TEAM DYNAMICS DURING A FOUR-DAY EFFORT TO MAP BENNU'S SURFACE: A COLLABORATIVE EFFORT. J. L. Molaro[1], K. Walsh[2], E. Jawin[3], R.-L. Ballouz[3], M. Pajola[6], S. Schwartz[3], J. P. Dworkin[5], H. C. Connolly[7], D. S. Lauretta[4]. [1]Planetary Science Institute (jmolaro@psi.edu), [2]Southwest Research Institute, [3]National Museum of Natural History, Smithsonian Institution, [4]Lunar and Planetary Lab, University of Arizona, [5]Goddard Space Flight Center, [6]INAF-Astronomical Observatory of Padova, Italy, [7]Rowan University.

Introduction: As scientists, and particularly in the field of planetary science, much of our research is conducted in groups, either developed informally by individuals of common interest across institutions or formally within institutions or mission teams. The intent of collaborations is to enhance the scientific output of a project by making it more robust (incorporating multiple areas of expertise on a team) and/or more efficient (incorporating diverse skillsets on a team). Yet, rarely do we discuss or share techniques in how collaborative efforts are performed. By doing so, we as a community can explore how to work together more productively, better leverage the skills and expertise that individuals bring to a project, and develop effective collaborations between institutions and groups. Here we share methodologies used by our OSIRIS-REx Regolith Development Working Group (RDWG) to communicate and collaborate effectively as a team during our preliminary mapping campaign, and how they allowed us to both successfully meet a time-constrained goal and foster a constructive and cohesive team dynamic.

The Goal: The goal of this effort was to look through the first high-resolution images of Bennu's surface returned by the OSIRIS-REx spacecraft. As the RDWG, it was our task to perform a preliminary survey of notable surface features and characteristics for the team to present at the American Geophysical Union (AGU) and Lunar and Planetary Science Conference (LPSC) meetings. The images were received from the spacecraft December 1 and 2, 2018, and the team celebrated its official arrival on December 3. Since AGU was the following week, a substantial surveying and mapping effort needed to be undertaken in a very short period of time in order to present preliminary results at the meeting. We were asked to provide the mission leadership with a summary of observations and a selection of images to use at AGU by December 6, leaving 3.5 days to work.

Team Organization: The mapping effort was performed primarily with the RDWG team, including a handful of team members that have co-membership on other working groups. The structure of the team consisted of the Working Group (WG) Lead and Mapping Lead, as well as subject matter leads for Regolith, Craters and Boulders, and Linear Features.

The primary role of the WG Lead was to direct mapping efforts, check in with team members on different activities, and facilitate communication with other working groups and mission leadership. The role of the Mapping Lead was to provide training, instruction, and support to those team members mapping surface features, and to collect and organize mapping products that were produced. The role of the subject matter leads was to direct discussion of individual topics during telecon and email communications, and prepare a written summary of initial observations based on the team's input.

Approach: The first day of the campaign was spent primarily with the Mapping Lead providing instruction on the mapping tools to team members. Leveraging their expertise to provide training to others instead of perform mapping themselves was an extremely effective way to get other team members ramped up on how to use the tools quickly. Members physically located at the OSIRIS-REx headquarters were able to receive instruction at the same time, and made up the primary mappers in the group. Having these core new mappers co-located allowed them to assist each other in learning to use the tools, leaving the Mapping Lead free to float from person to person where their expertise was required, support remote team members, or spend time organizing mapping products that were produced. As a result, the majority of RDWG learned to use the mapping tools much more quickly than if individuals had tried to learn on their own, and this training will continue to benefit the team throughout the mission. Overall, the first day also served as an "orientation" of Bennu's surface, enabling us to become familiar with the major features of the topography, common reference points, and informal names used by the team.

We began by mapping all of the boulders above a certain size threshold in a specific region on Bennu's surface, using an image and a polygon outlining the region provided by the Mapping Lead. We mapped each boulder as an ellipse, and marked it using pre-defined labels describing its attributes (e.g., dark fractured, hummocky). This served as a first exercise during mapping instruction. While it did duplicate effort, it also provided an assessment of how representative an individual's results were relative to the group as a whole, and thus one measure of the robustness of the scientific result.

Throughout day one, it became clear that some of the mapping labels we had previously agreed on were difficult to apply, either because they were too

subjective or because the attributes of the boulder population did not reflect our expectations. We discussed this in real time as we mapped, and modified our labeling convention to better suit our needs. The most important aspect of this change was that all team members had input and clearly understood the new labels, retaining their use as an effective tool for future mapping and analyses throughout the mission.

It also became clear after the first day which team members were most efficient at mapping. One member with mapping experience was particularly apt at mapping large numbers of boulders quickly, especially if they skipped adding the labels. They also happened to be located remotely in a different time zone, and we leveraged this to increase our group efficiency. We altered our process to have this new Primary Mapper be the sole person mapping boulders in subsequent regions. These new counts were performed during the night for co-located members, who then split up the task of labeling them during the following day.

Co-located team members who finished labeling more quickly were proactive in assisting slower members with their assignments. This left time for everyone in the group to spend at least part of the day pursuing analysis relevant to their individual subject expertise, and as a result the overall scientific scope touched on during the campaign was increased. As more of the mapping was completed, the number of mappers needed decreased during the week. This allowed some members to shift their attention full time to other tasks and ideas that arose during team science discussions. Additionally, remote team members who were not part of the core mapping group were asked, as needed, to perform individual, specific mapping tasks that only required a single person. Overall, this flexible approach of adjusting which and how many team members were focused on mapping tasks allowed us to be much more efficient later in the week than we had been during day one.

A few team members focused solely on mapping crater candidates instead of boulders. In this case, they individually assessed the surface for crater-like features, intentionally duplicating their effort. They compared their results to categorize the features into groups based on their strength as crater candidates. For example, features that all three mappers identified as craters are considered strong candidates, whereas those mapped only by a single member have greater uncertainty. Fewer mappers were required in this effort, and their sub-team operated most efficiently by waiting to receive input from the larger group until after the mapping was complete.

Each day during the campaign the WG Lead held a telecon to discuss the current state of the campaign and any new observations the team made about Bennu. Their primary purpose was to ensure that remote team members could be involved in the science discussions. The WG Lead set an informal and positive tone for these calls, allowing people to chime in or take the lead as desired, depending on where the conversation went. At the same time, they set a precedent for not talking over one another, respecting each other's ideas, encouraging questions, and specifically inviting comments from team members with relevant expertise who may have been less vocal during the discussion. Doing so helped to ensure that all team members had a voice in the discussion and could be part of the discovery process, as well as ensure that all of RDWG's combined expertise could be brought to bear in our science analysis.

Summary of Lessons Learned: 1) The team strongly benefited from an initial orientation of available tools and of the planetary surface they were exploring. 2) An individual's strengths and skills may be leveraged to support an existing task or by setting their expertise to work on a new problem, and which application is most beneficial to a collaborative effort may change during or between projects. 3) The willingness of team members to pitch in on activities that were not assigned to them or not directly related to their own research significantly increased the group's overall productivity. 4) We effectively used time differences with remote collaborators to our advantage to meet a goal on a short timeline. 5) Setting a precedent for positive, respectful, and inclusive group dialog strengthened the cohesion of the team and resulted in better science. 5) Leadership roles on the team were essential to performing collaborative research in an organized way, from managing the practical aspects of a research task to communicating results to the team and mission leadership.

Future Work: While our preliminary mapping campaign is over, the lessons we learned in working together and communicating as a team will continue to serve us moving forward. Throughout the campaign, the WG Lead both facilitated and encouraged collaborative efforts, and set a positive and constructive tone that has carried forward during group meetings. We developed methodologies that will be used in future collaborations, and will allow them to evolve over time to meet the current needs of the mission. We discovered the expertise and skills that different team members brought to the table, and the practice of flexibly modifying our research approach to leverage those strengths will be invaluable in the future. Overall, the four-day effort was a strong success, and the outcome of the collaborative efforts described above is evident in both the cohesion we developed as a team and in the science that we delivered as a result.