A Joint Exoplanet & UVOIR Surveyor

Prof. Julianne J. Dalcanton

Department of Astronomy, University of Washington

In preparation for planning for the 2020 Decadal Survey, Paul Hertz asked the Program Analysis Groups to solicit input on 4 distinct missions, some of which may be studied in more detail in advance of the Decadal. This white paper would like to endorse that a *combination* of the UVOIR Surveyor and the Habitable-Exoplanet Imaging Mission be evaluated as well.

In the current framework, it is inevitable that a UVOIR Surveyor and a Habitable-Exoplanet Imaging Mission will each produce concepts that are highly optimized for their top-line science goals. There may be some additional consideration given to the needs of other communities (such as the addition of the wide field imager on TPF-C, or the coronagraph on WFIRST-AFTA), but any additional instrumentation to support a larger science community is most likely to be an "add-on" that fails to deliver on the full vision of the broader community, and that necessarily accepts compromises in the need to optimize for the primary science goal.

If one steps back, however, it is clear that many of the fundamental design considerations for both a UVOIR Surveyor and a Habitable-Exoplanet Imaging Mission are *shared* by both likely mission concepts. As such, it makes sense to consider not just specialized missions that serve each goal separately, but a joint mission that aims to optimize both.

- *Common Wavelength Coverage:* The Habitable Exoplanet Imaging Mission is likely to focus initially on the optical, where the shorter wavelength allows one to probe closer to the host star for a given inner working angle (IWA) of a coronagraph or starshade starlight suppression system. Exoplanets that are slightly more distant from their host star can benefit from near-infrared spectroscopy, which contains a number of useful lines for constraining the properties of planetary atmospheres. Thus, the wavelength coverage needed for any Habitable-Exoplanet Imaging mission is likely to be encompassed by the coverage needed for the UVOIR Surveyor.

- *A Shared Need for Large Aperture:* Detecting and characterizing significant numbers of planets in the habitable zone absolutely requires large apertures. First, the IWA scales like the inverse of the telescope diameter, such that larger telescopes can detect planets closer to their host star, increasing the chances of finding rocky habitable zone planets around solar-type stars. Second, earth-like planets are incredibly faint, so even in cases where good contrast can be achieved in the habitable zone, an enormous collecting area is needed to ensure enough photons are collected to generate a spectrum whose signal to noise sufficient to characterize the atmosphere. Likewise, for a general purpose next-generation UVOIR mission, one expects transformative science gains when capabilities increase by an order of magnitude. Compared to Hubble, a factor of 10 times increase in the collecting area and in the number of resolution elements per square arcsecond would be achieved by going to a >8m class facility. Thus, the most scientifically compelling UVOIR mission is likely to be of comparable diameter to that required by a likely exoplanet mission.

- *Strong Parallel Science Capabilities:* Exoplanet observations are likely to involve very long integrations. If the Habitable-Exoplanet Imaging mission is also outfitted with general purpose astrophysical instrumentation, these long integrations become a ripe opportunity for very deep parallel observations that support a rich array of other science programs (galaxy deep fields, multi-slit UV spectroscopy, grism surveys, etc). The addition of this parallel science capability not only dramatically increases the scientific efficiency, it also greatly reduces scientific risk to the Habitable-Exoplanet mission by guaranteeing scientific results even when an individual planetary system fails to yield habitable exoplanets. In addition, the broad astronomical research carried out by Hubble has proven particularly compelling to the general public; while detection of a true Earth-analogue will be a major front-page result, general astrophysics provides a steady diet of varied, compelling science results that keep the public engaged with NASA during the long exoplanet search campaign.

Because of their similar aperture requirements, comparable wavelength coverage, and synergistic observing possibilities, we argue that in some implementations it is possible to consider the Habitable-Exoplanet Imaging Mission and the UVOIR Surveyor as a single flagship mission, rather than two separate entities.

We percieve a number of risks associated with only considering these mission concepts separately. By setting up the studies as two distinct missions, NASA may be inadvertently — and unnecessarily – framing the upcoming 2020 Decadal survey as a competition between the exoplanet and general astrophysics communities. Such an approach imperils both possible missions. The history of NASA's flagship missions has repeatedly shown that the largest challenges are frequently not technical, but political. Supporting the high cost of development and operation of a flagship mission over decades requires the highest level of community engagement and advocacy, and by splitting the community too soon, we risk fragmenting the support in the earliest stages where it is most needed.

Likewise, if a joint exoplanet and general UVOIR astrophysics facility is successfully launched, the breadth of the user community will guarantee that the mission remains highly relevant across essentially all fields of astrophysics, which will keep the mission in the public and the scientific eye. This on-going relevance increases the chances that the mission will be long lived, and possibly even serviced with higher-performance second-generation instruments.

Finally, the early pre-2020 design studies proposed by NASA will be useful and necessary investments for evaluating mission cost and for developing plans for critical technology development. Failure to fund evaluation of architectures that can *simultaneously* serve both exoplanet and general astrophysics science goals instantly puts a merged concept at a major disadvantage, effectively guaranteeing that its costing will be more uncertain and more expensive, due to lack of early investment. This will effectively cut off options for pursing a merged mission prematurely.

Based on the above considerations, we strongly endorse study of a merged mission concept that simultaneously addresses the scientific goals of the exoplanet and the UVOIR communities. The much larger community support and greater potential for scientific impact greatly increases the chances that the mission will actually be built.