ACROSS THE SOLAR SYSTEM: A SURVEY OF NASA PLANETARY SCIENCE SUMMER SEMINAR MISSION STUDIES 1999-2018. C. J. Budney[1], L. L. Lowes[1], K. L. Mitchell[1], and A. S. Wessen[1], [1]NASA Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, California 91109.

Introduction: Sponsored by NASA's Planetary Science Division, and managed by the Jet Propulsion Laboratory (JPL), the Planetary Science Summer Seminar (PSSS) prepares the next generation of engineers and scientists to participate in future solar system exploration missions. Ten years after its inception in 1989 in a lecture format, JPL evolved the experience to focus on the process of developing a robotic planetary exploration mission concept into reality through concurrent engineering, mentored by members of JPL's advance project design team "Team X". To maximize the immersive authentic learning experience[1], and raise its professional value, the choice of mission concepts is aligned with community priorities and the specific interest of the participants. As community consensus interests evolve due in large part to knowledge gained by flown missions and returned science, the studies developed by each cohort are designed to address appropriate medium-class planetary science missions (NASA New Frontiers Program guidelines). The paper surveys the PSSS mission concepts across the history of the Team X version.

The Planetary Science Summer Seminar Experience: PSSS is an intensive one-week team exercise at NASA's Jet Propulsion Laboratory's Project Design Center, preceded by a series of about 10 weekly preparatory webinars and assignments (requiring 8 hours per week). Under the mentorship of a lead engineer and a lead scientist (most recently, Dr. Charles Budney and Dr. Karl Mitchell), students select, design, and develop a mission concept from the Planetary Science Decadal Survey, following the guidelines of the NASA New Frontiers Announcement of Opportunity.

During the preparatory webinars, students select the mission and science goals from options based on high-priority missions as defined by the scientific community, and develop a preliminary suite of instrumentation and a science traceability matrix. Students have both a science team role and a mission development role with a JPL Team X mentor.

Once at JPL, students participate in a series of Team X project design sessions — their mentors aid them in finalizing the design of their mission and instrument suite, and in making the necessary trade-offs to stay within the cost cap. Tours of JPL facilities highlight the end-to-end mission life cycle. At week's end, students present their Concept Study to a "proposal review board" of JPL scientists and engineers and NASA Headquarters executives, who feed back the strengths and weaknesses of their proposal and mission design.

Planetary Science Mission Studies: A survey of mission concept selections shows the connection to community priorities (see Table 1) as point designs in the trade space of potential missions or as novel selections and usage of science instrumentation. In 2017, for example, PSSS participants developed a concept for a mission to study Centaur objects, a cutting-edge scientific destination lacking point designs in the trade space for potential missions at that time. Clarifications in the classification of Centaur objects by both photometric color and orbital dynamics (to distinguish from other debris) were necessary and limited the choice of specific destinations for the study. Students from a session in 2012 were invited to present their Venus Atmosphere, Descent, and Environmental Researcher mission concept at the 2013 Venus Exploration Analysis Group meeting. Some of the design elements from a 2003 PSSS Mars Geophysical Lander mission concept [2] were realized in NASA's InSight (Interior Exploration using Seismic Investigations, Geodesy and Heat Transport) mission, launched in May 2018 and currently in surface operations.

Each student group has presented papers and published in professional journals, describing their mission concept and/or highlighting a particular aspect of it, a compilation of which is available on Research Gate as the Planetary Science Summer Seminar project [3].

Participants: Applicants are sought who have a strong interest and experience in careers in planetary exploration, and who are science and engineering post-docs, recent PhDs, doctoral or graduate students, and faculty teaching such students. Disciplines include planetary science, geoscience, geophysics, environmental science, aerospace engineering, mechanical engineering, and materials science.

Participants are selected through a competitive review process, with selections based on the strength of the application and advisor's recommendation letter.

The majority of students come from US universities with planetary science or aerospace-related engineering programs, representing over 50 different universities total since 1999. In 2018, 47% of the students were women, continuing the upward trend in gender balance of participants since 1999 (almost doubling in that time).

636 individuals have participated in the Team X-based PSSS sessions since 1999. The majority are now employed or conducting postdoctoral research at NASA Centers; are employed at Federally-Funded Research and Development Centers, science research organizations and aerospace companies; or they are university faculty, staff, or postdocs.

Implementation: The Planetary Science Summer Seminar is implemented by the JPL Education Office in partnership with JPL's Team X Project Design Center. URL: http://psss.jpl.nasa.gov

References:

[1] Herrington, J. et al. (2014) Authentic Learning Environments, *Handbook of Research on Educational Communications and Technology*. 401-412.

[2] Shiro, B. R. et al. (2013) Mars Geophysical Lander Mission: A Mission Concept from the 2003 NASA Planetary Science Summer School. *LPSC Meeting #44*, Abstract #1706 https://www.lpi.usra.edu/meetings/lpsc2013/pdf/1706.pdf

[3] Planetary Science Summer Seminar Research Gate project https://www.researchgate.net/project/Planetary-Science-Summer-Seminar

[4] Vision and Voyages for Planetary Science in the Decade 2013–2022 https://www.nap.edu/catalog/13117/vision-and-voyages-for-planetary-science-in-the-decade-2013-2022

[5] New Frontiers 4 Announcement of Opportunity (2016) https://nspires.nasaprs.com/external/solicitations/summary.do?method=init&solId={F65A5657-0E72-362E-2D4C-DE87A16A82B7}&path=closedPast

[6] New Frontiers Announcement of Opportunity 2009 https://nspires.nasaprs.com/external/solicitations/summary.do?method=init&solId={CFE00B4A-2447-7325-7004-7C3B04ED5738}&path=closedPast

Table 1. Recent PSSS Mission Studies

Cohort	Mission Concept Type	Mission Name	Science Goals Described in:
2018	Uranus Observer	QUEST	2013 V&V[4]
2017	Centaur Reconnaissance	CAMILLA	2013 V&V, 2016 NF [5]
2016	Uranus Observer	OCEANUS	2013 V&V
2015	Ocean Worlds – Enceladus	THEO	2013 V&V
2014	Ocean Worlds – Enceladus	EVE	2013 V&V
	Uranus Observer	CAELUS	2013 V&V
	Io Observer	ARGUS	2009 NF [6]
2013	Uranus Observer	MUSE	2013 V&V
	Neptune Observer	TRIDENT	2013 V&V
2012	Io Observer	FIRE	2009 NF
	Venus Probe	VADER	2009 NF
2011	Venus Probe	VULCAN	2009 NF
	Trojan Tour and Rendezvous	TASTER	2013 V&V, 2009 NF