Team dynamics during a four-day effort to map Bennu's surface: a collaborative effort

J. L. Molaro[1], K. J. Walsh[2], E. R. Jawin[3], R.-L. Ballouz[4], M. Pajola[5], S. Schwartz[4], J. P. Dworkin[6], H. C. Connolly Jr.[7], D. S. Lauretta[4].

[1]Planetary Science Institute, [2]Southwest Research Institute, [3]National Museum of Natural History, Smithsonian Institution, [4]Lunar and Planetary Lab, University of Arizona, [5]INAF-Astronomical Observatory of Padova, Italy, [6]Goddard Space Flight Center, [7]Rowan University. Correspondence: jmolaro@psi.edu

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 either 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 Working Group 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 Regolith Devel-opment Working Group (RDWG), it was our task to perform a preliminary survey of notable features and characteristics of Bennu's surface for the team to pre-sent at the American Geophysical Union (AGU) and Lunar and Planetary Science Conference (LPSC) meet-ings. The images were received from the spacecraft Dec. 1-2, 2018, and the team celebrated its official Arrival Day on December 3rd. Since AGU was the fol-lowing 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 meet-ing. We were asked to provide the mission leadership with a summary of observations and a selection of images to use at AGU by December 6th, leaving us 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 (Figure 1) consisted of the Working (WG) Group 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 tasks, and facilitate communication with other working groups and mission leadership. The role of the Mapping Lead was to provide training, instruction, and support to the mappers, and to collect and organize the 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.

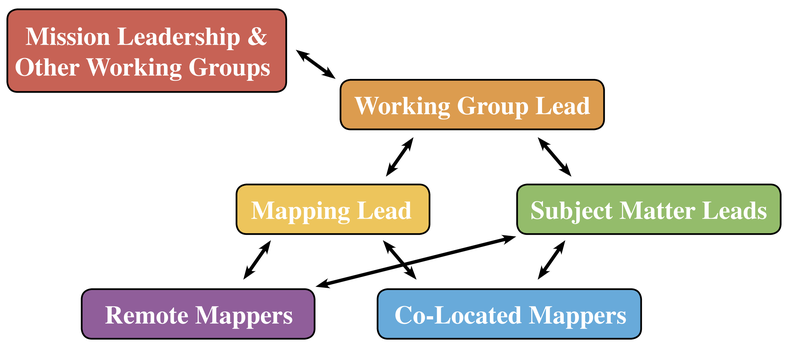

Figure 1. Team organization.

Mapping Approach

Learning the Tools

The first day of the campaign was spent primarily with team members receiving instruction on the tools from the Mapping Lead. Leveraging their expertise to provide training to others instead of performing the mapping themselves was an extremely effective way to get other team members ramped up on how to use the tools quickly. Members co-located at the OSIRIS-REx headquarters during were able to receive instruction at the same time, and made up the primary mappers in the group. Being co-located allowed them to assist each other in the learning process, leaving the Mapping Lead free to float where their expertise was required, support remote team members, or organize the mapping products 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. The first day also served as an "orientation" of Bennu's surface, enabling us to become familiar with major topographical features, common reference points, and informal names used by the team.

As an intructional exercise, we began by mapping all of the boulders above a certain size threshold in a specific region on Bennu's surface, with each mapper using the same 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). While this did duplicate effort, it provided an assessment of how representative an individual's results were relative to the group as a whole, and thus one measure of scientific robustness.

Figures 2 & 3. RDWG members hard at work during a daily telecon.

A few team members focused on mapping crater candidates instead of boulders for the week. 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.

A Flexible and Dynamic Workflow

Throughout day one, it became clear that some of the mapping labels we had 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 on 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 which team members were most efficient at mapping. One member with more experience was able to map a large numbers of boulders quickly if they skipped adding the labels. They were also located remotely in a different time zone, so 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 we 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 that arose during team discussions. Additionally, remote team members 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 during day one.

Setting the Tone

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. 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 both the available tools and 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 goals 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.**
6. **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.**