

# A New Era in Exoplanet Characterization with the Habitable Worlds Observatory



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## Background

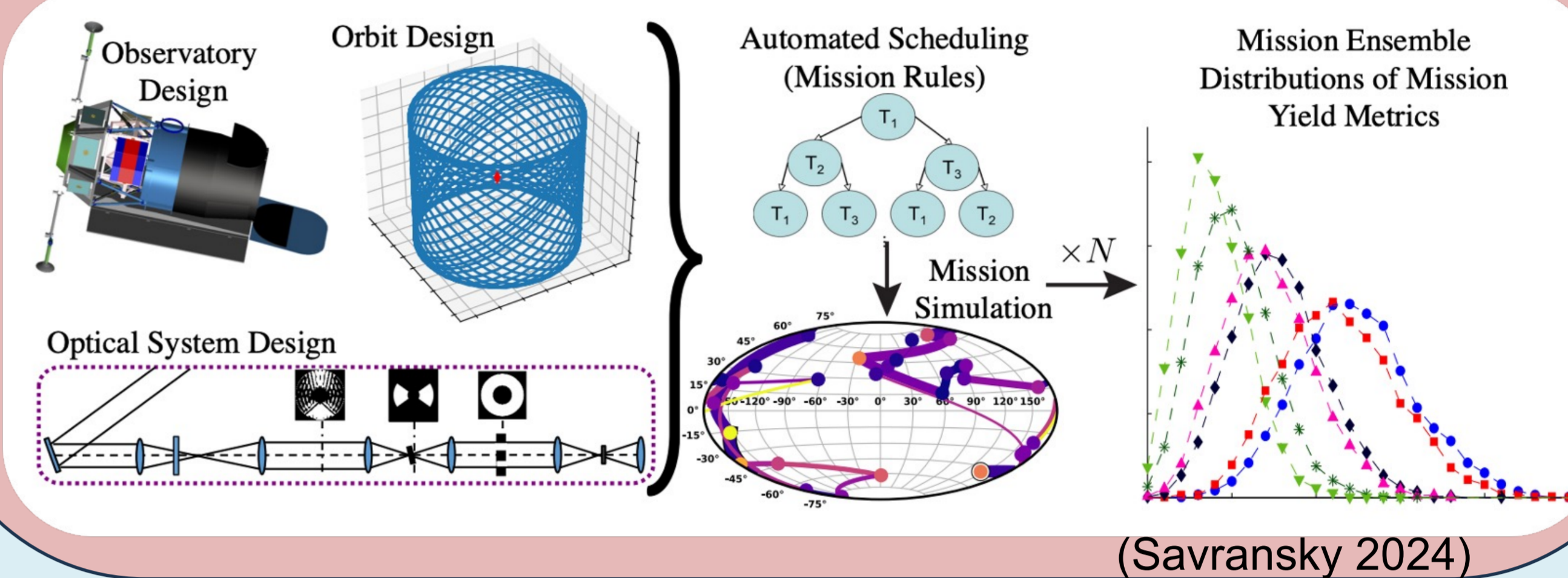
- We are entering an era of direct imaging of Earth-sized planets in the habitable zones of nearby, Sun-like stars.
- Habitable Worlds Observatory (HWO) will be the first telescope designed specifically to search for signs of life on planets orbiting other stars.
- EXOSIMS is a tool that generates ensembles of mission simulations to aid with space telescope design.

## Goal

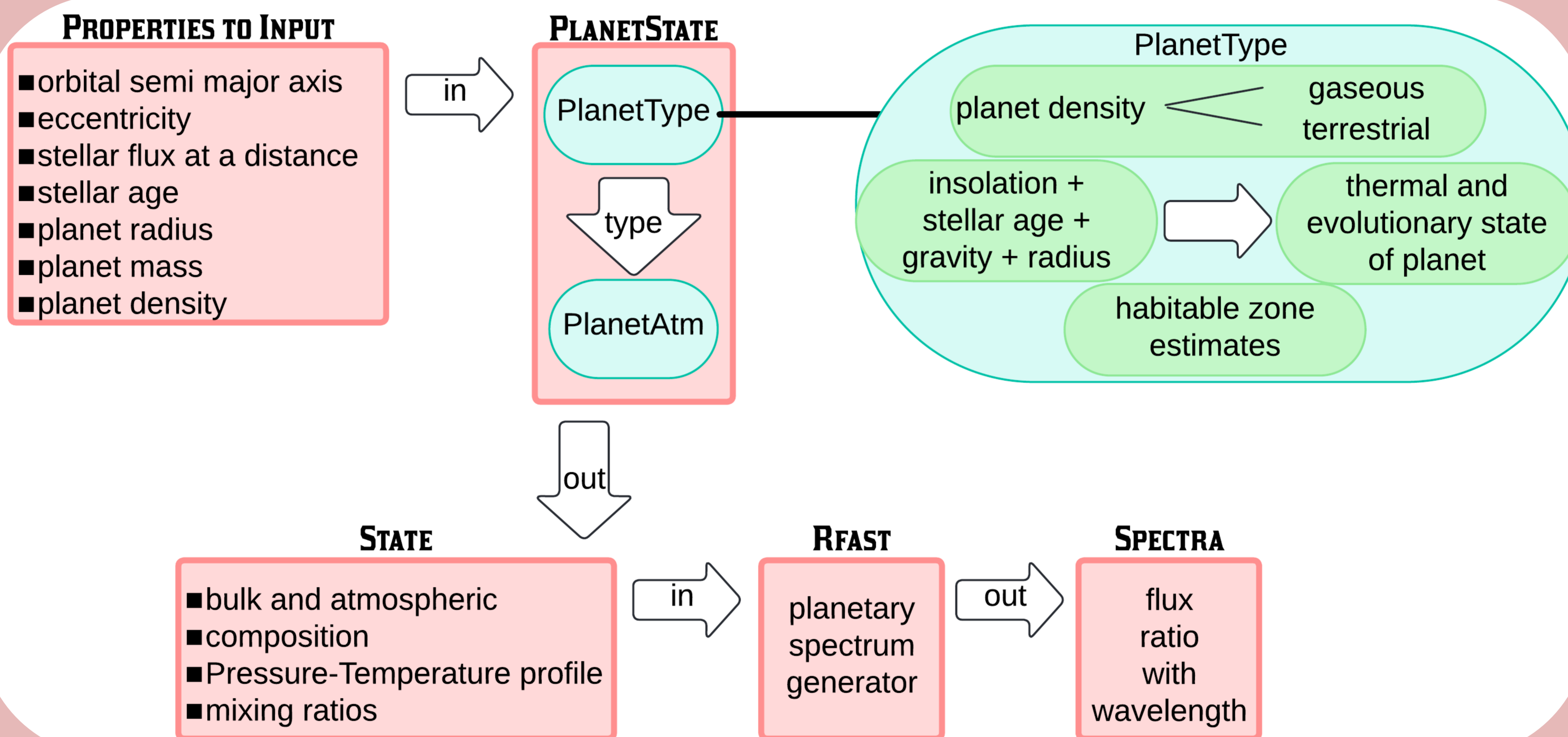
Create new strides in exoplanet direct imaging mission simulations to move away from the number of exoplanets observed and towards **the species detected in the atmospheres of those exoplanets.**

## Why It Matters

- EXOSIMS updates will best enable the search for habitable exoplanets and possible biosignatures.
- Our approaches emphasize *characterization* of exoplanet atmospheres to understand their evolution.
- Updates could increase exoplanet science yield for upcoming missions.



## Workflow with EXOSIMS



## Methods

- Update EXOSIMS to have the ability to better categorize planets by type given orbit/star/bulk parameters.
- Adopt existing planet synthesis and categorization models to help specify planet types (Kopparapu+ 2018; Krissansen-Totton+ 2022)
- Use the planet type to model the thermal, chemical, and evolutionary state of a planet.
- Generate phase-dependent reflected-light spectra given the planetary state.
- Difference simulated spectra to quantify species detectability, including key biosignature gasses.
- Ensemble simulations with gas detections inform how mission architectures perform when challenged with characterizing atmospheres.

## Conclusions and Future Work

HWO is driven by atmospheric characterization, so we need to push EXOSIMS into a regime where we can ask **statistical questions about the gasses that a given mission architecture detects for different types of exoplanets.**

Ultimately, we can **better detect and assess a potentially habitable world** with a mission like HWO.

Quick next steps include updating Earth's phase-dependent brightness, which is oversimplified in EXOSIMS and other yield tools.

- Move from a Lambert phase function to a more realistic Earth phase function.
- Quantify how realistic phase functions impact yields.

## References

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 Krissansen-Totton, J., Fortney, J. J., Nimmo, F., Wogan, N. (2021). Oxygen false positives on habitable zone planets around sun-like star. *Savransky, D., Delacroix, C., & Garrett, D. (2017).*  
 EXOSIMS: Exoplanet open-source imaging mission simulator. *Astrophysics Source Code Library*, ascl-1706.s. *AGU Advances*, 2, e2020AV000294. DOI: 10.1029/2020AV000294.

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