Benchmark Study of NASA and Air Force Space Operations Training

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ABSTRACT

In 2002, the National Aeronautics and Space Administration (NASA) conducted a comparative analysis of the space operations training programs used by the United States Air Force (USAF) Space Command with those used by the NASA's Payload Operations and Integration Center (POIC) at Marshall Space Flight Center, Huntsville, Alabama. The concentration of the study focused on improvements in payload operations ground controller training for the International Space Station Payload Program.

This report looked at the respective programs and investigated potential improvements for NASA's POIC ground controller training program in areas as diverse as staffing issues to database software capabilities. The report provided recommendations to NASA's POIC management, based on the findings, in such areas as separation of office and console operator staffing, centralizing the POIC training staff, developing a web-based tracking database, and implementing recurring training and evaluation into NASA's POIC training.

This paper will provide a brief review of the analysis and then present the benchmarking recommendations made by the Marshall Space Flight Center Training Organization. It will discuss the reasons for each recommendation and the implementation scheme that will be followed for each approved one. It will further focus on the cooperation between the two governmental agencies and the challenges to making the cooperative efforts successful.

ABOUT THE AUTHORS

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INTRODUCTION

At the Marshall Space Flight Center (MSFC) in Huntsville, Alabama, the Payload Operations and Integration Center (POIC) serves as a focal point for the task of payload operations support for the International Space Station Program (ISSP). The personnel staffing the POIC, the POIC *cadre*, routinely manage a wide variety of operational functions related to the science payloads operated by the astronauts. In order to function effectively in their jobs, they need to be trained and certified on the necessary tasks, procedures and equipment. It is with this goal – to discover best practices in operations training for Ground Controllers in a continuous operations environment – that NASA's POIC training team conducted a benchmark study with the United States Air Force (USAF) Space Command.

The NASA/USAF benchmark study performed a comparative analysis of the space operations training program used by the USAF Space Command (AFSPC) to train satellite and missile operations support personnel with the program used by NASA's POIC to train their ISS payload support *cadre.* The USAF Space Command was chosen as the best initial candidate outside of NASA for this benchmark study because of their experience in payload operations controller training, and because their user interfaces compare favorably with the POIC *cadre* user interfaces.

The NASA training team visited both the 50th Space Wing (Schriever AFB, Colorado Springs, CO) and the 90th Space Wing (F.E. Warren AFB, Cheyenne, Wy). These wings represent ground controllers for satellite operations and strategic missile operations, respectively. The study reviewed the respective programs and investigated unique training challenges posed by space operations ground controller needs in a continuous operations environment. The processes for setting up controller training programs, various phases of controller training, typical methods of controller training, appropriate techniques for evaluating adequacy of controller knowledge and skills resulting from training, and approaches to training administration were all reviewed in the study.

This paper provides a brief review of the comparison between the NASA and USAF training programs, presents the recommendations that the NASA trainers have made to Marshall Space Flight Center's POIC management, the reasons for each recommendation and the implementation scheme to be followed for each approved recommendation.

OVERVIEW OF CURRENT TRAINING PROCESSES

In order to present an adequate comparison between the training programs used by the groups, it is best to provide a brief overview of the current training programs in use by each group.

Overview of NASA's POIC cadre training program

The POIC *cadre's* training program is divided into three distinct phases. The first phase of training, Phase I, consists of generic knowledge building and is required of all *cadre* members assigned to positions within the POIC. The POIC training team has recently implemented what is known as the Payload Academy in order to address these fundamental training requirements. Payload Academy is an 8-day curriculum consisting of approximately 33 courses that provide general knowledge on the space station, payload operations concepts, processes and team definitions, and overviews of ISS systems and payload facilities.

Following Payload Academy, the *cadre* trainees enter phase II of their training. In Phase II, the trainees participate in training that is specific to the position to which they are assigned. Classroom, on-the-job training (OJT) and other training are developed, maintained and executed by experienced *cadre* members within the organizations that supply the personnel for

particular positions. For example, new Data Management Coordinators are trained by experienced Data Management Coordinators on the Cadre. Simulation is also a part of this training phase. Though the development and execution of simulations is the responsibility of the POIC training team, the training requirements/objectives and participation schedule for trainees is decentralized. It is the responsibility of the organization staffing each console position. At the end of Phase II training, the trainee will be subjected to examination and a certification simulation, resulting in final position certification.

Phase III prepares the *cadre* members for operations on specifically identified ISS increments/flights. This training consists of information regarding the complement of payloads manifested for that increment/flight, as well as information on systems or payloads that change with each increment/flight. Since a new increment begins about every 4 to 6 months, and additional shuttle flights to the ISS occur in between increments, Phase III training is constantly updated, with students returning for refresher or new information often during their preparation for flight. With the completion of each Phase III cycle, the trainees are considered qualified to operate on console for the identified increment/flight.

Finally, *cadre* members' knowledge and skills are maintained through recurring training called proficiency and currency training. Proficiency training maintains the knowledge and skills already learned, but which may not be exercised frequently, such as emergency procedures. Currency training occurs as needed to train *cadre* members on systems or procedures that are new or have changed, and have not been previously learned. It is only recently, with the publication of a new Training and Certification Plan, that the POIC has begun implementation of a proficiency and currency training program.

Overview of USAF 50th and 90th Space Wing training programs

The USAF Space Command ground controller training program was found to be similar in many respects to NASA's POIC *cadre* training process. For instance, training tools used by the USAF include courseware, simulation, OJT and hands-on emulator/part-task training systems, which is very akin to the NASA program. The USAF process is also similar in that it is basically a three-phase program. Ground controllers begin their generic training at the Air Educational Training Command's (AETC) schoolhouse, located at Vandenberg AFB. This can be compared easily to NASA's Phase I payload training academy. Once the USAF ground controllers have completed their generic courses at AETC, they begin Initial Qualification Training (IQT) that is specific to the position they will be operating on console. This can be compared to what NASA calls Phase II position specific training. Upon completion of the IQT at Vandenberg, the USAF ground controllers relocate to their unit within the 50th or 90th Space Wing, and continue their position specific training in what is called Unit Qualification Training (UQT). This training finishes their position training and leads to position certification. NASA's Phase II training also leads to position certification. The USAF ground controllers wrap up their training with "emulator check rides" and "initial evaluation", similar in concept to NASA's "certification simulation".

The USAF ground controllers may also attend Supplemental Training (ST). This training provides information on changes to the satellite control data, or perhaps a procedure change among other items. This is quite similar to NASA's Phase III increment/flight specific training that covers any operational changes inherent to the mission parameters of each new mission/flight.

Finally, maintenance of ground controller knowledge and skills is required. The USAF training program covers this through their Supplemental Training (ST) and what they call Monthly Recurring Training (MRT). Monthly Recurring Training is scheduled on a monthly basis, and includes both training and evaluation on the operational tasks for which the ground controller is responsible. In a given year, all tasks are trained and evaluated in these MRT sessions. The NASA training program calls this maintenance training proficiency and currency training, but it does not include evaluation.

COMPARISONS AND RECOMMENDATIONS

NASA's POIC training team made several comparisons with Air Force Space Command's training methodology. From these comparisons, process improvement ideas became apparent, and recommendations were made to NASA's POIC management. The following sections address the topics of comparison, recommendations that could

potentially improve NASA's POIC *cadre* training program and implementation schemes to be followed for each approved recommendation.

Ground Controller Staffing

Dedicated cadre
Discussions on dedicated cadre philosophy provided some noteworthy information. For example, it was noted that one of the significant difficulties faced by the POIC is rotation of *cadre* members between console duties and office duties. This has a serious impact on the office duties to be performed, fellow office employees, customers, and the *cadre* members themselves. Continual shifting in office staff results in inconsistent application of knowledge and skills to the required office tasks, frustration of the customers for access to the cadre member and fellow office workers, and stress on the shifting *cadre* members. It also results in a much larger number of people to be trained and certified for console duty since other *cadre* members need to be on console while their *cadre* members are working office duties.

To meet best practices, NASA's POIC ground training team recommended that the POIC console *cadre* and office personnel be divided into two distinct staffs. That is a set of professional *cadre* members dedicated solely to serving console duty and a staff of professional office personnel dedicated to the increment preparation work could alleviate several of these problems. First, both console duties and office duties would receive consistent attention by personnel familiar with, and current on, the details of on-going activity. Efficiency would be gained by not having to constantly "spin back up" to the console or office duties. Second, customers and fellow office personnel would have more consistent contact with knowledgeable people without being confused as to who their contact currently is. Third, fewer personnel would need to be trained and certified on console operations. This alone could alleviate training schedules and costs. Finally, the burden of constantly switching mindset between console duties and office duties would reduce stress for *cadre* members.

It is worth noting that this separated staffing policy would not preclude any possibility of rotation between console duty and office duty. In fact, a carefully controlled rotation plan would broaden the experience and perspective base of everyone involved while maintaining consistency of expertise in both the POIC and office.

NASA's POIC management is currently examining the merits of this recommendation. Upcoming realignments within the POIC organizational structure may address the console duty versus office work concerns.

Technical cadre
In addition to alleviating the concern over sharing office duties with console duties, a professional *cadre* would help in further lowering costs. Not all console positions require personnel who are fully trained engineers. Instead of rotating engineers between office and console duties, a professional *cadre* could be staffed with non-engineers in certain positions. This practice would be consistent with the Air Force model of staffing with enlisted technical personnel versus officers for most of their operations positions. By staffing with technical personnel rather than engineers, a lot of money would be saved in salaries.

NASA's POIC training team has recommended that each console position be examined for minimum background requirements. Those not requiring fully trained engineers should be staffed with technical personnel. However, it is doubtful that this recommendation will be addressed within the near future due to current staffing structure and management culture.

Trainers from console operators
NASA's POIC *cadre* trainers have a broad range of operations experience. Some have never been a console operator while others have had years of experience. Staffing for console operator trainers is lean and is often filled with new hires or available personnel. Being in the training organization does not imply expertise in the jobs they are training.

In contrast, at the USAF Space Command, the staff of trainers is drawn from ground controllers who have demonstrated excellence in job performance and skills in line training (mentorship) on console. It is considered upward mobility and recognition of skill to move from console operations into the training organization.

To follow the USAF Space Command model, NASA's POIC ground training team recommendedthat the training organization be staffed with *cadre* members who have proven themselves experts in their console jobs and who would be competent and qualified to train others.

Cadre members who have been on console for a respectable amount of time and have demonstrated mastery in their function should be given an opportunity to be *elevated* to the status of trainer and moved to the training organization, at least for a specified tour of duty. Length of assignment to the training organization could be offered or negotiated on a case-by-case basis, but serving the training function would be a sign of upward movement and recognition of excellence.

These individuals would be discipline experts within the training organization, and would ensure that high quality training is consistently delivered to the console trainees. To date, POIC management has encouraged temporary assignment of experienced *cadre* members into the training organization in response to this recommendation. Temporary assignments have yet to occur because of manpower accounting issues needing to be addressed.

Ground Controller Evaluation

A training program is not complete if it does not include evaluation. Evaluation is the process of measuring and validating the success of a training program. This does not only include immediate assessment of successful learning at the completion of a training program, but the continued retention of knowledge and skills after the training program. By holding periodic evaluations through observing performance, written examination, and performance testing, a ground controller's retention of knowledge and skills can be measured. If a performance gap is detected, additional training can be provided to return performance to specified standards, and the initial training program can be altered as necessary to ensure the performance gap is not propagated further. If necessary, performance gaps may be grounds for restricting ground controllers from duty until additional training is provided and the ground controller passes evaluation.

The USAF Space Command's training program includes evaluations of ground controllers immediately upon completion of position training, a follow up evaluation six months after initial certification, and recurring evaluations on a monthly basis as part of Monthly Recurring Training (MRT). During MRT, ground controllers are evaluated on subsets of their required operations tasks. By the end of each year, each ground controller has been evaluated on all operations tasks. MRT is scheduled such that ground controllers know about them in advance. As an added element of training validation and skill retention measurement, randomly scheduled, unannounced evaluations are sometimes conducted. USAF Space Command ground controllers can be restricted from duty if a performance gap is detected in these evaluations, and Individual Training (IT) is prepared to return the ground controller to full active status.

NASA's POIC *cadre* training program, on the other hand, does not conduct periodic evaluations, and marginally succeeds in conducting evaluations at the time of positional certification. Most, but not all, of the *cadre* positions are required to participate in a simulation to complete position certification, but there are no follow up evaluations conducted after initial certification. Nor is there any provision for restricting *cadre* members from duty, other than gross errors leading to de-certification by the Payload Operations Director (POD) or management.

NASA's POIC ground training team recommended that an evaluation program be implemented. Performance criteria should be identified and periodic evaluations should be conducted for each *cadre* position. Periodic examinations and performance testing should be scheduled within all *cadre* members' schedules, and unannounced evaluations, at least in the form of performance observations, should be considered. Restriction from active duty should be an acknowledged status for *cadre* members who demonstrate a performance gap during evaluation, and a return to full active status should be achievable upon completion of specifically identified training.

In response to this recommendation, the POIC training organization established an action team to develop implementation ideas. At the time of writing this paper, the action team is actively assessing potential evaluation methods that would be acceptable to the POIC *cadre*, their management, and the NASA culture in general.

Currency and Proficiency Training

USAF and NASA have similar challenges in maintaining a qualified ground controller work force as personnel depart or change jobs. Both agencies face challenges in continually qualifying

ground controllers, as well as maintaining their proficiency and currency.

As such, the USAF Space Command training program allows for training days within each ground controller's schedule; every month, to support currency and proficiency training while still accomplishing real time operations. Called Monthly Recurring Training (MRT) and Supplemental Training (ST), this training allows certified ground controllers to maintain proficiency on mission operations and currency on updated tools and procedures.

Some changes in NASA's POIC training program, based on the USAF example, could easily improve the overall effectiveness of *cadre* training. NASA's POIC training team has recommended that a process be established that requires proficiency and currency training be built into *cadre* members' schedules while they are supporting real time operations. Though an attempt to do this is being made by including guidelines in the new Payload Training and Certification Plan, the content of these requirements is still in the process of being determined by the same POIC training action team looking into evaluation methods. Once this is established, a determination of the feasibility of establishing training days to accomplish this requirement each month could follow. This scheduled training could include training sessions for all *cadre* members, whether on console or not.

Training Management

Centralized Training

Clearly observed was the fact that the USAF Space Command has a training program that is managed through a centralized office and staff, and is responsible for training, certification, evaluation, proficiency, currency, and even duty status tracking for all ground controllers. Their training office, with its staff of trainers and evaluators, assures compliance with established USAF regulations and requirements for assurance that ground controllers are appropriately trained, and then certified; to perform their assigned functions. They develop and instruct courseware, evaluate and recommend certification of ground controllers, maintain proficiency, currency and evaluation schedules, and perform administrative tracking.

The documentation and guidance for the USAF training program comes from the highest levels of the Air Force, down through the Major Air Commands, and finally to the specific units' training offices. This chain of command type of program management ensures that there is standardization throughout the entire Air Force, and throughout each unit, without regard to mission. Commands and units across the Air Force, including the Space Command, all have similar training organizations to carry out training management and administration for all operational units.

By contrast, NASA's POIC training program has a decentralized approach relying on each discipline's manager at the lowest level to ensure that trained and certified operators are available to fill the real time operational positions. Guidance is provided through NASA's POIC Training and Certification Plan document; in relatively general terms, with no direct assurance that training, certification, proficiency and currency are standardized, executed consistently, or sustained. Evaluation requirements are barely addressed.

This fractured approach often allows for training to be compromised because of funding constraints, which translates to personnel and resource limitations. With this being the case, most *cadre* members will only get an initial certification upon completion of their training.

NASA's project engineering management approach to training is a basic philosophy difference between the USAF centralized approach and NASA's decentralized approach. As NASA gets deeper into truly continuous operations they will have to consider the merits of a centralized training management approach to ensure they have a standardized, consistent and verifiable program for providing trained and certified individuals for all console positions.

NASA's POIC ground training team recommended that an attempt be made to establish a centralized training approach without reliance on operational managers dictating personnel and resource constraints. The POIC training office should be staffed sufficiently to provide POIC *cadre* training standardization, execution, scheduling and tracking. The training office's responsibilities should include keeping track of all personnel assigned to all *cadre* positions and what their duty statuses are, maintenance of a database hosting all training and evaluation objectives for all positions, and tracking *cadre* completion dates of training, evaluations and certifications.

Responsibility for course development, execution and configuration management should reside in the centralized training office; as well, to ensure quality, consistency and accuracy. This centralized approach will ensure more consistent adherence to policy and better accuracy in making Certification of Flight Readiness (CoFR) inputs, mitigating risks inherent to the current decentralized approach.

Since implementation of this recommendation is likely to result in a staffing growth, establishing a stronger training management organization will be a difficult endeavor. The training action team established to examine proficiency, currency, and evaluation will present staffing requirements and strategies that will optimize manpower use. The outcome of the training action team is yet to be revealed at the time of this writing.

Training Tools

Training Database

As part of any training approach, it is imperative that a useful and appropriate database tool be developed for training administration purposes. The USAF Space Command benchmarked by the POIC training team has just recently made marked improvement in their database tool. A software "collaboration", for lack of better terminology, was recently conceived and developed by a young lieutenant in the 90th Space Wing, called CONUNDRUM, that offers extensive interactive database capability for tracking, scheduling and reporting training and evaluation statuses of all ground controllers in all Space Wing units. CONUNDRUM allows web based active server pages (ASP) data retrieval from SQL databases via HTML language in such a way that users can generate custom pages to view specific database information important to their function. That is, trainers can look at training requirements, managers can look at status reports, crewmen can look at their duty schedules, and more.

By contrast, the NASA's POIC *cadre* training database is fractured between phases of training and between the organizations staffing the cadre positions, with no web interactive capability, report generation capability or scheduling capability. The POIC training office currently keeps a database that contains information on personnel assigned to all positions, positions certification dates, and completion dates for some training requirements. The database within each position's organization maintains information, at their own discretion, on position training requirements, completion dates, and increment/flight assignments.

NASA's POIC training team recommended that the USAF CONUNDRUM database tool, or a similarly centralized, web-interactive database tool, be developed for *cadre* training use and tracking. In line with the centralized training approach discussed previously, this centralized database with decentralized accessibility would reduce the risks currently inherent to our fractured database while increasing efficiency and communications between all of our organizations. COFR inputs could easily be generated, metrics could be reported, personnel duty statuses could be tracked, and training/evaluation schedules could be maintained.

The POIC training team is currently working with the USAF 50th and 90th Wings to build a collaborative effort that will help NASA's POIC training team in implementation of a centralized database. It is hoped that CONUNDRUM can be installed in the POIC training organization and linked to the team's training databases to facilitate a more centralized training management.

Emulators

One final, but certainly not least, comparison observed by the POIC training team during the benchmark was that the USAF, particularly the 90th Space Wing, used an emulator/part-task training system. This emulator was a full-scale mockup of a missile crew station with software capability for trainers to input nominal and malfunction scenarios. This emulator, or the Missile Procedures Trainer (MPT) as they called it, offered a realistic environment for training and evaluation purposes. Though the USAF Space Command uses OJT, as we do, their emulator allowed constant training and evaluation use without interfering with real time operations, allowed malfunction training not available in OJT, and was available to be scheduled flexibly enough to meet the trainer's and trainee's needs.

NASA's POIC, in contrast, has no locally available emulator for *cadre* training or evaluation. The POIC simulator system can be used marginally for general console operations training, but must be interfaced with ISS systems models resident at the Johnson Space Center (JSC) Space Station Training Facility (SSTF) for simulations and part-task training sessions that require any

sense of realism. But even this joint-systems simulation capability does not include science payload models beyond the host payload racks. At the time of the benchmark study, there was no payload modeling capability currently available other than a non-dynamic lookup table that sent out predetermined static data. Also, scheduling the remotely located SSTF for POIC simulations/part-task training is logistically difficult despite recent improvements with a specialized data trunk between the centers.

NASA's POIC training team recommended that dynamic payload emulators be developed and interfaced to the POIC for simulation, part-task training, and evaluation purposes. As a result of this, NASA's POIC training organization has been able to make strides in the part-task trainer development area. Approval was received from POIC management to fund development of some hardware and software payload modeling to be used for *cadre* training. To date, the modeling has been in the form of standalone trainers, but growth into part-task trainers is anticipated over time.

CONCLUSION

In conclusion, both programs are currently able to satisfy their respective requirements adequately. What remains to be determined is whether actions taken in the future will be able to sustain this adequacy and even improve upon it. It will become incumbent on NASA's management to recognize the value and necessity of a well-structured ground controller training program, focus on development of training tools which will improve effectiveness of ground controllers, and thereby cultivate efficiencies and saving resources. The realized savings will benefit the overall ISS program in future years.

It is worth noting that NASA's POIC training team will continue to work with their management beyond simply making these recommendations. Implementation concepts for the recommendations made in this paper are currently being conceived and proposed. Though many of these recommendations may imply changes in manpower and associated costs, others may simply imply changes in current practices and culture. It is the view of the training team that the realized efficiencies and risk mitigations will in some cases offset costs in the long run, or will at least justify cost. To support their efforts to justify such necessary efforts and costs, NASA's POIC training team will continue its relationship with the USAF Space Command by looking at their implementation techniques, as well as gathering metrics demonstrating the improvements they have seen as a result of implementing these techniques.

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