Dynamically Scheduling Direct Imaging Missions

Corey Spohn[1,2], Dean Keithly[1,2], Gabriel Soto[1,2], Dmitry Savransky[1,2]

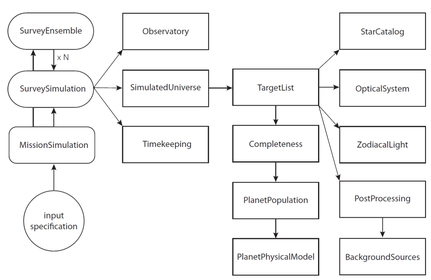
[1]*Sibley School of Mechanical and Aerospace Engineering, Cornell University, Ithaca, NY, United States*

[2]*Carl Sagan Institute, Cornell University, Ithaca, NY, United States*

Introduction

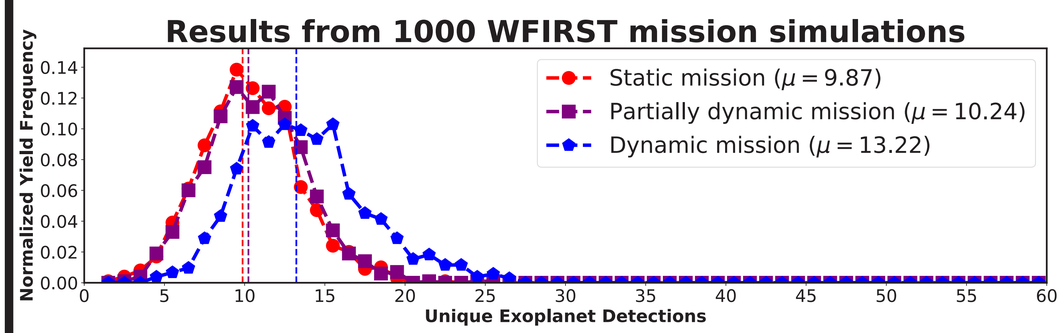
Direct imaging missions being planned, like HabEx and LUVOIR, use a partially dynamic mission schedule. In the first half of the mission they make a series of predetermined observations and revisit promising targets in the second half. However, this kind of mission schedule risks missing the optimal times to revisit promising target stars when during the first half of the mission. Here, we show a method for a fully dynamic mission schedule. To do this we generate a cloud of potential planets around the list of target stars and identify which planets in the cloud would be detectable to the telescope. We use that to calculate the probability of detecting a planet around the star. After an observation we update which potential planets can be eliminated from the search. We show mission simulation results comparing the approaches and demonstrate that when implemented, this process finds more exoplanets by allowing a mission to focus on the most beneficial target stars. Additionally the follow up observations provide information on observed exoplanets, such as better bounds for orbital parameters, that a more static mission plan cannot.

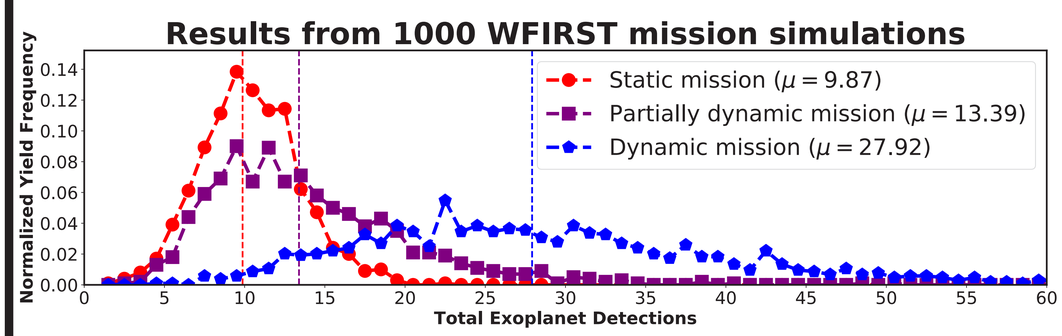
EXOSIMS



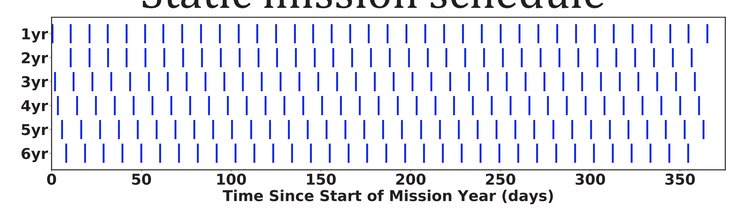
- Exoplanet Open-Source Imaging Mission Simulator
- End-to-end simulations of direct imaging missions
  https://github.com/dsavransky/EXOSIMS
- All simulations shown are done on the branch Spohn-dev

Results for 1000 Mission Simulations with WFIRST Instruments and 7 Months of Observation Time

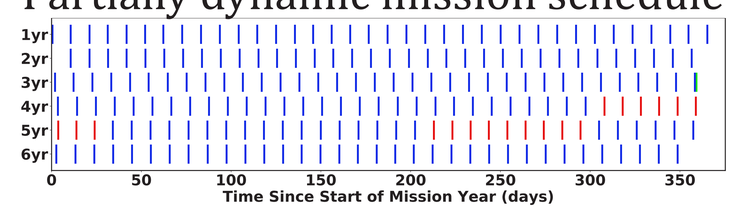




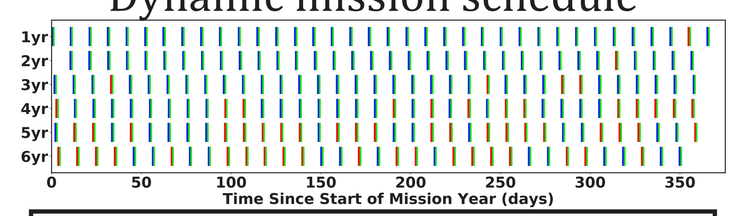
Static mission schedule



Partially dynamic mission schedule



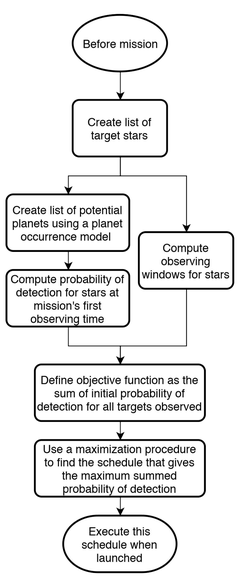
Dynamic mission schedule



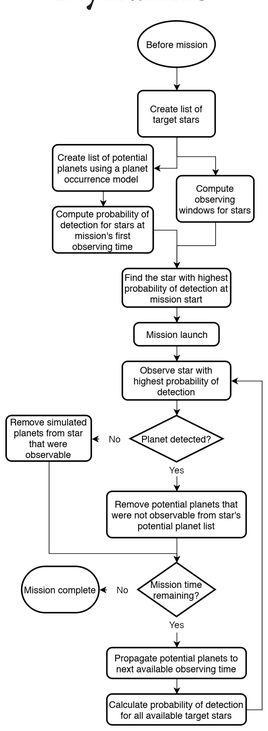
Initial observation of a star | Follow-up observation of a star | Re-evaluate schedule

Schedule Planning

Static

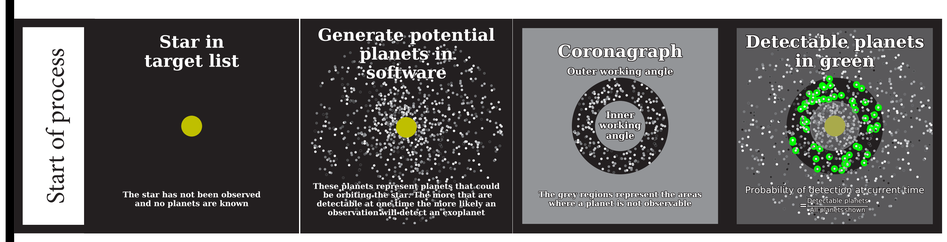


Dynamic



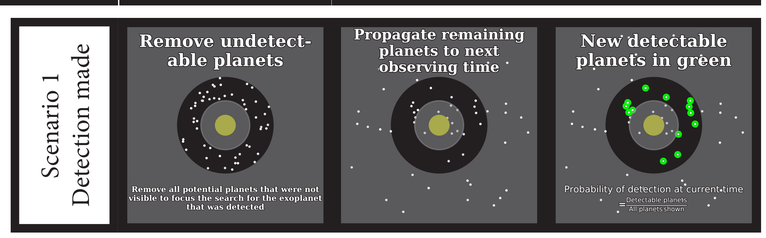
Probability of Detection

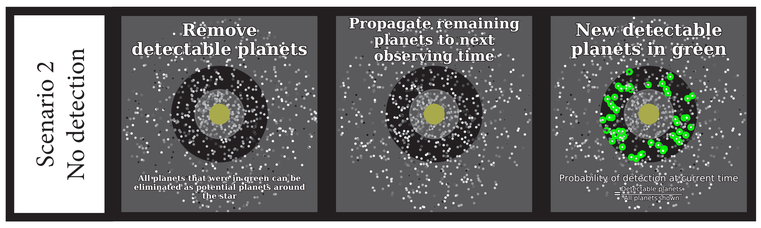
- The probability of detection is the number of detectable potential planets divided by the number of potential planets remaining in the simulation.
- The potential planets generated are dependent on the assumed planetary occurrence rate. The results above assume the SAG13 [1] occurrence rate to give a general exoplanet distribution.
- This metric is an extension of completeness [2][3].



- After calculating the probability of detection an observation is made and two scenarios are possible.
  1. Detection made
  2. No detection

- These scenarios follow directly from the "Detectable planets in green" figure
- Note that these figures only have 1000 potential planets but actual simulations should have between 100,000 or more potential planets





- For the rest of the mission the potential planets around the stars are progressively removed by making more observations and repeating these two scenarios.

Conclusions

- A dynamic schedule outperforms static and partially dynamic schedules for both total exoplanets and unique exoplanets.
- Partially dynamic schedules outperform static schedules.

Contact

Corey Spohn: cas584@cornell.edu

Acknowledgments

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[2] Brown, R. A., (2005). Single-Visit Photometric and Obscurational Completeness. ApJ, 624:1010-1024.

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