Direct Imaging of the Nearest Planetary Systems with NASA's WFIRST Mission. M. C. Turnbull[1], B. Macintosh[2], N. J. Kasdin[3], S. Seager[4], A. Roberge[5], M. Marley[6], A. Mandell[5], R. Lupu[7], S. Hildebrandt[8], N. Lewis[9], S. Shaklan[8], C. Stark[9], the WFIRST Science Investigation Teams, and the Starshade Probe Study Team [1]SETI Institute (turnbull.maggie@gmail.com), [2]Stanford University (bmacint@stanford.edu), [3]Princeton University (jkasdin@princeton.edu), [4]Massachusetts Institute of Technology (seager@mit.edu) [5]NASA Goddard Space Flight Center (roberge@nasa.gov), [6]NASA Ames Research Center (mmarley@ames.nasa.gov), [7]Bay Area Environmental research Institute (roxana.e.lupu@nasa.gov), [8]Jet Propulsion Laboratory (srh.jpl.caltech@gmail.com; stuart.b.shaklan@jpl.nasa.gov), [9]Space Telescope Science Institute (nlewis@stsci.edu; cstark@stsci.edu)

Introduction: Using the Coronagraph Instrument (CGI), WFIRST will enable our generation, for the first time in human history, to directly image and characterize planets similar to those in our Solar System. The CGI will also perform detailed studies of the properties of debris disks around nearby stars, giving us insight into the formation of planetary systems. Finally, the mission is baselined to include accommodations for operating with a starshade, should a separate starshade probe rendezvous mission be approved.

We will provide a status update for the mission as a whole (currently nearing the end of Phase A), including results from the currently ongoing independent cost and technology review. To address WFIRST's pathfinding role in achieving the ultimate goal of directly detecting a "pale blue dot" around a sunlike star and search for signatures of habitability, we will describe the specific advances in both (1) the technological capability and (2) the scientific methodology that will contribute to future 4- to 12-m class exoplanet mission concepts such as LUVOIR and Hab-Ex.

Imaging and Photometry with WFIRST Coronagraph: The primary science targets of the WFIRST CGI are giant planets that are already known to exist through radial velocity measurements. However, this imaging survey will also be sensitive to currently unknown planets orbiting the nearest stars. With the constraints of limited mission time and scheduling, such a survey would likely target 20-60 nearby stars, selected to optimize planet detectability [1][2]. Simulations show that such a survey would discover a mean of 4 planets (+-2) with radii as small as ~2 Earth radii. The smaller planets would be too faint for spectroscopic characterization, but photometry could determine whether the planets have methane/hydrogen-dominated atmospheres, and the systems thus discovered would be prime targets for follow-up with future missions.

The survey would also identify circumstellar dust down to 10-20 times the solar zodiacal level. These measurements, combined with observations in the infrared by LBTI, represent direct precursur science for missions like Hab-Ex and LUVOIR.

Spectroscopy with the WFIRST IFS: Lupu et al. [3] and other groups have found that a range of exoplanet atmospheric chemical processes can be reliably probed with the current WFIRST CGI+IFS design for a small, but meaningful, sample of known exoplanets if the spectral resolution (>50) and SNR of the spectrum (>15) are adequate. The current sensitivity predictions show that 3-4 known RV planets will be spectroscopically characterizable at high SNR, and ~18 planets will be accessible to photometry, in addition to potential new-planet discoveries. This presentation will describe how the complete process of acquiring images, selecting targets for spectroscopic followup, and conducting retrieval studies to constrain planetary properties is crucial to refining the scientific methodology and setting requirements for the larger HabEx/LUVOIR missions.

WFIRST Starshade Readiness and Probe Study: Finally, the WFIRST Project has been directed to determine the minimum required impact to the observatory in order to make it "starshade ready." No starshade is planned as part of the WFIRST mission itself, but should a future probe mission be approved to rendezvous with WFIRST, certain decisions must be made now in order to insure compatibility.

A WFIRST starshade mission would enable the detection and spectral characterization of smaller planets (down to flux ratios of ~1e-10 or fainter) orbiting at smaller angular separations (down to ~75 mas) from their stars, potentially including binaries (if used in tandem with the CGI). At the same time, the lack of an *outer* working angle will reveal the distribution of exozodiacal dust present in these systems, which may be indicative of the presence of unseen far-out planets and/or asteroid belts. This "deep dive, big picture" capability would represent a significant step forward in constructing complete family portraits of our nearest neighbors, allowing a first look at the relationships between planetary system architectures and planetary properties.

References:

[1] Stark, C, et al., 2014, ApJ. 795, 2. [2] Garret, D., et al 2017 A.J. 154, 47. [3] Lupu, R., Marley, M., Lewis, N., Line, M., Traub, W., Zahnle, K. (2016). ApJ 152, 217.