

# Does Commercial Space Really Need MOA?

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**[Abstract] The Mission Operations Assurance (MOA) discipline actively participates as a project member to achieve their common objective of full mission success while also providing an independent risk assessment to the Project Manager. The cornerstone element of MOA is the independent assessment of the risks the project faces in executing its mission. Especially as the project approaches critical mission events, it becomes imperative to clearly identify and assess the risks the project faces. This has been the paradigm for robotic space exploration missions, but does the same apply to commercial space operations? This is the question which is the driver for this year's MOA track at the 18<sup>th</sup> Annual Improving Space Operations workshop in April at the Jet Propulsion Laboratory, and the question we examine in this paper. Corollaries to this driving question are why shouldn't MOA apply and are there factors beyond mission success with acceptable risk which apply to commercial space operations that are not present in government scientific missions? To address these questions, areas we focus on include risk (both mission and profit) management for commercial space operations and the practical extension of robotic mission MOA to commercial space operations. Another key area to look at is command file errors which are a major concern for deep space robotic missions, but can we worry about them less with manned missions or unmanned supply mission? Further, with the growing concern about space debris, we delve into the role of MOA relative to End-of-Mission activities. This paper examines these topics and in particular the perspectives presented at the workshop to begin charting the appropriate course for MOA in the emerging sector of Commercial Space Operations.**

## I. Introduction

The importance of an independent risk assessment as well as other elements of Mission Operations Assurance (MOA) to the success of robotic space exploration missions is well established. However, these elements have traditionally meant cost to the project for the personnel that were independent of direct project influence. This is nominally acceptable when projects are focused on maximizing mission success rather than shareholder profits. Does this paradigm need to change as we increase the degree of commercial enterprise participating in the exploration of space?

The short answer is yes with the caveat that it must be changed prudently. Failures in space can be costly in terms of material and equipment, human life, and increased government regulation in response to such failures. Each of these costs will eat into a commercial enterprise's profit margin. When the costs grow too high, the commercial enterprise will no longer be viable, regardless of the depth of the corporate pockets. To come up with a possible new paradigm for MOA, we will begin with a look at the elements of MOA that must be folded into the commercial environment. Once we have a set of MOA functions that is reasonable, we can explore options for building them into the commercial system to achieve lower cost over the long term when compared with typical personnel costs for MOA. Finally, we examine if we can properly incorporate MOA to actually improve the likelihood of repetitive, reliable, low risk missions which minimize ground operations, avoid delays, and mitigate the risk of loss of material and personnel. We can begin with a look at the genesis of MOA at the Jet Propulsion Laboratory (JPL) and carry that forward to see the elements of MOA that are applicable to the commercial space operations sector.

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## **II. MOA's Genesis and Approach for Current Exploration Missions**

When the Mars Climate Orbiter, failed to achieve orbit around Mars in 1999, the Failure Review Board concluded that the lack of documentation of a discrepancy in delta-velocities between the Navigation Team and the Attitude Control Team was a major proximate cause of the ultimate failure. Contributing to the documentation void was the lack of a post-launch independent Mission Assurance function. This event was the genesis of the formal instantiation of a MOA program at JPL. The program has evolved over the dozen years to become a robust effort that is maintained throughout the life of each JPL flight project. MOA's general objective is to enhance the likelihood of mission success by proactively contributing to the identification, assessment and mitigation of risks through the implementation of MOA processes.<sup>1</sup> To accomplish this general objective, MOA programs on JPL flight projects have a set of eight specific objectives to meet:

1. Improve operational reliability of projects during mission operations
2. Assess the mission objectives, spacecraft/payload design & capabilities, and flight operations planning and implementation for compatibility and consistency.
3. Facilitate integration of mission operations assurance into the project so that all team members share responsibility for mission success
4. Assess the design, implementation, integration, validation & execution of robust processes to successfully accomplish mission objectives
5. Facilitate, when appropriate, Software Quality Assurance (SQA) support during post launch software development, Flight Software modifications, and resolution of software related problem reports.
6. Provide project manager with visibility into mission operations assurance processes and recommend actions as appropriate
7. Provide independent risk assessment to project manager & higher level safety and mission assurance offices.
8. Provide direct transfer of knowledge and experience to existing and future projects<sup>1</sup>

The implementation approach to satisfy these objectives includes 11 MOA practices that are employed throughout the life cycle of the project.

### **A. Risk Assessment**

The role of the Mission Operations Assurance Manager (MOAM) begins prior to launch in association with the project's systems engineer (PSE) and the development phase Mission Assurance Manager (MAM). The MOAM must understand the risks identified prior to launch and their relationship to the operational mission. He/she is also responsible for insuring that a project risk management plan/program extends into operations through the end of the mission. The MOAM is responsible for independently assessing the pre-launch risks and risks identified during operations (either by the project or independently) and providing this assessment to the Project Manager and JPL's Office of Safety and Mission Success (OSMS). The independent risk assessment is an ongoing process that is key to the project's operational readiness..

### **B. Project Operational Readiness**

The MOAM works with flight team to ensure adequate training and well documented and practices operational procedures are in place to ensure operational readiness. The MOAM has the responsibility to review plans/procedures/scripts to ensure that good operational practices are being followed as a proven technique for reducing operational risk.

### **C. Problem Reporting**

An important element in reducing risk and precluding recurrence of a problem is identification and correction of causative elements. The MOAM is responsible for ensuring implementation of the institutional problem reporting system and that appropriate corrective action and residual risk assessment are included in the problem documentation prior to report closure.

### **D. Operations Training**

The MOAM has a role in two aspects of operational training. First, as part of the implementation of a problem reporting system, the MOAM provides training and guidance in system usage and on the MOA process for the flight project. Second is an assessment of the project's training program to ensure that it is sufficiently thorough to address all aspects of mission operations and provide the team with skills sufficient to conduct the mission properly and safely with as low a level of risk as is possible.

#### **E. Operational Requirements**

The MOAM works with key team members to assure that operations requirements are implemented into the flight hardware, software and operations designs. The MOAM is responsible for providing project management and the institutional safety and mission assurance organization with an independent assessment of the project's ongoing verification and validation program's effectiveness in demonstrating that requirements are satisfied and that an acceptable level of risk is being maintained.

#### **F. Project Planning**

Key mission documents, specifically the Mission Plan, Navigation Plan, and Operations Plan are continually assessed by the flight team. As necessary changes are identified, the MOAM and the project's configuration management (CM) personnel are responsible for ensuring rigor in following the change management process, especially an assessment of any risk to the mission introduced by such changes.

#### **G. Flight Rules**

Flight rules provide constraints to operations to ensure that the flight system is not damaged by planned operational activities. The MOAM continually assesses the project's comprehensiveness and rigor in implementing flight rule checking and reports on issues discovered that might increase risk to the mission.

#### **H. MOA Reporting**

A key MOA process is reporting monthly risk and anomaly resolution status for the projects he/she supports. The MOAM also presents assessments of risk, project readiness, anomaly resolution, and other issues germane to mission success at Critical Events Readiness Reviews (CERR) and other key readiness or risk reviews throughout the mission.

#### **I. Project Operations Configuration Management**

As an active participant in the change control process the MOAM continually evaluates compliance with the process. Key activities include reviewing change requests and waivers to mission or flight rules for risk to elements of the flight system and the mission. The MOAM is obligated not to approve waivers that have an unacceptable risk level.

#### **J. Interface With Other Quality/Operations Assurance Functions**

The MOAM facilitates the appropriate support from the institutional safety and mission assurance organization for appropriate support of software modifications, hardware testing, and use of test facilities. Additionally, the MOAM works with the mission assurance elements of project partners to ensure a consistent MOA implementation across all elements of the flight project.

#### **K. Lessons Learned Assessment**

Issues, anomalies and idiosyncrasies discovered on one mission are reviewed by the MOAM for applicability to other missions. The MOAM works with the other project MAMs/MOAMs to assess the applicability of one project's problems to other projects.

The above 11 practices capture the essence of MOA for existing space exploration robotic missions, We next want to assess which of these current practices are applicable to commercial space operations. We will also consider if there are additional related practices that should be included for commercial space.

### **III. MOA Applicability to Commercial Space Operations**

At the 18th Annual Improving Space Operations Workshop, Lt. Michael Nayak addressed the evolution of mission assurance from government run to commercially run space operations. He examined a Near-Earth Asteroid Hopping Mission as a representative case to capture the essential elements of such an evolution. While Lt. Nayak looked at the complete spectrum of mission assurance, we will focus on whether this evolution leads to a mission operations assurance paradigm for commercial space operations.

One foreseeable impediment to commercial space operations is the inevitable government red tape. Of course the commercial perspective is that being put in a holding pattern by red tape or too much legislative oversight can be a death knell for profitable commercial space operations. Whether this is a reality or just a perception, it is a factor to consider for MOA because MOA is a team effort. Consequently, even a perception of its putting operations in a

holding pattern will lessen buy-in and reduce MOA's effectiveness for commercial operations. We look now at our 11 MOA processes described above and assess their importance to commercial space from a commercial space perspective. We want to identify those that can actually be incorporated and improve the likelihood of repetitive, reliable, low risk missions which minimize ground operations, avoid delays, and mitigate the risk of loss of material and personnel.

#### **A. Risk Assessment**

Clearly commercial ventures desire to maintain a risk posture that is compatible with their desire to make a profit. This means avoiding catastrophic loss of equipment, materials, and personnel, but being willing to accept a certain level of loss in areas where the cost of further mitigation eats into the bottom line. In fact, most of the risk mitigation for commercial ventures can be instantiated during the design of the commercial system. The limitation is what is known about the environment the commercial missions will encounter. Clearly, it is the unknowns that can pose a risk which must be dealt with during operations. It certainly is beneficial to have a good risk mitigation approach in place, but is an independent assessment of value to a commercial enterprise? This will depend on the cost and the perceived benefit. It is likely that, unless it is funded by an oversight organization, the cost of an independent risk assessment task will not be considered sufficiently value added for a commercial organization.

#### **B. Project Operational Readiness**

Commercial project operational readiness is implicit with a profit oriented activity since failures and errors can add cost and significantly impact profits. Further, the nature of successful commercial space operations is that their conduct will be repetitive to minimize risk introduced by constant change. This can easily lead to the conclusion that additional oversight will not prove to be value added for the cost involved.

#### **C. Problem Reporting**

The benefit of an effective problem reporting system is that problems and their fixes can be well documented and the information easily disseminated within a project or to other projects to avoid a recurrence. The avoidance of problem recurrence is a definite benefit to the profitability of any commercial project. This clearly continues throughout the operational life of a commercial project as well as any follow on projects. In our commercial operations paradigm for MOA, we would want to include an effective problem reporting process throughout the mission.

#### **D. Operations Training**

Operations' training is primarily an element of operations readiness, and a similar conclusion can be reached for additional oversight. Specific training related to a problem reporting system will depend on the level of automation incorporated in the system and the level of intuitiveness incorporated in the user interface. A case can be made for MOA related training for the problem reported system is value added, given that the system requires it.

#### **E. Operational Requirements**

With commercial operations likely to be somewhat repetitive, then once operations begin, there should be no need to additionally demonstrate that the requirements are being met. Consequently, an assessment of risk related to requirements satisfaction/non-satisfaction is likely to be unnecessary for commercial operations.

#### **F. Project Planning**

If significant changes to operational plans are anticipated during a commercial mission, then an independent assessment of risk as a result of such changes is advisable from a profit protection perspective. Significant changes to a well thought out plan are inherently risky because of unknown unknowns introduced by rushing to decisions on plans that have not been vetted. If such risk are realized, then the likelihood of a failure or error is increased which can be costly. However, commercial operations should be well understood in advance of being instituted which will reduce the need for plan changes and MOA oversight of such changes.

#### **G. Flight Rules**

Whether formally documented or not, flight rules will exist for commercial space operations. No commercial operator, unless they are going for insurance fraud, wants to damage their spacecraft. If an MOA function is available from an external organization, then oversight which is authorized to share information regarding flight

rules could be a benefit to all commercial operators, unless the information could be used by others to gain an unfair competitive advantage.

#### **H. MOA Reporting**

Reporting to the project manager, higher level corporate management, and outside agencies on risk aspects which may be unacceptable from a profit perspective or from a general safety perspective could clearly be beneficial. The question then is whether this information will be readily available through routine channels or if an independent assessment is required. Ideally, an automated system which captures and disseminates such information could be incorporated as part of the standard business model for commercial space operations and thus not be an added cost with no value.

#### **I. Project Operations Configuration Management**

While it is beneficial to have an independent review of a corporation configuration management process, the most important point is that a reasonable process is in place to ensure an audit trail of changes to the commercial system. Such a trail facilitates costly revisiting of proposed changes that have already been assessed and deemed impractical for the specific commercial operation. As with several of the other traditional MOA processes, independent risk assessment is not likely to be of significant added value, unless the commercial endeavor is running into cost issues because it has an inadequate or improperly managed configuration control process.

#### **J. Interface With Other Quality/Operations Assurance Functions**

Quite candidly, there are not likely to be “other” active quality/operations assurance functions in the early stages of commercial space operations. Often, until events such as NASA’s Mars 98 missions, the value of a permanent, independent, task to provide operational mission assurance functions is not recognized. Clearly, as the functions mature with the commercial space operations sector, the exchange of information will be of benefit to the entire community.

#### **K. Lessons Learned Assessment**

If a corporation has multiple commercial space operations activities that can learn from each other’s challenges, then this is vital. It may also be beneficial to other corporations in the space operations business, however, there may also be a tendency not to share for competitive advantage reasons. Should there be a sort of clearing house, perhaps sponsored by a government agency, which corporations can contribute to, then clearly this function would be of benefit to the entire commercial space operations community.

In reviewing the 11 functions of MOA, we see, that at least initially, there are several areas where the value added may not be immediately clear. Consequently, our new paradigm for MOA in commercial space operations must take this into account. Two closely associated areas, Problem Reporting and MOA Reporting, would seem to be logical areas to push for incorporation into every commercial space operations endeavor. As commercial space operations mature and expand, it will likely be feasible to incorporate more functions, such as independent risk assessment, into the overall MOA process for each corporation involved space operations. The question then is how to begin without an amount of overhead that is just not feasible for a profitable organization.

### **IV. Implementation Approaches for MOA in Commercial Space Operations**

One possible approach is through the use of decision support systems. The concept of decision support systems is not particularly new, and they have been considered as a means of supplementing training for space operations on the government side in the past. However, initial investment costs for a single project and the perceived difference between space exploration projects were challenges that seemed insurmountable. A significant benefit of incorporating an effective decision support system is its independence from the project since its knowledge data base is populated by subject matter experts in the field, not specifically associated with a project. With an independent decision support system which is sufficiently automated to generate reports on anomalies encountered and responses as well as make recommendations for action that consider risk of various options, the core processes of MOA can be incorporated in a commercial space operations system without separate overhead. As time has marched on, so has progress in developing the tools for an effective decision support system for space operations.

Paul Giangarra, an IBM Distinguished Engineer, presented his ideas on an “Advanced Decision Support System for both Structured and Unstructured Decisions for NASA” at the 18<sup>th</sup> Improving Space Operations Workshop. If we consider his concepts, we can see the applicability, not just to NASA, but to any space operations enterprise. The system Paul considers builds on existing technology to result in a decision support system to deal with Anomaly/Failure (A/F) detection, isolation, and recovery. Properly developed, ideally under NASA sponsorship, such a system could be made available and adapted to multiple commercial ventures, thus reducing the risk of commercial space operations for each individually and the community in general. Paul summarizes his recommendation as follows:

**Building an Advanced Decision Support System**

- Build on and utilize existing computer based A/F Detection systems
- Pass all relevant information collected when an Anomaly/Failure is detected to existing and new A/F Isolation Structured Decision Support Systems
- Use NLP and Deep QA technologies to create a corpus of Knowledge focused on Space Exploration Mission Operations problems
- Add Unstructured Decision support based on this Corpus when the Structured decisions support needs assistance
- Build a smaller Unstructured Decision Support system with a smaller (subset ) Corpus of Knowledge for crewed vehicles (CV) that can deal with questions that need immediate advice in particular situations where the communications latency between the CV and mission control is long<sup>3</sup>

Some notes on the third bullet above, where NLP refers to natural language programming and Deep QA refers to deep question and answer technologies. That these technologies are here and available is clear from Paul’s presentation. Watson, IBM’s Jeopardy phenom, demonstrated these technologies superbly as Paul points out. These are key to the advances in decision support system that will enable the MOA processes to be imbedded in a commercial space operations structure.

When you take these features as a whole it is clear that the MOA functions can be included while maintaining some independence from the operational team. Dealing with problems through A/F components and folding those into decision recommendations as well as both structured and unstructured support systems which make recommendations based on an expert knowledge data base addresses several areas of MOA. The need for risk assessment of existing conditions and new problems, the reporting of problems, their analysis, and the sharing of the lessons from their resolution as well as providing guidance to operators on how to respond to situations (a learning opportunity) are all functions of MOA, but built into the operations system, rather than an add on as is the situation at present.

## V. Conclusion

The functions which are currently elements of MOA will certainly benefit commercial space operations, but it isn’t clear that all would be immediately value added. Many commercial entities have a means of tracking and resolving problems and ensuring that issues are not repeated, so this function certainly seems doable and of value to every commercial venture. Then as we look at other tools that can be of assistance in such complex and challenging conditions, we consider advancements in decision support systems. The core capabilities exist, but they need to be coalesced into a system that can benefit all commercial space operators. The implication here is that the best approach would be for a government agency, such as NASA or the FAA, to take the lead in bringing the concept to the commercial space community. Until a unified approach is in place, the piecemeal implementation of any MOA functions by commercial operators will be subject to the pressures of shareholders interested in a profit. By making a system available that can be adapted by each company, the cost of implementing the MOA functions will be significantly reduced and the functions will be almost transparent, but still providing a benefit to reduce risks to profit by reducing risks to missions.

The purpose of MOA is to reduce risk which means less loss and more profit in terms of a commercial space venture. So, whether a company feels it is cost effective to incorporate the MOA functions directly as an MOA element or indirectly through use of an advanced decision support system, will be largely dependent on their business model. Those companies with a business model that allows for an effective and economical inclusion of the essence of the MOA functions are those with an improved likelihood of success in the commercial space sector.

## VI. Acknowledgments

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## VII. References

<sup>1</sup>Bryant, L. W., "Mission Operations Assurance," Jet Propulsion Laboratory Plan Template, 2009.

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<sup>3</sup>Giangarra, P., "Advanced Decision Support Systems Supporting both Structure and Unstructured Decisions for NASA (A Key Step on the Way to Fully Autonomous Operations)," *AIAA-SOSTC 18<sup>th</sup> Annual Improving Space Operations Workshop*, , AIAA-SOSTC, Pasadena, CA, 2012.