HWO and Working Groups Intro

Science Data Simulation Working Group full meeting

March 5, 2024

(thanks to C. Dressing for much of this material!)

HABITABLE WORLDS OBSERVATORY

Today's Agenda

Introductions

HWO START / TAG and Working Groups Structure

Community Involvement

Code of Conduct and Open Science

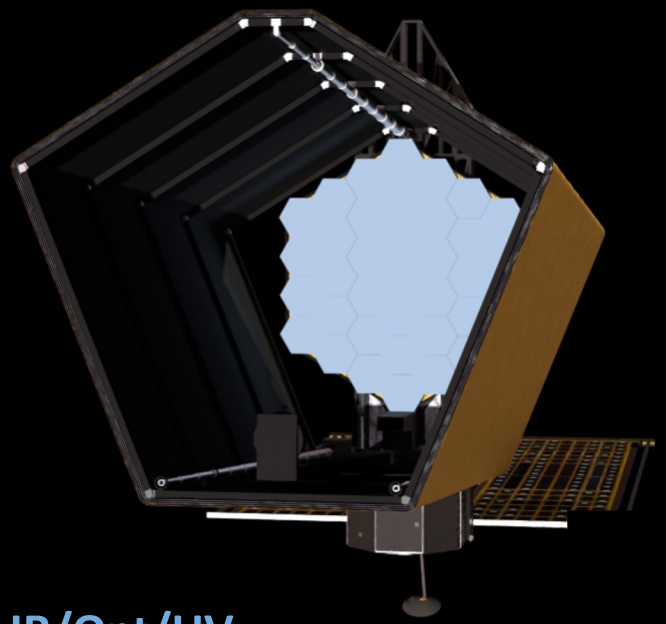
Science Data Simulation Working Group and Subgroups (20 min)

Resources and next steps

Q&A

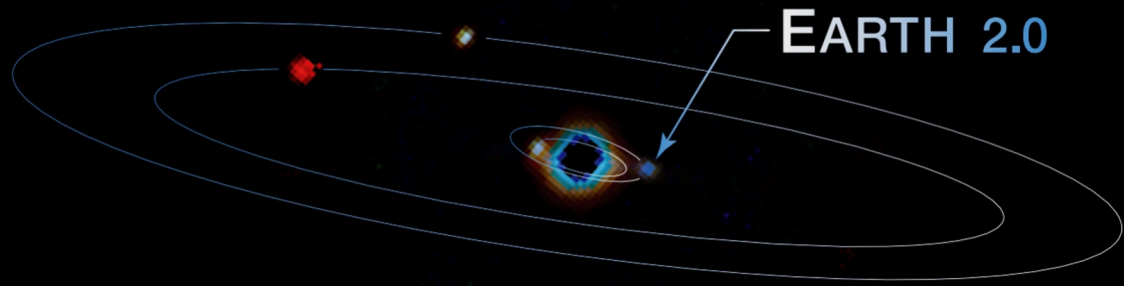
Habitable Worlds Observatory (HWO)

NASA's next flagship mission concept recommended by Astro2020 Decadal Survey



Large IR/Opt/UV observatory performing transformative astrophysics

First telescope designed specifically to search for signs of life on planets outside our solar system



Slide by Megan Ansdell (GOMAP PS)

GOMAP Integration Group (GIG)

NASA HQ Leadership

Program Executive

Julie Crooke

Program Scientist

Megan Ansdell

Deputy Program Scientist

Joshua Pepper

NASA GOMAP Website

Community START + TAG Leadership

START Co-Leads

Courtney Dressing
UC Berkeley

John O'Meara
W.M. Keck Observatory

TAG Co-Leads

Lee Feinberg
GSFC

Bertrand Mennesson
JPL

Aki Roberge
GSFC

John Ziemer
JPL

Slide by Megan Ansdell (GOMAP PS)

The START & TAG Will Guide HWO Maturation

Science, Technology, Architecture Review Team (START)

- Quantify HWO's science objectives using Astro2020's guidance
- Outline the observatory and instrument capabilities needed to accomplish those goals.
- Develop the science goals and objectives portions of the Science Traceability Matrix.
- Assess the fidelity of models needed in the future to execute future trades.

Technical Assessment Group (TAG)

- Study architecture options.
- Identify and assess the mission architectures and technologies needed to enable those options.
- Evaluate the risks associated with those options.

START First Steps

HWO Science Goals from Astro2020	Goals to Objectives	Objectives to Measurements	Measurements to Observations
High-level Questions	*Define Investigations*	*Determine Physical Parameters to Measure*	*Define Needed Observations*
"How did the seeds of Solar System planets first come together?"	*"Discover trans-Neptunian objects down to sizes that distinguish between different planetesimal formation scenarios"*	*"Detection of 30 TNOs with diameters ~4km out to 40 AU to constrain the small end of the size distribution at X precision"*	*"Detection of R< 31.5 mag objects at SNR > 5 in a 0.017 deg^2 region imaged in R band"*

Quantify science returns as functions of observatory capabilities.

Determine correlations & derivatives.

Start building an integrated science model that will connect to engineering models.

Dynamic Integrated Science Return Analysis (DISRA)

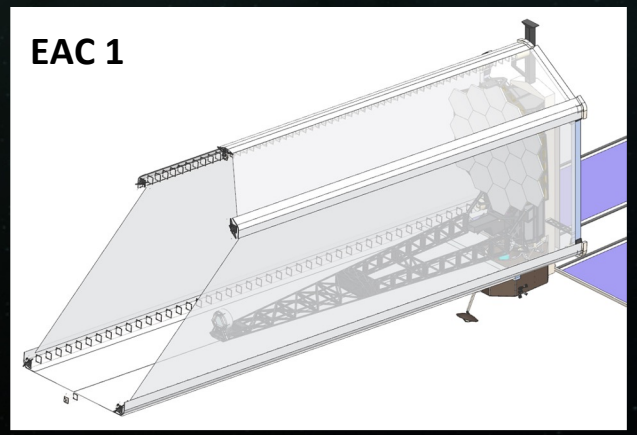
Slide by Aki Roberge (TAG co-chair)

TAG First Steps: Exploratory Analytic Cases (EACs)

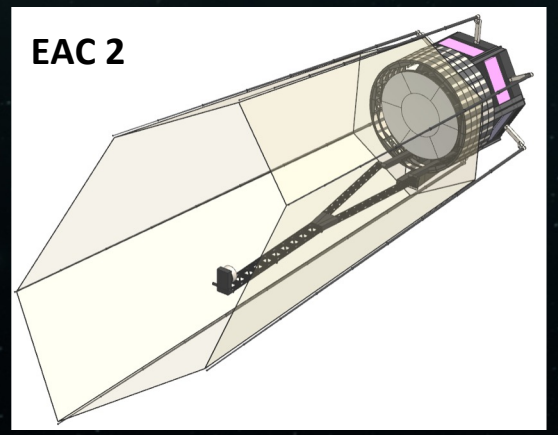
1st round mission architectures that will be used to explore the HWO trade space. Purposes …

- Practice end-to-end modeling, from science to engineering. Develop initial models & codes to ”pipeclean” the process using representative examples
- Use EACs to identify key technology gaps and guide maturation of potential technology solutions
- Provide feedback to rocket vendors as soon as possible to help influence their direction

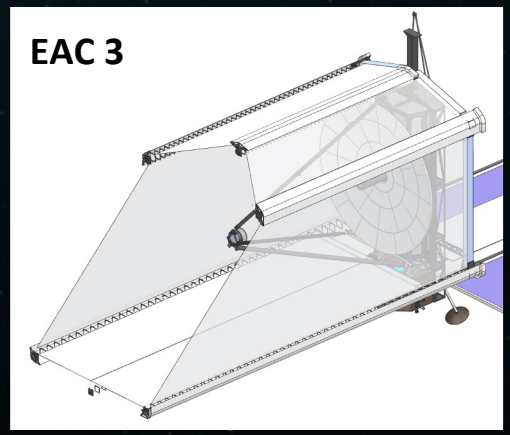
Exploration of three 1st round EACs will take ~ 1 year. Findings will fold into 2nd round of EACs.



6-m inner diameter / 7.2-m outer diameter off-axis



6-m diameter off-axis



8-m diameter on-axis

HWO Working Group Structure

Science Working Groups (SWG)

Living Worlds (LW)

- Biosignature Possibilities
- Biosignature Interpretation
- Target Stars & Systems

Solar Systems in Context (SSiC)

- Characterizing Exoplanets
- Solar System Observations
- Demographics & Architectures
- Birth & Evolution

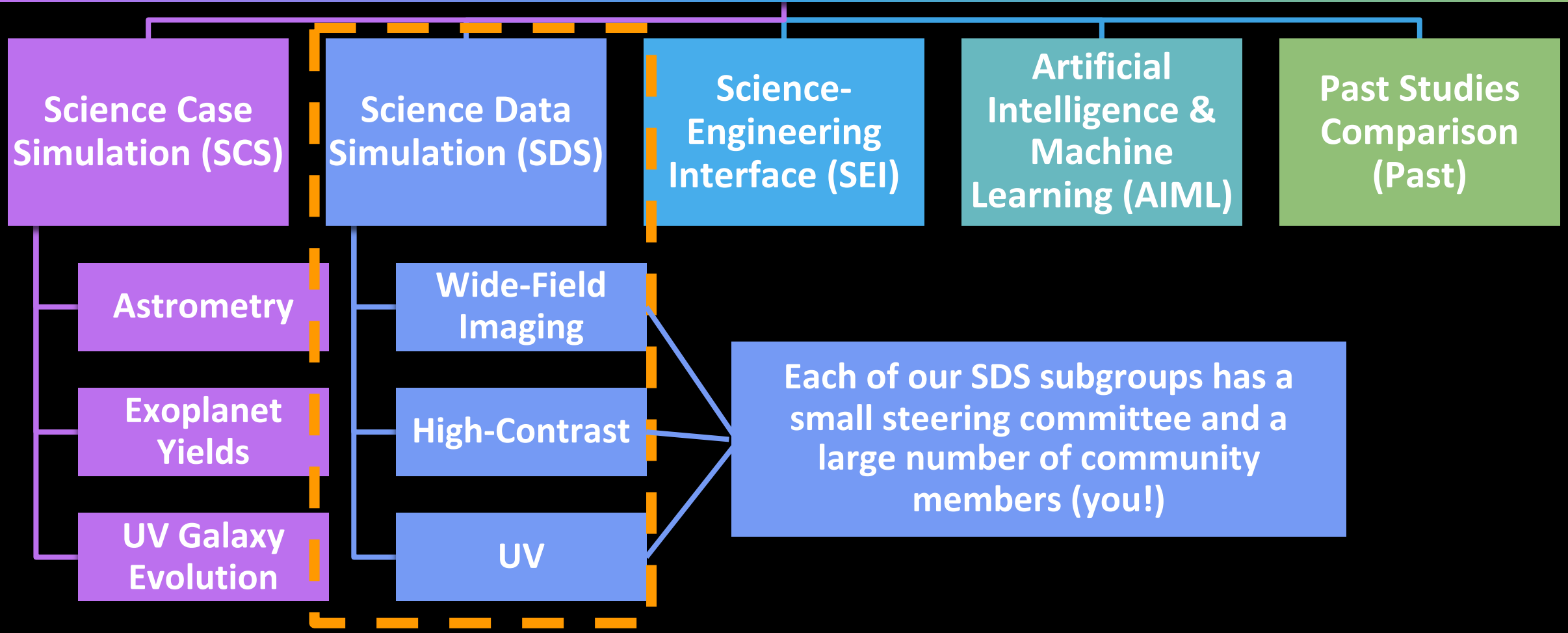
Evolution of the Elements (EE)

- Stars & Stellar Populations
- Star Formation
- Transients

Galaxy Growth (GG)

- IGM & CGM
- AGN
- Ionizing Photons
- Dark Sector

Joint Working Groups (JWG)



Technology Working Groups (TWG)

Integrated Modeling (IM)

- Model Standards & Uncertainty Quantification
- Model Validation
- New Methods & Collaborative Environment

Servicing

Systems

- Starlight Suppression Error Budget
- High-Contrast Post-Processing & ConOps
- Starshade Compatibility
- Computational Architecture

Technology

- Sensing & Control
- Mirrors
- Coronagraphs
- Detectors
- UV Technology
- Cross-Cutting Technologies

Various Levels of Community Involvement

- Major Contributor: leads and guide effort (e.g., on steering committee)
- Full Contributor: participates in task group and provides significant content
- Minor Contributor: provides feedback and attends meetings
- Major Event Participant: attends HWO workshops or major meetings
- Observer: subscribes to mailing list and follows HWO

Kudos to John Ziemer for proposing and writing up descriptions of these terms

Code of Conduct & Reporting

NASA Astrophysics Division Statement of Principles

All participants in GOMAP-HWO activities must adhere to the APD Statement of Principles

American Astronomical Society (AAS) Code of Ethics

The AAS Code of Ethics is required to be followed under the APD Statement of Principles

Reporting Protocol

Follow the procedures in the APD Statement of Principles and contact the HWO GIG

Use institutional reporting channels, as appropriate

NASA-funded individuals have access to NASA programs (Ombuds, Anti-Harassment, ODEO) and a facilitator to help navigate the various options

Slide by Megan Ansdell (GOMAP PS)

Open Science is critical to the success of HWO's GOMAP phase

HWO WG activities → starting point for future HWO Project Office

- Open science enables traceability & reproducibility of work, which is needed for WG outputs to effectively support a future HWO Pre-Phase A Project Office

Openly sharing WG activities → avoid Conflicts of Interest (COIs)

- COIs can arise when individuals have certain information not made available to others
- COIs could prohibit WG members from participating in future HWO opportunities (e.g., submitting to ROSES calls, working at a future Pre-Phase A Project Office)

Compliance with NASA requirements for Open-Source Science

- SMD Science Information Policy (SPD-41a) requires that scientific information (data, software, publications, event materials) produced using SMD funding be made publicly available
- Exemptions for restricted information (e.g., export control, IP) are also required to be carefully followed
- Exceptions for preliminary information (e.g., software in development) are also allowed, but encouraged to be openly shared when possible in accordance with open science best practices

Slide by Megan Ansdell (GOMAP PS)

HWO-GOMAP OSDMPs

Slide by Megan Ansdell (GOMAP PS)

POLICY + REQUIREMENTS

NASA Open-Source Science

- *SMD Science Information Policy (SPD-41a)*
- *SMD Open-Source Science Guidance*

HWO-GOMAP OSDMP

- *High-level requirements + process*
- *Includes Documentation Plan, Open Meetings Plan, Data & Software Plan*
- *Supplemented by WG OSDMPs*

written by GIG, approved by NASA HQ

WG/SG OSDMPs

- *Specific plans + process*
- *Exceptions for restricted info*
- *SWG OSDMPs, as needed*

written by WG/SG approved by GIG & NASA HQ

Link to [DRAFT] full HWO-GOMAP OSDMP

DOCUMENTATION PLAN

- Covers documents such as meeting materials, white papers, technical reports, journal publications, workshop materials, etc.
- Openly sharing HWO WG/SG ***meeting summary notes/actions*** and key decision-making trails will be critical to ***avoiding COIs*** that prohibit WG/SG members from participating in a future HWO mission.
- See next slide for details on open sharing of documentation.

OPEN MEETING PLAN

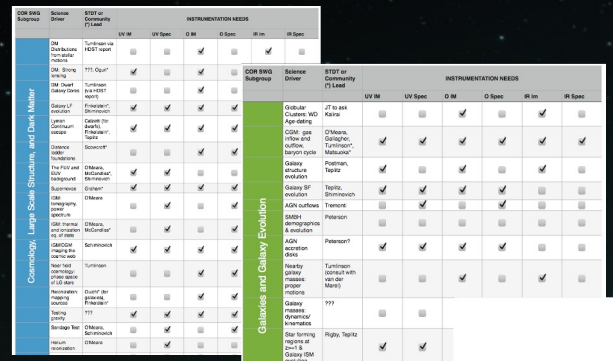
- WG/SG meetings will be ***advertised publicly and open when possible***; unrestricted meeting materials will be publicly posted in timely manner.
- WG/SG-related conference/workshop slide decks, proceedings, poster presentations, etc. supported by NASA/SMD funding will be made openly available with a persistent identifier.
- Certain WG/SG meetings will contain ITAR or otherwise restricted information and therefore will be closed with cleared meeting materials publicly posted in a timely manner.

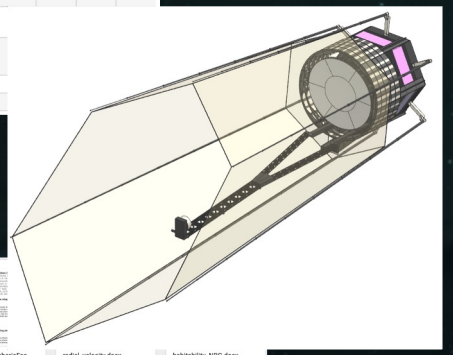
DATA & SOFTWARE PLAN

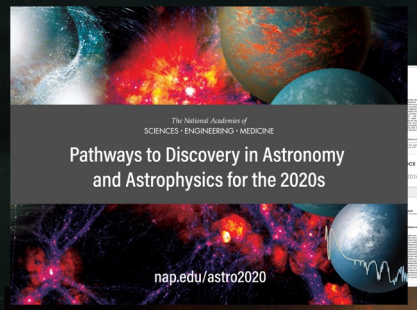
- Data + codes critical for the ***traceability/reproducibility*** of WG/SG analysis, model/tool development, etc. will be version controlled and made openly available unless restricted (e.g., by ITAR).
- WG/SG ***OSDMP supplements*** are expected to tailor this to their needs.

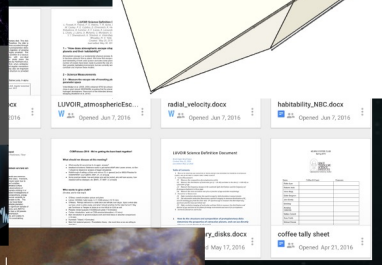
Science Data Simulations Working Group and Subgroup Information

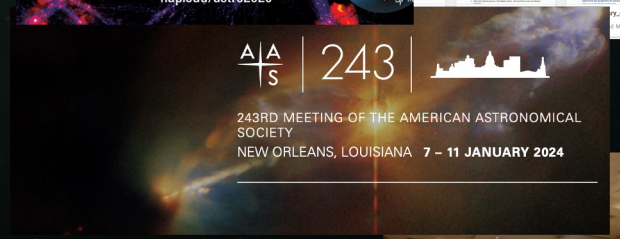
Science Simulation Goals



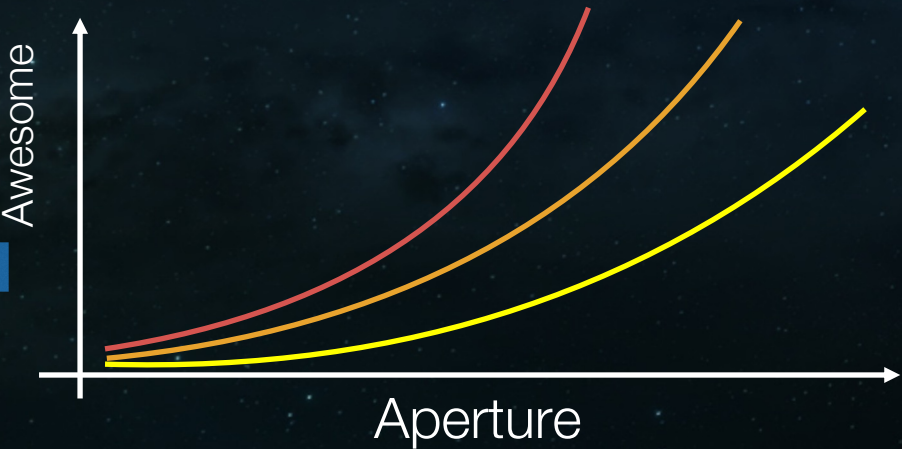








Simulation



If we want:
(1) killer app plots
(2) focused on science rather than capability
(3) based on robust community input,
we have to have a healthy simulation program.

Implications for the Tradespace

- We should not be comparing raw capacity when we compare telescopes & instruments.
- We should compare total science programs, considered holistically, bound by the ultimate limited resource: mission lifetime

Simulation WGs structure

Science Case Simulation Modules

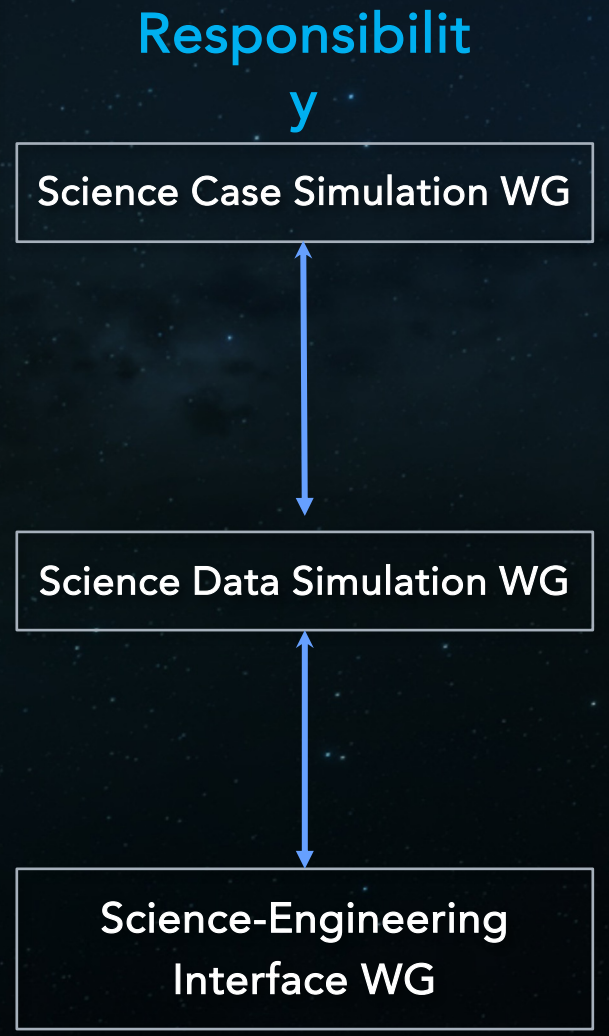
- Enable creation by large range of community scientists
- Developers need streamlined access to ETCs but should not need extensive technical expertise
- Modules should be accurate but not computationally intensive. Fidelity can increase with time.
- Computationally intensive high-fidelity simulations may need to be done separately to find lower fidelity parameterizations for use in modules and/or do spot-checks for accuracy

Data Simulation / Exposure Time Calculators (ETCs)

- Interface between science results and observations
- Translates observatory capabilities parameters into observation requirements
- Model candidate science instruments & basic observing modes
- Produce higher fidelity simulated data later

Science / Engineering Interface

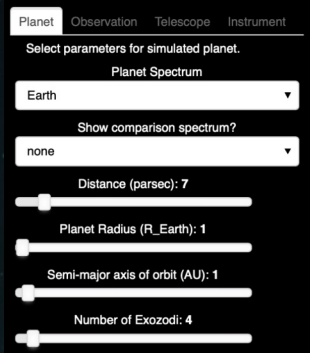
- Translates hardware (e.g., optical elements) into observatory capabilities parameters (e.g., throughput)
- Holds unified set of astrophysical parameters and telescope / instrument capabilities parameters
- Will eventually interface with integrated engineering model
- Initially, will be used to explore large ranges of high-level observatory parameters

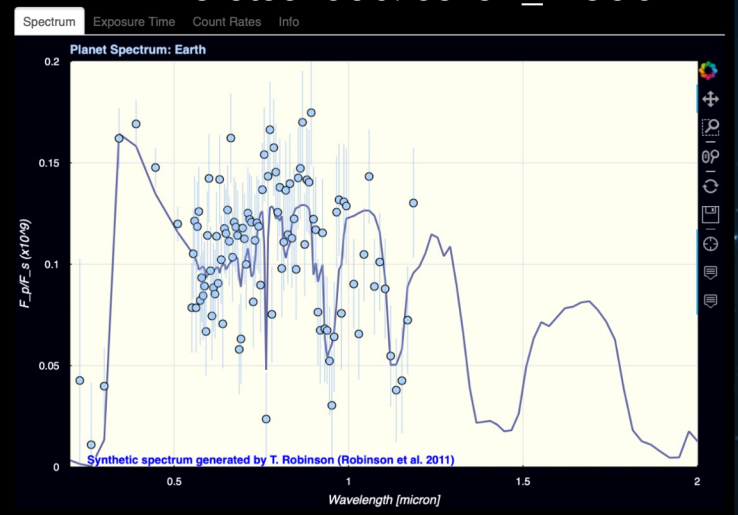


Existing Simulation Tools

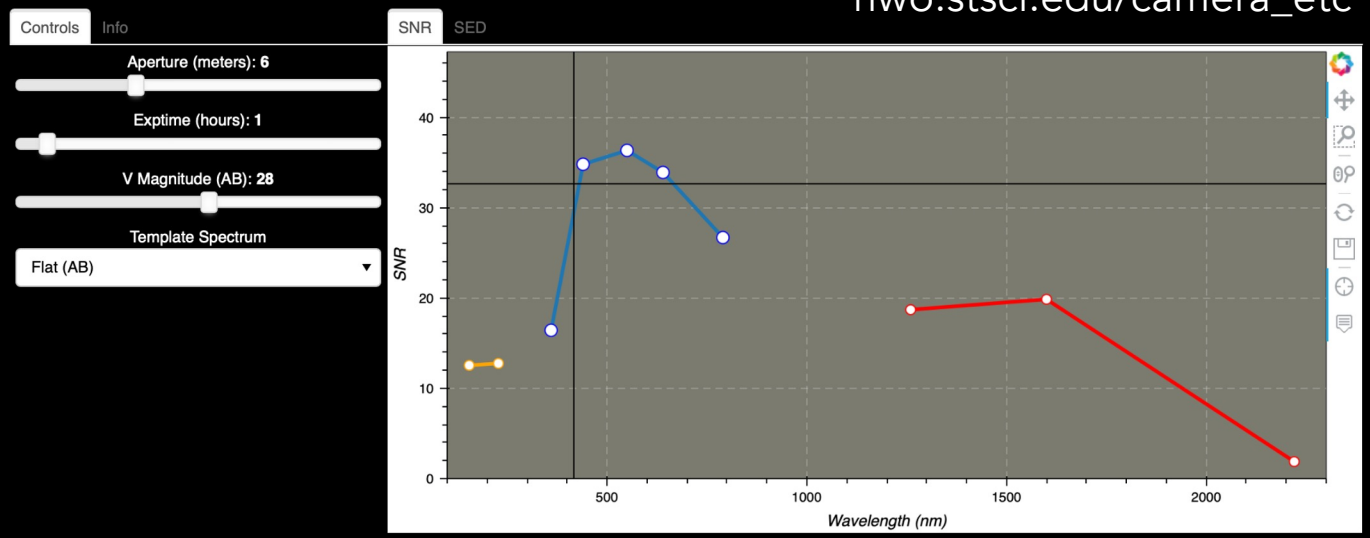
- based on LUVOIR tools, were also adopted by HabEx
- bokeh wrapped around python
- uses STScI pysynphot libraries for sources
- coronagraph model based on code from Ty Robinson & Jake Lustig-Yaeger, adapted by Giada Arney & JT for LUVOIR

hwo.stsci.edu/coron_model





hwo.stsci.edu/camera_etc



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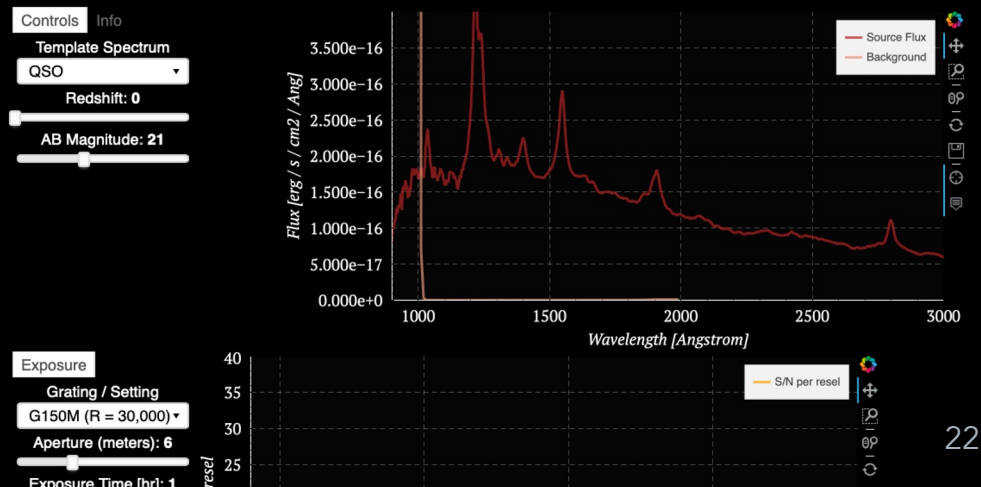


Science Simulation Working Groups

Organized by function / task

Primary interface groups between START & TAG

Science Case Simulation WG

Natasha Batalha & Rachel Osten

- Parametric science cases that exercise each candidate instrument
- Facilitate high-fidelity science case modeling if necessary

Exoplanet Direct Imaging Yields *Dmitry*

Astrometry *Scott Gaudi & TBD*

Galaxy Evolution in the UV *Edmund Hodges-Kluck & TBD*

Data Simulation WG

Tom Greene & Jason Tumlinson

- Tool survey
- Exposure time calculators
- Eventually, output high-fidelity simulated data products

High-Contrast *John Krist & Bruce Macintosh*

Wide-Field Imaging *Sangeeta Malhotra & Pierre-Olivier Lagage*

UV *Kevin France & Sarah Tuttle*

Science / Engineering Interface WG

Patrick Morrissey & Breann Sitarski

- Interface with Systems & IM WGs
- Hold observatory performance parameters
- Archive astrophysical input parameters
- Coordinate DISRA parameter studies

Science Analysis Flow

SEI = Science-Engineering Interface WG
SCS = Science Case Simulation WG
SDS = Science Data Simulation WG

1. Science Goals to Observations

What: Link physical parameters to desired observations

- Example: # of objects detected vs. imaging depth
- Stop before observatory characteristics are needed

Needs: Astrophysical input assumptions

Who: Science WGs; SEI

Deliverable: Science Case Development Document

2. Observations to Observatory

What: Link desired observations to observatory characteristics

- Example: imaging depth vs. telescope diameter / instrument sensitivity / exposure time
- Static observatory performance parameters (not varying over the observation)

Needs: Exposure time calculators; starting engineering input assumptions

Who: SCS; SDS; SEI (consult Science WGs)

Deliverable: Design Concept Mission

3. Static to Dynamic Observatory

What: Add realism by allowing observatory characteristics to vary

- Example: simulated dataset that can be analyzed to assess science returns
- Dynamic observatory performance parameters (e.g., PSF varying over the observation)

Needs: Engineering model outputs

Who: SDS; SEI; Science WGs

Deliverable: Design Reference Mission

CML 3 | CML 4

HWO Science Data Simulations WG

Charter

- Purpose: Produce exposure time calculations and simulated data useful for evaluating HWO performance and to be used for science case simulations
- Objectives: Incorporate current HWO design parameters into tools that simulate HWO observations to support science case simulations WG with sufficient fidelity and timeliness
- Scope: Develop instrument models, exposure time calculators, and example simulated data. Start with idealized assumptions (e.g., photon noise) and add fidelity over time as needed

Team Members

- Subgroup co-chairs: High-contrast (John Krist, Bruce Macintosh), Wide-field imaging (Sangeeta Malhorta, Pierre-Olivier Lagage), and UV (Kevin France, Sarah Tuttle)

HWO Science Data Simulations WG

Key First Year Products

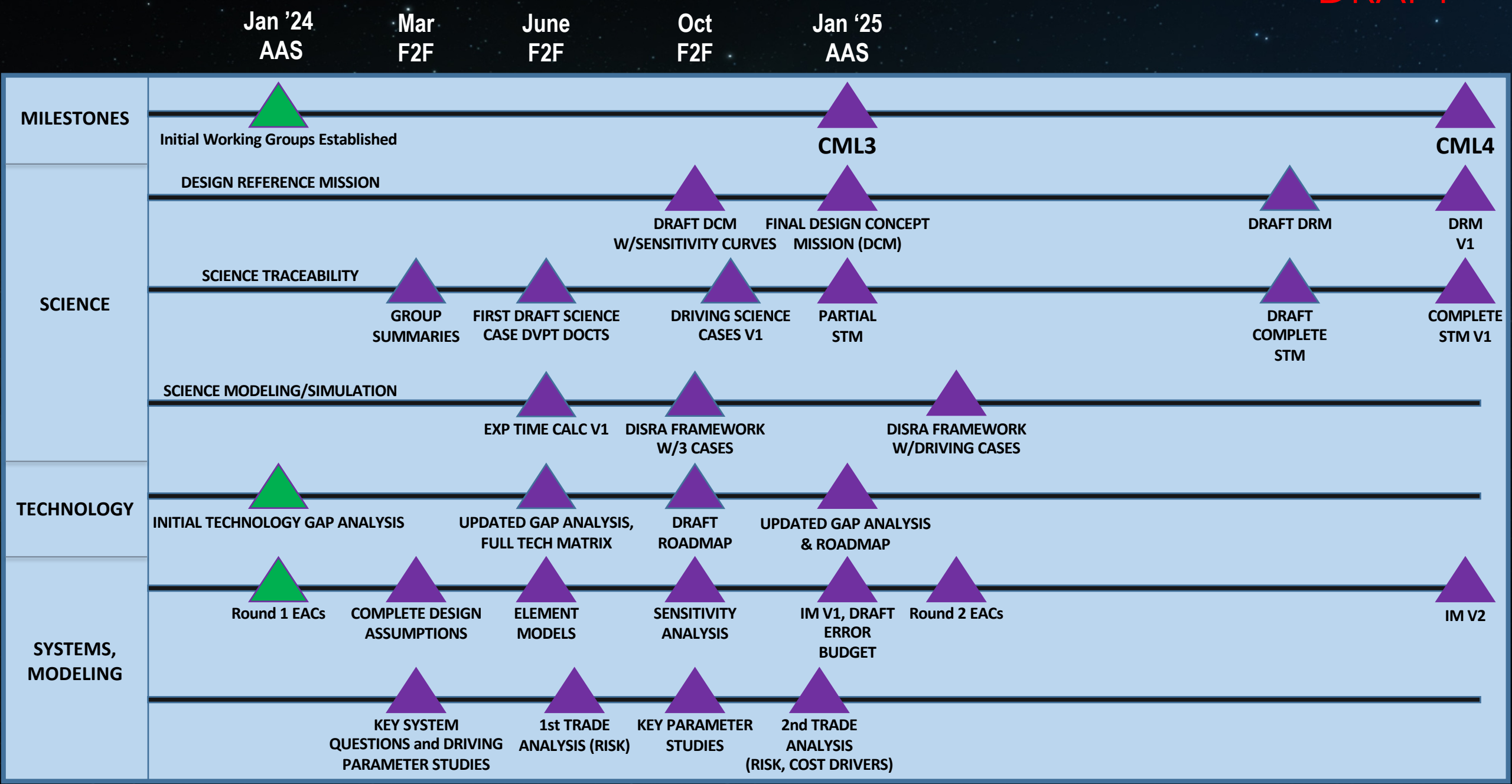
- Descriptions of current instrument/system models, 1st gen simulators for ≥ 1 mode of each HWO instrument, some ETCs, example simulated data products
- Include status updates at team meetings

Giver-Receivers

- Work flow: START science WG products + TAG Science/Engineering WG ←→ *Science Data Simulations WG* ←→ Science Case Simulations WG
- Needed inputs: 1) Exoplanet and general astrophysics system parameters and spectra; 2) HWO instrument mode descriptions; 3) System performance data
- Products: Data simulation tools usable by Science Case Simulations WG and…

Top-Level Milestones Schedule

DRAFT



HWO Wide-Field Data Simulation SG

- Charter
  - Purpose: Develop tools for START/TAG/community to estimate sensitivity and simulate data for primary (anticipated) HWO Wide Field imager (similar to HDI)
  - Objectives: Generate an exposure time calculator, build simulated WFI datasets for a small number of key science cases, outreach to the community.
  - Scope: Develop a straw-person instrument model based on the LUVOIR/LUMOS-B instrument, populate with current and future component projections (in concert with Science/Instrument Interface WG, various Science Groups), develop exposure time calculator w. user-selectable levels of tech advancement (e.g., today, 3 years, 6 years out). Simulate imaging data products for key science cases.
- Team Members
  - Sangeeta Malhotra(GSFC) and Pierre-Olivier Lagage(CEA) are co-chairs. Membership in steering group is being considered.

HWO Wide-Field Data Simulation SG

- Key First Year Products
  - Straw-person instrument model with components and throughput.
  - Exposure Time calculator
  - Development of generic inputs for ETC, path to user inputs
- Giver-Receivers
  - Workflow: Technology WGs + Science Case simulations WGs
  - Inputs: Consult on straw-person design
  - Products: ETCs support DRM and community engagement; data simulation tools usable by Science Case Simulations WG and science community

HWO UV Instrument Data Simulation SG

Charter

- Purpose: Develop tools for START/TAG/community to estimate sensitivity and simulate data for primary (anticipated) HWO Uv Multiobject Spectrograph (HUMS) modes
- Objectives: Generate HUMS exposure time calculator, build simulated HUMS datasets for a small number of key science cases, outreach to the community
- Scope: Develop a straw-person instrument model based on the LUVOIR/LUMOS-B instrument, populate with current and future component projections (in concert with Science/Instrument Interface WG, UV Tech SG), develop exposure time calculator for all anticipated HUMS modes with user-selectable levels of tech advancement (e.g., today, 3 years, 6 years out). Simulate spectral data products for key science cases.

Team Members

- Kevin France (Univ Colorado) & Sarah Tuttle (Univ Washington); names and institutions of confirmed steering group members provided at the end

HWO UV Instrument Data Simulation SG

Key First Year Products

- Straw-person instrument model with component curves incorporated
- HUMS ETCs for key modes
- Development of generic inputs for ETC, path to user inputs

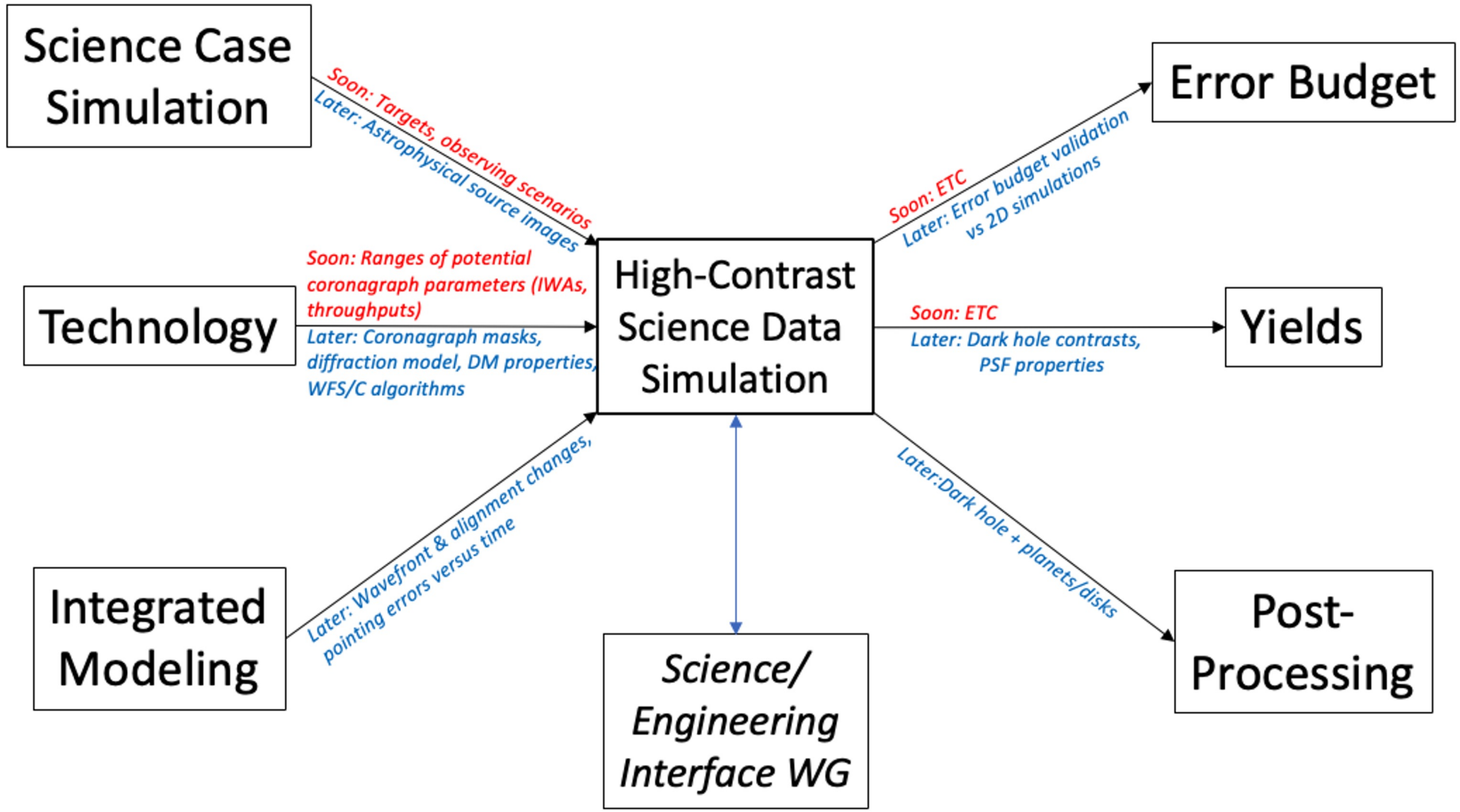
Giver-Receivers

- Workflow: Technology WG -> UV instrument data sim SG -> Science Case simulations WG
- Inputs: Consult on straw-person design, components with UV Tech SG
- Products: ETCs support DRM and community engagement; data simulation tools usable by Science Case Simulations WG and science community

HCSim: High-contrast simulations working group

- Co-chairs: Bruce Macintosh (UCSC) and John Krist (JPL)
- Goals: coordinate tools for producing estimates of coronagraph science capability and products
  - From exposure time calculators to full-physics coronagraph simulations
- Products
  - Provide ETCs to yield simulations group, exoplanet characterization groups, etc.
  - Provide PSF scenarios to groups considering post-processing
- Coordination
  - Complicated with many subgroups from STOP modeling to science
- Near-term tasks:
  - Select steering group (36 responses to survey)
  - Inventory existing tools
  - Build coordination with other subgroups
  - Identify representative coronagraph cases for exploration in all subgroups
  - Build workflow

Note: only inputs/outputs to/from SDS WG shown



SDS working group actions, resources, and near-term plans

ACTIONS: WHAT YOU/WE SHOULD DO NEXT

- **Fill out the survey describing your interests and availability that was sent by your sub-group co-chairs (due ASAP if not already submitted)**
  - We need this info to help you work effectively in the group
  - You must submit this form and agree to the code of conduct (form question) in order to work in this group and HWO

- **Join the HWO_Community Slack to continue discussions with your subgroup.**
- **Go to the Science Data Simulations github wiki for working group info (including these meeting materials)**
  - **Slack and github links are on the next slide**

- **Stay tuned!**
  - **WG co-chairs are cranking up simulation efforts and will keep you informed**
  - **Co-chairs will participate in a START+TAG meeting next week March 11 - 13 when we will do more planning.**

Community Communication Channels for SGs and WGs

- **NASA-provided GitHub:** https://github.com/HWO-GOMAP-Working-Groups
  - Code repository
  - wiki: public meeting and SG/WG materials (slides, summaries, actions)
  - We also use Google Drive and Box for internal START/TAG communications
- **HWO_Community Slack (open to all):** https://join.slack.com/t/hwocommunityworkspace/shared_invite/zt-2dw5oilo4-DYxm9Q47pUCRO9GgpTbPJA
  - General HWO community information
  - Our working group uses the # jwg_sds channel - use that for science data simulation discussions
- **General HWO email list:**
  - **join: hwo-news-join@lists.nasa.gov**
  - **leave: hwo-news-leave@lists.nasa.gov**
- **START/TAG meeting next week, March 11-13**
  - **Aenda and WebEx link will be posted on or linked to from the GOMAP website: https://science.nasa.gov/astrophysics/programs/habitable-worlds-observatory/meetings/**
  - **We will have discussions on the HWO_Community Slack workspace during the meeting**


Questions?