SIGNFICANCE OF SCIENCE-TACTICAL LIAISON ROLE IN MISSION CONTROL FOR THE KRASH LUNAR ANALOGUE SAMPLE RETURN MISSION. S. Abou-Aly[1], M. M. Mader[1], E. McCullough[1], L. J. Preston[1], J. Moores[1], L. L. Tornebene[1], G. R. Osinski[1], and ILSR team. [1]Centre for Planetary Science and Exploration, University of Western Ontario, London, ON, Canada. (saboual2@uwo.ca) (gosinski@uwo.ca)

Introduction: In order to prepare and test operational protocols for future lunar sample return missions, our team carried out an analogue mission at the Mistastin Lake (Kamestastin) lunar analogue site, funded by the Canadian Space Agency (CSA) (see [1] for detailed description of mission and [2] for analogue site description). The first mission took place over two weeks in August and September 2011 and included a mechanical rover and simulated astronaut surface operations. The analogue mission was divided into two groups, the Field team and Mission Control (MC); each with a different set of responsibilities. The field team, based at the Mistastin Lake impact structure, Labrador, Canda, comprised of both astronauts and scientific technicians (and engineers) that operated the rover. The MC team was based at the University of Western Ontario located in London, Ontario, over 1900 km away; and communication was via satellite terminal in the field. Neither the MC team nor the two 'astronauts' had previously visited the site and only had precursor remote sensing data prior to the mission.

Mission Control: The MC structure included the following processes: Planning, Science Processing and Science Interpretation, Tactical, and Evaluation (figure 1) [3]. The MC processes were divided into three different rooms with a Science team, Tactical team, and Planning team in separate rooms. Evaluation team members were embedded in each of these teams. As the mission progressed the Planning process was absorbed into the Science process (see [3] regarding this evolution].

The *Science team* performed planning, interpretation and processing functions as a group and led science discussions with the astronauts before and after their EVAs. Daily plans consisted of a document containing a suggested path, science questions to be answered along the way, and suggested activities. This allowed a great deal of flexibility within the plan.

The *Tactical team* was tasked with directly supporting astronaut EVAs and was led by a Flight Director assisted by a team of personnel to monitor communications with the astronauts, manage their resources and adjudicate modifications to the day's plan.

The *Science Liaison* (SL) was a position that was situated at the intersection of these two teams (see Fig. 1) and was responsible for relaying any information between the Science and Tactical teams. This role was also tasked with double-checking that the astronauts were reaching all of the objectives that the science team had requested.

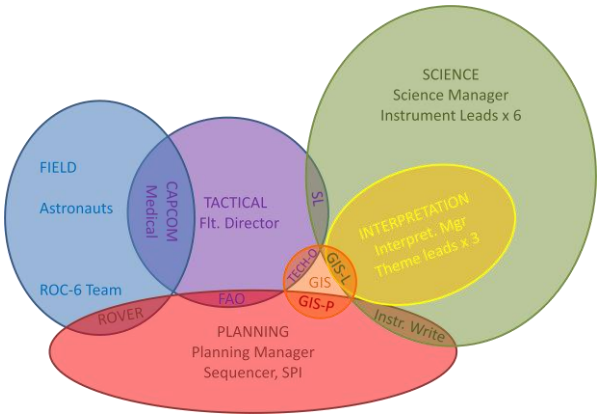

Figure 1: Venn diagram summarizing Mission Control structure [2]. The Science Liaison (SL) role is situated at the intersection of the Science and Tactical teams.

Description of Science Liaison Role: The SL was considered a representative of the Science team in the Tactical room and relayed the aims and motivations of the Science team to the Tactical team. These relays were crucial in allowing the Flight Director to make the most appropriate decisions that best reflected the science goals. In order to fulfill this role successfully the SL needed to be knowledgeable of the current priorities, science goals and hypotheses of the ongoing EVA. The SL also had to maintain involvement in the Science team activities: attending Science meetings and understanding ongoing science interpretations. The SL had to balance their time between both Tactical and Science rooms to fulfill these requirements. This often involved frequent and timely movements between both sections.

Evolution of Science Liaison Role during the Mission: Unfortunately, conditions in the field at the Mistastin Lake impact structure did not permit effective two-way communications when the astronauts were located outside of their base camp. The conditions in the Tactical room were such that absolute silence was needed when communications between the CAPCOM and astronauts was attempted, due to poor quality of voice transmit ion. This affected how the SL could communicate: it was difficult for this person to move freely between the Science and Tactical rooms when communication was needed in order to maintain quiet environment. This created a need for a new and innovative way for the SL to communicate with the Science team from the Tactical room, without disturbing the live communication with the astronauts. Com-

puter-based instant messaging was used to mitigate the need for the frequent movements between rooms.

Another difficulty was that during poor communications with the Field team, the SL was required to be constantly present in the Tactical room to reiterate science goals to the tactical team. This made it difficult for the individual to be at all the Science team meetings which was needed in order to stay up-to-date with all of the science priorities. When the SL could not be in attendance in the science meetings, they received the information through daily face-to-face brief summaries from the Science Manager as well as written instructions at the times that the Tactical team was not in live communications with the astronauts. The SL also took advantage of the computer-based instant messaging (Skype) by receiving any changes for the current EVA updated by the science room. These adjustments helped reduce these issues and also allowed the SL to continue doing their job in an efficient manner.

Communication Tools Used by the Science Liaison: The central purpose of the SL role was communication between the Tactical and Science teams, thus effective communication methods were critical.

The SL was constantly positioned directly beside the Flight Director in the Tactical room in order to have face-to-face communication because it allowed for the fastest transfer of information. Face-to-face communications was found to be the best practice to receive two way information during the Mars Exploration Rover (MER) missions and proved to be the most simplistic and effective way to avoid error discrepancies [4]. Members in the MER mission claimed that this communication "enabled gestures, eye contact, tones of voice, degrees of confidence, and other redundant and rich aspects of personal communication to be utilized in conveying possible different mental models" [4, 5, 6] and this proved to be helpful in our mission as well. Whenever there was a change in traverse plan by the Science team, the SL could easily and accurately relay it to the Flight Director, without disrupting the CAPCOM's conversation with the Astronauts.

Written communication methods that incorporated visual aids (e.g., print-outs of outcrops images, maps, sketches, etc.) were also helpful when the Science Manager gave the SL a brief summary of the EVA, because it allowed for better understanding of current field priorities and how they related to the overarching science goals. By adding these lines of communication, the SL could conduct their responsibilities in an efficient manner. Written instructions combined with face-to-face meetings were also used as best practices during the MER missions [4]. According to Scientist Lagner, the members would use written support in order to "reduce the risk of erroneous communication and also allows one to specify ahead of time what communication are most important and should not be left out"[4].

An additional critical communication tool was Skype - a computer based instant messaging program. This program allows either written messages to be sent instantaneously as well as the option of a video call, which allowed the SL to have several options in the way they could reach the Science team. Another feature of Skype is it allows a third party to join the conversation. This proved beneficial by allowing the Planning team (when it existed) to link in with communications between the other rooms. Skype also proved to be helpful because it automatically kept track of the times messages were sent and received, which allowed the conversation to be kept as documentation for post mission analysis. The time reference made it much simpler to keep track of where the astronauts were in their EVA.

Recommendations: Some recommendations for communication between the Tactical and Science teams that were used during the mission and could also be implemented in future analogue missions are:

1) Use of a room layout that allows the tactical and science rooms to have less distance between them for easier and quicker maneuvering.
2) Ensure the Science team is updated in real-time as to where the astronauts are located in the EVA through the use of Skype.
3) Compile a document which states all the questions proposed throughout the daily operations from each team. During out mission, this document was compiled by the SL and was used during debriefing meetings between MC and the Field team. This is similar to the ideology used in the MER mission, which made sure to complete a checklist for effective shift handovers.

References: [1] Marion et al. (2012) LPSC XXXXIII (this meeting), [2] Mader et al., 2010 Nördlingen International Workshop, [3] Moores et al. (2012) LPSC XXXXIII (this meeting), [4] Bonny Parke and Mishkin. (2005) Int. Ass. for the Advancement of Space Safety Conference [5] Hopkin (1980) Human Factors, 22 (5), 547-560 [6] Knapp, M. L., *Essentials of nonverbal communication*, N.Y., Holt, Rinehart, & Winston, 1995.

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