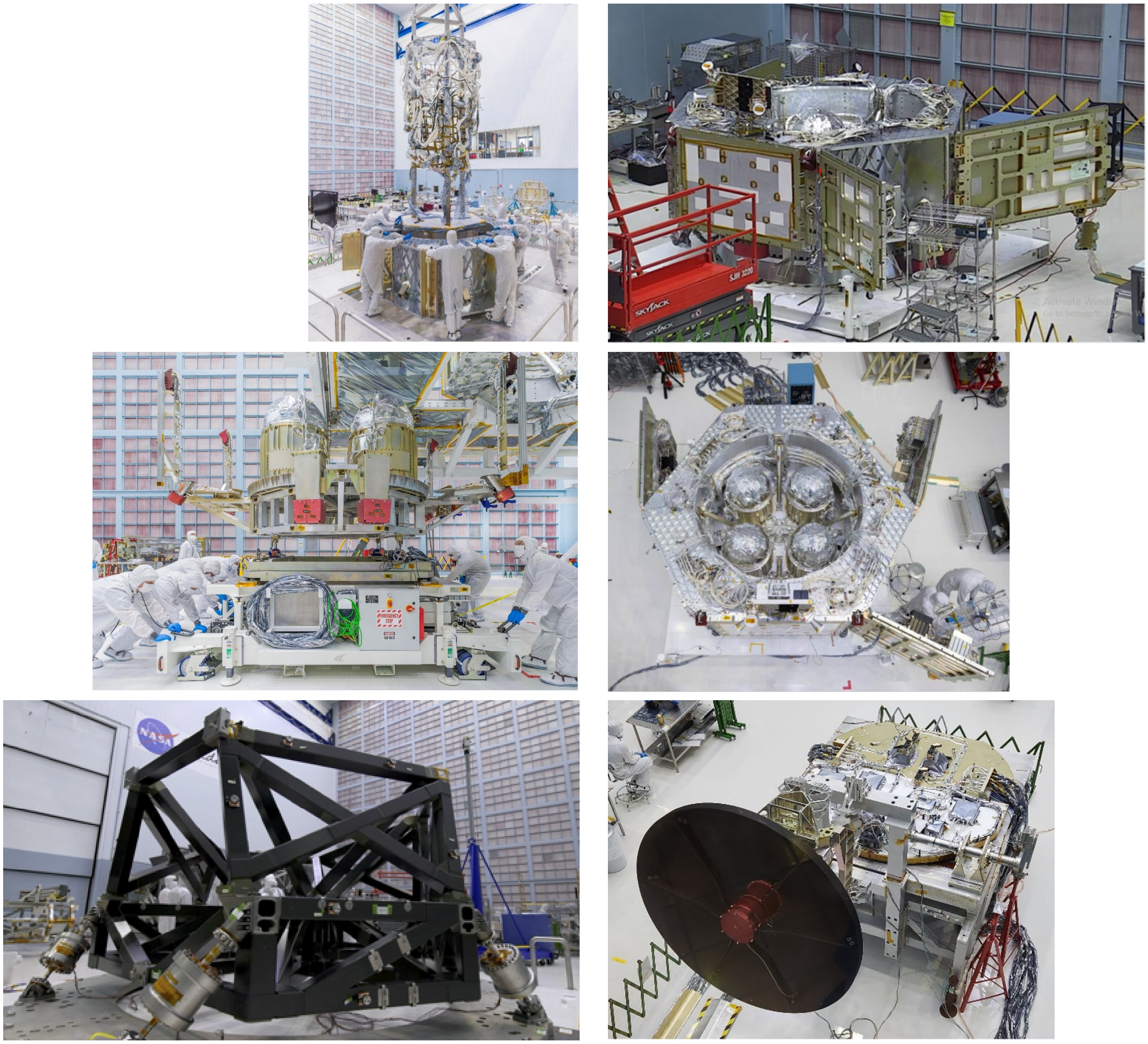

Figure 2. The Roman spacecraft is fully assembled and functionally tested except for the installation of the communications module. Clockwise from the top left, installation of the spacecraft harness, the hexagonal spacecraft bus, a top view of the bus showing the four hydrazine tanks, the communications module including the high-gain antenna, the instrument carrier with surrogate struts, and the installation of the propulsion module.

The Spacecraft bus (Fig. 2) is a hexagonal aluminum isogrid structure with six avionics panels that house the spacecraft avionics needed for power generation and distribution (including the ESA provided batteries); command and data handling; deployment and propulsion control; and attitude control. In addition, the avionics panels also house the control electronics for the telescope and Wide Field Instrument (2.3). The central cavity of the spacecraft bus contains the propulsion module. The propulsion system is a mono-propellant hydrazine system that consists for four propellant tanks with a propellant capacity of approximately 1000kg, sixteen 5N thrusters and eight 22N thrusters. On the bottom of the spacecraft bus is the Communications Module, which contains the deployable, 1.7m dual-band (S- and Ka-) high gain antenna, the dual-axis (Azimuth/Elevation) antenna pointing system, and the Radio Frequency communications hardware. S-band communications is used for command uplink and housekeeping telemetry downlink and Ka-band communications is used for high-speed science data downlink. Also part of the spacecraft bus are the deployable Lower Instrument Sun Shades (LISS) that provide straylight protection to the payload at the extremes of the field of regard.

The ST/IRU assembly is mounted on the instrument carrier and contains three ESA-contributed star trackers and one internally redundant inertial reference unit mounted on an aluminum isogrid panel. The ST/IRU assembly is mounted on the cold-side of the Observatory to allow for a thermally stable environment that minimizes thermally-induced alignment shifts of the STs and IRU.

The OSD provides thermal and straylight protection to the integrated payload assembly and power generation for the Observatory. The composite OBA is thermally controlled to maintain a stable thermal environment for the telescope and consists of an assembly of ten baffles for straylight mitigation. The DAC is a one-time deployable aperture cover that is shaped to prevent sun from entering the boresight at the extremes of the field of regard. The SASS consists of two fixed panels and four deployable panels that generate in excess of 4kW of power and provide shading and straylight protection to the payload.

The Instrument Carrier (IC) Element on the Roman Space Telescope consists of two distinct segments. The metering structure and the Launch Loads and Vibration Isolation System (LLVIS). The metering structure accommodates the two science instruments and telescope assembly. It provides critical on-orbit alignment stability by means of low CTE (coefficient of thermal expansion) composite structures and tight thermal control of the titanium nodes. The Launch Loads and Vibration Isolation System (LLVIS) consists of six struts arranged in a hexapod configuration that is the primary load path between the Integrated Payload Assembly (IPA) and the Spacecraft Bus Structure. The LLVIS provides launch load attenuation for the IPA components and on-orbit vibration isolation for the optical systems.

2.2 Optical Telescope Assembly

The Optical Telescope Assembly[5] (OTA, Fig. 3 and Fig. 4) is in the integration and test phase of the program at L3Harris in Rochester, NY. The OTA is comprised of the Imaging Optical Assembly (IOA) and the Telescope Control Electronics (TCE). The IOA has completed ambient optical alignment for both the WFI and CGI channels. The OTA comprises of a primary and secondary mirror that collects and focuses light for both channels, and two dedicated aft-optic assemblies that pick-off the light for each channel. The Tertiary Mirror Assembly and the two fold-mirrors in the Aft-Optics Module (AOM) support the WFI channel, and the Tertiary Collimator Assembly (TCA) supports the CGI channel. The AOM and TCA optics are aligned to their on-orbit predicted positions. Both channels exceeded expectations for achieving optical alignment; the wavefront error is below the target and all ambient alignment objectives are met.

2.3 Wide Field Instrument

The WFI provides the wide-field imaging and multi-object spectroscopic capabilities necessary to perform the high latitude, microlensing, and supernova surveys (§2). A partnership between BAE and Goddard, the WFI design accomplishes this with an 11-position optical Element Wheel Assembly (EWA) and 18 near-infrared (NIR) detector arrays mounted onto a mosaic plate assembly (MPA). In addition, the WFI acquires guide star images in an interleaved fashion with science image readouts using the same detector arrays, and processes them to provide the Spacecraft Attitude Control Subsystem (ACS) with the Fine Guidance System (FGS) Attitude Correction Estimates needed to enable the required fine pointing control. WFI functions as a guider for both its own observations as well as those of the technology demonstration Coronagraph Instrument (CGI).

The WFI consists of two main assemblies that are electrically connected by various harnesses:

- A Cold Sensing Module (CSM), which contains the EWA and optical elements, the MPA, the Simplified Relative Calibration System (sRCS), and the Alignment Compensation Mechanism (ACM), is supported by and optically aligned to the Instrument Carrier (IC) via three latch points.
- A Warm Electronics Module (WEM), located on the Spacecraft bus, is comprised of the WFI's Instrument Command and Data Handling (ICDH) and Mechanism Control Electronics (MCE) boxes.

For more information on the WFI in these proceedings please see Schlieder (2024).[6]

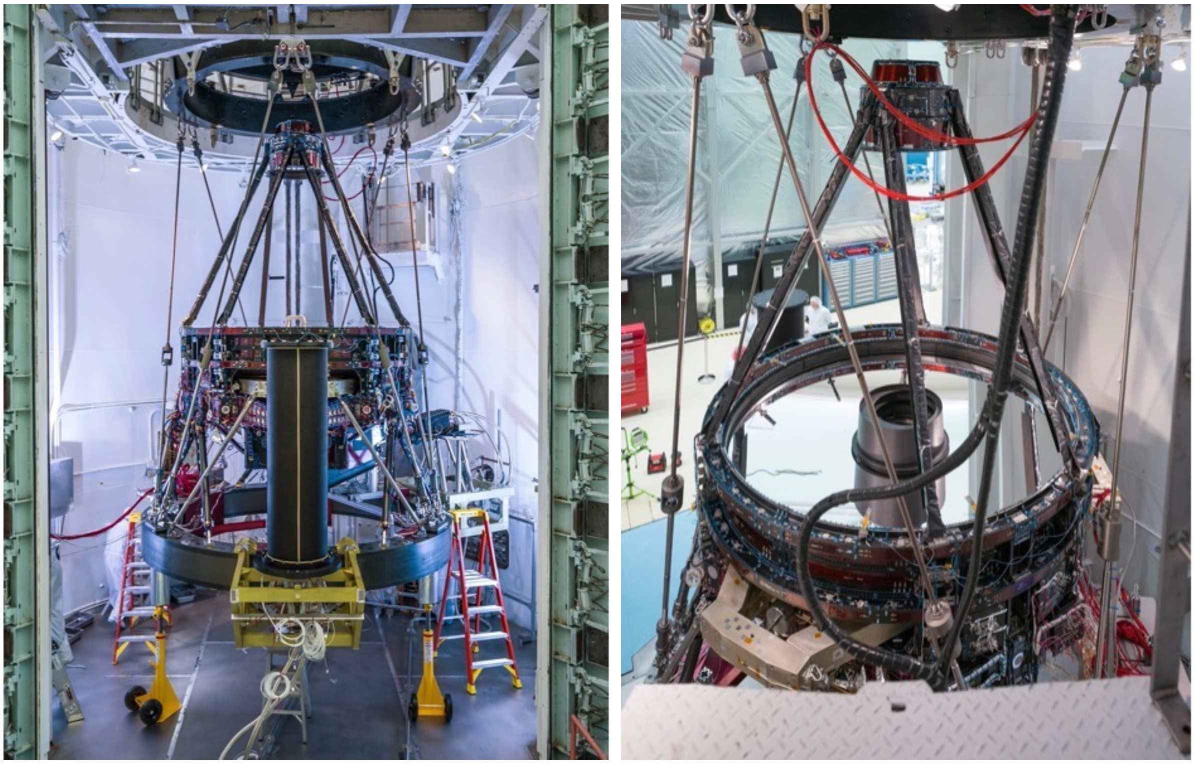

Figure 3. The IOA undergoing ambient optical testing in environmental Chamber IIIB at L3/Harris.

2.4 Coronagraph Instrument

The Roman Coronagraph Instrument is the technology demonstrator of high performance active coronagraphy in space as a precursor for the Habitable Worlds Observatory (HWO). The coronagraph instrument was built and tested at JPL with participation from GSFC (spectroscopy and JAXA provided polarimetry optics) and several international contributions. The coronagraph is mechanically mounted to the IC; it accepts collimated light from the RST telescope's TCA. The power and data interfaces come from the Roman Spacecraft. Within CGI, the light from the telescope is reimaged by 4 pairs of CNES provided off-axis parabolic (OAP) mirrors to create a series of pupil and image planes, where appropriate masks and stops are inserted by 6 Precision Alignment Mechanisms (PAMs) for starlight suppression. Two large format (48x48 actuator) deformable mirrors are used to correct the wavefront error from both the telescope and CGI optics and manage diffraction from the telescope struts. CGI employs two identical cameras with ESA provided EMCCDs used in different ways: Exoplanet Systems Camera (EXCAM) used for suppressing the starlight and imaging the planet light as well as for various calibrations, and the Low Order Wavefront Sensing Camera (LOCAM) used for sensing the line of sight jitter and low spatial order optical wavefront drifts.

CGI design was described in Poberezhskiy et al. (2022)[7] and its status on the verge of I&T campaign was subsequently described in Poberezhskiy et al. (2020).[8] Since then, CGI has completed its I&T campaign and was delivered to GSFC for integration with the Roman observatory in May 2024 (Fig. 5). The I&T campaign began with the completion of CGI integration, when the electronics pallet was fully populated with six electronics subassemblies, each previously extensively tested including subsystem-level performance, dynamics, and thermal vacuum test campaigns. The completed electronics pallet was attached to the aligned optical bench producing the complete coronagraph instrument.

The testing campaign began with the Full Functional Test (FFT) in an ambient environment; the objective of the Full Functional test was to demonstrate for the first time full functionality of the CGI flight software with the flight hardware. It is worth noting that the ambient environment included air turbulence and warm camera

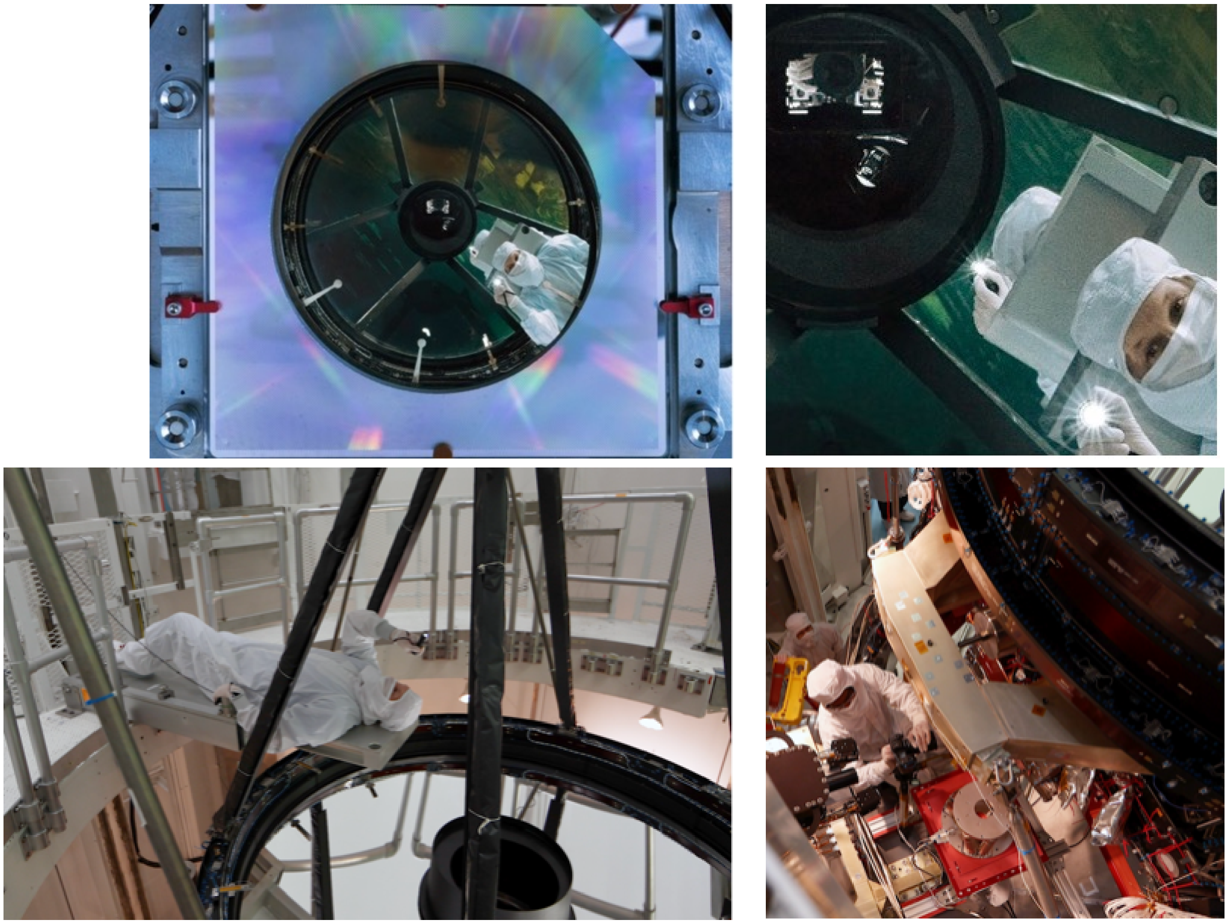

Figure 4. This image (upper left) captures an optical technician on a diving board above the primary mirror (lower left) and re-images them to be a few inches tall at the Widefield optical interface. The optical system is in double-pass, which is why you can see both the back and front of the technician. In the zoomed region (upper right), the photographer's camera and hand are captured in the Widefield aperture mask, i.e. the notable Widefield detector arch. The photographer is seen in full in the lower right). Photo Credit: Criss Gunn and Sophia Roberts.

sensors, which precluded the camera from operating with gain and CGI from demonstrating meaningful starlight suppression. As intended, the FFT campaign was successful in uncovering a number of software-hardware emerging behaviors that were subsequently addressed in the flight and ground software prior to the thermal vacuum (TVAC) "run for the record" testing.

An electromagnetic interference (EMI) and electromagnetic compatibility (EMC) test campaign measured CGI radiative and conducted emissions and susceptibility. The "do-no-harm" focus was on the CGI emissions; no concerns for the observatory were identified based on the test results. Next, the dynamics campaign started with the CGI modal test to verify the requirement that CGI first mode must exceed 35 Hz, and to characterize and correlate all major structural modes under 100 Hz. Modal testing was followed by the random vibration and sine vibration testing to expose the instrument to the launch dynamic environment. Later, CGI will go through additional sine vibration tests at higher level of RST integration.

Finally, CGI testing culminated in the TVAC test campaign. The objectives of the TVAC campaign were two-fold:

1. Thermal verification and validation (V&V), to demonstrate CGI operation at flight-like temperatures with operational and survival heaters, verify thermal control requirements, and collect data to correlate CGI

Figure 5. The Roman CGI has been delivered to Goddard and is awaiting installation into the IC. This image shows the unpacking of the CGI and installation in a holding fixture.

thermal models.

2. Performance V&V, testing the system as a coronagraph. This was a particularly critical campaign because testing the coronagraph requires a complex GSE stimulus to simulate both the star and the telescope. This stimulus will not be available during the subsequent tests during Roman integration, thus CGI TVAC is the only opportunity to test the Coronagraph performance prior to in-orbit commissioning.

The detailed results of the Coronagraph I&T campaign will be described in other publications, but a short summary is that all of its major requirements were met and objectives accomplished. Currently, the instrument is at GSFC preparing for the next phase of the observatory integration.

For more information on the CGI in these proceedings please see Millar-Blanchaer et al. (2024)[9] and Krause et al. (2024).[10]

3. INTEGRATION AND TEST PLAN

Subsystem delivery is expected to be complete this year (2024). The CGI is delivered and is undergoing checkout in the Space Systems Development and Integration Facility (SSDIF) at Goddard (Fig. 5). The IC has been delivered to Goddard and is undergoing integration and test (Fig. 2). The OTA and WFI will be delivered later this year. The spacecraft will be completely assembled at Goddard later this summer with the integration of the communications module. The CGI, WFI, and OTA will be installed into the IC to produce the integrated payload assembly. After this, the IPA will be integrated into the spacecraft bus and a brief pre-environmental test campaign will take place including EMI testing. Vibration testing will take place at this level. Finally, the system will undergo TVAC testing in the space environment simulator (SES) at GSFC wih an OBA simulator.

In addition to demonstrating the functionality of the observatory, the SC + IPA (SCIPA) TVAC will verify workmanship of the observatory as well as demonstrate performance over temperature extremes. This will be a chance to verify the thermal modelling and validate the thermal design. It is the final crosscheck of the end-to-end wavefront error (WFE) performance as well as a verification of the alignment and vignetting of the system. It's the final optical check of the observatory prior to launch since it's the final time the WFI is at operating temperatures until it is in orbit. It will also be a chance to test the end-to-end data flow (commanding and telemetry).

During this time the OSD is being integrated and tested in parallel which includes deployment testing, vibration testing, acoustic testing and TVAC and thermal balance. After SCIPA TVAC is complete the fully-tested OSD and SCIPA will be integrated. A final observatory vibration test will then take place prior to shipment to the launch site in the third quarter of 2026.

3.1 Integrated Modelling

Throughout the build, integration, and test phase, detailed modelling is performed to validate the performance of the observatory. Integrated Modeling (IM) is a cross-disciplinary, physics-based analysis method capturing the complex interactions between observatory components and their impact on optical performance. Examples include predicting how control and mechanism systems introduce image motion or affect line-of-sight stability, and how temperature changes distort mirrors and cause wavefront error. The IM team is embedded in all subsystem development activities and has been from the very start (prior to Phase A). They are an essential contributor to the evolution of the mission design. A key benefit of IM is its ability to verify system-level requirements that cannot be fully verified through testing alone. The IM team has demonstrated the observatory design meets the specified requirements for quasi-static WFE, WFE stability, and pupil alignment for all design reviews. Recently, the focus of IM has shifted to validating the analytical models used for IM predictions, requiring test demonstrations to compare model predictions with real-world behaviors.

The Roman model validation program encompasses two major efforts: (1) dynamics model validation for micro-vibration or jitter predictions, and (2) thermal, structural, and optical model validations for structural-thermal-optical (STOP) predictions. For dynamics model validation, there are five primary types of tests:

1. Induced Vibration Measurements: Characterize mechanism disturbance inputs to the structure.
    (a) Relevant mechanisms include six reaction wheels, 2-axis gimbal stepper actuators for the High-Gain-Antenna-System, WFI Element Wheel Assembly mechanism, and CGI Fast Steering Mirror.
2. Modal Survey for Stowed Dynamics: Validate models for launch and in-flight performance analyses.
    (a) Prior experience has shown that correlating the model for low-frequency launch improves backbone response prediction at high frequencies, which is necessary for jitter analysis.
    (b) The IM team has also identified and targeted jitter-sensitive modes up to 400 Hz for frequency validation. The 400 Hz cutoff was chosen based on the highest response mode from the primary mirror that significantly contributes to jitter.
3. Vibration Isolation System (VIS) and Damper Performance: Verify isolator transmissibility requirements and test correlate isolators to $\geq$ 400 Hz
    (a) Vibration isolator tests are also used to confirm damping performance and validate the damping model.
    (b) Furthermore, the team manages and correlates any mechanical shunt paths such as harnesses, thermal straps, and blankets that cross the same interface as the VIS or damper.
4. Deployed Frequency Verification: Verify deployed frequency requirements for large components that drive line-of-sight stability
    (a) The driving low-frequency modes include the DAC, high gain antenna system boom, SASS, and WFI Focal Plane Assembly post-deployment.
5. Frequency Response Functions (FRFs) or Transmissibility Measurements: Augment with frequency response measurements to assess backbone to 400 Hz for important disturbance energy flow paths to optics
    (a) FRF tests are performed at the high level of assemblies to demonstrate the structural model correctly captures the average dynamic response from disturbance sources and sensitive optics. These measurements also validate interface models between major elements.

For STOP model validation, the test plan is divided among three disciplines:

1. Thermal Model Validation
   (a) Standard TVAC balance and transition tests are used to correlate steady-state and transient thermal behavior.
   (b) Special tests demonstrate heater tuning and temperature stability during TVAC tests.
2. Structural Model Validation
   (a) Material characterization leverages the extensive JWST material database, includes additional tests for key Roman materials, and tests all composite laminate components.
   (b) The dynamics model validation plan supports STOP structural model validation to capture model and key interface stiffnesses.
   (c) Distortion measurements are captured either through direct structural displacement measurements (e.g., photogrammetry, laser radar/target, distance measuring interferometry) or indirect optical measurements through the flight optical system during TVAC tests.
3. Optical Verification
   (a) The optical verification plan outlines the process for generating "as-built" optical models.
   (b) The IM team uses optical verification and alignment/distortion test measurements to validate both thermal and structural models for ambient to cold changes, long-term variation due to temperature variations, and gravity sag effects.

For other long-term changes that impact optical performance, such as material changes, hygroscopic dryout, and Invar growth, model validation for these errors may not be practical beyond limited material testing. However, the observatory includes alignment compensators that can re-align the system on-orbit to compensate for these effects. Consequently, an extensive campaign to validate model predictions for long-term variations is not necessary. The Roman model validation plans have mostly been completed and have shown great results at the element level prior to delivery to NASA Goddard. A few more system-level tests will be performed at Goddard post-assembly to validate the system model.

4. BUILD, TEST, AND VERIFICATION STATUS

4.1 Spacecraft and Instrument Carrier

Integration and test of the Roman spacecraft is being performed at Goddard Space Flight Center in the SSDIF, the largest clean room of its class in the world. Spacecraft bus integration started in April 2023 with integration of the harness into the central cylinder. Once the harness was integrated, the avionics panels were mounted to the spacecraft bus, and mechanical and electrical integration of the avionics proceeded. In parallel, the propulsion system was built up as an assembly by the Goddard Propulsion Branch and delivered to the SSDIF for integration. As of May 2024, the spacecraft bus is completely assembled and functionally tested with the exception of the communications module, which has recently undergone thermal vacuum testing in the Space Environment Simulator. Integration of the communications module to the spacecraft bus is planned for July 2024.

In parallel to the spacecraft bus activities, the SASS, OBA, and DAC are also being assembled and environmentally tested at Goddard. Assembly of the SASS and DAC to the OBA is planned for late 2024 with environmental testing to following in early 2025.

4.2 Optical Telescope Assembly

The TCE has completed box assembly and environmental testing, including EMI, TVAC, and vibration testing. The TCE is ready for IOA TVAC testing, where it will be used to drive the OTA heaters and actuators.

The next step for the OTA is to undergo environmental testing, i.e. the modal and transmissibility test, acoustic test, and sine vibe test. Then, the OTA blankets will be installed before moving into Chamber A at L3Harris for the post-vibe optical and TVAC test. The IOA will be subjected to the flight-like thermal environment to confirm optical and thermal performance under the TCE thermal control.

4.3 Wide Field Instrument

At the time of this writing, the WFI has been fully integrated, completed instrument-level vibration and acoustics testing, and is finished with thermal vacuum testing. Vibration testing of the WFI to protoflight levels was performed to sufficiently stress the hardware so as to verify the design with appropriate margin to requirements. The successful vibration testing, and completion of post-dynamics alignment and functional testing, provided verification that the WFI can withstand the anticipated vibration load environment experienced at launch and meet performance requirements after exposure to that anticipated dynamics environment.

WFI TVAC testing functions as the opportunity to verify performance of the WFI (CSM and the WEM) before and after completion of the structural tests. WFI TVAC is the only opportunity to test the WFI with an optical stimulus in a flight-like environment. The optical stimulus provides diffraction limited point source and flatfields with a wide range of light sources. Higher levels of integration accommodate only minimal stimulus capabilities, so WFI TVAC is the primary opportunity to characterize and understand WFI.

The WFI is currently undergoing EMI and EMC testing and will be delivered to be integrated with the rest of the observatory later this year. The integration and testing at the instrument level is being conducted at BAE Systems' (formerly Ball Aerospace) facilities in Boulder, CO.

5. SUMMARY AND PATH TO LAUNCH

Roman is NASA's next flagship observatory and is designed to answer key questions in dark energy and planetary formation. It is in integration and test with all major subsystems scheduled for delivery in 2024. The final environmental test campaign is underway and will span the next two years. Observatory delivery is anticipated in first quarter of 2026 and Roman will launch to L2 via a Space-X Falcon Heavy. Following launch, a 90-day commissioning period will take place followed by the start of science operations. For continuously updated information on Roman please see `https://roman.gsfc.nasa.gov/` and `https://roman.gsfc.nasa.gov/instruments_and_capabilities.html`.

ACKNOWLEDGMENTS

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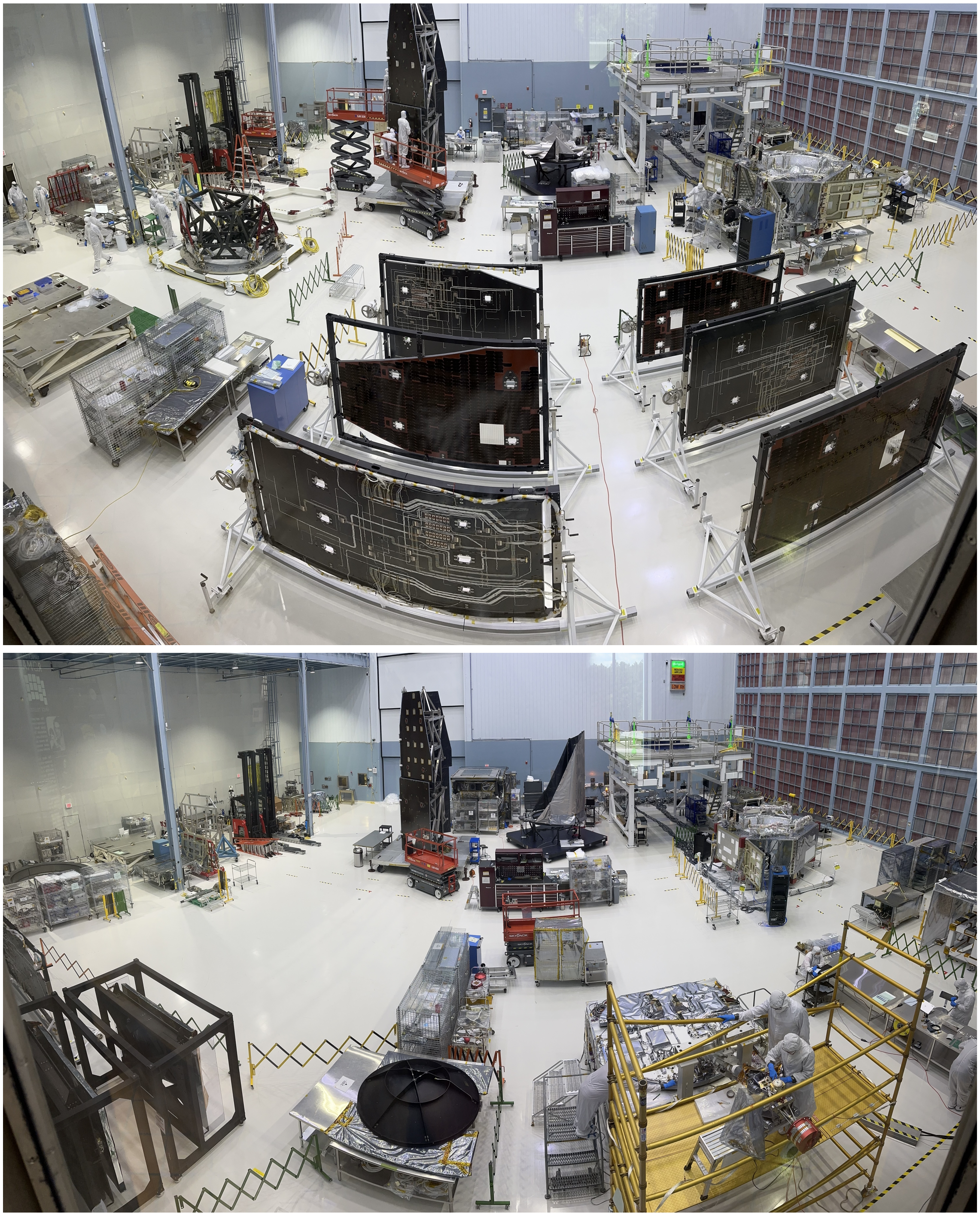

Figure 6. RST is in integration and test with all major components being delivered to Goddard this year. The observatory will undergo TVAC, Vibe and EMI over the next two years and will be launched on a Falcon Heavy in 2026 to an L2 orbit. RST will survey the sky to answer key questions in astrophysics about Dark ENergy and Planet formation. The top image shows the state of the SSDIF in May 2024: clockwise from the middle left is the instrument carrier (§2.1, the solar array simulator, the deployable aperature cover, the spacecraft, and in the foreground are the flight solar array sun shields. The image on the bottom is the SSDIF in June, 2024: clockwise from the bottom middle is the Hight Gain Antenna on the left and the comm panel on the right, the lower instrument sun shieds in their GSE ,the solar array simulator, the deployed deployabole aperature cover, and the spacecraft. The CGI is to the right off image.