

Toward a NASA-Specific Project Management Framework

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Abstract: One of the most common myths in the discipline of project management is the assumption that all projects are the same and can be managed with the same set of processes and techniques. In reality, however, projects differ and "one size does not fit all." Based on our previous research, we have learned that adapting the right approach to the right project is critical to project success; yet, very few organizations know how to distinguish among their project efforts. Furthermore, we have also learned that there is no universal framework that works effectively for all organizations. NASA's procedures suggest several distinctions among projects based on product lines and priority levels. These distinctions form a base for different approval processes. The next step will be to help managers actually manage different projects in different ways. The purpose of this research was to study several NASA programs and start identifying a framework that would work for project managers and teams in the NASA environment. We used four current projects as case studies to test the validity of potential frameworks, and have suggested an initial NASA-specific framework that could eventually lead to guidelines for tailoring project and program management to project type.

Keywords: Project Management, Project Classification, Project Success, Contingency

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In the traditional project management world, project managers and teams are typically focused on efficiency, operational performance, and meeting time and budget goals. This approach is mainly process-oriented, where project

teams are required to follow a structured process of planning, execution, and control; however, today's dynamic environment, rapid technological change, and global competition as well as cooperation require looking at projects in a new way (Cleland and King, 1983; Jugdev, 2003; Shenhar, 2004). The new way is much more strategic in nature. It views project managers as leaders, who must deal with the strategic, operational, and human sides of project leadership. They must employ an integrated systems approach in order to achieve the strategic goals of their projects and maximize the benefits and satisfaction of their stakeholders. In the business world, this means being responsible for business results; in the public sector, it means being responsible for value creation and customer satisfaction.

One of the common myths and misconceptions in the traditional project management world is that all projects are the same, and that similar tools and methods can be used for all project activities. Furthermore, most books, articles, software applications, and training treat all projects in a similar way, suggesting that success in projects can be achieved if a common set of tools and techniques are used. To this date, while there are several suggestions in the literature (Souder and Song, 1997; Steele, 1975; Wheelwright and Clark, 1992), there is no standard framework for distinction among projects, that is commonly accepted and applied across the project management discipline.

In reality, however, projects differ in many ways, yet, very few organizations have acknowledged this in a formal way, implemented an organization-specific framework to distinguish among their project efforts, or created guidelines on how to select the right approach for each project. As we have seen, this misconception has often led to project failure and disappointment (Dvir et al., 2003; Shenhar, 1993). Recent research has demonstrated that the "one-size-does-not-fit-all" concept is both theoretically grounded in scholarly research (Shenhar, 2001; Shenhar and Dvir, 1996) and practically applicable in the real world (Shenhar and

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Dvir, 2004). We, therefore, believe it is time to move from the classical one-size-fits-all approach to a more project-specific way, where an organization must develop its own framework that will better respond to its specific situational variables.

NASA is no exception. In its long history of project management experience, it has conducted numerous projects of various kinds; however, in spite of several suggestions, there is still no agency-specific framework that is widely used for distinction among projects, and there are no guidelines on how to manage different projects in different ways. In this research, we focused on the development of an initial, NASA-specific, project management framework to distinguish among different kinds of projects. The goal is that NASA will eventually be able to implement such a framework into its procedures, as well as career development and performance enhancement practices.

Background

Because the focus of this research is the distinction among different project types for NASA, this section will review current knowledge of project typologies as well as the distinctions that exist at NASA. Classical contingency theory asserts that different external conditions require different organizational characteristics, and that the effectiveness of an organization is contingent upon the fit between structural and environmental variables (Lawrence and Lorsch, 1967; Pennings, 1992). While correlates of structural and environmental attributes have been well studied when the organization is the unit of analysis, they have been much less investigated in the project

context. The project management literature has often assumed that all projects share a universal set of managerial characteristics (Pinto and Covin, 1989; Shenhar, 1993; Yap and Souder, 1994). Yet projects can be seen as “temporary organizations within organizations” and may be different than their mother organizations. Indeed, several authors have expressed disappointment from the universal, one-size-fits-all idea, and recommend more contingent approaches (Balachandra and Friar, 1997; Brown and Eisenhardt, 1997; Eisenhardt and Tabrizi, 1995; Souder and Song, 1997; Wheelwright and Clark, 1992; Yap and Souder, 1994).

The NCTP Model. Shenhar and Dvir (1996) have developed a typological theory of project management and a three dimensional framework for project analysis called, the UCP Model—for uncertainty, complexity, and pace (Exhibit 1a). Their research has also shown how the theory can be applied to the practicing organization, offering that different project management styles should be associated with different types of projects. Shenhar (1993) has used this framework to suggest that events leading up to the Challenger accident could have been the result of incorrect project management style. He also extended the concept of classical contingency theory to project management (2001). Finally, Shenhar and Dvir (2004) have recently suggested a more refined model consisting of four dimensions of novelty, complexity, technology, and pace—the NCTP “Diamond” Model (see Exhibit 1b and Exhibit 2 for the definitions of project types on each dimension). This work has demonstrated not only how

Exhibit 1. (a) The Theoretical UCP Model and (b) the Practical NCTP “Diamond” Model

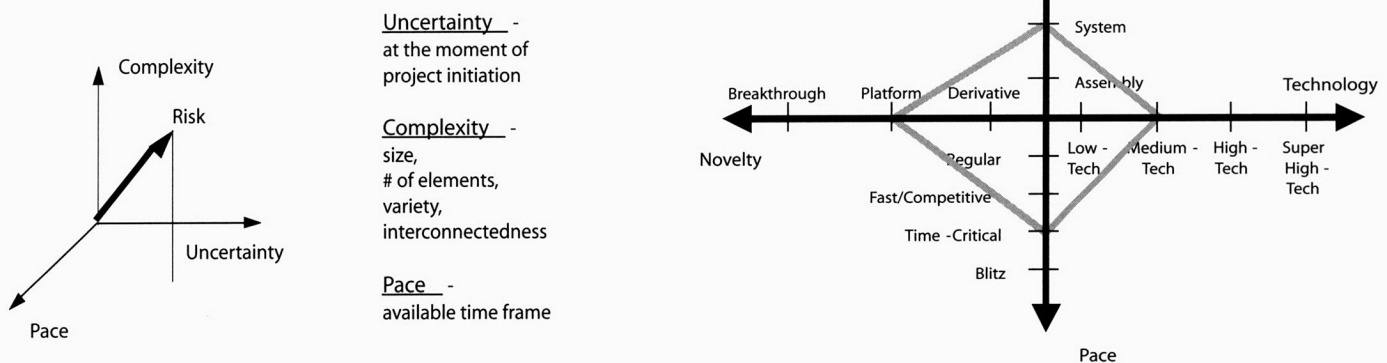


Exhibit 2. Dimensions of the NCTP Model

Novelty: How new is the product to the market: • Derivative: Improvement of an existing product • Platform: A new generation of existing product line • Breakthrough: A new-to-the world product	Complexity: How complex is the product: • Assembly: Subsystem, performing a single function • System: Collection of subsystems, multiple functions • Array: Widely dispersed collection of systems with a common mission
Technology: Extent of new technology to the company used by the project: • Low-tech: No new technology is used • Medium-tech: Some new technology • High-tech: All or mostly new, but existing technologies • Super high-tech: Necessary technologies do not exist at project initiation	Pace: Project urgency and available timeframe: • Regular: Delays not critical • Fast-competitive: Time to market is important for the business • Time-critical: Completion time is crucial for success-window of opportunity • Blitz: Crisis project- immediate solution is necessary

to classify projects, but also how to adapt the right management approach to the right project.

The PMI Study. The Project Management Institute (PMI) has recognized the problem of “one size fits all” and has initiated an extensive survey on existing project classification systems. Crawford, Hobbs, and Turner (2004) have explored how organizations actually distinguish among projects. They identified the primary organizational purposes for categorization of projects. Such purposes include strategic alignment, capability alignment, and categorization that enable differentiation between projects and ongoing operations. They have also identified a range of attributes that are used in practice in organizations to categorize projects and found that the same attributes are often used for different organizational purposes. At this time, the significance of the research done by the Crawford and Shenhar teams suggests that there is a solid starting point to define an organizational-specific framework for identifying different project types. This starting point led us to our research at NASA.

Existing Classifications at NASA. Some of NASA’s classification systems are directly or indirectly related to projects. NASA’s

manned and non-manned missions are currently organized in four enterprises (Science, Exploration, Space Operations, and Aeronautics) and ten space centers. Each enterprise or center has different goals and sometimes different standards and guidelines. NASA’s central procedures on program and project management are constantly improving. At the time of this research, some NASA documentations were updated. We provide here the most recent version at the time this article was written. NASA documents NPD 7120.4B and NPR 7120.5C outline the processes for project initiation, approval, planning, and execution. These guidelines include categorizations based on NASA’s major product lines (Exhibit 3a), and on a life-cycle cost versus priority-level matrix (Exhibit 3b) (Bushcmann, 2003; NPR 7120.5C, 2005). These guidelines describe the processes and the organizational groups that are used in different projects and programs to make the executive approval decisions by management, and less guidelines to managers on how to actually manage their projects.

Other NASA procedural requirements mention nine technology readiness levels (TRL), PI versus non-PI led projects, and four risk classification levels (see Exhibit 4). None of these ideas, however, have become an agency-wide formal framework that is regularly applied to all projects. Some (such

Exhibit 3. (a) Major NASA Product Lines and (b) Priority Life-Cycle Matrix

Product Lines • Basic and Applied Research • Advanced Technology Development • Flight Systems and Ground Support • Institutional Projects	Priority	High	Category II	Category I	Category I
		Medium	Category III	Category II	Category I
		Low	Category III	Category III	Category II
			Low	Medium	High
	Life-Cycle Cost				

Exhibit 4. NASA Existing Frameworks for Project Classification

Technology Readiness Level (TRL): A systematic metric/measurement of the maturity of a particular technology and the consistent comparison of maturity between different types of technology Level 1: Basic principles observed and supported Level 2: Technology concept and/or application formulated Level 3: Analytical and experimental critical function and/or characteristic proof-of-concept Level 4: Component and/or breadboard validation in laboratory environment Level 5: Component and/or breadboard validation in relevant environment Level 6: System/subsystem model or prototype demonstration in a relevant environment Level 7: System prototype demonstration in a space environment Level 8: Actual system completed and “flight qualified” Level 9: Actual system “flight proven” through successful mission operation	
Project Lead: • Principal Investigator Led (PI-Led): The PI is the project owner • Non PI-Led: NASA is the owner of the project	Risk Classification: Using criteria such as project priority and acceptable risk, national significance, complexity, mission lifetime, cost, launch constraints, and achievement of mission success criteria. Class Priority/National Significance Acceptable Risk A High/very high Very low B High Low C Medium Medium D Low/Low to medium High

as the TRL) are only specific to technology development and not project management.

Research Process

Our research methodology involved a contemporary case study approach, focusing on understanding the dynamics present within settings, of either single or multiple cases (Eisenhardt, 1989; Strauss, 1987; Yin, 1994). Because few NASA projects use any framework at all, we needed to test a hypothetical use of the framework and assess its validity in retrospect. Four case studies were selected to represent a wide spectrum of projects in several NASA centers. According to this concept we finally selected projects based on available data across different NASA centers and access to project team members.

- Kepler, Ames Research Center
- Orbiter Boom Sensor System (OBSS), Johnson Space Center (JSC)
- Stratospheric Observatory for Infrared Astronomy (SOFIA), Ames Research Center
- Space Technology 5 (ST-5), Goddard Space Flight Center/Jet Propulsion Laboratory

Each project was visited by a research team that conducted interviews and studied project documents and plans. As required by case study research, interviews were conducted on project sites to increase the validity and authenticity of information. In addition to the project manager, we interviewed numerous team members, the managers at the executive level above the project, and, where possible, subcontractors and customers. Interview teams used a standard interview guide and structured questionnaires that were developed during the first phase of the study. The questionnaire included questions about project characteristics, project processes, organization, and metrics about project success. Notes were taken during the interviews and, in some cases, voice recordings were collected. Interviews were summarized in writing and, after each day of interviews, teams conducted crosscheck meetings to guarantee that all impressions were captured and documented.

Following the data collection phase, individual case study reports of 30–50 pages were written according to a common standard for all cases. In some cases, during the report writing teams returned to interviewees to obtain additional information and clarification. Each report was then assessed by another team member to guarantee completeness and clarity of the information. The final step included within-case and cross-case analysis and involved additional team members who did not participate in the data collection, as well as the writing of the final report (Shenhar et al., 2005).

Findings and Analysis

Brief Summary of Major Individual Project Findings.

Kepler: The Kepler project is a special purpose space mission project in the NASA Discovery Program. In search of possible life in the universe, its objective is to build a spacecraft and photometer, that can detect terrestrial planets, both rocky and Earth-size, around other stars. The photometer allows for the observation of periodic dimming in starlight caused by planetary transit. This mission will help understanding of the essence of other planets like Earth. The Kepler project is a principal investigator (PI)-led project. It has a budget of \$467 million and an expected duration, including operations, of 144 months.

Kepler was initiated after a long process of proposal and

mission definition. The project is well-managed, and it follows a well-defined procedure and plan. Some concern was expressed, however, during our study about the clarity of roles of project partners and subcontractors.

Orbiter Boom Sensor System (OBSS): The OBSS project is part of the Return-To-Flight (RTF) effort of the Space Shuttle Program. Its objective is to develop a self-inspection system for the Orbiter while in orbit. This inspection capability was requested by the Columbia Accident Investigation Board (CAIB) before returning the shuttle to flight. The effort involves extending a 50-foot boom with two sensors and a camera to the existing shuttle remote manipulator system. The OBSS will increase the capability of detecting potential post launch damage to the Thermal Protection System (TPS) of the Orbiter. The project had to be completed in one year with a budget of approximately \$108 million. Because of launch delays, the project was extended to at least 19 months.

The team managed the project at a very high pace. They found numerous innovative ways to accelerate project activities and yet not compromise technical performance and safety issues. The toll on team members, however, was very high, because many of them invested long working hours and weekends for an extended period of time. Yet the organizational and formal system beyond the project did not fully fit the project's high pace. The team had to find ways to work with the regular NASA procedures, that were not built for projects of this type. Those guidelines are well-suited to "regular" NASA projects and this situation created some barriers and difficulties to the project team.

Stratospheric Observatory for Infrared Astronomy (SOFIA): The SOFIA project was managed by the University Space Research Association (USRA). It involved an airborne-based observatory under NASA's Origins Program. Its objective is to build a modified Boeing 747SP aircraft to accommodate a 2.5 meter reflecting telescope that can obtain infrared radiation from space. The observation of infrared radiation is impossible even with the largest and highest quality ground-based telescopes because of the obstruction from water vapor in the Earth's atmosphere. SOFIA will be "the world's largest and most sensitive" airborne observatory. The project has a total budget of \$235 million with an expected duration of 60 months in development and 240 months in operation.

SOFIA is another well-run project. The only concern that was raised related to technical interface management, particularly with some overseas partners. Cultural differences created communication difficulties and integration problems, where partner roles needed better definition and more seamless coordination.

Space Technology 5 (ST-5): The ST-5 is one of several projects within the New Millennium Program (NMP). Its objective is to design, develop, and flight-validate three full-service small spacecraft, that will be used to support research-quality scientific measurements. Because these spacecraft have a mass of less than 25 kg each, they will be operated as a single constellation rather than as individual elements. This will enable NASA to test innovative concepts and technologies in the harsh environment of space. The ST-5 has a project budget of \$130 million, and project duration of 42 months.

The project was observed at an early state with few available lessons. Our assessment found that the project team members

were focused strongly on the specific project. Its impact on the entire New Millennium Program was not clear at the time of this research.

Cross-Case Analysis. Because our goal was to identify a NASA-specific framework for project management, we tested known existing NASA classifications as well as the NCTP model on our four case studies. We tried to understand how much NASA projects were using any framework or even aware of what was available, and we tried to explain some of the concerns in projects based on our frameworks analysis.

Our first observation and finding suggests that most of the projects we studied did not definitively distinguish their project from other projects within the agency. The only indication of distinction related to whether or not the project was PI-led, and somewhat to the risk level A to D, yet none of these distinctions has impacted the project management in an explicit or deliberate way.

Because our study was done on on-going projects, it is too early to assess project success. Our research suggests that almost all of the projects in our study were essentially well managed; however, several projects demonstrated some difficulty in one area or another. Our analysis using the NCTP model was able to explain these difficulties and suggest improvement in specific areas.

A summary of how the four cases can be classified based on NASA typologies as well as on the NCTP model is presented in Exhibit 5. It presents an overview of how we interpreted project adaptation to project type for each of the projects. In addition, it illustrates the implication of the NCTP model in identifying concerns in project management. We compared the actual observed project management style as described by the project team to a suggested optimal style, that is based on the project's unique characteristics.

Toward a NASA-Specific Framework for Project Types. As mentioned earlier, the main objective of this research was to develop an initial, NASA-specific project management framework in order to distinguish among different kinds of projects. With an ambitious vision that is based on finding and extending life in the universe, NASA is faced with a unique challenge in technology, organization, and culture. This challenge was evident in all four projects that were studied. As we have seen, in most cases, NASA's unique ways of distinguishing among projects provides little guidance on how to manage different types of projects; however, the cross-case analysis revealed that adapting the NCTP framework to NASA could be a valuable tool in classifying and defining NASA projects. It could also help identify how to tailor project management to project type, and how to identify difficulties in existing projects. In the following discussion, we summarize our observations and outline suggestions for how the NCTP's existing dimensions could serve as a base for a NASA-specific framework.

Novelty. This investigation revealed that many of NASA's projects are breakthrough projects. The scientists and engineers working on these projects may not always be fully aware of the uniqueness of the product and its impact on managing requirements. Projects often build on technology that may have come from previous projects; thus, technology is not the main challenge, but the mission is. NASA projects are rarely repeated and thus are almost always unique to the market. Our conclusion is that most NASA projects are either platform or breakthrough and, thus, require careful attention to the management of project requirements. That

often involves extensive periods of refinement of requirement. For example, Kepler had the opportunity to refine its requirements over a long period of pre-project activity. Other projects may not be so lucky, but a high level of novelty will always require extensive effort before the final requirements are set.

Complexity. The complexity of all four projects was at the systems level with no assembly or array projects. NASA prides itself on being a systems organization and has many documents and guidelines for system projects. With an agency structure, bureaucracy, and policy that creates a management environment for systems projects, this investigation raises the question, "Do the complexity classifications need to be further refined for NASA-specific projects?" or "Does the current classification provide the right level of detail and guidance to correctly classify and manage a NASA project?" One possibility would be to make a distinction between Projects (Systems) and Programs (Arrays). Another is to emphasize the need for intensive integration and formal procedures for communicating and coordinating among project subteams. It is clear, however, that system projects require extensive focus on integration and coordination. With cross-organizational and sometimes cross-national projects, this focus can never be ignored.

Technology. In three of the projects (Kepler, OBSS, and SOFIA), the technology being used was predominantly commercial off-the-shelf and well tested. This by itself could classify the project as medium-tech. Only ST-5 was not classified as medium-tech as it has an ambitious and an exciting vision to speed up space exploration through the development of highly advanced technologies. This investigation revealed a challenge with both the interviewees and the investigators in classifying a NASA project's technology in distinguishing between medium-tech and high-tech. For NASA, NCTP may need to be defined in more detail to create a more distinctive difference between the classifications. It is recommended that when there is a doubt regarding the technology level, always choose the higher classification.

Pace. Kepler, SOFIA, and ST-5 had schedule constraints that were imposed and stressed by management. This put them in the category of fast-competitive. OBSS, in contrast, was under very strict launch timelines and had no room for error, thus can be seen as a blitz project. Most NASA projects in the past were not under such pressure until the introduction of the "faster, better, cheaper" policy in the 1990s. This realization should have an impact on guidelines for project management. NASA should learn to distinguish between fast-competitive, time-critical, and blitz projects, and should develop the appropriate guidelines and procedures to manage each type differently.

The Diamond as an Analysis Tool. The benefit of the NCTP model is not limited to its use in understanding project characteristics and selecting the right style. It can also be used to analyze an existing project management approach and identify potential difficulties and gaps. For example, the blitz pace of the OBSS project required working in parallel, shortening requirements processes, etc. Even though the team attempts to apply an appropriate project management approach, NASA procedures and guidelines do not provide sufficient guidelines. Similarly, the coordination difficulties of SOFIA could be explained by the distinction between a system and an assembly mindset. Identifying gaps during project execution can be a useful way

Exhibit 5. Project Classification Based on Different Models

Mission	NCTP Categorization – Optimal versus Actual*	Project Analysis Using the NCTP Model	NASA Classifications
Kepler		Well managed project. Long period of requirements and project definition as needed by a breakthrough project.	PI-Led Risk Classification: B No specific or explicit impact on project management
OBSS		Very urgent project, but NASA management procedures, guidelines, and some organizational components did not match a Blitz project. However, the team adopted certain procedures—e.g., simplified review process, establish communication channel—to work around this challenge.	Non-PI-Led Risk Classification: A* High priority and low acceptable risk required extensive focus on safety and testing as common on all shuttle components
SOFIA		Having a cross-cultural partner (i.e., Germany) and a new type of partner role (privatization) requires cultural integration for seamless coordination and communication. Seeing the project as a system project, rather than assembly, would enhance focus on integration and additional communication efforts.	Non-PI-Led Risk Classification: C* No specific or explicit impact on project management
ST-5		The team focused on meeting technical requirements. No specific difficulties reported.	PI-Led Risk Classification: C* No specific or explicit impact on project management

— Optimal project management style based on a project's unique characteristics.

--- Actual observed project management style as described by the project team.

* The risk classification was determined by the research team, not by the project team.

for management to assess the performance of a project at mid-course, not just based on time and budget performance.

Implications

Based on our research, an initial framework has emerged. It seems that NASA is ready for the next step in building a NASA-specific project management framework. This framework can go beyond the general categorization of product lines and three categories based on life-cycle cost and priority. The NCTP model may provide such a framework. While the NCTP model is universal and applies to other industries, it can benefit NASA in at least two ways. First, it may help sort out the exact project priority, that is currently based on a general assessment. Translating the NCTP levels of a specific project into clear priority levels can be helpful. Second, and perhaps most effective, the model may provide guidelines for project managers and teams on how exactly to manage a specific project based on its characteristics.

It is recommended that each project add a step during the planning and conceptual phase in which unique project characteristics be identified, and their impact on the project management style be determined. Although based on a small number of cases, the NCTP model may provide the initial working

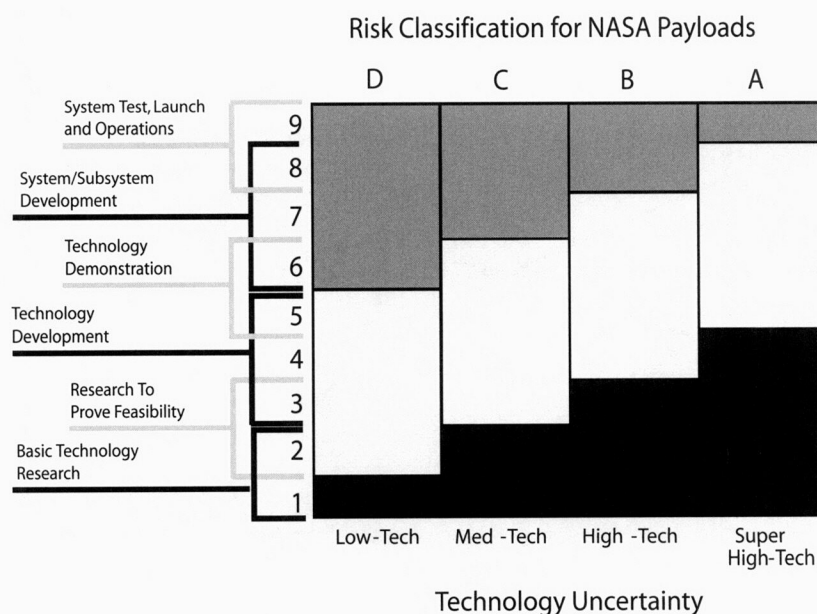
framework for NASA project classification together with a few existing frameworks. While further research would be helpful, the model, at this time, can help a project team understand project characteristics and help the team identify appropriate project management styles. In addition, this information could help the Agency in selecting an appropriate contractual type based on project mission, project owner, and risk classification (A-D). Those can be integrated with the NCTP model to develop a more refined and specific NASA project typology. Exhibit 6 provides a possible framework for planning the impact of project type on project management. After selecting the specific project type, they would need to complete the third column in Exhibit 6.

In addition, some existing NASA frameworks can be influenced by some dimensions of the NCTP model. For example, one can use the TRL to identify the level of project technology (low-tech to super high-tech) in the technology dimension of the NCTP model (Exhibit 7). While TRL is a measure of the maturity of an individual technology, technology in the NCTP model represents a collection of technologies. As expected, a super high-tech project will have a greater number of lower TRL technologies. The exhibit also indicates a level of risk and/or uncertainty (the lower the TRL, the greater the risk/uncertainty).

Exhibit 6. A Framework for Adapting NASA Project Management to Project Type

Category	Possible Project Types (Select one in each row)	Impact on PM Style
Mission	Science, Exploration, Space Operations, Aeronautics	
Flight	Manned, Non-manned Payload	
Owner	PI-Led, Non PI-Led	
Risk Class	A-D	
Novelty	Derivative, Platform, Breakthrough	
Complexity	Assembly, System, Array	
Technology	Low-tech, Medium-tech, High-tech, Super High-tech	
Pace	Regular, Fast/Competitive, Time-Critical, Blitz	

Exhibit 7. Technology Uncertainty to Technology Readiness Level



Conclusion

It seems that NASA is ready to develop and adopt a refined, specific project management framework for project classification. This framework will create a *one-size-does-not-fit-all* mindset, that will lead to an adaptation of appropriate project management styles to projects. Specifically, we noticed that NASA projects can be categorized by using multiple dimensions—some of them exist within NASA and others should be adapted to its environment. In particular, our research indicated that the NCTP model based on project novelty, complexity, technology, and pace works well as an initial project classification framework for NASA. These dimensions can provide a good understanding of project characteristics and build more confidence in tailoring project management to project type. In addition, the NCTP model can be used as a framework to identify gaps and problems in projects that need to be addressed by management.

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Additional Bios

Dov Dvir is the head of the Management Department at the Ben Gurion University in Israel. He received his BSc in EE from Israel Institute of Technology, his MBA in business administration, MSc in operations research, and PhD in management of technology from Tel Aviv University. He has been involved in managing projects, innovation, R&D, and high technology businesses for more than 20 years. He served as the commander of a large technological center in the Israeli Defense Force at the rank of a Colonel. Dr. Dvir published more than 70 publications in the areas of project management, management of technology, entrepreneurship and operations research.

Dragan Milosevic is an associate professor of engineering and technology management at Portland State University. He received his BS in chemical engineering from the University of Belgrade and his MBA and PhD from Belgrade University. He has more than 20 years experience in program and project management theory and practice and has managed projects worth more than \$600M with partners from more than 50 countries. He has consulted to companies such as Intel, Hewlett-Packard, Armstrong World Industries, Daimler Chrysler, Tyco, Tektronix, InFocus, and Sprint. He is an expert in PM standardization, and his new book, *Project Management Toolbox*, is the first to document the existing tools of the discipline.

Peerasit Patanakul is an assistant professor of technology management at Stevens Institute of Technology. In project management, his research interests are in project manager appointments, strategic project management, and standardization. Several of his works were presented in well-recognized international conferences and were published as book chapters and articles in peer-reviewed journals. Dr. Patanakul holds a BE in chemical engineering from Chulalongkorn University (Thailand), an MS in engineering management and a PhD in systems science/engineering management from Portland State University.

Richard Reilly is a research professor and executive director of technology management research at Stevens Institute. He received his PhD in organizational psychology from the University of Tennessee and his BS from Fordham University. He has an extensive background in organizational research and has published more 60 articles in areas such as assessment and methodology. He is the co-author of an award-winning book on new product development and conducts research on the behavioral side of projects. Dr. Reilly is on the editorial board of *Personnel Psychology* and is a consulting reviewer for the *Journal of Applied Psychology*. He has been a consultant to Fortune 500 companies on organizational assessment and organizational effectiveness. He is a Fellow of the American Psychological Association and the American Psychological Society.

Andrew P. Sage is university professor, First American Bank Professor at George Mason University, and a member of the National Academy of Engineering (for his contribution to systems engineering and management). He received his MSEE and PhD degrees from MIT and Purdue, two honorary doctorates in engineering, and numerous awards, among them, Fellow of the IEEE, the AAAS, and INCOSE, the Frederick Emmonds Terman Award from the ASEE, the Outstanding Service Award from the International Federation of Automatic Control, the first Norbert Wiener Award, the first Joseph G. Wohl Outstanding Career Award, the Simon Ramo Medal, and the Third Millennium Medal from the IEEE, and the Eta Kappa Nu Eminent Member Award. He was editor of the *IEEE Systems, Man, and Cybernetics Transactions* for 27 years and founder of *Systems Engineering*, INCOSE journal. With numerous influential books and publications, he is perhaps the leading scholar today in system engineering and management.

Brian J. Sauser holds a BS from Texas A&M University in agriculture development with an emphasis in horticulture technology, an MS from Rutgers University in bioresource engineering, and a PhD from Stevens Institute of Technology in technology management. He has worked in government, industry, and academia for more than 10 years as both a researcher/engineer and director of programs. He is currently a research assistant professor at Stevens Institute of Technology in the Systems Engineering and Engineering Management Department.

Hans Thamhain is a professor of management and director of MOT and project management programs at Bentley College, Waltham/Boston, specializing in R&D and technology-based project management. His industrial experience includes 20 years of management positions with high-technology companies such as GTE/Verizon, General Electric and ITT. He holds PhD, MBA, MSEE and BSEE degrees, and is well known for his research on technology-based project management. He has written more than 70 research papers and five professional reference books in project and technology management. He is the recipient of the *Distinguished Contribution Award* from the Project Management Institute in 1998 and the *IEEE Engineering Manager of the Year 2000 Award*.

Jerry (Gerald) Mulenburg holds a PhD in business administration, from Golden Gate University, an MS in systems management from the University of Southern California, an MS in aerospace engineering from the Air Force Institute of Technology, and a BS in aero-mechanical engineering from Oklahoma State University.

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