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

Patrick Lowrance, Jim Ingalls, Alexandra Greenbaum

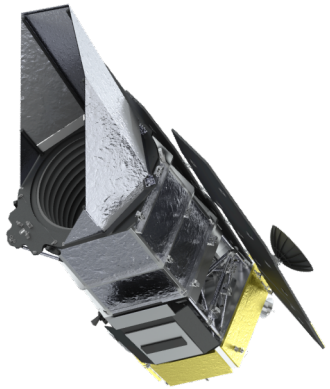
Roman Science Support Center

Caltech/IPAC

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



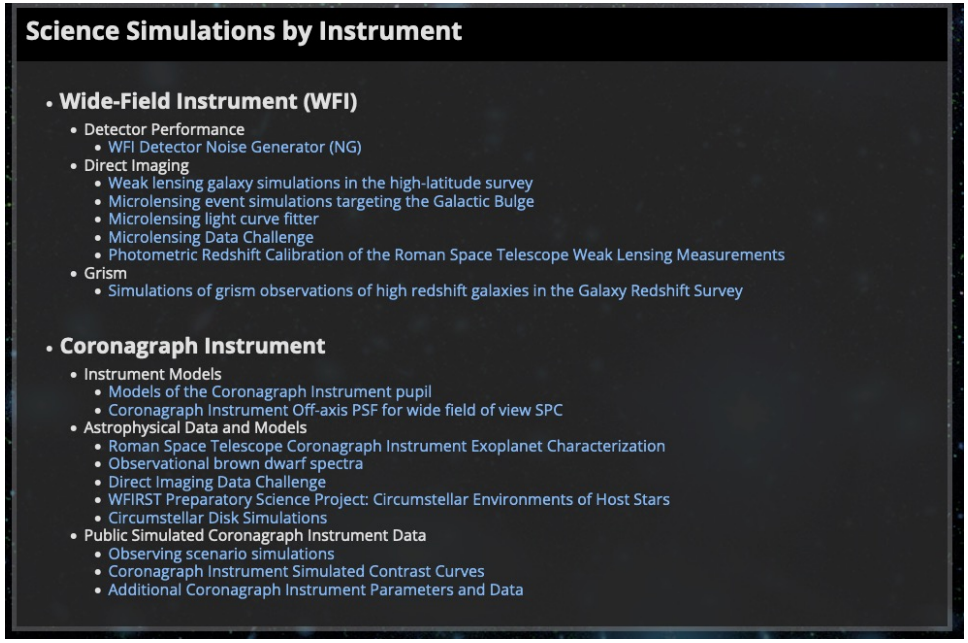
Wide-Field science briefing Nov. 15-19
https://roman.gsfc.nasa.gov/science/workshop112021/

SSC 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

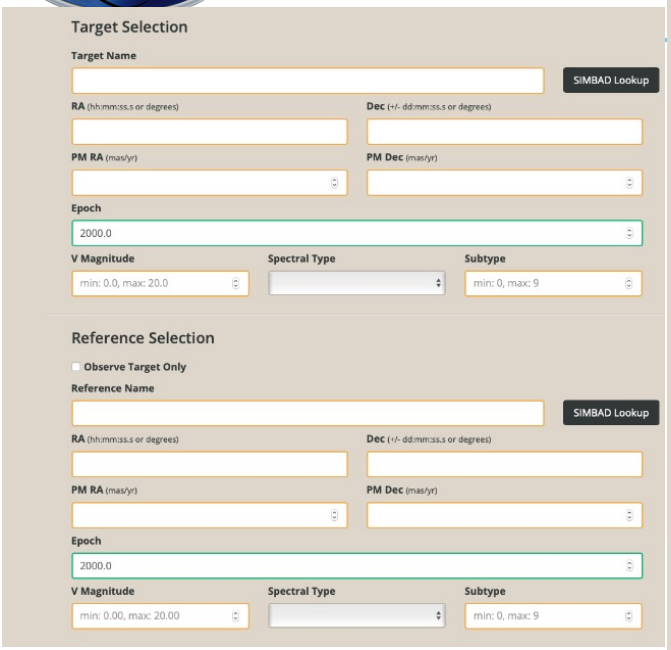
- www.roman.ipac.caltech.edu
  - Simulations created by many teams you heard Tuesday and today
    - https://roman.ipac.caltech.edu/sims/Simulations_csv.html
  - Data Challenges held by Exoplanet SITs
    - https://roman.ipac.caltech.edu/sims/Exoplanet_Data_Challenges.html
  - Simulation code you heard about yesterday: (CGISim, Falco+PROPER)
    - https://roman.ipac.caltech.edu/sims/Code.html
  - Instrument paramaters 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

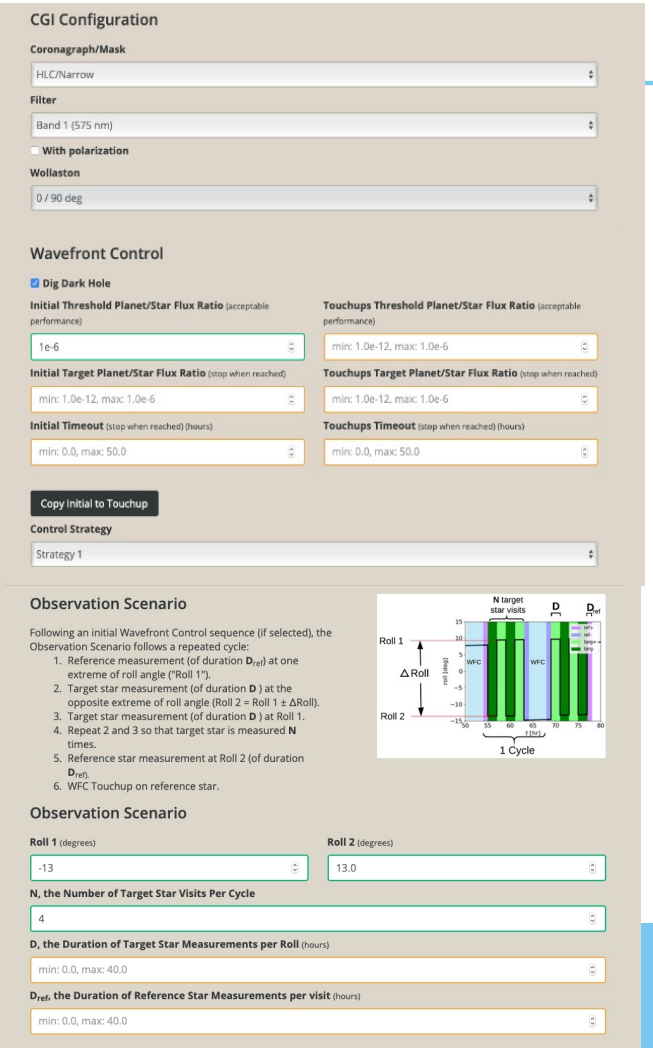


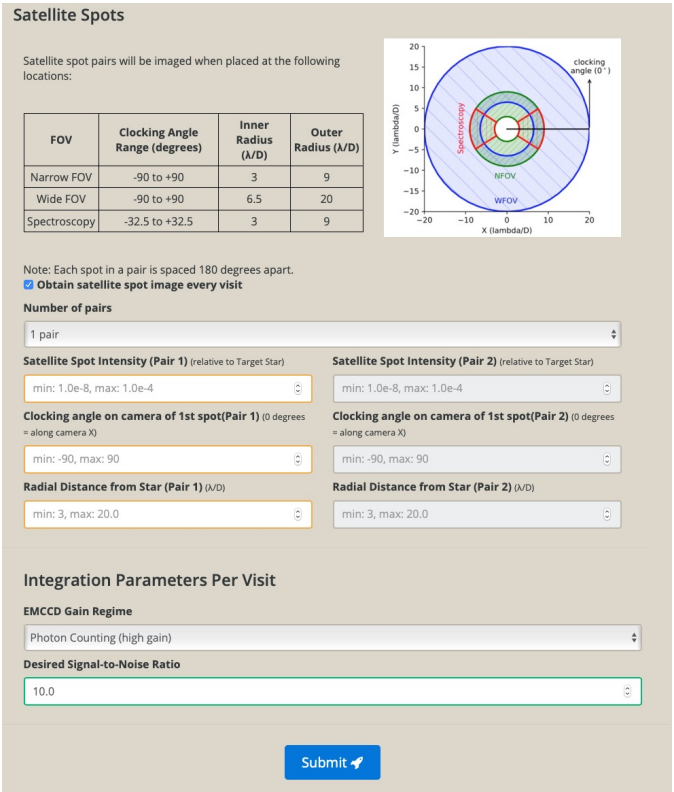
Supporting the Observation Generation

- 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

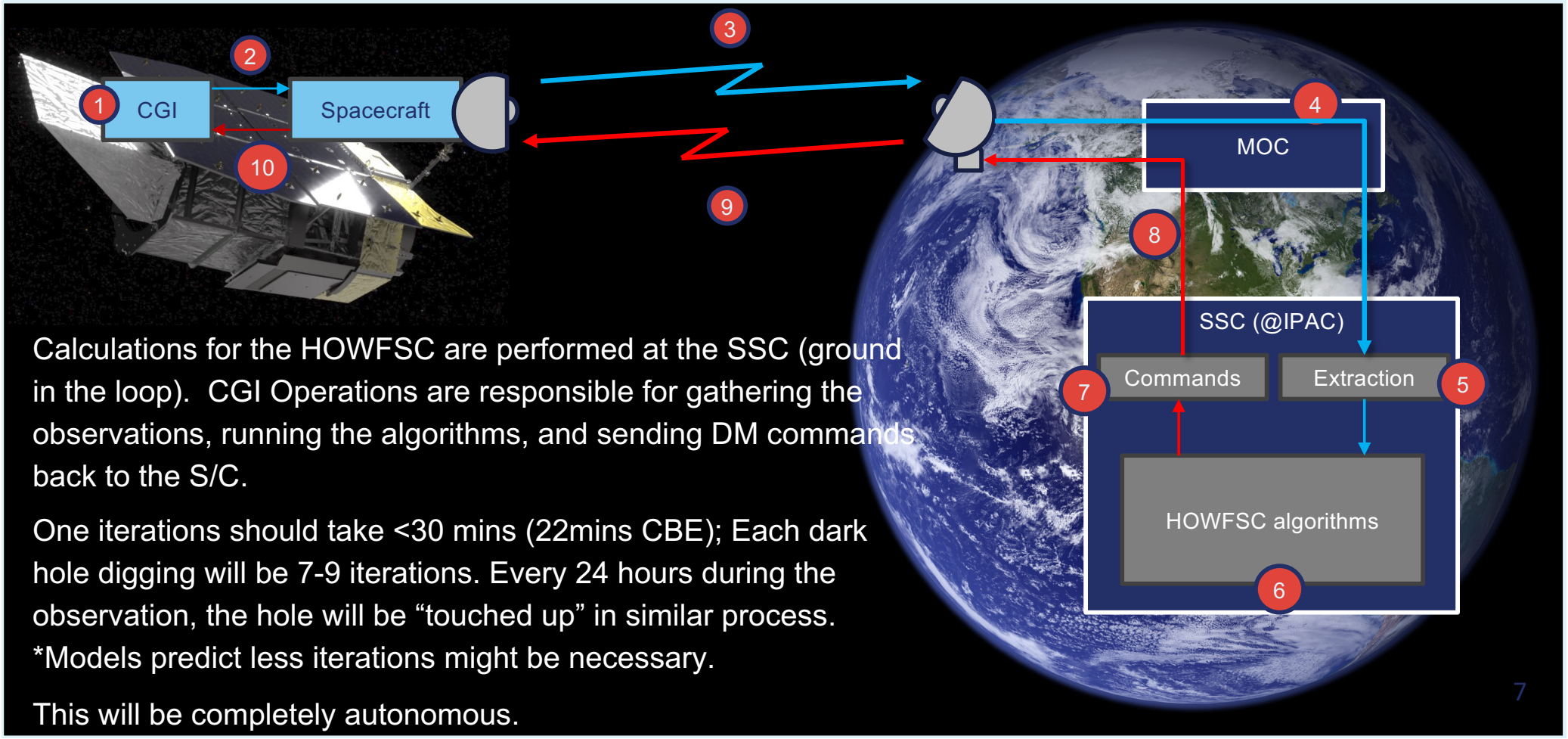






- Clicking “SUBMIT” will create Observation Specification file
- One or more Observation Specification files will be combined into a *CGI Observing Program* file for submission to SOC for planning and scheduling.

Supporting the observations (HOWFSC/GITL)



Calculations for the HOWFSC are performed at the SSC (ground in the loop). CGI Operations are responsible for gathering the observations, running the algorithms, and sending DM commands back to the S/C.

One iterations should take <30 mins (22mins CBE); Each dark hole digging will be 7-9 iterations. Every 24 hours during the observation, the hole will be “touched up” in similar process.
*Models predict less iterations might be necessary.

This will be completely autonomous.

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)
- 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

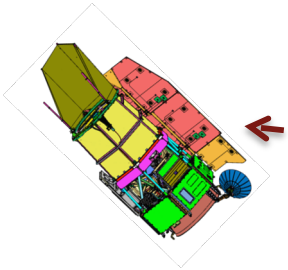
SSC in the Ground System Architecture

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!



Housekeeping Data and HOWFS GITL Images

Observatory Commands

Mission Operations Center (MOC; GSFC)

Observation Data Files

Observation Planning & Scheduling Products

Science Operations Center (SOC; STScI)

Data Archive

Observation Planning & Data Products

Science Support Center (SSC; IPAC)

Observation Data Analysis Environment

HOWFS Data Analysis Environment

CGI Housekeeping/HOWFS Data

CGI Commands & Products

Coronagraph Community Participation Program (CPP)

Coronagraph Technology Center (CTC; JPL)

Observation Specifications & Data Products

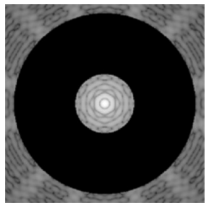
CGI Data Levels

- 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.

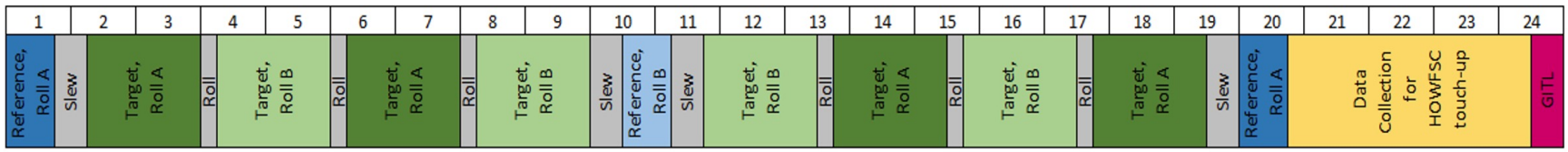
Items in Blue are responsibility of CTC in collaboration with CPP

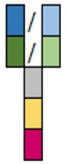
Observing with Coronagraph Instrument

- 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.



Initial HOWFSC Data Collection
(only a few iterations shown)





Reference star observations (Roll A, Roll B)
Target star observations (Roll A, Roll B)
Roman repointing (slew/roll)
HOWFSC data collection for touch-up
HOWFSC data processing for touch-up (GITL)

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