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**LEADERSHIP CHALLENGES IN ISS OPERATIONS:
LESSONS LEARNED FROM JUNIOR AND SENIOR MISSION CONTROL PERSONNEL**

James L. Clement, Jr., P.E., M.B.A.
NASA Johnson Space Center, USA
james.l.clement@nasa.gov

Jennifer Boyd Ritsher, Ph.D.
University of California/San Francisco and Department of Veterans Affairs Medical Center, San Francisco, USA
jennifer.ritsher@ucsf.edu

Nick Kanas, M.D.
University of California/San Francisco and Department of Veterans Affairs Medical Center, San Francisco, USA
nick.kanas@ucsf.edu

Stephanie Saylor, M.A.
University of California/San Francisco and Department of Veterans Affairs Medical Center, San Francisco, USA
stephanie.saylor@va.gov

ABSTRACT

The International Space Station (ISS) is operated by a multi-national, multi-organizational team that is dispersed across multiple locations, time zones, and work schedules. At NASA, mission control personnel have had to find ways to address the leadership challenges inherent in such work, but have not had systematic training in how to do so. We interviewed 12 junior controllers and 14 senior controllers to examine the major leadership challenges they face and to highlight the solutions that they have found most effective to surmount them. We contrast the perspectives of the two groups. Further, we contextualize our survey results with new analyses of standardized questionnaire data from 186 mission control personnel and a contrasting group of 30 space station crewmembers. The interview data showed that respondents had substantial consensus on several leadership challenges and on key strategies for dealing with them, but junior and senior controllers' perspectives were different. The questionnaire data showed that the US mission control sample reported a level of support from their management that compared favorably to national norms. Although specific to space station personnel, our results are consistent with recent management, cultural, and aerospace research.

Background

The International Space Station (ISS) is operated by a multi-national, multi-organizational team that is dispersed across multiple locations, time zones, and work schedules. This is an unprecedented level of global cooperation, and mission safety is constantly at stake. At NASA, both junior and senior mission control personnel have had to be pioneers in finding ways to address the leadership challenges inherent in such work, and have not had systematic training in how to do so.

Complex as it is, operating the ISS is about to become even more challenging as additional control centers in Japan and Europe join in ISS operations. Currently the ISS is operated bilaterally from control

centers in the US and Russia. Thus, it is important to take the opportunity now to prepare the NASA team for future multilateral operations.

The goals of this study were to examine the major leadership challenges faced by NASA ISS mission control personnel and to highlight the approaches that they have found most effective to surmount them. In previous work [1], we presented a more detailed literature review, a transcript of the structured interview questions, and detailed results from our original sample of senior controllers. The goal of the present paper is to supplement that work with a new comparison sample of junior controllers as well as new analyses of a different dataset that included mission control personnel [2,3].

Methodology

Participants.

Interview participants. We interviewed 14 senior and 12 junior flight controller personnel involved in various aspects of mission planning and the conduct of day-to-day operations on-board the ISS. Consistent with the demographics of the population of flight controllers, the senior sample included 13 men and 1 woman, and the junior sample included 6 men and 6 women. All 26 respondents were white, and all appeared to be from the American cultural mainstream. We did not collect specific age information, but senior controllers appeared to range in age from their 30s to late 40s, while the junior controllers were mostly in their late 20s. All participants had worked with international partner flight controller counterparts in developing ground and on-board procedures for crewmember activities. Interview participants were anonymous in the sense that records of their identities were not kept, and identifying information was removed from their data, although their identities were known to the senior author (JLC).

Questionnaire participants. To further explore the meaning of the interview findings, we also conducted new analyses of data from a previous questionnaire study of 13 American astronauts, 17 Russian cosmonauts, and 150 U.S. and 36 Russian mission control personnel supporting the ISS or Mir space stations. This dataset has been extensively described elsewhere [2,3,4,5].

All participants provided informed consent, and the study procedures were approved by human subjects committees at the University of California/San Francisco, and at the NASA Johnson Space Center.

Procedure.

Interview participants were requested to describe their observations and perceptions of the cultural and leadership challenges associated with the job of operating the ISS. All participants received a written copy of the interview questions as well as a verbal explanation of the goals of the study. Both written and verbal responses were accepted. Additional unstructured discussion or follow-up questioning took place as needed to achieve clarity. Verbal responses were transcribed as verbatim notes by the senior author (JLC). The content of the transcripts (written responses and/or transcribed verbal responses) was independently categorized by the authors into emergent themes, and the two resulting coding systems were integrated through discussion

until consensus was achieved about the categories. The entire dataset was then recoded using the final coding system.

Questionnaire participants completed a standardized well-established instrument designed to measure group interpersonal climate called the Work Environment Scale [6] on a weekly basis. They endorsed statements about their work group for the previous week as either “true” or “false”. Subscales were produced for data analysis by combining the scores from nine related WES items. Differences between subgroups of respondents were assessed using a one-way ANOVA of weighted means, to adjust for the varying number of observations per person. Results from a model that included a ‘country x crew’ interaction term are reported here for the Supervisor Support subscale.

Results

Survey participants were consistent and substantially in agreement in identifying key leadership challenges associated with the ISS. They identified solutions that they found to be helpful for meeting these challenges. Table 1 lists our consensus issues and the percent of respondents mentioning at least one example of the issue. Respondents gave a wealth of specific details supporting each of these items, but it is beyond the scope of this paper to present a thorough review of them.

	% of Senior respondents	% of Junior respondents
<u>Leadership Challenges:</u>		
• Team members dispersed across sites, organizations, time zones	100%	92%
• Historical differences between partner organizations	100%	92%
• More effort required to maintain morale and motivation of local team	86%	42%
• Constant change	64%	0%
<u>Successful Solutions:</u>		
• Ensuring effective communication	100%	100%
• Cultivating robust relationships	93%	92%
• Fostering flexibility and open-mindedness	86%	75%
• Expanding cultural awareness	57%	92%
• Seeking and providing training	86%	92%

Table 1: Leadership Challenges Involved in Operating the ISS, and Successful Solutions for Addressing Them

Leadership Challenges in Operating the ISS

Operating the ISS involves the same fundamental leadership challenges as any large project, but here we set those aside in order to focus on the special challenges that are posed by the extra complexity of operating the ISS versus previous space missions. Participants highlighted four main types of leadership challenges.

Team members dispersed across sites, organizations, time zones

The first leadership challenge (noted by 100% of our senior and 92% of our junior respondents) is that team members are dispersed across sites, organizations, and time zones. The implications of this include, for example:

- Team meetings occur outside of normal hours
- Loss of face-to-face communications cues
- Dissimilar organizational structures and cultures
- Building working relationships more difficult

Historical differences between partner organizations

The second main leadership challenge, identified by 100% of our senior respondents and 92% of the junior respondents, is historical differences between partner organizations. This primarily referred to differences between the Russian and American space programs. For example:

- Russians have 35 years space station experience
- Russian and American controllers have incompatible shift schedules but must work together
- Different approaches to documentation, planning, problem solving

The results from the questionnaire data also highlighted a difference across organizations. As shown in Table 2, the US mission control sample reported a level of support from their management that compared favorably to national norms. American mission control personnel and Russian crewmembers reported significantly higher supervisor support than American crewmembers and Russian mission control personnel [3].

Variable	Crew		Ground		Norm
	US	Russia	US	Russia	
Supervisor Support	4.78	6.63	6.12	4.66	5.18

Table 2: Supervisor Support

More effort required to maintain morale and motivation of local team

The third leadership challenge is the increased amount of sheer effort required to conduct ordinary leadership tasks in this more complex and stressful leadership environment. Aspects of this issue were raised by 86% of the senior but only 42% of the junior respondents of our sample. For example:

- Missions are marathons, not short sprints as before
- Ambiguities and frustrations that are never resolved
 - Multi-national, multi-organizational teams = confusion
 - Local team not told why other group changed plan
 - Worker often has to carry on without answer

Constant change

The fourth leadership challenge is that even if leaders manage to successfully meet the above three types of challenges, their efforts must be unflagging because they are working in the midst of constant change. This issue was noted only by our senior respondents (64% of senior versus 0% of junior respondents). Junior respondents were apparently not aware of the impact of this issue. By contrast, senior respondents felt the effect of change at multiple levels of analysis, as summarized below:

- National political changes = funding instability
- Space agencies reorganize = confusion
- Management priorities change = uncertainty
- Job turnover = need to train new people
- ISS procedures change = must tell all groups

Leadership Approaches for Successfully Addressing these Challenges

A special skill set is needed for ISS operators involved in international cooperation. This extraordinary occupation poses impressive leadership and cultural challenges. Procurement of the requisite skills can theoretically be obtained by education or the expertise of others. However, ISS controllers have gained such knowledge “the hard way”, primarily through trial and error. The lessons drawn from the experiences of our participants would be helpful in any leadership situation, but their unique context is especially applicable to the ISS program. Suggested approaches for successfully addressing leadership issues associated with this kind of globally distributed team can be summarized into five general categories: 1) ensuring effective communication, 2)

cultivating robust relationships, 3) fostering flexibility and open-mindedness, 4) expanding cultural awareness, and 5) seeking and providing training. Our survey data are rich with examples of both intuitive and non-obvious strategies, and the most salient are summarized in bullet points in each section below.

Ensuring Effective Communication

All of the study participants (100% of senior and 100% of junior controllers) stressed that strategies to improve communication were critical for working with the large, geographically dispersed team charged with operating the ISS. The following are some of the strategies that respondents found helpful:

- Learn chain of command in other organization, and how information flows through it.
- Give written agenda to international team in advance.
- Ask others to repeat what was agreed, to find hidden misunderstandings.
- “Overcommunication” across multiple modalities.

Cultivating Robust Relationships

Almost all participants in both samples (93% of senior, and 92% of junior respondents) stressed that it was critical to cultivate strong working relationships with team members at other sites. The consensus seemed to be that this is an essential part of the job itself, not just a nice thing to do. They especially stressed the following points:

- Remember trust is built slowly on dispersed teams
- Socialize with team members (esp. Russians)
- Face to face meetings are crucial (esp. at first)

Fostering Flexibility and Open-Mindedness

There was also substantial consensus (86% of senior and 75% of junior respondents) that flexibility and open-mindedness are crucial for successfully leading multicultural, multi-organizational, geographically dispersed teams. The following are some of the strategies that study participants found to be effective in maintaining the flexibility necessary to deal with the differences associated with operating the ISS:

- Adapt your work as situation changes
- Focus on joint goals, not winning a disagreement
- Tolerate ambiguity or disagreement (for non-essential issues)
- Do extra work to eliminate ambiguity (for important issues)

Expanding Cultural Awareness

About half (57%) of the senior respondents and almost all (92%) of our junior respondents said that they learned how important it is to be aware of specific cultural differences, such as about expected behavior during meetings or outside of formal work time. For example:

- Be aware of cultural differences relevant to your job (national, organizational, professional, gender, etc).
- Show that you are making an effort to accommodate
- Look for clues that you and partners are operating under different assumptions

Seeking and Providing Training

Most study participants mentioned some type of training that they thought would be helpful (86% of senior controllers and 92% of junior controllers). Although both groups mentioned this, it was striking that junior controllers generated many more specific topic ideas, and that these training requests were for themselves and their managers, not just for beginning controllers. To summarize:

- Junior controllers had many training requests.
- (One request was for their managers to get more training themselves!)
- The collective wisdom and detailed advice gathered from our ISS experience should be shared with all team members including the International Partners.

Although it is beyond the scope of this paper to report a great deal of detail, we do intend to develop a training curriculum using the collective wisdom and detailed advice that we gathered from our respondents.

Conclusion

An important factor in the success of ISS operations to date has been the ability of the individuals on the flight control team to effectively resolve the many leadership and cultural challenges identified in this study. Although there was substantial consensus between the senior and junior groups of controllers, the senior group was more aware of the following:

- Extra effort is needed in conducting ordinary leadership tasks when working in a dispersed team
- The context of constant change (at all levels)
- A hard-won repertoire of specific tried-and-true solutions

The junior controllers were more aware of the following:

- The importance of cultural issues (not just national culture)
- An array of training needs (for themselves and for their managers)

Although specific to space station personnel, our results are consistent with recent management, cultural, and aerospace research [7-20].

Our results showed that the day-to-day operational management of the ISS requires a variety of leadership and interpersonal skills. These skills will become even more critical as European and Japanese control centers are added to the team. Fostering the development of these leadership and cultural skills along with the requisite technical skills in those charged with operating the ISS will continue to be critical for addressing future challenges associated with completing the ISS assembly, working more closely with European and Japanese partners, and preparing for missions to the Moon and Mars. The leadership approaches identified in this study will be useful in selecting, training, and supporting the teams involved in these future missions. Training which includes enhanced leadership and cultural awareness content supports safety and mission success.

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