

FAA NextGen ADS-B Project Case Study: An analysis of project management practices and knowledge areas

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ABSTRACT : Application of the Standards of Project Management (Project Management Institute, 2013) have been recognized as a major contributing factor to the successful outcome across major projects within the U. S Government and its agencies. The size and scope of programs that engage stakeholders within governmental agencies, across agencies, and among industry partners, ensure their resources are carefully planned and require analysis of risk in order to reach successful and impactful results as defined by the project objectives and endorsed by key stakeholders. By utilizing PMI's Project Lifecycle Phases and Project Management Knowledge Areas (Project Management Institute, 2013), research into specific knowledge areas within program and project management will be explored in order to identify the contributing factors of success. We expect that the conclusions drawn from this research will validate the findings of other research and publications about the shift of task oriented project management to a more people management oriented discipline. Our hypothesis is that Project Management, as a discipline, has evolved towards inclusion and collaboration as part of the planning, organization, execution and closure of future project management processes. We expect that knowledge areas related to soft skills will rate higher. The ADS-B presents a great opportunity to validate this hypothesis due to the fact that it is a recently completed known project and presents more modern project management trends throughout its lifecycle.

KEYWORDS –Collaboration,FAA, Project Management, Project Lifecycle, Government.

I. INTRODUCTION

The U.S. Air Traffic Control System's NextGen program, and in particular the Automatic Dependent Surveillance-Broadcast (ADS-B) project, is one of four components of the program that was initiated to "transform the United States' air traffic control system from a ground-based surveillance system to a satellite-based surveillance system using GPS technology" (PMI, 2014). An analysis of the project's success by utilizing the project life cycle approach will be conducted. The objective of this study is to evaluate the life cycle phases of the ADS-B project and identify unique activities that contributed to the success of this complex project. The scope of this project involved strategic change to domestic air traffic control. The global expansion of this technology was dependent upon the successful implementation and demonstration of value within and among domestic aviation industry partners. It is recognized that effective communication with key stakeholders has been a meaningful driver of success. We will study how this and other effective process tools that were utilized throughout the project life cycle to gain stakeholder acceptance and sustain sponsor support. Project management knowledge areas are defined throughout the project life cycle phases as starting the project, organizing and preparing, carrying out the work, and bringing the project to closure. Extra control can be applied to effectively manage processes when projects are broken down into phases.

Within each of the knowledge areas and across the projects life cycle phases, research into key success factors will be assessed and areas of risk and opportunity will be identified. A numeric evaluation of performance will be assessed to each of the knowledge areas based on identification of areas of strength and opportunities within NextGen's ADS-B project (Appendix A).

Research in recent years has suggested the shift of project management from technical requirements to more soft skills discipline. Kwak, Y.H. and Anbari, F. T. (2009, p.100) quote a project management practitioner that establishes that "Fundamentally, project management today is more about people management than about task orientation". Even though the same practitioner also theorizes that the trend will be reaching a peak point, the following closing statement was presented in the paper: "In the future, project management as a discipline will be getting closer to the general management and organization theory fields because project management needs the theoretical advances that exist within these fields, and because management and organizational theory

need project management, as projects are becoming an integral part of modern management in a number of industries and sectors” Kwak, Y.H. and Anbari, F. T. (2009, p.100)

We have established a hypothesis based on our research that an evolutionary trend of project management discipline towards inclusion and collaboration is occurring. We expect to demonstrate our hypothesis by performing a thorough analysis of knowledge areas throughout the ADS- B project lifecycle. The ADS-B project was baseline in 2007 for a duration of 7 years until 2014 and we expect it will provide modern and recent project management trends that will reflect in the evaluation of the knowledge areas.

II. LITERATURE REVIEW

As it is considered a staple reference and guide for project management, A Guide to the Project Management Body of Knowledge (5th ed.) will be studied for this paper. Research will include scholarly publications in the professional and academic fields of project management. We will also reference resources in industry-recognized theoretical and practical applications into the subject matter of project life cycle tools and analysis within a governmental project environment that partnered with the U.S. airline industry.

The Next Generation Air Transportation System was designed to overhaul the National Air System (NAS). One of the major components of the program was the ADS-B, which started in 2007 and completed government operations in 2014. This was meant to transform the air traffic control industry. The ADS-B has many government published documentation and supporting analytics. Our function will be to evaluate several professional and academic publications to determine the successes and setbacks of the program. In addition, this will allow us to provide a lessons learned subset of information through our findings. We will also reference resources in industry-recognized applications into the project life cycle.

III. METHODOLOGY

In order to complete our research study, we will perform a literature review of the NextGen program, focusing on the ADS-B project. Our expectation is to utilize PMI’s Project Lifecycle Phases to analyze the specific knowledge areas within the program to ascertain the contributing factors of success, knowledge areas of potential improvement and knowledge areas that were not considered.

To summarize our findings we will use a grading table and mechanism using the following rating: 5–Excellent, 4–Good, 3–Satisfactory, 2–Poor, 1–Very Poor. Each phase of the project lifecycle will be graded by analyzing the use of each knowledge area within each phase.

The basis for our research will be the case study “Transforming Air Traffic within the US National Airspace System” that is part of PMI’s Series on Program Management Success in Government. We developed our hypothesis from our research on latest project management trends and the case study referenced above. We also researched other sources and publications as we identify the need to support our hypothesis and evaluate different knowledge areas. The fact that the ADS-B project is a government funded project provides us with an opportunity to have a considerable amount of publications and articles related to the project that we can refer to for our research study.

After careful evaluation of the project management practices used in the ADS-B project, we expect to identify specific knowledge areas that were utilized during each phase of the project life cycle which were integral to its success. The multiple sources and publications provided for the ADS-B project will aid us in determining areas within the project we believe were established in order for the life cycle phase to be effective. Based on the data collected, we also believe there is enough information available to help us better understand and learn from the project’s success. Improvement opportunities that may not have been considered will be explored through our research and will impact grading evaluation for the activity and life cycle phase areas that may need to be improved or would benefit from a more structured process will be determined.

The main limitation identified for our research is the inability to use structured interviews for this project. However we will have open source resources that will provide quantifiable data to bolster our case study. Also the case study contains vast amounts of interviews from project team members that we will refer to throughout our research to support and build our own case.

IV. SUMMARY OF NEW FINDINGS

Adherence to the project management life cycle phases was demonstrated during initiation, planning, executing, controlling and closing the ADS-B project. Within each sequential phase, similar activities occur that provide a comprehensive and organized approach towards execution of the project deliverables. Within

each of the activities, project management tools are utilized to plan and monitor time, resources, cost, quality and risk. During the organizing and planning phases, these activities include: initiation of the project scope; creation of the project charter; creation of the project budget; work breakdown structure; risk assessments; stakeholder analysis; development of a communication plan. Once these activities have been completed and accepted by key stakeholders, the execution phase of the project can commence. During this phase, cost management, quality management, and change management are closely monitored and significant variations in cost or scope will be evaluated to determine if the project can be completed. Finally, project closure activities document lessons learned and acceptance of product deliverable by the project sponsor.

5.1 Starting the Project

During the start of a project, certain processes are performed to define a new project or a new phase of an existing project by obtaining authorization to start the project or phase (PMBPK[®] Guide, 2013). This method is called the Initiating Process, which defines the initial scope of the project, as well as its initial financial resources. This process also identifies the project manager, if not already selected, and the internal and external stakeholders who will be there to support and influence the overall outcome of the project. “The key purpose of this Process Group is to align the stakeholders’ expectations with the project’s purpose, give them visibility about the scope and objectives, and show how their participation in the project and its associated phases can ensure that their expectations are achieved” (PMBPK[®] Guide, 2013). Any information collected for this Process Group is documented on a project charter and stakeholder register. The project will become formally authorized once the project charter is approved. Once approval is granted, the project manager will be given the authority to apply structural resources to project activities.

Integration - The project charter is developed under the first knowledge area integration, which is a part of the initiating process. It is made up of inputs, tools and techniques, and outputs that are used to establish a partnership between the performing and requesting organizations. Chartering a project validates alignment of the project to the strategy and ongoing work of the organization (PMBPK[®] Guide, 2013). The charter for this project covers the Aviation Rulemaking Committee (ARC) for the Automatic Dependent Surveillance - Broadcast In (ADS-B In). ADS-B Out incorporates GPS technology to determine an aircraft's location, airspeed and other data, and broadcasts that information to a network of ground stations, which relays the data to air traffic control displays and to nearby aircraft equipped to receive the data via ADS-B In (FAA, 2014).

Summarized in the ADS-B project charter is the team's organization, responsibilities, and tasks required for completion. The ADS-B ARC provided a forum for the U.S. aviation community to discuss and review an NPRM for ADS-B Out, formulate recommendations on structuring the proposed ADS-B mandate, and consider additional actions that may be necessary to implement those recommendations (FAA, 2014). As a result, the ARC prepared 36 summary recommendations for the FAA as part of their concluding report. These recommendations were in regard to the ADS-B link strategy, security measures, the business case, any equipment that was required, and privacy. Two broad categories were allocated based on the ARC’s recommendations, which included items to be resolved before the rule was enacted and those for future action.

The FAA will form a committee of supporters of the aviation community who will be carefully chosen based on their expertise on ADS-B In, analysis, and regulatory compliance. Membership will be composed of viewpoints, interests, and understanding of the committee's objectives and scope. Discussion is extremely encouraged so membership is limited for the ARC Full participation, commitment, and attendance by members is essential for achieving the ARC and for continued membership. When necessary, the ARC may set up specialized work groups that include at least one ARC member and invited subject matter experts from industry and government which will consist of members from approximately 25 representatives from various Aviation User Groups and segments of Industry and Government (FAA, 2014). We rate the project charter that was documented in the integration process a 5.

Stakeholder Management - During the initiating process, it is critical to identify the people, groups, or organizations that could impact or be impacted by a decision, activity, or outcome of the project, analyzing and documenting relevant information regarding their interests, involvement, interdependencies, influence, and potential impact on project success (PMBPK[®] Guide, 2013). Leadership’s role in the development and early

implementation stages played a critical role the program's success, especially since the lead program manager's reputation on ADS-B was established off of his strong leadership capabilities and management techniques. He provided his internal workforce, as well as external partners and stakeholders, with a clear roadmap that would not accept anything short of success which were essential to meet the aggressive schedule and other goals set by executives (PMI, 2014). His effective and transparent communication created an atmosphere where team members remained highly engaged and motivated, and feeling part of the same winning team. We rate identifying stakeholders during the start of the project a 5.

5.2 Organizing and Preparing

Integration- During integration, the processes and activities that are needed to identify, define, combine, unify, and coordinate process and project management activities are defined. "Characteristics of unification, consolidation, articulation and integrative actions crucial to project completion fall within the context of integration" (Project Management Knowledge, n.d.). A service-provider approach was the foundation for integration activities on the NextGen project (PMI, 2014), recognizing that stakeholder engagement was critical to the success of a project the size and scope of ADS-B. Throughout 2014, FAA subject matter experts met with aviation industry representatives to establish proposed milestones and to define commitments from industry that would be necessary to reach those goals (FAA, 2014). The FAA's *NextGen Priorities Joint Implementation Plan* summarizes the high-level commitments between the FAA and the aviation community and provides a timeline of capability milestones and location (FAA, 2014). Integration activities were strong and were rated a "5".

Scope - The NextGen Priorities Joint Implementation Plan was revised in 2014 to create and maintain transparency on specific program objectives, impacted stakeholders, benefits, budgets, and scheduled delivery as the underlying roadmap of all of NextGen projects (NextGen Priorities JIP, 2014). These capabilities were measured against a set of operational performance metrics that were previously negotiated with industry via the NextGen Advisory Committee (NAC). Automatic Dependent Surveillance–Broadcast (ADS-B) is a precise satellite-based surveillance system. ADS-B Out uses GPS technology to determine an aircraft's location, airspeed and other data, and broadcasts that information to a network of ground stations, which relays the data to air traffic control displays and to nearby aircraft equipped to receive the data via ADS-B In. Operators of aircraft equipped with ADS-B In can receive weather and traffic position information delivered directly to the cockpit (see Appendix B). The benefits and service objectives of the project are fuel efficiency, increased capacity, distance, safety, reduction of delays, and regional benefits related to decreasing time for search and rescue in remote locations (PMI, 2014). Scope is rated a "4".

Time - The Plan identifies milestones for operational implementation at specific locations spanning a period of time from a planned start date of June 2006 through completion that was planned for September 2014. A careful analysis of resources required and available was conducted and the method for acquiring those resources was determined from results of a sourcing survey. This is rated a "4" on the grading table.

Cost - Specific commitments are requested and funded through the President's Budget Request and the FAA's Capital Investment Plan based on analysis of previously completed projects, the number of procedures to be implemented in the fiscal year, and the level of effort needed to complete the work.

Continued funding decisions were made on the achievement of defined milestones. "Cost estimates are developed based on engineering analysis and known historical costs for industry operations, procedure conceptual design, data collection, analysis and training". (FAA, 2014) Expert judgment, guided by historical information, provides valuable insight about the environment and information from prior similar projects (PMI, 2014). This is rated "3".

Quality - Safety analyses and engineering studies were conducted for capabilities that the FAA and the aviation industry community were mutually interested in pursuing. There was a commitment by industry to complete activities required for successful implementation. The significant interdependencies with other FAA projects, subject the project to risks in cost, schedule, and performance (FAA, 2014). Investment in proper quality

frameworks and integrated quality controls throughout the project life cycle can enhance not only customer and stakeholder satisfaction but also improve time-to-market and lower project costs (Ho, 2005). Quality during this phase is rated “4”.

Human Resource -The scope and size of the ADB-S project required the FAA to contract outside of the agency for talent and resources that would be assigned exclusively to this project and work alongside internal subject matter experts and other subcontractors. In 2009 they conducted a market survey in order to assess the quality and scope of talent available in order to assess their “acquisition strategy, contract vehicle type(s), quantities, and whether the acquisition(s) should be open competition, limited competition, small business set aside, sole source procurement, or some combination of these acquisition types” (Federal Aviation Administration Contract Opportunities, 2009). In an integrated project organization, project team members from different companies or company units work together in a common project organization to “optimize a holistic project view instead of having competing parallel project organizations with project hierarchies” (Turner, Huemann, Anbari&Bredillet, 2010). Human Resources is rated “5”.

Communication -Creation of the NextGen Advisory Committee was created in response to a request from the U.S. House of Representatives’ Committee on Transportation and Infrastructure, Subcommittee on Aviation as a mechanism for the FAA to collaborate with the aviation industry on project initiatives that included the ADB-S project (NextGen Priorities Joint Implementation Plan, 2014).

The Aviation Subcommittee of the House Transportation and Infrastructure Committee requested that the FAA work with the aviation community to create an implementation plan that defined milestones, locations, timelines, costs and metrics. The NextGen Advisory Committee (NAC) served as the forum for this collaboration. “Four working groups of industry stakeholders and agency subject matter experts worked to consensus” (FAA, 2014). The NAC monitored progress against the plan and as well as progress against milestones. The NAC is a Federal advisory committee made up of high-level representatives from throughout the aviation community. It is the FAA’s principal source of stakeholder advice on NextGen issues and is tasked to provide recommendations that help fine-tune the agency’s plans. Momentum was sustained through internal meetings held at least monthly while the NAC worked with industry stakeholders to ensure their commitments were funded and met (FAA, 2014). “Senior FAA executives met with NAC representatives on a weekly basis to guide effort and met with their industry counterparts at several critical junctures to resolve questions about the content of the plan and the Communication Plan” (FAA, 2014).

Plan Communications Management is the process of developing not only a plan, but an appropriate approach for project communications based on stakeholder’s information needs and requirements as well as available organizational assets.

Effective communication throughout the ADS-B project was recognized as a key building block to success (PMI, 2014). The project “utilized both internally and externally with industry and other stakeholders, effective and transparent communication that kept everyone highly engaged and motivated, and feeling part of the same winning team” (PMI, 2014). Transparency was facilitated through the use of the NextGen Performance Snapshots website on which the FAA reported progress against milestones for each focus area (FAA, 2014). Communications is rated “4”.

Risk - Collaborative Decision Making (CDM) is an operating philosophy whereby traffic flow management decisions are based on a foundation of real-time data sharing, a common view of constraints, and a decision making process that is focused on improving the predictability and efficiency of flight operations. CDM participants include representatives from government, airlines, general aviation, business aviation, private industry and academia, all working together in developing new processes which often rely less on technology and more on stakeholder agreements that are intended to achieve mutually beneficial outcomes which support the efficiency and safety of the NAS. The success of these types of initiatives depends on all parties making a clear commitment to the new processes while realizing a return on their investment. Risk is rated “3”.

Procurement -In a 2005 progress report to Congress, the FAA focused on strategic initiatives for transforming National Air Space rather than addressing implementation costs, establishing priorities and specific sequencing of airports and air space as well as lacking detail on how needed technologies will be developed or integrated (Department of Transportation, 2013). Without a specific procurement schedule and detailed hardware and software needs, decision makers and stakeholders lacked sufficient information to plan for cost, capacity goals, milestones, and risk (Department of Transportation, 2013). This area was rated poor at “2”.

Stakeholder Management -Senior FAA executives met with the agency’s representatives on a weekly basis to guide the effort, and met with their industry counterparts at several critical junctures to resolve questions about the content of the plan and the process for overseeing its completion (NextGen Priorities JIP, 2014).

The Aviation Subcommittee of the House Transportation and Infrastructure Committee requested that the FAA work with the aviation community to create an implementation plan that defined milestones, locations, timelines, costs and metrics. The NAC served as the forum for this collaboration. “Four working groups of industry stakeholders and agency subject matter NAC forum that included four working groups of industry stakeholders and agency subject matter experts that worked to consensus (NextGen Priorities Joint Implementation Plan, 2014). Throughout the project lifecycle, frequent updates and transparency in processes and decisions were maintained through the Communication Plan included: the FAA executives meeting with industry counterparts at several critical junctures to resolve questions about plan content and oversight of completion of key milestones; the NAC conducting internal meetings at least monthly to monitor progress against the plan; Senior FAA and industry leadership providing quarterly updates to the NAC’s subcommittee; publication of progress reports publicly through the NAC with advance notice available to the public in the Federal Register; and the Agency reporting progress against milestones for each focus area on the NextGen Performance Snapshots website” (FAA, 2014). Strong stakeholder management was achieved and is rated a “5”.

5.3 Carrying Out the Work

The “carrying out the work section” phase as analyzed in this research is the equivalent of the execution, monitoring and control phases per the *PMBPK® Guide, 2013*. We will perform the knowledge area analysis of this as one whole phase. The ADS-B Project execution phase started in 2007. Per PMI’s case study, the project “was granted a US\$1.7 billion program baseline for 2007-2014” (PMI, 2014). The establishment and approval of a project baseline, is the trigger for the project execution stage which we will analyze in this section.

Integration - Integration in the context of a project includes the “processes and activities to identify, define, combine, unify, and coordinate the various processes and project management activities” (PMBPK® Guide, 2013, p.63). During execution, effective change management is needed for a successful integration. The program lead made the following statement related to a change that impacted the project, “When the program baseline was set in 2007, the FAA was not aware that the ADS-B avionics standards would need to be modified. Through international coordination, the FAA determined that the standards needed to be changed to provide better quality data. These changes were completed in time to support the rulemaking, but it then took about two years for manufacturers to start developing avionics that met these new standards.” (PMI, 2014)

If we only focus on the change management part of this situation, we can infer that when the need for this change was identified, it immediately went through a structured change management process. They were able to integrate the stakeholders that will be affected by the change and identify the impact it will have. Even though the change did not impact the project schedule, it did have a big impact for external stakeholders and subsequently to the overall program. As a result of following a change management process and good integration practices, they were able to identify a new unknown risk and prepare a workaround plan. In specific terms of integration during execution, we will rank 5 in our grading table.

Scope - The scope management knowledge area is defined as “the processes required to ensure that the project includes all the work required” (PMBPK® Guide, 2013, p.105). In terms of the execution of the work, the scope management knowledge area consists of controlling of this scope to avoid “gold plating” or scope creep that are not really a project requirement. It also included in the Validate Scope process before the project formally starts

the project closing phase. The following statement was obtained from the ADS-B Case Study from PMI (2014), “In general, the system meets availability, latency and update interval technical performance measures (or TPMs) for all services. There are occasional (<1%) TPM’s that do not meet requirements for a given month, but for > 99% of the TPMs, the system meets or exceeds requirements. Insiders insist that context is important: it is natural, often expected for systems to go through continuous improvement once fielded, as operators find innovative ways to use the system and issues continue to be debugged.” The fact that this statement establishes that requirements are exceeded in some of the technical performance and that operators find innovative ways to use the system, is a concern from a scope management perspective. Delivering more functions than what was established in the original scope (gold plating) is not a good project management practice. This is a more common practice when the PMO executing the project is an internal group within the company that is also the customer. Because the PMO is internal, the operational success is as important as the project so there may be more tolerance for including additional enhancements. It still isn’t a good PM practice so we rate Scope Management a 3 in our grading table.

Time - Controlling the schedule during execution of the ADS-B Project appears to be very well conducted. The project controls team utilized a schedule variance measurement throughout the project that allowed them to accurately measure how well the schedule aligned with the forecasted baseline. The following statement is made in the Case Study from PMI (2014) “Although slightly behind with one delay in Service Volume Design Approvals, all variances are within 5% of the program baseline.”(Appendix C). Details of schedule variance metrics for all project work streams are included in Appendix D. From this statement and the available metrics we can conclude that the project was successfully controlled within the baseline forecasted variance and we rate the project with a 5 in the knowledge area.

Cost - The ADS-B Project utilized an Earned Value Management (EVM) approach to control project cost. “EVM shows the program meets baseline cost and schedule expectations, and project expenditures are lower than the current plan.” (PMI, 2014) (Figure 1). However they also highlight in a side note referring to the negative cost variance in Figure 2 that “This variance is associated with the two congressional plus-ups, which added scope outside of the original baseline. Otherwise, the program is estimating completion within the baseline cost” (PMI, 2014). Even though this statement support our lower rating in the Scope Management knowledge area for allowing scope creep, in terms of cost management it does reflect a very good process established and understanding of good cost management practices. Even though the Cost Variance is below expected for 0.95%, it is within the allowed baseline variance so we conclude that Cost Management rating for the project execution phase is ”5”.

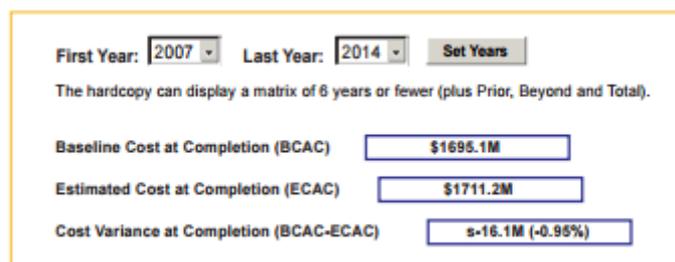


Figure 1. Adopted from PMI, 2014

Quality -The quality management area includes the “processes and activities of the performing organization that determine quality policies, objectives and responsibilities so that the project will satisfy the needs for which it was undertaken” (PMBPK® Guide, 2013, p.227). Specifically under the project execution phase, it includes the performance of quality assurance and quality control.

Per the PMI case study the project “Achieved 15 of 16 technical performance goals, including interval and latency requirements”. Additionally, the project also “achieved all benefits and service objectives at its various target sites, which resulted in increased safety (lower accident rates) in remote regions, fuel savings, capacity, distance savings and decreased search-and-rescue and flight-delay times, among other positive outcomes” (PMI, 2014).

Rose (2005, p.4) said the following about quality processes in a project: “Users focus more on the product and how it performs than on how it was produced... whether they are delivering a product that results from manufacturing or purely intellectual activity, the processes that produce that product have a great effect on the outcome. What you do might keep a smile on your customer’s face, but how you do it will keep you on schedule and on budget...”

Even though we did not find literature about specific quality assurance and quality control measures utilized in the ADS-B project, we can infer by the accomplishments of the project stated above that a robust quality management process was utilized. We will rate this knowledge area as “4” due to lack of evidence of the processes utilized.

Human Resource -Human Resources Management during execution is about developing and managing the project team once it is selected. The feedback from project team members in the Case Study speaks very positive about the overall project team environment and the improvement of competencies throughout the project lifecycle. On developing the project team, and interviewee in PMI (2014) Case Study states that, ADS-B encouraged everyone to be intentional in their decision-making. It has become much more common to challenge oneself to doing things differently than in the past, to do everything with regard to the baseline or to consider the service-provider approach or, more generally, to find cheaper alternatives. These represent just a few examples of the change in mindset. One interviewee explains it more eloquently: It’s about being intentional in all your decisions...you didn’t see that back in the day, and you don’t see it across all programs” (PMI, 2014).

On managing the project team by the program lead, the interviewee continues,

“The lead program manager had established a reputation for taking programs from concept to deployment successfully, and ADS-B was no exception. His leadership effectively managed expectations and identified key documents and control mechanisms that were necessary to take the program from beginning to end, so we stayed focused on the work we needed to do” (PMI, 2014).

The ADS-B leadership in project management and building those competencies in all the project team members is a great example of good team development and is an example other Federal Agencies are trying to adopt as well. We rate the Human Resources Management at “5”.

Communications - The Communication Management knowledge area through the project execution and controlling consists of mostly ensuring all information needs of the project stakeholders are met. The following statement made by an interviewee in the project case study PMI (2014), speaks of the positive communication during the project execution and it reduced as the project entered closing stage.

“Overall there appears to be a decline in general communication with stakeholders. As a program begins to twilight, it naturally loses visibility, and communication with stakeholders correlates with that. During the key phase, it was very active, there were frequent articles in the trade journals... Furthermore, there is no longer a strong, consistent message from the FAA to the broader community, especially that of “second-tier” stakeholders such as operators, suppliers and installers” (PMI, 2014).

In another paragraph it also speaks of how impressed the Congress was with the program performance. This is also a high-quality example of effective the communication with the more influential stakeholders and sponsors. “Congress was impressed with the solid performance of the program in its first two years – meeting milestones, developing traction and engaging industry – and felt it was critical to investigate future applications and continue to stimulate equipage” (PMI, 2014).

Finally a project member also made the following statement on communication was throughout the project, “Effective and transparent communication. Utilized both internally and externally with industry and other stakeholders, effective and transparent communication kept everyone highly engaged and motivated, and feeling part of the same winning team” (PMI, 2014).

The feedback from the Case study on the overall project communication is very positive in terms of effectiveness and meeting all the stakeholders' needs. It also addresses a number of communication dimensions like internal, external, vertical, horizontal, official, written and oral communication that are also highlighted in the *PMBPK® Guide, 2013*. Based on this we rate the project with a "5" in Communication Management during execution.

Risk - The risk management knowledge area during execution is divided by two main processes, the qualitative risk analysis and quantitative risk analysis. The process is then followed by planning risk responses and controlling the risks by implementing the risk response. Even though we do not have the specific tools and practices utilized for risk management in this project, risk management was practiced throughout the project. As part of the lessons learned captured in the PMI (2014) Case study, risk identification was one of them. "[Described by one interviewee as a "brutal, introspective and transparent" (PMI, 2014) approach, the Program Office encouraged the admittance of risk and problems early on. As a result, it was able to efficiently allocate and manage those resources and to pre-empt and solve problems. "I've not come across that elsewhere," he continues. "It should be brought, not only elsewhere in the FAA, but also in the federal government. I'm glad they did it.]" (PMI, 2014, p.14).

Another statement reads: "The Lead Program Manager was able to successfully manage the many disparate areas of risk that were encountered, whether they were technical, programmatic or political risks, while allowing his workforce to not only stay focused but also to remain highly motivated throughout" (PMI , 2014).

However there is some evidence of instances where workarounds for unidentified risks had to be completed per the following statement:

"When the program baseline was set in 2007, the FAA was not aware that the ADS-B avionics standards would need to be modified. Through international coordination, the FAA determined that the standards needed to be changed to provide better quality data. These changes were completed in time to support the rulemaking, but it then took about two years for manufacturers to start developing avionics that met these new standards" (PMI, 2014).

From the all previous statements, we can infer there was definitely a risk identification and control process implemented in the ADS-B project. However the risk identification process, even though it continues throughout the project lifecycle, the expectation is that it is mostly part of the planning phase. There is no evidence in our literature review of a qualitative or quantitative risk analysis and or tools utilized but definitely a risk control process that was implemented as needed. Because of this we rate the risk management during the project execution and control phase at a satisfactory rate of "3".

Procurement -Procurement Management during project execution consists of conducting procurement (awarding contracts) and controlling procurement once the contracts are awarded. The following statement speaks very specifically to focus the team had in the selection of contractors and vendors for this project while conducting procurement, "[An emphasis on transparency helped to ensure a productive working relationship with ITT Exelis, the manufacturer of the ADS-B ground infrastructure and service provider. It did not hurt that the contractors also believed in the same overriding principle of transparency, not just transparency, but also early identification of risk and joint problem-solving. It was interesting to see the leadership of the program managers complemented by the same type of behavior on the contractor side," recalls one interviewee. "It was a fantastic fit" (PMI, 2014).

The previous statement suggests a very well executed contractor selection and contract rewarding based on a planned procurement process. However given we don't have more literature on effective procurement control practices utilized during project execution, we will give the procurement management a satisfactory rating of "3".

Stakeholder Management -Stakeholders Management during project execution focuses in the management and control of stakeholder's engagement. The project case study presents what it seems as a very effective stakeholder's management process. The following statement was made by a project team member:

The Program Management Office's decision to engage and sustain engagement between internal and external stakeholders resulted in the program being able to avoid the many pitfalls that cause delays such as lack of continuity of congressional or FAA funding or resistance from key stakeholders. "The lack of engagement has created problems elsewhere while ADS-B hasn't had those problems," says one interviewee (PMI, 2014). "By encouraging frank, open and regular dialogue among the various parties, ADS-B was able to circumvent some problems and fix others in a timely, cost-efficient manner" (PMI, 2014).

The previous statement describes a very effective stakeholder's engagement management and control process to ensure their expectations and needs are address and consider. It encompasses all the requirements as described by the (*PMBPK® Guide, 2013, p.391*). We rate the Stakeholders Management knowledge area with a "5" for the execution phase.

5.4 Closing the Project

A project is a temporary endeavor undertaken to create a unique product, service, or result (*PMBPK® Guide, 2013*). Within every project there is a sequence that needs to be followed to ensure that each cycle follows the overall project management plan. Closing is when the project has performed all defined project objectives, reassigns or releases project resources, and the customer has formerly accepted the project's product. During the closure phase of the project life cycle there are many factors and personnel involved to ensure the final product is completed to the desired specification. The closing phase also contains close project procurements where the project team ensures that all deliverables meet requirements, technical specifications, and all other requirements laid out within the project management plan.

There are administrative tasks that must take place to successfully close project procurements. These functions provide the documentation and backup information required to close procurements within a project. The project team must identify and assess the following areas to ensure their intended end states were met. We have identified core areas within the project and analyzed their effectiveness and timeliness. Below are the areas that we determined were of significance:

Integration -The ADS-B with the various airline organizations was a challenge due to the sheer size and volume of the program. However, the program team was able to integrate the ADS-B through strong leadership, success through prior installs, consistent and clear communication, and strong cost forecasting through Earned Value Management (EVM). The program team demonstrated strong leadership through dedicated quality and a schedule that was adhered. The program was able to learn from their mistakes and mishaps and put their lessons learned to use. If a mistake was made they would document the faults and put the mitigation plan into effect across the rest of the program. Their communication plan was consistent and direct. The Program Manager clearly communicated the end state of the project to both the employee base and stakeholders. In doing so, he conveyed his approach and dedication to the schedule set forth. In addition, the ADS-B leveraged EVM to monitor cost and schedule deviations. This allowed the program to fully understand the cost of missed schedules and how to better utilize resources across the program. However, there is still one major issue in regards to the ADS-B, and it does not refer to the initial phase of the program, but to long term integration of ADS-B into the private sector. This was reported by the Department of Transportation (DoT) in their "ADS-B Benefits are limited Due to a Lack of Advanced Capabilities and Delays in User Equipage" (PMI, 2014). The premise of this report detailed the lag in installing ADS-B in all aircraft. Nonetheless, there is a federal mandate to have all aircraft install ADS-B by 2020 (PMI, 2014), . Although the ADS-B program has exemplified program management, schedule adherence, and cost containment it has an Achilles heel because of its reliance on the private sector and private aircraft owners to install the ADS-B. This is a problem that is still being worked to-date and will become Federal law in 2020. Based on the variables depicted above we rate this sections as a "4" because of its long-term dependence on the private sector.

Scope - The Scope of the ADS-B was gargantuan and was spread across seven years of delivery (caveat: 2020 for all aircraft to become equipped with ADS-B). In addition, this program had two Engineering Change

Proposals (ECPs) that increased scope and cost. This program was broken into thirteen major sub-projects that had their own life cycle costs, schedules, and budget that rolled up into the overall program. Each of these sub-projects was given “green” status and maintained their schedule. Due to some scope creep and minor issues within some of the sub-projects we rate this section as a “4”.

Time - The ADS-B program was awarded official program status in 2007 (launched in 2006) with options that extended through 2014. The Federal Aviation Administration (FAA) hopes to have all aircraft operating in its borders ADS-B by 2020. The seven years that ADS-B operated has been looked upon as a success. All schedules listed within the thirteen subprojects have been in “green” status. This program was very impressive as it moved through the project life cycle, which enabled us to rate this program as a “5”.

Cost - The ADS-B had a baseline cost at completion (BCAC) of \$US1695.1M and an estimated cost at completion (ECAC) of \$US1711.2M. This shows a \$US16.1M under run from baseline to the latest estimate. This provides a quantifiable measurement on how the program performed. When looking at how this program closed out under budget with two ECPs that expanded their scope and the program team still maintained a baseline that saved the government money. They did have a few areas where their delivery date slipped, but overall they executed the program within the scheduled time frame and under budget. This program is a great example of how EVM was used to ensure costs were contained and within the plan. The ADS-B was able to stay under cost and qualifies for a “5” rating from our group.

Quality - The value of the ADS-B has been realized across the airline industry. ADS-B brings a heightened level of safety to the pilot, traveler, and airport(s). It has the ability to provide pertinent information to the pilot on the dashboard in real-time. This allows pilots to make adjustments for weather, other aircraft, and runway capacity. The overall quality of the program has been realized across industry, but the final phase of implementation into the personal and commercial aircraft still remains. The quality of the program and its gains in safety and capability allow us to rate this program as a “4”.

Human Resource - The Human Resources aspect of this program provided great support to the program through integrated management and communication open communication channels. This allowed the program manager a clear and concise communication channel across the program to ensure all members of the team were on the same page in regard to tempo, project status, and future operations. The program had solid lessons learned and provided clear and concise communication that allowed the program team to clearly understand end-states. We rate this section as a “5”.

Communications- The communications plan for the ADS-B was executed beautifully and relied on clear and concise communication across the program. At each phase of the program, the program management office conveyed strategic messaging depicted the current status, benefits, and capabilities of the program. This program required conjoined efforts between project managers to ensure they maintained schedule and clearly communicated their current status on a regular basis. These would then be rolled up and send out to the entire program and stakeholders. The communications plan across the program and to its stakeholders was one of their lynch pins of success. We rate this section as a “5”.

Risk - The risks associated with the program of this size relate to implementation of the plan. However, the program team was able to mitigate this by breaking the entire program into 13 sub-projects that align to the overall end state of the program. A major risk aligned to the ADS-B relates to the procurement of ADS-B for individual and commercial pilots and airline organizations. In addition, this is a major investment for the FAA that will be in implementation mode through 2020 and relies on the pilots and airline industry to comply. These are still opened risks and will require constant oversight. There is marginal risk to the program because of its reliance on private sector. We rate this section as a “3”.

Procurement -The ADS-B program was a major program for the FAA and remains an active program. The program costs \$US1711.2M for the implementation of the ADS-B into airports and equipment. This investment will need to be maintained in terms of oversight through 2020 to ensure the end state is met. Overall, the giant price tag has provided great benefits and capability to the airline industry by making a safer and more reliable

network for passengers and pilots. The price tag of the materials and their dependence on other subcontractors allowed for a “3” rating.

Stakeholder Management - The program did a great job integrating stakeholders across the program and updating them on each phase. One of their initial plans was to engage stakeholders early and regularly. In reading over their lessons learned library they were able to maintain a very high level of confidence from their stakeholders because of the consistent and clear messaging. This was one of the legacy management traits that was left as a true positive for the program. The program team did an amazing job of keeping their stakeholders updated and providing clear understanding of each sub-project. This was a learning moment that was noted by the program team and found to be a major success factor. We rate this section as a “5”.

As for the closing of the project, it was able to accomplish a tremendous amount of gains in modernization, surveillance, weather forecasting, and overall air safety. The closing of the project provided a qualitative and quantitative example of a major program with multiple sub-projects being run successfully.

V. ANALYSIS AND DISCUSSION OF RESULTS

We conducted an analysis of the NextGen, ADS-B project’s success throughout this research paper by utilizing the project life cycle approach. Specific knowledge areas within the program were used to determine the contributing factors of success, knowledge areas of potential improvement, knowledge areas that were not considered, and their potential impact to the overall program. Each knowledge area was provided a rating which, in the end, had an effect on the project life cycle process. Through research, we have come to the realization that effective communication with key stakeholders has been a meaningful driver of success.

The first project life cycle process, starting the project, received a score of 100%. During this process, the ADS-B project charter included a strategic outline of the team's organization, responsibilities, and tasks required for completion. Recommendations from the U.S. aviation community, regarding the ADS-B link strategy, security measures, the business case, any equipment that was required, and privacy were strategically organized into two broad categories of things to be resolved before the rule was enacted and those for future action. This process also united a committee of supporters of the aviation community that were carefully chosen based on their expertise on ADS-B In, analysis, and regulatory compliance. Membership was composed of viewpoints, interests, and understanding of the committee's objectives and scope.

Specialized work groups were also set up that included at least one member of the ARC and subject matter experts from industry and government. The lead program manager’s strong leadership capabilities and management techniques played a valuable role in the success of this project. In order to meet an aggressive schedule and other goals set by executives, the lead program manager provided his internal workforce, as well as external partners and stakeholders, with a clear roadmap that would not accept anything short of success. His effective and transparent communication created an atmosphere where team members remained highly engaged and motivated, and feeling part of the same winning team, which is the reason this process received a perfect score.

During the organizing and preparing process, the ADS-B project received a total score of 78%, with knowledge areas like integration, human resources, and stakeholder management being the contributing factors of this project’s success, and cost, risk, and procurement being knowledge areas that need potential improvement. Stakeholder engagement was critical to the success of the ADS-B project’s size and scope with the service-provider approach being the foundation for all integration activities in this project. Due to the size and scope of the project, it was essential for the FAA to incorporate integrated organization and contract outside of the agency for talent and resources that would be assigned exclusively to this project and work alongside internal subject matter experts and other subcontractors. Senior FAA executives met with agency representatives on a weekly basis to resolve any questions or concerns they had with the content of the plan and the process for managing its completion. Also, throughout the project lifecycle, the Communication plan was a beneficial tool used to maintain frequent updates and transparency in processes and decisions.

Through our research, it was established that decision makers and stakeholders didn't provide enough sufficient information to plan for cost, capacity goals, milestones, and risk due to the lack of a specific procurement schedule, and detailed hardware and software needs. In the 2005 progress report to Congress, the FAA focused more on strategic initiatives for transforming National Air Space and failed to address implementation costs, establishing priorities and specific sequencing of airports and air space, as well as lacking detail on how the technologies that were needed would be developed or integrated, which is the reason all three of the mentioned knowledge areas have potential for improvement.

Carrying out the work received a score of 86% with scope, risk, and procurement being the top areas for potential improvement. During the scope of this project, certain processes were required to ensure the project included all the work that was essential for project success. Scope management is an area that consists of controlling the scope in order to avoid "gold plating" or scope creep, but requirements were exceeded in some of the technical performance areas and operators found innovative ways to use the system. This was very concerning from the scope management perspective because "gold plating" or delivering more functions than what was established in the original scope is not a good project management practice.

During risk management, the qualitative risk analysis and quantitative risk analysis are two main processes used for execution, which is then followed by planning risk responses and controlling the risks by implementing the risk response. Risk management was practiced throughout this project, but it was unclear what specific tools and practices were utilized for risk management. There is also no evidence that supports any findings of a qualitative or quantitative risk analysis and or the tools that were utilized, but a risk identification and control process was definitely implemented in the ADS-B project as needed.

The procurement management for the execution phase consists of awarding contracts and controlling procurement once that contracts are granted. Even though there was a much executed contractor selection and contract rewarding for the ADB-S project, through our research, we were unable to identify more literature on an effective procurement control process utilized during this project phase, leaving much room for potential improvement.

The last process we analyzed was closing the project, which we rated an 86% with risk and procurement being areas for potential improvement. Implementation of the project plan was a major risk for the program, but the program team mitigated this risk by breaking the entire program down into 13 sub-projects, which aligned with the overall end state of the program. Being as though this project is a huge investment for the FAA that will be in implementation mode through 2020, it relies on the pilots and airline industry to comply. There are also unidentified risks that will require continuous oversight.

The ADS-B was such a major program for the FAA and it still remains an active program with costs totaling \$US1711.2M for the implementation of the ADS-B into airports and equipment. To ensure project success, this investment will be maintained in terms of oversight into 2020. Even though this expensive investment has provided great benefits and capability to the airline industry by making it a safe, more reliable network for passengers and pilots, its cost of materials and dependence on other subcontractors caused its low rating.

Table 1. Research Project Knowledge Areas Grading Table

Project Management Knowledge Areas	Project Life Cycle Phases			
	Starting the project	Organizing and preparing	Carrying out the work	Closing the project
Integration	5	5	5	4
Scope	n/a	4	3	4
Time	n/a	4	5	5
Cost	n/a	3	5	5
Quality	n/a	4	4	4
Human Resource	n/a	5	5	5
Communications	n/a	4	5	5
Risk	n/a	3	3	3
Procurement	n/a	2	3	3
Stakeholder Management	5	5	5	5

5–Excellent, 4–Good, 3–Satisfactory, 2–Poor, 1–Very Poor, Adapted from PMBPK® Guide, 2013

VI. CONCLUSION

We explored specific knowledge areas within the project life cycle phase of the NexGen, ADS-B project in order to analyze its key success factors, potential areas of improvement, and the impact that each knowledge area can have on the overall project. The objective of this study was to evaluate the life cycle phases of the ADS-B project and identify unique activities that contributed to the success of this complex project. Through our research, we have found that Risk and Procurement Management were the two main knowledge areas that needed improvement throughout each phase of the project life cycle. They received a rating of “3” or lower across the chart and could have potentially caused the downfall of this project. Major factors that propelled this program to success were the Communication Plan and Stakeholder Management. The theoretical application of stakeholder management became evident as a key performance indicator as we conducted our research into the ADS-B project. The FAA recognized that aviation industry leaders needed to partner with the project team and demonstrate high influence in decision making as well as a high engagement in the project and a commitment to their guarantees for equipment installation.

The scope of this project involved strategic change to domestic air traffic control. The global expansion of this technology was dependent upon the successful implementation and demonstration of value within and among domestic aviation industry partners. Throughout our research and within each project life cycle, stakeholder management emerged as a strong and positive measure of success. The NAC was tasked with the engagement of subject matter experts within industry to ensure streamlined decision making as well as transparency throughout the project life cycle. In order to strengthen its philosophical foundation, project management needs to be “engaged in adapting new ideas and changes and look at how social networks and collaborative thinking work in project management” (Kwak&Anbari, 2008, p. 71). We expect that in the future recognition of a philosophical change in project management from control to collaboration will occur, as demonstrated in this highly visible government project. “The project management community should focus on enhancing its capabilities in both the hard and soft disciplines. It should embrace all research that improves the interaction of people to people, people to technology, as well as technology to technology” (Kwak&Anbari, 2008, p. 71).

The conclusions drawn from this research validate the evolution within the project management discipline towards inclusion and collaboration as part of the planning, organization, execution and closure of future project management processes. Stakeholder management will evolve from control to collaboration as organizations, sponsors, and project management professionals recognize the value of support from “many people who have to commit substantial resources including time, effort, money, emotion, and political will” (Turner, Huemann, Anbari&Bredillet, 2010). Communication planning will recognize the need for transparency throughout the project life cycle by establishing avenues for communication upwards to win the support of top management, outwards to win the support of professional colleagues, users, and operations of the project’s output and managers who provide resources to the project as well as downwards to win the support of the project team members who invest considerable personal commitments to the project(Turner, Huemann, Anbari&Bredillet (2010).

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