

Nancy Grace Roman Space Telescope Science Support Center (SSC) Overview



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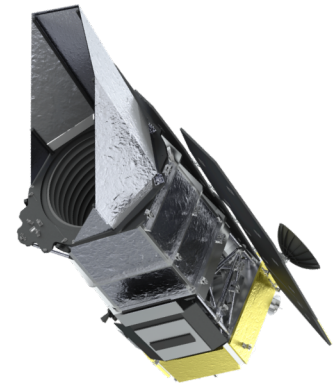


Nancy Grace Roman Space Telescope



- **The Science Support Center works with the other Ground System elements to support the scientific and operational goals of the Roman Space Telescope mission**
- **SSC Primary Responsibilities**
 - Data pipeline implementation and operation
 - Microlensing Science Operations System (MSOS): Level 3 and 4 data products
 - Grism-prism Data Processing System : Level 4 data products
 - **CGI Data Management System (CDMS): Level 1 data products**
 - **CGI Operations System (COS)**
 - Manage proposals, peer review and community grants (Roman Telescope Proposal System)
 - Astronomical community outreach for Roman Exoplanet science, spectroscopy science and proposal submission

- 2.4 m Wide Field of View telescope
- Wide Field Instrument science (dark energy, dark matter, exoplanet census)
- Coronagraph Instrument tech demo
- L2 orbit
- Launch in 2026; 5 year mission lifetime



Wide-Field science briefing Nov. 15-19

<https://roman.gsfc.nasa.gov/science/workshop112021/>



SSC in the Ground System Architecture

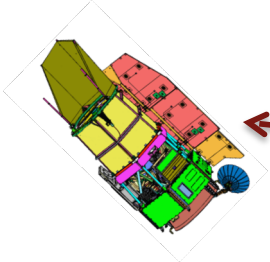


HOWFS = high-order wavefront sensing
GITL = Ground In The Loop

Data Downlink:
Ka-Band (observation data)
S-Band (commands, housekeeping and HOWFS data)

Raw observation image files ("L1 data products") will be in Roman Archive < 72hr after observation.

CGI scheduling done weeks or months in advance to ensure ground station contact during critical HOWFS GITL periods. CGI does not support 'joysticking' or mid-observation changes!



Mission Operations Center (MOC; GSFC)

Science Operations Center (SOC; STScI)
Data Archive

Science Support Center (SSC; IPAC)
Observation Data Analysis Environment
HOWFS Data Analysis Environment

Coronagraph Technology Center (CTC; JPL)

Coronagraph Community Participation Program (CPP)

Housekeeping Data and HOWFS GITL Images
Observatory Commands

Observation Data Files

Observation Planning & Scheduling Products

Observation Planning & Data Products

CGI Housekeeping/HOWFS Data
CGI Commands & Products

Observation Specifications & Data Products



SSC Responsibilities for Coronagraph Instrument



- Exoplanet Community Support
- Coronagraph Instrument Operations
 - Commanding and operations
 - Develop tools to create observations
 - HOWFSC/GITL operations, including commanding and uplink
 - Assess and trend health, safety and instrument performance
- Coronagraph Instrument Data Management
 - Develop and operate Data Analysis Environment (DAE) for CTC and community participants
 - Process L0–L1 data and deliver to SOC for archiving
 - Validate and deliver L2 – L4 CGI data (calibrated, higher products) produced by CTC +CPP to SOC for archiving
 - HOWFSC/GITL data processing (includes CTC algorithms)



Supporting Observation Planning Tools and simulations repository



- www.roman.ipac.caltech.edu
- Simulations created by many teams you heard Tuesday and today
 - https://roman.ipac.caltech.edu/sims/Simulations_csv.html
- Data Challenges held by Exoplanet SITs
 - https://roman.ipac.caltech.edu/sims/Exoplanet_Data_Challenges.html
- Simulation code you heard about yesterday: (CGISim, Falco+PROPER)
 - <https://roman.ipac.caltech.edu/sims/Code.html>
- Instrument parameters you want to know
 - https://roman.ipac.caltech.edu/sims/Param_db.html
 - Python code to calculate and plot Roman Coronagraph Instrument's flux ratio v separation
- Roman Virtual Lecture Series and other Workshop announcements
 - <https://roman.ipac.caltech.edu/Lectures.html>
- We will have links to Exposure Time Calculator for the Coronagraph Instrument to be discussed later today

Science Simulations by Instrument

• Wide-Field Instrument (WFI)

- Detector Performance
 - WFI Detector Noise Generator (NG)
- Direct Imaging
 - Weak lensing galaxy simulations in the high-latitude survey
 - Microlensing event simulations targeting the Galactic Bulge
 - Microlensing light curve fitter
 - Microlensing Data Challenge
 - Photometric Redshift Calibration of the Roman Space Telescope Weak Lensing Measurements
- Grism
 - Simulations of grism observations of high redshift galaxies in the Galaxy Redshift Survey

• Coronagraph Instrument

- Instrument Models
 - Models of the Coronagraph Instrument pupil
 - Coronagraph Instrument Off-axis PSF for wide field of view SPC
- Astrophysical Data and Models
 - Roman Space Telescope Coronagraph Instrument Exoplanet Characterization
 - Observational brown dwarf spectra
 - Direct Imaging Data Challenge
 - WFIRST Preparatory Science Project: Circumstellar Environments of Host Stars
 - Circumstellar Disk Simulations
- Public Simulated Coronagraph Instrument Data
 - Observing scenario simulations
 - Coronagraph Instrument Simulated Contrast Curves
 - Additional Coronagraph Instrument Parameters and Data



Supporting the Observation Generation



- The SSC is developing the tools to create observations
- CPGS (Command Product Generation Software) will be the first step in the process of creating the basic CGI observation.
- Web-based tool designed to allow users to select targets and choose from the subset of well-calibrated and tested modes.
- Includes signal to noise (S/N) code to help plan exposure durations
- Tool will include ability to check observability with project planning and scheduling (SOC) based on target, observation specifications, and other observations in the queue.



CPGS Prototype



Target Selection

Target Name SIMBAD Lookup

RA (hh:mm:ss.s or degrees) DEC (+/- dd:mm:ss.s or degrees)

PM RA (mas/yr) PM Dec (mas/yr)

Epoch

V Magnitude Spectral Type Subtype

Reference Selection

Observe Target Only

Reference Name SIMBAD Lookup

RA (hh:mm:ss.s or degrees) DEC (+/- dd:mm:ss.s or degrees)

PM RA (mas/yr) PM Dec (mas/yr)

Epoch

V Magnitude Spectral Type Subtype

CGI Configuration

Coronagraph/Mask

Filter

With polarization

Wollaston

Wavefront Control

Dig Dark Hole

Initial Threshold Planet/Star Flux Ratio (acceptable performance)

Touchups Threshold Planet/Star Flux Ratio (acceptable performance)

Initial Target Planet/Star Flux Ratio (stop when reached)

Touchups Target Planet/Star Flux Ratio (stop when reached)

Initial Timeout (stop when reached) (hours)

Touchups Timeout (stop when reached) (hours)

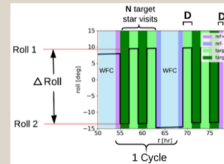
Copy Initial to Touchup

Control Strategy

Observation Scenario

Following an initial Wavefront Control sequence (if selected), the Observation Scenario follows a repeated cycle:

1. Reference measurement (of duration D_{ref}) at one extreme of roll angle ("Roll 1").
2. Target star measurement (of duration D) at the opposite extreme of roll angle (Roll 2 = Roll 1 \pm Δ Roll).
3. Target star measurement (of duration D) at Roll 1.
4. Repeat 2 and 3 so that target star is measured N times.
5. Reference star measurement at Roll 2 (of duration D_{ref}).
6. WFC Touchup on reference star.



Observation Scenario

Roll 1 (degrees) Roll 2 (degrees)

N, the Number of Target Star Visits Per Cycle

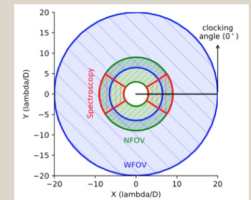
D, the Duration of Target Star Measurements per Roll (hours)

D_{ref} , the Duration of Reference Star Measurements per visit (hours)

Satellite Spots

Satellite spot pairs will be imaged when placed at the following locations:

FOV	Clocking Angle Range (degrees)	Inner Radius (λ/D)	Outer Radius (λ/D)
Narrow FOV	-90 to +90	3	9
Wide FOV	-90 to +90	6.5	20
Spectroscopy	-32.5 to +32.5	3	9



Note: Each spot in a pair is spaced 180 degrees apart.

Obtain satellite spot image every visit

Number of pairs

Satellite Spot Intensity (Pair 1) (relative to Target Star)

Clocking angle on camera of 1st spot(Pair 1) (0 degrees = along camera X)

Radial Distance from Star (Pair 1) (λ/D)

Satellite Spot Intensity (Pair 2) (relative to Target Star)

Clocking angle on camera of 1st spot(Pair 2) (0 degrees = along camera X)

Radial Distance from Star (Pair 2) (λ/D)

Integration Parameters Per Visit

EMCCD Gain Regime

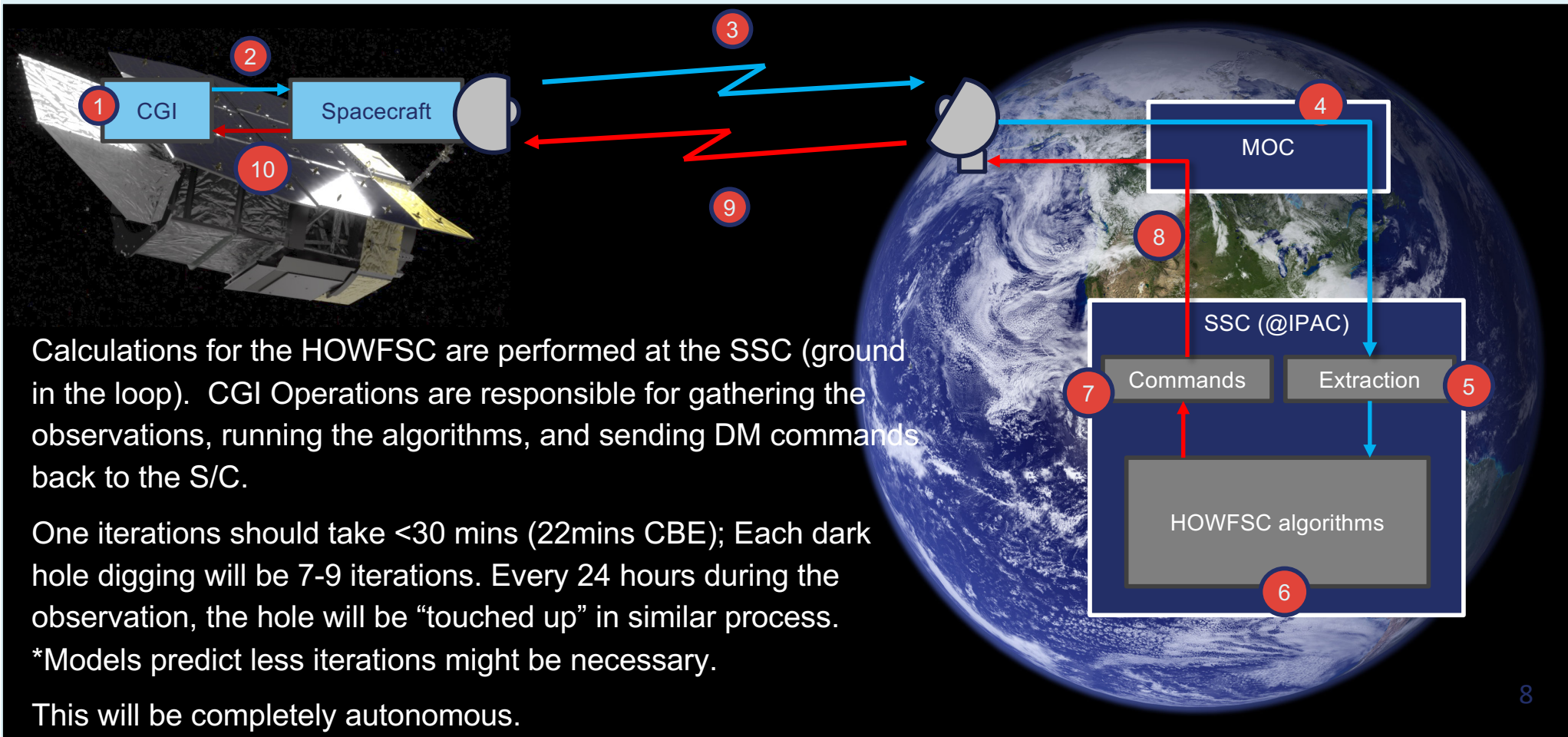
Desired Signal-to-Noise Ratio

Submit

- Clicking "SUBMIT" will create Observation Specification file
- One or more Observation Specification files will be combined into a CGI Observing Program file for submission to SOC for planning and scheduling.



Supporting the observations (HOWFSC/GITL)





Supporting CGI Data Analysis



- The SSC will provide and maintain a *Data Analysis Environment* (DAE) with storage and data processing resources to do the following:
 - Automated Level 0 to Level 1 data processing (SSC responsibility)
 - Host CGI Level 2 to 4 data processing (performed by the CTC in collaboration with the CPP) (see next slide for data processing levels)
- Performs data quality assessment on L1 data, which includes performance monitoring/trending and reporting.
- Deliver L1 data to the SOC for ingest to the Roman archive at STScI.
- Validates the L2-L4 data for format, header integrity, and data anomalies.
- Delivers L2 to L4 processed imaging and spectroscopic data, plus CGI ancillary and calibration data, to SOC for ingest into the Roman archive



Summary



- The SSC at IPAC is the interface to observing with CGI.
- We are developing tools to support CGI operations.
 - Planning an observation (Webpage/ simulations)
 - Creating the observation (CPGS)
 - Analyzing the observation data (Data Analysis Environment)
- We are also responsible for operations, GITL, and instrument support.



Backup



CGI Data Levels



- Level 0: Raw packetized science data received at the Roman ground stations. The data taken on the science recorder are transferred to the SOC. The SSC accesses these data from the SOC archive. (GITL data are taken on housekeeping recorder and transmitted to SSC via the MOC.)
- Level 1: Raw, uncalibrated images (FITS) with formatted engineering telemetry and appropriate metadata. Generated by the SSC, transmitted to the SOC. Also stored in the DAE for further processing.
- Level 2: Cleaned, calibrated images.
- Level 3: Astrometric or wavelength calibrated images normalized by exposure time.
- Level 4: final image and/or spectrum; including PSF subtraction, if applicable.
- Final products validated for format, naming convention and data quality by SSC, transmitted to the SOC archive.

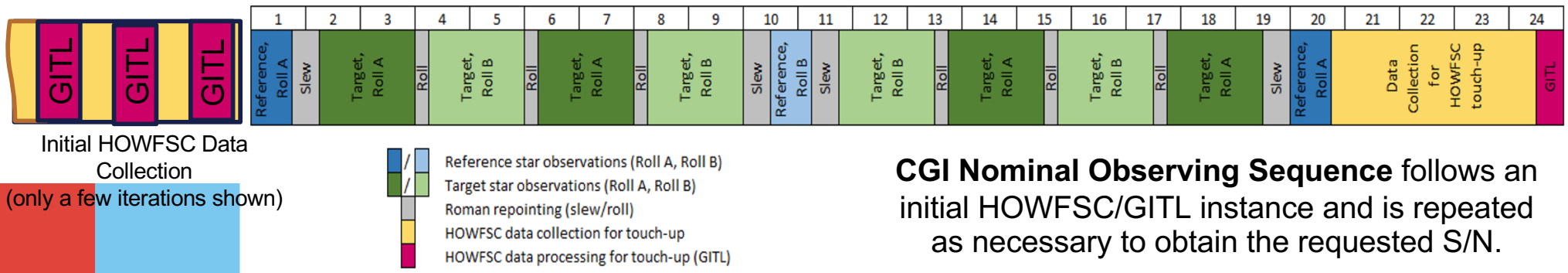
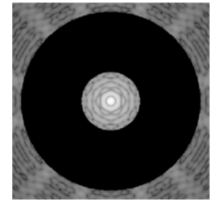
Items in Blue are responsibility of CTC in collaboration with CPP



Observing with Coronagraph Instrument



- Common nominal observing sequence includes a bright reference star and target star with faint companion
- The reference star is used for PSF subtraction of target star (reference-differential imaging); rolled measurements support angular-differential imaging of faint companion (both done by CTC in post-processing)
- High Order Wave Front Sensing and Control (HOWFSC) uses 48x48 deformable mirror actuators to “dig a dark hole” when viewing the reference star on the main imager (EXoplanetary systems CAMera, or EXCAM), providing deep contrast for imaging faint companions
- The calculations needed to dig a dark hole are performed at the SSC using Ground In The Loop (GITL). The ground loop takes <30 minutes.



CGI Nominal Observing Sequence follows an initial HOWFSC/GITL instance and is repeated as necessary to obtain the requested S/N.