LEARNING WAYS TO IMPROVE COLLABORATION AND COMMUNICATION WITHIN A DISTRIBUTED, LARGE TEAM – VIA THE EUROPA CLIPPER MISSION SOCIAL SCIENCE JOURNAL CLUB. S. Diniega[1], R. Klima[2], C.B. Phillips[1], C. Richey[1], E. Turtle[2], S.D. Vance[1], J. Vertesi[3], R. Pappalardo[1]. [1]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., Pasadena, CA 91109, USA (serina.diniega@jpl.nasa.gov), [2]Johns Hopkins University, Applied Physics Laboratory, [3]Princeton University.

Introduction: Most planetary science mission teams, and some research groups, involve a large number of technical experts distributed across institutions and timezones. Anyone involved in such a team is familiar with the many types of issues that can arise within communication and collaboration between these team members – which can result in poor or inefficient decisions, people feeling (and perhaps being) left out of pertinent conversations, interpersonal conflicts, and ineffective sharing of information. While such issues can seem insurmountable, there fortunately are many experts who study such issues and can present options for mitigating or preventing these problems.

The Europa Clipper Social Science journal club series is organized by Europa Clipper science team members to bring peer-reviewed insights and recommendations regarding organizational and individual best practices into our design of team communication and collaboration. Of particular interest are social science studies about how teamwork, communication, and decision-making can be improved within a large, distributed team with a diversity of individual priorities, technical expertise, and cultural backgrounds—or conversely, to learn from case studies what can go wrong and how to avoid such missteps. This is especially important given the "One Team" Europa Clipper science team philosophy [1,2]. Our goal in this area is to improve how we execute our collaborations and communication on the Europa Clipper mission.

The Europa Clipper Team context: The Europa Clipper mission has 10 investigations [3] that will work together to find critical clues about Europa's potential habitability. The synergy arising from the combined datasets and associated expertise is needed for clarity into the multi-disciplinary mysteries of Europa. Such integrated science is promoted by communication and collaboration across the science team as well as with all associated engineering teams.

The Europa Clipper science team, including affiliates, contains >200 scientists from >50 institutions and 8 countries. Additionally, the overall team comprises hundreds of experts: managers, scientists, and engineers involved with the many spacecraft subsystems, and numerous additional personnel work with Communications/Public Engagement and administrative support. Thus, as a group, we are working toward a common goal with:

- a highly distributed team, where some people are co-located but most interactions will involve remote participants;
- a very large and complex system, where decisions in one area can ripple through the full system and induce new issues; and
- a range of cultures, perspectives, nomenclature, and individual priorities that can depend on technical expertise, institution, personal identity and background, and involvement with a particular investigation or subsystem.

Additionally, we are working with several finite resources (such as cost and time), so efficiencies and robustness in communication and collaboration are valuable. Thus, it has been helpful for us to invest energy and time to understand different models for team building and structure; strategies and practices for communication (in-the-moment as well as reporting/archiving); and methods for identifying and resolving conflicts.

The Social Science Series structure: In addition to learning about results and recommendations from relevant social science literature, an aim of this journal club was to introduce a common framework and language for discussing issues that can arise within human interactions on a spacecraft team. Thus, we have sought to allow for in-depth discussion by people able to delve deeply into these topics, as well as introduce the general ideas and actionable recommendations to as many team members as possible. Thus, our journal club aimed to include two types of meetings per topic. First we discuss in-depth two social science papers, with discussion led by a few group members who summarize the papers with an aim of identifying questions and ideas specifically relevant to the Europa Clipper team. When logistics permit, this is followed by a presentation by a relevant social science expert to summarize key results within the field, and of whom we could ask questions and identify relevant actionable recommendations for the Europa Clipper team.

Topics to date have been chosen by journal club organizers based on concerns raised within the Europa Clipper team or noted issues or challenges. Dr. Janet Vertesi, a social scientist at Princeton who was on sabbatical with the Europa Clipper team, helped connect us with relevant papers and social science experts.

Meetings were conducted via WebEx and in-person attendance: JPL and APL rooms were reserved and set up for video-sharing for attendees at those institutions, and we encouraged other institutions to consider the same. Attendance to the Social Science series discussions was voluntary and open invitations were initially sent to the full team (after a few meetings, we used a separate opt-in email list). Anyone associated with the Europa Clipper team – scientists, engineers, support staff – was welcome to attend. (And for later reference, papers, experts' presentation files, and meeting notes were posted to an internal team website, accessible to the full Europa Clipper science team.)

Our topics and some results: Our first meetings (Nov 2016, Jan 2017) focused on distance collaboration -- how to design communication and structure within a group or meeting that includes people physically located in different places. This topic was of special interest given a recent decrease in planned Europa Clipper team meeting cadence. We sought to answer the questions: (1) Are we using "remote access collaboration" in the right areas? (2) Are we using the technology(s) for remote access in the best way? (3) How do we better accommodate and mitigate the mix of in-person and remote participation ongoing within this team? At our in-depth meeting, we discussed the papers *Distance Matters* [4] and *Understanding Conflict in Distributed Teams* [5]. Experts on distributed work within scientific and technical collaborations, Drs. Gary Olson and Judy Olson (Prof. Information & Computer Sciences, U. California Irvine, and authors of [4]), then presented on *Distance Matters: How to Make Distance Work Work*. From these meetings, we learned the importance of enabling regular or strategic co-location for people involved in highly-coupled tasks, the need to explicitly develop and agree upon communication practices that consider the distances between people, and practices that can enhance communication within remote meeting forums (such as encouraging camera usage within WebEx; providing remote attendees with a bell or other defined way to smoothly break into a conversation; and having someone with training explicitly responsible for setting up the AV and helping with remote communications, including a chat window) – yielding concrete changes to how our meetings are conducted and information is shared.

Our second topic (April 2017) was focused on ways to recognize and resolve conflict, especially within the context of distributed teams. Within the small-group meeting, we discussed the papers *The Dynamics of Silencing Conflict* [6] and *Understanding conflict in geographically distributed teams: The moderating effects of shared identity, shared context, and spontaneous communication* [7]. From these papers, we learned about different types of conflict – and in particular that task conflict (i.e., different opinions and viewpoints about the work being performed, often including differences of opinion about what should be done), which was associated with lower team performance, occurred more often within distributed teams. Spontaneous communication can play a key role in mitigating both the occurrence of conflict and team performance. In particular, spontaneous communication can enhance a shared team identity (which induces more trust and cooperative stances) and shared context – yielding recommendations related to those from our first meetings. (Because of time limitations, we were unable to bring in a speaker; but the small-group discussion was still illuminating and helpful.)

Our third discussion was organized differently, to take advantage of the 5th Europa Clipper Project Science Group (PSG) meeting (May 2017). As many social science journal club attendees were co-located, we met for lunch and picked a "fun" discussion topic – "stories" we have heard that create unrealistic, biased, or completely irrelevant views of what it means to be a successful planetary scientist. Discussion was prompted by an excerpt of a book chapter about the kinds of experiences and behavior expected of young physicists who will eventually "make it" in their field [8]. While this discussion was more informal than previous meetings, it still introduced many ideas relevant to interactions within our team that can lead people to feel less able or welcomed to contribute.

Potential next steps: We plan to continue our journal club, with a focus on topics that have risen within our current mission phase, such as recommended policies and practices for sharing science observations and relevant information (e.g., calibration, interpretations) across a broad team and encouraging collaboration and decision making within crises. Such topics have relevance as we design our science observation planning, acquisition, and distribution plans.

References: [1] Pappalardo, 2018, One Science Team, in https://europa.nasa.gov/news/15/the-sextant-europa-clipper-newsletter. [2] Richey et al., this conference. [3] Pappalardo et al., 2017, *LPSC 48*, 2732. [4] Olson & Olson, 2000, *Human-Computer Interaction*, **15**: 139-178. [5] Hinds & Bailey, 2003, *Organization Science*, **14**(6): 615-632. [6] Perlow et al., 2009, *Research in Organizational Behavior*, **29**: 195-223. [7] Hinds & Mortensen, 2005, *Organization Science*, **16**(3): 290-307. [8] Traweek, 1988, Pilgrim's progress: Male tales told during a life in Physics, in *Beamtimes and Lifetimes: The World of High Energy Physicists*: 74-105.