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Program Management Practices: Comparison Between DoD and NASA

September 2022

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Department of Defense Management

Naval Postgraduate School

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Prepared for the Naval Postgraduate School, Monterey, CA 93943

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ABSTRACT

The Government Performance and Results Act Modernization Act of 2010 emphasized the necessity of partnerships between federal agencies to achieve common goals. In order to successfully execute cross-agency programs and projects, it is important to understand processes and policies across organizational boundaries. Knowing where guidance overlaps, converges, and diverges can help better inform program and project managers. This project compares and contrasts program and project management practices of two government agencies: the Department of Defense (DOD) and National Aeronautics and Space Administration (NASA). DOD's big-A and little-a acquisitions are compared with relevant NASA Policy Directives and NASA Procedural Requirements in order to identify similarities and differences. These similarities and differences are then assessed against the twelve program management principles identified in the Project Management Body of Knowledge to finally inform a strengths, weaknesses, opportunities, and threats (SWOT) analysis. The comparison shows more similarities than differences. Similarities resulted in common strengths to both DOD and NASA, for instance a culture of innovation and focus on tailoring. Differences informed possible best practices, such as DOD's multiple acquisition pathways for time-phased and product-based programs and NASA's structured tailoring approach.

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TABLE OF CONTENTS

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LIST OF FIGURES

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LIST OF TABLES

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LIST OF ACRONYMS AND ABBREVIATIONS

AAF	adaptive acquisition framework
AAFDID	adaptive acquisition framework document identification
ACAT	acquisition categories
AI	artificial intelligence
AFI	Air Force instruction
ATP	authority to proceed
BCAT	business system categories
CAE	component acquisition executive
CAP	capstone applied project
CCA	Clinger-Cohen Act
CDD	capability development document
CIO	Chief Information Officer
CJCSI	Chairman of the Joint Chiefs of Staff instruction
CMO	Chief Management Officer
DA	decision authority
DAS	defense acquisition system
DAU	defense acquisition university
DAWIA	Defense Acquisition Workforce Improvement Act
DBS	defense business systems
DD	disposition determination
DevSecOps	development, security, and operations
DME	development, modernization, and enhancement
DOD	Department of Defense
DODD	Department of Defense directive
DODI	Department of Defense instruction
DSMC	Defense System Management College
EMD	engineering and manufacturing development
Ent	enterprise
ESOH	environment, safety, and occupational health
EU	European Union

EVMS	earned value management system
FAQ	frequently asked questions
FITARA	Federal Information Technology Acquisition Reform Act
FOC	full operational capability
FRP	full rate production
GAO	Government Accountability Office
GPRA	Government Performance and Results Act
I	iteration
ID	identification
IOC	initial operational capability
IT	information technology
JCIDS	joint capabilities integration and development system
KDP	key decision point
LCC	life-cycle cost
LCS	littoral combat ship
M	millions
MDAP	major defense acquisition program
MDD	materiel development decision
MS	milestone
MSA	materiel solutions analysis
MTA	middle tier of acquisition
MVCR	minimum viable capability release
MVP	minimum viable product
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NDAA	National Defense Authorization Act
NODIS	NASA online directives information system
NPD	NASA policy directive
NPR	NASA procedural requirements
NPS	Naval Postgraduate School
O&S	operations and sustainment
OD	outcome determination

OMB	Office of Management and Budget
P&D	production and development
PLAN	People's Liberation Army Navy
PMBOK	*Project Management Body of Knowledge*
PMO	program management office
PPBE	planning, programming, budgeting, and execution
PPBS	planning, programming, and budgeting system
R	release
R&T	research and technology
RFP	request for proposal
SECDEF	Secretary of Defense
SECNAVI	Secretary of the Navy instruction
SoS	system of systems
SW	software
SWOT	strengths, weaknesses, opportunities, and threats
SWP	software package
TMRR	technology maturation and risk reduction
U.K.	United Kingdom
U.S.	United States
USSOCOM	United States Special Operations Command
UON	urgent operational needs
USD(A&S)	Under Secretary of Defense for Acquisition and Sustainment
VU	Villanova University
WHS	Washington Headquarters Services

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EXECUTIVE SUMMARY

This project compares and contrasts program and project management practices of two government agencies: the Department of Defense (DOD) and National Aeronautics and Space Administration (NASA). First, it identifies similarities and differences between these agencies' program management practices. Then, leveraging *Project Management Body of Knowledge* (PMBOK), similarities and differences are assessed as strengths, weaknesses, opportunities, or threats (SWOT) to inform possible best practices.

In the background, DOD's structured big-A and little-a acquisitions are compared with relevant NASA Policy Directives (NPD) and NASA Procedural Requirements (NPR). DOD's big-A consists of three interconnected elements: Joint Capabilities Integration and Development System (JCIDS); Programming, Planning, Budgeting, and Execution (PPBE); and Defense Acquisition System (DAS). DAS is referred to as the little-a. The little-a utilizes six acquisition pathways. NASA does not identify a big-A, but their policies and procedures map well to the big-A elements of requirements, budgeting, and acquisitions. NASA does not use the term "acquisition pathways," but three NPRs identify similar acquisition pathway information.

The literature review is two-fold. With the abundance of information available to program managers, it first discusses resources available to DOD and NASA program managers to provide an appreciation of the amount of material available. Second, it identifies other comparative assessments. Comparison between DOD and NASA has been relatively understudied; however, there are comparisons of DOD to other countries' defense agencies, including several Asian countries and several European countries.

The analysis is limited to overarching policies and information technology (IT), specifically software. The overarching policies were selected because they set the foundation and identify priorities for program managers. DOD identifies twenty-five policies, while NASA identifies fifteen; however, there are more commonalities than differences. Similarities include promoting competition, having a disciplined approach, maintaining a professional workforce, developing a culture of innovation, focusing on cost and schedule, planning for the program life-cycle (such as product support and operations), and maintaining transparency, to name a few. The primary difference is that DOD identifies six acquisition pathways that address time-phased and product lines, while NASA has three NPRs, which are all product focused. The IT acquisition policies comparison between DOD and NASA identified similarities such as an emphasis on tailoring and an incremental approach. Differences were more nuanced but consisted of life-cycle options, baseline requirements, delivery of software updates, and decision authority. Based on PMBOK's twelve program management principles, the similarities and differences were categorized as strengths or weaknesses. DOD and NASA shared common strengths as well as individual strengths. Both the strengths and weaknesses informed opportunities and threats, which completed the SWOT analysis.

The SWOT analysis informed future recommendation for both DOD and NASA. For DOD, it included leveraging areas where NASA's approach was more structured. This included how to document a tailored approach for programs and projects as well as baselining and rebaselining IT acquisitions. For NASA, the prominent recommendation was to expand their guidance beyond the three product-driven NPRs for space flight, IT, and research and technology to other non-technical products. Future research focuses on additional comparisons at various levels.

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I. INTRODUCTION

With the passage of the Government Performance and Results Act (GPRA) Modernization Act of 2010, federal agencies were required to "identify major management challenges that are Governmentwide or crosscutting in nature and describe plans to address such challenges" in their annual performance plan (GPRA Modernization Act, 2010, sec. 3(a)(6)). This placed more emphasis on interagency collaborations. Verkuil and Fountain (2014) note

> Greater interagency coordination within the federal government and intergovernmentally is increasingly viewed as essential to meeting complex policy challenges, wicked problems, that lie inherently across agency boundaries and jurisdictions. Streamlining through some carefully framed cross-agency initiatives is a means to increase efficiency, effectiveness, and accountability by reducing unnecessary overlap, redundancy, and fragmentation. (p. 11)

The Department of Defense (DOD) collaborates with multiple agencies, one of which is the National Aeronautics and Space Administration (NASA). As these agencies continue to come together to deliver on missions, program and project managers will be challenged to work across organizational boundaries. To better understand program management boundaries, this Capstone Applied Project (CAP) compares and contrasts the core program and project management guidance and policies between DOD and NASA.

There is an abundance of literature on the topic of program and project management. An internet search for program or project management produces many results. Topics include, but are not limited to, definitions, principles, frameworks, relationships between program and project management, tools, certification, leadership, and skills.

At the core of this literature is defining programs and projects. The seventh edition of *A Guide to the Project Management Body of Knowledge* (PMBOK) provides the following definitions:

> **Program.** Related projects, subsidiary programs, and program activities that are managed in a coordinated manner to obtain benefits not available from managing them individually …

> **Project.** A temporary endeavor undertaken to create a unique product, service, or result. The temporary nature of projects indicates a beginning and an end to the project work or a phase of the project work. Projects can stand alone or be part of a program or portfolio. (2021, p. 4)

To effectively manage programs or projects, program and project managers leverage three finite resources—time, cost, and scope—to deliver quality products (Villanova University [VU], 2021). This model is called the Iron Triangle as depicted in Figure 1. This established model emphasizes the interdependencies of schedule, budget, and scope with quality as an overarching influencer. According to VU (2021), "effective project managers must balance the ebb and flow of trade-offs within these constraints in order to achieve success" (para. 2). For example, if scope increases, budget and/or schedule will shift. If the budget goes down, schedule and scope are impacted. If schedule adjusts, cost and scope adjust as well. Changes to scope, budget, or schedule influence quality. Project managers are at the heart of balancing this ebb and flow to meet performance metrics and efficiently execute their projects.

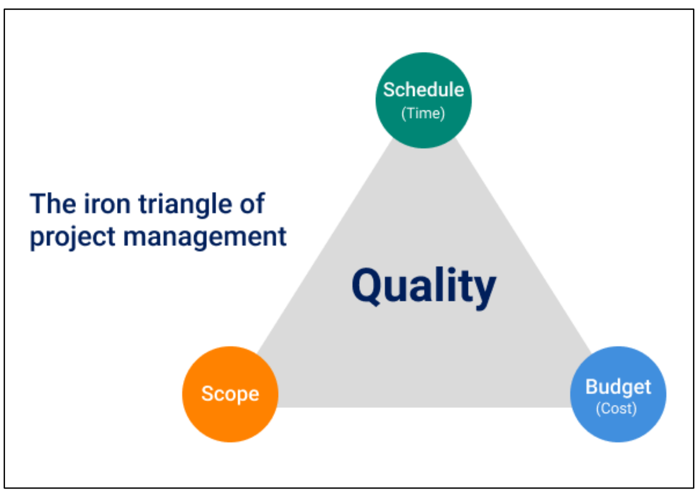

Figure 1. Iron Triangle. Source: VU (2021).

Well-executed programs and projects are key to meeting business objectives, satisfying stakeholder expectations, delivering the right products at the right time, responding to programmatic and technical risk, optimizing shared resources, and managing interdependencies. Program Management Institute (2017) states that poorly managed projects or the absence of project management may result in schedule delays, cost overruns, substandard quality, expensive rework, scope creep, and loss of future work (p. 10).

The Government Accountability Office (GAO) regularly assesses how well programs and projects meet cost objectives, schedule, and performance requirements. Year after year, GAO continues to report excessive cost overruns, unruly schedule delays, and failure to meet minimum performance criteria.

For the past 19 years, GAO assessed Department of Defense (DOD) programs. The **GAO's 2021 DOD** assessment took place while the DOD was in the midst of restructuring its program management (McDonough et al., 2021). Despite that, the report found the following for DOD's major defense acquisition programs (MDAPs):

> Excluding [the F35 program], quantity changes and other factors such as schedule delays contributed to one-year portfolio cost growth. Sixteen MDAPs also showed schedule delays since GAO's 2020 report. Such delays are due, in part, to delivery or test delays and poor system performance. (McDonough et al., 2021, Highlights)

The previous year, GAO identified a similar cost growth. **GAO's 2020 DOD** assessment reported:

> MDAPs have accumulated over $628 billion (or 54 percent) in total cost growth since program start, most of which is unrelated to the increase in quantities purchased. Additionally, over the same time period, time required to deliver initial capabilities has increased by 30 percent, resulting in an average delay of more than 2 years. (Durbin et al., 2020, Highlights)

GAO assessed the National Aeronautics and Space Administration's (NASA) major programs for the last 14 years. **GAO's 2022 NASA** report continues to show trends of cost and schedule overruns for their portfolio and major projects (Russel et al., 2022). Figure 2 provides historical data for cost and schedule overruns.

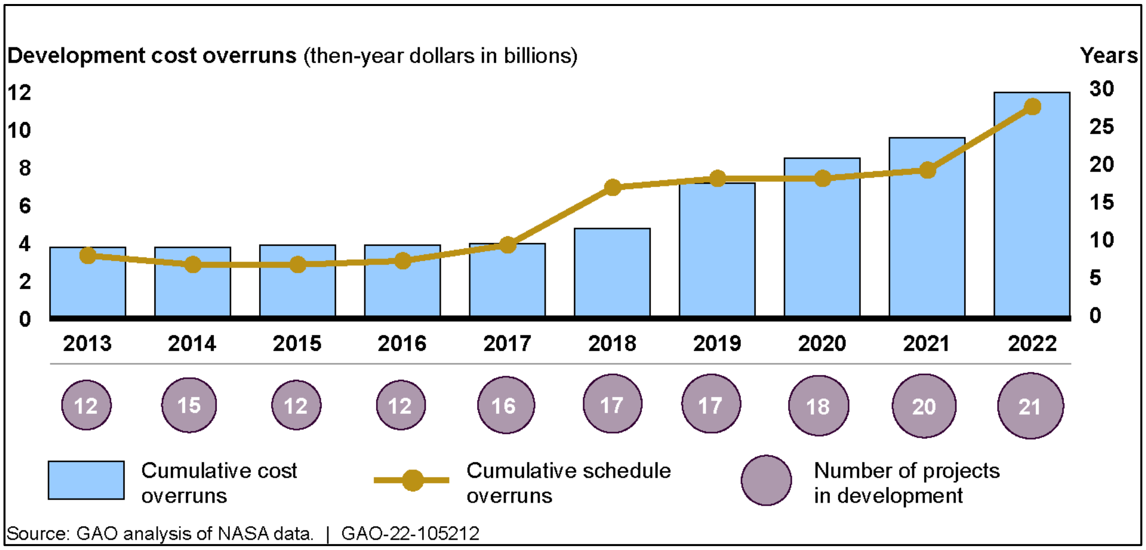

Figure 2. Cumulative Cost and Schedule Overruns for NASA's Major Projects in Development. Source: Russel et al. (2022).

GAO's 2022 NASA report highlights the following:

> Of the 21 major projects in the development phase of NASA's acquisition process (which includes building and launching the system), 15 were responsible for cumulative cost overruns of about $12 billion and cumulative schedule delays of 28 years. But just three projects—the James Webb Space Telescope, Space Launch System, and Orion—are responsible for more than three-quarters of the cost growth and almost half of the delays. (Russel et al., 2022, Highlights)

GAO's 2021 NASA report highlights the same cost and schedule overruns attributing cost overrun to two of the same programs.

> This marks the fifth year in a row that cumulative cost and schedule performance deteriorated. The cumulative cost growth is currently $9.6 billion, driven by nine projects; however, $7.1 billion of this cost growth stems from two projects—the James Webb Space Telescope and the Space Launch System. (Russell et al., 2021, Highlights)

Program and project managers are assessed based on how well they balance the three legs of the iron triangle. Based on recent GAO reports, both DOD and NASA continue to experience cost and schedule overruns. The foundational level guidance used by program and project managers at DOD and NASA sets the stage for their management approach. This may influence their success or failure which is why this CAP compares guidance between the two agencies.

A. RESEARCH QUESTIONS

The primary research question is, "What are the fundamental similarities and differences between the program and project management guidance of DOD and NASA?" The secondary research question is, "Are there strengths and weaknesses in either DOD or NASA policies that can be leveraged as best practices?"

B. METHODOLOGY

This research project uses qualitative methods to compare and contrast DOD's and NASA's program management guidance. First, documents selected from DOD's 5000 Policies are compared with NASA's equivalent policies resulting in a list of similarities and differences. Next, these similarities and differences are assessed as strengths or weaknesses as compared with PMBOK's program management principles. Lastly, opportunities and threats are identified. This evaluation of strengths, weaknesses, opportunities, and threats is known as a SWOT analysis.

The project is organized as follows:

- Chapter I (Introduction) provides an overview.
- Chapter II (Background) focuses on the most basic foundational guidance: DOD's big-Acquisition (big-A), which has stayed constant over time. NASA does not have an equivalent, but several processes fulfill the same roles. Next, it introduces the little-a and the recent DOD program guidance changes. Lastly, it introduces NASA's equivalent.
- Chapter III (Literature Review) first summarizes program management resources for DOD and NASA to provide an appreciation of the amount of information available. Next, it identifies other research that compares DOD program management practices to other entities, primarily that of other countries.

- Chapter IV (Analysis) focuses on DOD's little-a with NASA's program and project management guidance. Initially, the analysis compares selected DOD Directives (DODD) to the NASA Policy Directives (NPD) and DOD Instructions (DODI) to NASA Procedural Requirements (NPR), with particular attention to overarching program/project policies and information technology (IT) guidance. This produces a record of similarities and differences between DOD and NASA policies, which answers the primary research question.

  Next, these similarities and differences are assessed to determine possible best practices: the secondary research question. This investigation leverages the strengths, weaknesses, opportunities, and threats (SWOT) analysis in a two-step process. First, similarities and differences are evaluated against twelve program management principles identified in the *Project Management Body of Knowledge* (PMBOK) to determine strengths and weaknesses. These strengths and weaknesses inform opportunities and threats.

- Chapter V (Conclusion) summarizes the analysis, which includes similarities and differences as well as the results from the SWOT. The analysis shows that there are more similarities than differences between DOD and NASA policies. The SWOT analysis shows unique strengths and differences for DOD and NASA, which are then used to develop recommendations for each agency. The chapter ends with suggestions for future research opportunities that can be leveraged from this project.

II. BACKGROUND

This chapter summarizes the foundational program management policies for both DOD and NASA. For DOD, it discusses the defense acquisition framework starting with the big-A, then delving into the little-a. Moran (2008) states "The term big-A usually refers to this larger framework of three interconnected and interlinked acquisition systems" (p. 177). The three systems are requirements, resources, and management. The little-a refers to the management system guidance. NASA does not have a big-A or little-a structure, but their policies map well to DOD's acquisition framework.

Since this CAP compares and contrasts DOD and NASA program management policies, the background summarizes the DOD acquisition framework and NASA's equivalent. The analysis chapter identifies similarities and differences.

A. DOD GUIDANCE

The big-A governs DOD's acquisition process. The term acquisition in the big-A encompasses a greater scope than simply the purchase of an end item or service. It is a cradle-to-grave process including design, engineering, construction, testing, deployment, sustainment, and close-out. The big-A is comprised of three decision support systems: 1) the Joint Capabilities Integration and Development System (JCIDS); 2) Programming, Planning, Budgeting, and Execution (PPBE); and 3) Defense Acquisition System (DAS) or little-a, which is shown in Figure 3 (Moran, 2008, p. 177).

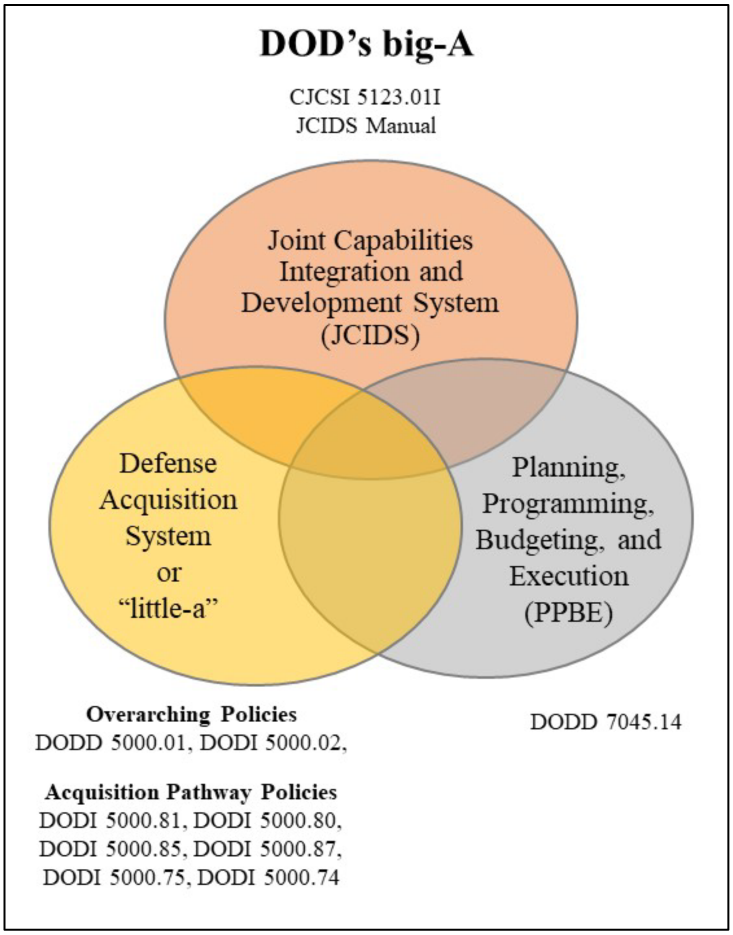

Figure 3. DOD's big-A. Adapted from Moran (2008).

JCIDS is the requirements system established in June 2003 (Defense Acquisition University [DAU], n.d.d.). Its predecessor, Requirements Generation System, was in effect since 1991 (DAU, n.d.d.). JCIDS guidance is a 399-page manual that "provides the baseline for documentation, review, and validation of capability requirements across the Department" (DAU, n.d.e., para. 1). It is the primary means for the Joint Requirements Oversight Council to 1) assess joint military capabilities, and 2) identify, approve, and prioritize gaps in these capabilities. JCIDS is a capability-based process (DAU, n.d.d.). JCIDS interacts with the other three support systems by guiding the little-a and informing PPBE (DAU, n.d.d.).

The PPBE process is DOD's process to plan, allocate, and execute resources (DAU, n.d.e.). It is a calendar-driven process with an external delivery of the annual President's

Budget Request to Congress submitted the first Monday in February (DAU, n.d.e.). Of the three systems, PPBE guidance is a short 13-page document that provides high level guidance.

DAU (n.d.e.) explains how and why the Planning, Programming, and Budgeting System (PPBS) evolved to add execution, becoming the PPBE process we know today.

> PPBE evolved from the Planning, Programming, and Budgeting System (PPBS), which was introduced into DOD in the early 1960s by Robert McNamara during his tenure as Secretary of Defense (SECDEF). PPBS was a cyclic process consisting of three distinct, but interrelated, phases: planning, programming, and budgeting. PPBS established the framework and provided the mechanisms for decision making for the future and provided the opportunity to annually re-examine prior decisions in light of the existing environment at that particular time (e.g., evolving threat, changing economic conditions, etc.) …
>
> Then in May of 2003, more substantive changes were made to PPBS. Among other changes, PPBS was renamed the Planning, Programming, Budgeting, and Execution (PPBE) process. Adding "Execution" to the process was intended to give greater emphasis to the need to better manage the execution of the budget authority provided by Congress by the appropriations acts. This "execution" was to be more than simply ensuring obligation of the budget authority in a timely manner; it was to include an analysis of the comparison between what DOD said it would do with its appropriations and what it actually accomplished (i.e., outcomes achieved). (DAU, n.d.e.)

The Defense Acquisition System (DAS) (DODD 5000.01, 2022b) is the overarching directive describing the principles and policies for all DOD acquisitions. This includes, but is not limited to, weapon systems, automated information systems, services, and business systems. *Operation of the Adaptive Acquisition Framework* (AAF) (DODI 5000.02, 2022a) outlines six acquisition pathways.

In September 2020, DODD 5000.01 and DODI 5000.02 were revamped. DOD's press release states it represents "one of the most transformational changes to acquisition policy in decades, the DODD 5000.01 re-write was part of a comprehensive redesign of the DOD 5000 Series acquisition policies, which were streamlined and modernized to empower program managers, facilitate flexibility and enhance our ability to deliver capability at the speed of relevance" (Department of Defense [DOD], 2020b, para. 2). Summarized below is the current guidance and a comparison to its predecessor.

The 2020 update to DODD 5000.01 established twenty-five overarching principles, which will be referred to by name in the pages to follow:

a) Deliver Performance at the Speed of Relevance …
b) Conduct System of Systems (SoS) Analysis …
c) Develop a Culture of Innovation …
d) Develop and Deliver Secure Capabilities …
e) Emphasize Competition …
f) Be Responsive …
g) Employ a Disciplined Approach …
h) Manage Efficiently and Effectively …
i) Focus on Affordability …
j) Emphasize Environment, Safety, and Occupational Health (ESOH) and Requirements Management …
k) Employ Performance Based-Acquisition Strategies …
l) Plan for Product Support …
m) Implement Effective Life-Cycle Management …
n) Implement Reliability and Maintainability by Design …
o) Conduct Integrated Test and Evaluation …
p) Apply Human Systems Integration …
q) Deploy Interoperable Systems …
r) Plan for Corrosion Prevention and Mitigation …
s) Employ Artificial Intelligence, Machine Learning, Deep Learning, and Other Related Capabilities throughout Execution of the Acquisition Process …
t) Plan for Coalition Partners …
u) Maintain a Professional Workforce …
v) Comply with Statute and International Agreements …
w) Maintain Data Transparency …
x) Manage Records Effectively …
y) Employ a Collaborative Process. (DOD, 2022b, pp. 4–9)

The preceding DODD 5000.01 (2003) was a concise, four-page document emphasizing five policies: flexibility, responsiveness, innovation, discipline, and streamlined and effective management. Enclosure 1 to DODD 5000.01 (2003) identified 29 additional policies such as collaborations, competition, cost and affordability, test and evaluation, interoperability, information assurance, performance based decisions, legal compliance, professional workforce, total system approach, and safety, to mention a few.

Some core policies are the same between the two versions. Direct alignments include responsiveness, developing a culture of innovation, implementing a disciplined approach, and managing effectively. Other similarities included competition, safety, and maintenance of a professional workforce. There are various changes or a greater emphasis on policies in the 2020 version of DODD 5000.01 (Johnson, 2020). This includes empowering program managers; simplifying the acquisition process; actively managing (rather than avoiding) risk; managing capabilities withing funding constraints; planning for sustainment throughout the program or project life-cycle; maintaining data transparency; employing artificial intelligence, machine learning, and deep learning; conducting system of system analysis; and placing more emphasis on affordability versus cost (Johnson, 2020).

Operation of the Adaptive Acquisition Framework (AAF) (DODI 5000.02, 2022a) is an event-based process, referred to as little-a. During the life-cycle of a project, there are reviews to pass and milestones to complete in order to proceed through various phases from the beginning to the end. DODI 5000.02 (2022a) identifies six acquisition pathways as shown in Figure 4.

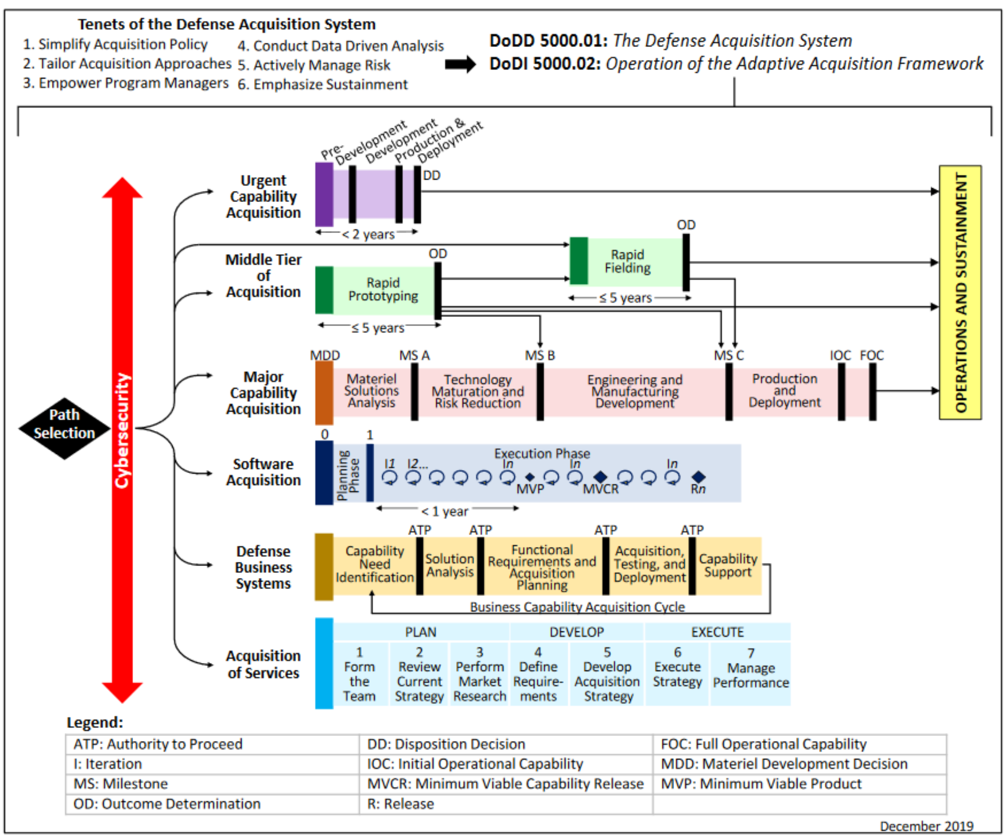

Figure 4. AAF Pathways. Source: DOD (2022a).

DODI 5000.02 (2022a) defines each acquisition pathway as summarized below:

- **Urgent Capability Acquisition** is "To field capabilities to fulfill urgent existing or emerging operational needs or quick reactions in less than 2 years" (p. 12). "The estimated cost of any single solution must not exceed $525 million in research, development, and test and evaluation; or $3.065 billion procurement" (p. 12). Further details can be found in DODI 5000.81.
- **Middle Tier of Acquisition (MTA)** is "To rapidly develop fieldable prototypes within an acquisition program to demonstrate new capabilities or rapidly field production quantities of systems with proven technologies that require minimal development" (p. 13). "The objective of rapid prototyping is to field a prototype meeting defined requirements that can be demonstrated in an operational environment and provide for residual operational capability within 5 years of the MTA program start date" (p. 13). Further details can be found in DODI 5000.80.
- **Major Capability Acquisition** is "To acquire and modernize military unique programs that provide enduring capability" (p. 13). "This process is designed to support MDAPs, major systems, and other complex acquisitions" (p. 14). Further details can be found in DODI 5000.85.
- **Software Acquisition** is "To facilitate rapid and iterative delivery of software capability (e.g., software-intensive systems or software-intensive components or sub-systems) to the user" (p. 14). Further details can be found in DODI 5000.87.
- **Defense Business Systems** is "To acquire information systems that support DOD business operations" (p. 15). This pathway is used for business systems such as finance, contracts, logistics, budgeting, and human resources. It may also be used for "non-developmental, software intensive programs that are not business systems" (p. 15). Further details can be found in DODI 5000.75.
- **Acquisition of Services** is "To acquire services from the private sector including knowledge-based, construction, electronics and communications, equipment, facilities, product support, logistics, medical, research and development, and transportation services" (p. 16). Further details can be found in DODI 5000.74.

DODI 5000.02 (2022a) stresses the importance of choosing the appropriate pathway and tailoring the pathway to best suit the program. When selecting an acquisition pathway, program managers "may leverage a combination of acquisition pathways to provide value not otherwise available through use of a single pathway" (p. 10).

Its predecessor, *Operation of the Defense Acquisition System* DODI 5000.02 (2013), focused on Major Capability Acquisitions but also highlighted various models such as hardware, defense unique software, incrementally deployed software, accelerated, and hybrid programs.

B. NASA GUIDANCE

NASA guidance relies on NASA Policy Directives (NPD) and NASA Procedural Requirements (NPR). NASA does not have a big-A equivalent, but its NPDs and NPRs fill similar roles shown in Figure 5. Each NPD and NPR has a specific expiration date.

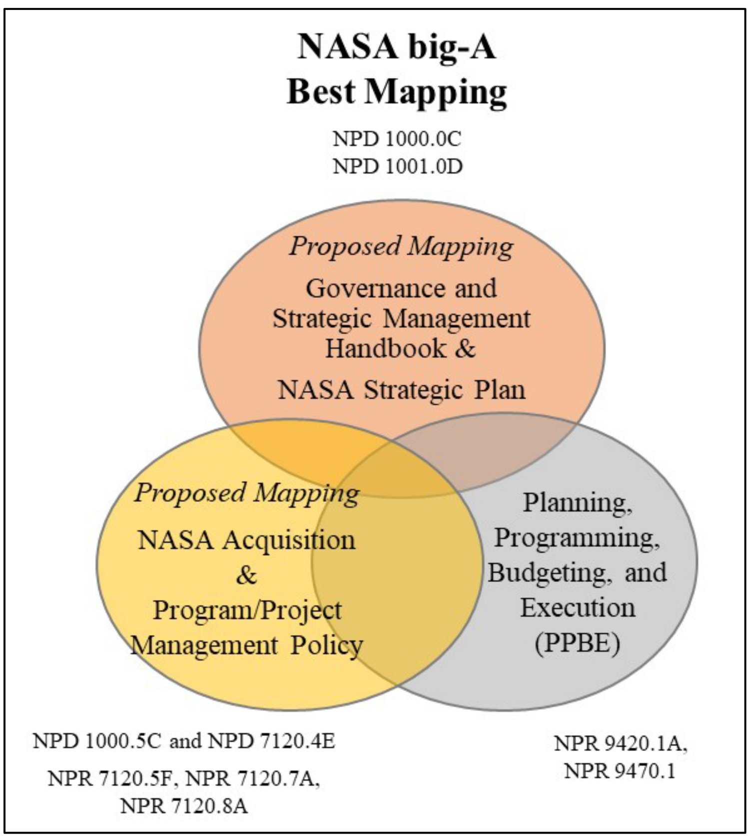

Figure 5. NASA big-A Best Mapping. Adapted from NASA (n.d.).

Although NASA does not have a specific JCIDS process, two directives provide similar information. *NASA Governance and Strategic Management Handbook* (NPD 1000.0C, 2020a) "sets forth NASA's governance framework—principles and structures through which the Agency manages mission, roles, and responsibilities—and describes NASA's Strategic Management System—processes by which the Agency manages strategy and its implementation through planning, performance, and results" (p. 4). *NASA Strategic Plan* (NPD 1001.0D, 2022) identifies a vision, mission statement, core values, strategic goals and objectives, and the overarching approach. It is updated every four years in accordance with the Government Performance and Results Act Modernization Act of 2010. Compared with the JCIDS process, which is a capability-based process, NASA requirements align with six strategic goals identified in the *NASA Strategic Plan*. The goals are revisited at least every four years and more often if needed, to adjust for changes in national priorities and Congressional guidance.

As in the DOD, NASA's PPBE process is calendar-driven with the same major output being the annual President's Budget submission to Congress the first Monday in February. Two NPRs address the PPBE cycle. *Budget Formulation* (NPR 9420.1A, 2016) focuses on the first three phases of PPBE: planning, programming, and budgeting. *Budget Execution* (NPR 9470.1, 2008) addresses the last phase. NPR 9420.1A "provides requirements and a general overview on how to develop, refine, justify, and submit NASA's annual request for direct budget authority to be appropriated by Congress" (National Aeronautics and Space Administration [NASA], 2016, p. 4). It includes information on establishing NASA budget estimates in the President's Budget Request and an overview of how the Agency monitors the Congressional appropriations process. NPR 9470.1 specifically addresses budget execution. NPR 9470.1 provides "the process for which financial resources made available to the Agency are directed and controlled toward achieving the purposes and objectives for which the budget was approved" (NASA, 2008, p. 4). This includes processes and responsibilities for operating plan submissions; funds distribution; commitment, obligation, and expenditure cycles; and anti-deficiency compliance. It also mentions reporting requirements such as the Performance Accountability Report. This report is a government requirement from GPRA and similar to DOD. NASA relies on *External Reports – Budget* (NPR 9311.1) to provide guidance for reporting requirements.

NASA does not define a DAS or AAF structure; however, there is a hierarchy of NPDs and NPRs that serve the same purpose of providing program managers with policies to acquire end items. DODD 5000.01 states that "the acquisition system will be designed to acquire products and services that satisfy user needs with measurable and timely improvements to mission capability, material readiness, and operational support, at a fair and reasonable price" (DOD, 2022b, p. 4). For NASA, the focus is on research, technology, and satellites with the same objective: delivering products and services in a timely manner at a fair and reasonable price. Given NASA's mission of human space flight, safety is a key factor.

Most similar to DODD 5000.01 is the *Policy for NASA Acquisit*ion (NPD 1000.5C) which provides the overall policy framework for NASA's strategic acquisition process including roles and responsibilities. NPD 1000.5C is a short 11-page document that identifies the fifteen policies, which will be referred to by name in the pages to follow:

1. Have a strategic acquisition process that complies with (a) All applicable laws and regulations. (b) Applicable Agency and Center directives, requirements, procedures, and processes. (c) The Agency's core values …
2. Execute the strategic acquisition process through a disciplined strategic management system …
3. Have checks and balances built into the strategic acquisition process …
4. Ensure that personnel involved in the strategic acquisition process have the appropriate skills, competencies, and certifications …
5. Ensure that organizations, having a substantive interest in the acquisition strategy, are effectively engaged into the strategic acquisition process …
6. Ensure acquisitions have realistic cost estimates and achievable schedules …
7. Ensure when acquisition decisions are made, execution phases have consistent acquisition commitments to assure overall alignment of Agency resources with cost estimates by fiscal year and applicable Federal budget account projections …
8. Ensure organizations meet programmatic, institutional, technical, cost, and schedule commitments to fulfill the NASA acquisition strategy …
9. Incorporate a risk-informed decision-making process …

10. Consider, when developing an acquisition strategy, the full spectrum of acquisition approaches to advance the Agency's mission and objectives, taking into consideration best value, appropriate competition, supply chain, and the Agency's policies, principles, and guidance related to its core capabilities …
11. Ensure that execution of the acquisition strategy respects and appropriately maintains the relationship between NASA and its suppliers or partners …
12. Promote competition and small business participation …
13. Require disclosure of financial interests from those persons participating in the strategic acquisition process, and avoid personal conflicts of interest …
14. Ensure that organizational conflicts of interest are identified and resolved as early as possible in the strategic acquisition process …
15. Require robust and formal documentation of NASA Acquisition Plans. (NASA, 2020c, pp. 2–3)

Although there is significant crossover between DOD and NASA, NASA policies seem to address a different level than DOD acquisition policy documents.

Most similar to DODI 5000.02 is *NASA Engineering and Program/Project Management Policy* (NPD 7120.4E) which "provides the statement of policy, principles, and responsibilities for program and project management and system and software engineering disciplines" (NASA, 2017, p. 1), Similar to DODI 5000.02, the program/ project management process is events-driven. NPD 7120.E states that

> Programs and projects are managed based on a phased life cycle with key decision points (KDPs) where a program or projects status and readiness to proceed to the next phase are determined. This determination is supported by reviews through the life cycle and at KDPs and documented in evolving principal documents that govern the conduct of each phase and by the logical progression of four overarching processes: formulation, approval, implementation, and evaluation. (NASA, 2017, p. 1)

NASA systems engineering process identifies entrance and exit criteria for each life-cycle review to be tailored specific for each program.

NASA has consistently had three product-driven NPRs, as compared with DOD's six acquisition pathways.

- ***NASA Space Flight Program and Project Management Requirements* (NPR 7120.5F)** establishes the policy for

> all NASA space flight programs and projects including spacecraft, launch vehicles, instruments developed for space flight programs and projects, some research and technology (R&T) developments funded by and to be incorporated into space flight or aeronautics programs and projects, technical facilities specifically developed or significantly modified for space flight systems, Information Technology (IT) acquired as a part of space flight programs and projects, and ground systems that are in direct support of space flight operations (NASA, 2021, p. 4).

- ***NASA Information Technology Program and Project Management Requirements*** **(NPR 7120.7A)** defines IT and exceptions below.

> IT projects do not include IT incorporated within space flight, space technology, or aeronautics research projects. IT incorporated within space technology projects are governed by NPR 7120.5, NASA Space Flight Program and Project Management Requirements. IT incorporated within space flight research projects and aeronautics research projects are governed by NPR 7120.8, NASA Research and Technology Program and Project Management Requirements. (NASA, 2020d, p. 3)

- ***NASA Research and Technology Program and Project Management Requirements*** **(NPR 7120.8A)** establishes policy to

> formulate and implement Research and Technology (R&T) … including but not limited to, scientific research, aeronautics research, and technology developed for space activities. Due to the wide range of activities, this NPR does not standardize their development into a single process, but rather provides a minimum management requirement set for R&T programs and projects that is tailorable to suit their type and complexity (NASA, 2018, p. 7).

Unlike DOD, NASA NPRs only address product lines. NASA does not have unique NPRs for time sensitive programs like *Urgent Capability Acquisition* (DODI 5000.81) that provide capabilities in two years or like *Middle Tier of Acquisition* (DODI 5000.80) that field a prototype and provide operational capability within five years. NASA NPRs do not address support functions such as business systems and services acquisitions. Although NASA does not refer to these three NPRs as acquisition pathways, the pages to follow will refer to these three NPRs as acquisition pathways or simply pathways.

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III. LITERATURE REVIEW

This literature review starts with a discussion of resources available to program managers for both DOD and NASA. Program managers have a wide range of online resources including websites, handbooks, and articles. Before analyzing and comparing the foundations of DOD and NASA program management processes, this chapter delves into these resources to provide an appreciation of how much information is out there.

Next, this chapter identifies other analyses that compare DOD program practices to that of other entities. Comparisons between DOD and NASA have been relatively understudied; however, there are comparisons of DOD to other countries' defense agencies.

A. PROGRAM MANAGEMENT RESOURCES

Program management resources for both DOD and NASA are widely available. From website resources to handbooks to published articles, one can find an abundance of resources. These resources provide processes, policies, and structure for program managers. Resources for DOD and NASA are independent of one another. Before probing into how they are similar and different, it is important to understand the breadth of available guidance for DOD and NASA.

1. DOD

DOD has an immense resource for program managers within the Defense Acquisition University (DAU). Karnes (2020) notes that DAU was established in response to the Defense Acquisition Workforce Improvement Act (DAWIA) of 1990 (p. 2). It is the main source of training for defense acquisition professionals. In addition to formal courses in-person and online, the website also provides news, blogs, workshops, seminars, certification standards, and job aids. There is a separate module for AAF summarized below.

The AAF homepage shows the six acquisition pathways (DAU, n.d.b.). As you scroll down, you can access the 5000 policies, guidebooks for business practices, and guidance for tailoring. The 5000 policies include more than the DODD 5000.01, DODI 5000.02, and AAF, as described in the next paragraph. At the forefront is a key message of tailoring with a link to help select a pathway or multiple pathways. It provides summaries for each pathway, time considerations, and examples of programs that have utilized multiple pathways.

The 5000 policies include the overarching policies, acquisition pathways, fundamental policies, and service and agency acquisition policies as presented in Figure 6 (DAU, n.d.a.). The overarching policies include the big-A, little-a, and DOD's Financial Management Regulations. Functional policies provide information for various activities that crosscut acquisition pathways. Service and agency acquisition policies provide specific information for branches of the military.

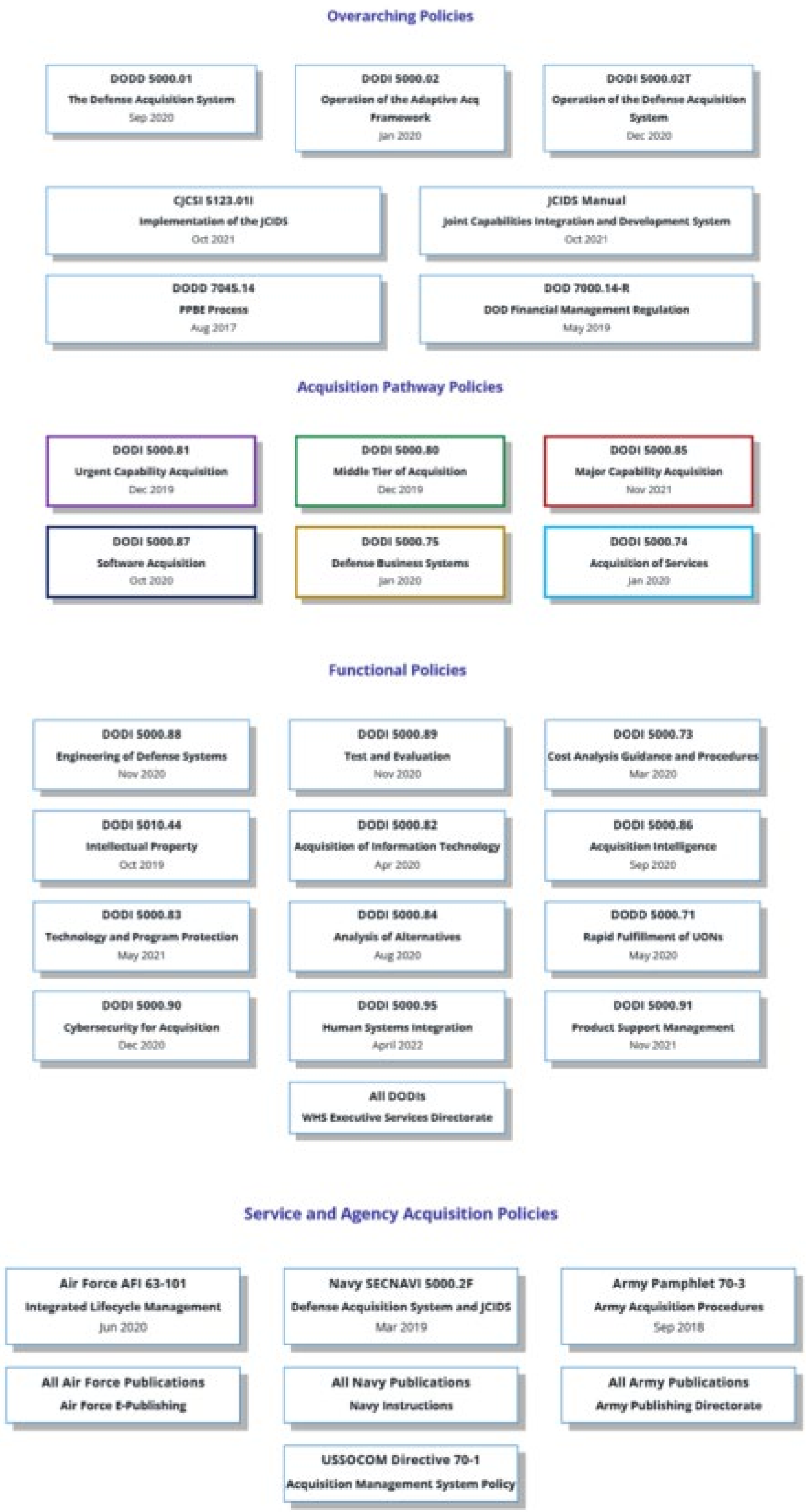

Figure 6. DOD Policies. Source: DAU (n.d.a.).

Each pathway has a dedicated link that provides a deep dive into relevant information (DAU, n.d.b.). These are topics that are uniquely important for that pathway. Tables 1 and 2 provide a comprehensive list of deep dive topics for each pathway.

Table 1. Acquisition Pathway Information for Urgent Capability Acquisition, Middle Tier of Acquisition, and Major Capability Acquisition. Source: (DAU, n.d.b.).

Urgent Capability Acquisition	Middle Tier of Acquisition (MTA)	Major Capability Acquisition	
Policies & Guidance	**MTA Pathway**	**Activities Across Phases**	**Milestone B**
Responsibilities	Overview & Benefits	Technical Reviews	EMD PHASE
Types of Urgent Operational Needs (UONs)	Statutes & Policy	Develop Strategies	Development Contracts
Pre-Development	Responsibilities	Program Management	Complete System Design
Development Milestone	Resources	Cost Estimation/Affordability	Develop System
Development	FAQs & Definitions		Developmental Testing
Production & Development Milestone	MTA Tips	**MDD**	
Production and Deployment	**Enter Program Data**	MSA PHASE	**Milestone C**
Operations and Support	------------------------------	Develop Requirements	P&D PHASE
Disposition Decision	Rapid Prototyping Path	Analysis of Alternatives	Production Contracts
Costs and Funding	Rapid Fielding Path	Study Contracts	Low Rate Initial Production
Contracting			Operational Testing
Test & Evaluation		**Milestone A**	FRP Decision
		TMRR PHASE	Full Rate Production/Deployment
Best Practices		Mature Requirements	O&S PHASE
Scenarios and Interviews		Prototype Contracts	Sustainment Contracts
Templates		Prototyping	Sustain System
Resources		Develop Preliminary Design	
Points of Contact		CDD Validation	**IOC/FOC**
Glossary		Dev RFP Release Decision	Acquisition Categories (ACATs)
Frequently Asked Questions (FAQ)			Glossary

Table 2. Acquisition Pathway Information for Software Acquisition, Defense Business Systems, and Acquisition of Services. Adapted from DAU (n.d.b.).

Software Acquisition	Defense Business Systems	Acquisition of Services
Phases	Overview	**Contracted Services**
Planning Phase	Business System Categories (BCATs)	Policy
Execution Phase	Requirements & Acquisition Roles	Category Management
	Resources	Procedures
Activities	------------------------------	IT Services
Define Capability Needs	Capability Need ID Phase	FAQs & Resources
Develop Strategies	Solution Analysis ATP	Responsibilities
Cost Estimation	Solution Analysis Phase	
Engage Users, Assess Value	Functional Requirements ATP	**Seven-step Process**
MVP, MVCR, Deployment	Functional Req and Acq Planning Phase	**Planning Phase**
Architecture, Interoperability	Acquisition ATP	Step 1: Form the Team
Cybersecurity	Acq, Test, and Deployment Phase	Step 2: Current Strategy
Ent Services, DevSecOps	Deployment ATPs	Step 3: Market Research
Metrics and Reporting	Capability Support ATP	
DBS in SWP	Capability Support Phase	**Development Phase**
	------------------------------	Step 4: Reqts Definition
SWP Programs	CMO Certification	Step 5: Acquisition Strategy
SW In NDAAs	Contracting	
Glossary	Cost & Funding	**Execution Phase**
FAQs	Test & Evaluation	Step 6: Execute Strategy
	Documentation	Step 7: Performance Mgmt
	Capability Implementation Plan	
		Glossary

Another helpful job-aid is the Adaptive Acquisition Framework Document Identification (AAFDID) (DAU, n.d.c.). Customized for a specific pathway, AAFDID provides an overview of required documents throughout the life-cycle of a program acting like a checklist for program managers to ensure requirements are met. It is available for all pathways, except Acquisition of Services that is coming soon. Table 3 summarizes requirements for the five available pathways.

Table 3. AAFDID for Five Acquisition Pathways. Adapted from DAU (n.d.c.)

Urgent Capability Acquisition	Middle Tier of Acquisition (MTA)	Major Capability Acquisition	Software Acquisition	Defense Business Systems
Overview	Overview	Overview	Overview	Overview
Statutory/Regulatory Requirements	Submission of Deliverables and Timeline	Milestones and Phase Information Requirements	Application and Embedded Software Information Requirements	Statutory Requirements
	Statutory/Regulatory Requirements	Recurring Program Reports	Clinger-Cohen Act Requirements	
		Exceptions, Waivers, and Alternative		
		Acquisition Program Baseline		
		Statutory Program Breach Definition		
		Cost Data Reporting Requirements		
		EVMS Application Requirements		
		EVMS Reporting Requirements		
		CCA Compliance		

2. NASA

NASA does not have a site like DAU; however, there are many resources available to program managers. The first is the NASA Online Directives Information System (NODIS) Library which can be accessed at https://nodis3.gsfc.nasa.gov/main_lib.cfm (National Aeronautics and Space Administration [NASA], n.d.) The most relevant to this research project is the NASA-wide Directives, which has all NASA NPDs and NPRs. These are broken down by function as displayed in Figure 7.

Figure 7. NODIS Library. Source: NASA (n.d.).

NASA does not have a DAU resource that deep dives various acquisition pathways; however, similar information is part of each of the NPRs. For Space Flight Programs and Projects and Information Technology Programs and Project, the NPR provides a list of required documents and maturity level at each life-cycle phase. For Research and Technology Programs and Projects, the NPR includes a table of requirements, but it is not time-phased.

Another excellent resource for program managers is part of the NASA Office of the Chief Engineer website at https://www.nasa.gov/oce. It provides links to other NASA standards, handbooks, courses, and lessons learned. The lessons learned are part of a public database on various topics, including program management. There is a separate section for program management, which provides a link to NASA Engineering Network Communities of Practice. However, this is a NASA internal site.

With all of this easily accessible information, narrowing down what to compare is critical. This research project focuses on the little-a overarching policies and acquisition pathways because they are the foundational building blocks for a program manager.

B. OTHER COMPARISONS

There are few, if any, published comparative analyses of acquisition pathways within DOD and NASA. There are publications that assess DOD and NASA individually. Examples of these are the GAO program assessments for programs and projects in Chapter 1. Several works compare DOD program management aspects to other countries such as China, Taiwan, United Kingdom (U.K.), Germany, France, Australia, Japan, South Korea, and Singapore.

Liu (2021) compared the naval acquisition process between the United States (U.S.) and Taiwan. In the background, he compared DOD's big-A (requirements, resources, and acquisition) to Taiwan's system. The U.S. uses JCIDS to identify requirements by assessing capability requirements and capability gaps. Liu noted that "Taiwan does not have an independent system to govern the requirement identification process" (p. 24). Furthermore, requirements were captured during the design phase of a program (p. 10). The resource allocation processes were similar as Taiwan based their system on what the U.S. used at that time, which was Program, Planning, and Budget System (Liu, 2021, p. 14). The acquisition path is notably different. AAF has six pathways, while Taiwan only includes two different types of acquisition (Liu, 2021, p. 15). Overall, Liu asserted the U.S. process is more complete, detailed, and clearly stated (p. 25).

Liu (2021) then compared real-life shipbuilding acquisition programs using the U.S. Littoral Combat Ship (LCS) Program and Taiwan's Tuo Chiang-Class Corvette. Liu pointed out the LCS was not developed through the typical JCIDS process, rather the requirements were directed by U.S. Navy leaders (p. 33). From a resource standpoint, the LCS costs grew over time (Liu, 2021. p. 35). He noted that the program adopted a more experimental acquisition approach (p. 44). The U.S. Navy's original plan was to design two ships, build four prototype ships, and down-select after testing (Liu, 2021, p. 45). The program suffered from delayed delivery of capabilities and reduction of production amounts. The LCS program was eventually canceled.

For the Tuo Chiang-Class Corvettes, the requirements process was not structured, and requirements documents were classified therefore difficult to compare (Liu, 2021, p. 40). The program also experienced cost growth over time (Liu, 2021, p. 41). Conversely, the acquisition approach was more conventional, starting with a feasibility analysis, concept study, prototype, and production (Liu, 2021, p. 49). This program is in the middle of the acquisition process. Liu concluded the different acquisitions contributed to programs' progress, rather than the countries' system (requirements, resources, acquisition) (p. 44).

Lorge (2018) conducted research comparing the efficiency of naval acquisitions in the U.S. and in China. In the background, he compared the big-A (requirements, resources, and acquisition) to China's process (p. 20–21). With respect to requirements generation, the U.S. is capabilities-based while China is threat-based. DOD uses JCIDS to develop capabilities to meet the goals of the National Security Strategy. China focuses on identifying threats to meet its national security goals. Lorge (2018) continued stating that the resource allocation processes for both countries are structured and involve interaction between military and civilian leadership; however, the U.S. is far more formal. Lastly, Lorge (2018) provided the acquisition life-cycle for both countries. The U.S. life-cycle has five phases: 1) material solution analysis, 2) technology maturation and risk reduction, 3) engineering and manufacturing development, 4) production and deployment, and 5) operations and support. China has seven phases: 1) pre-research, 2) validation, 3) planning, 4) engineering and research and development, 5) product finalization, 6) employment, and 7) retirement.

Lorge (2018) then established a framework for analyzing shipbuilding acquisition efficiencies between the U.S. Navy and People's Liberation Army Navy (PLAN). His framework identified 10 efficiency factors based on quantitative and qualitative approaches to assess the U.S. Navy and PLAN. His assessment determined which country was more efficient in each factor, as discussed below.

27

1. **Cost.** This quantitative assessment was two-fold. First, Lorge calculated the shipbuilding budget as total number of battle force ships added to the country's fleet ratio from 2012–2016 (p 67). Second, he calculated the cost per ship for five comparable ship classes (large surface, small surface combatant, amphibious transport dock, nuclear-powered attack submarine, and aircraft carrier) (p. 67). Both amounts per battle force ship calculated for China was lower than the U.S. (p. 70).
2. **Schedule.** This quantitative assessment was based on the total battle force ships for the same five ship classes added to each country's fleet from 2012–2016 (p. 70). China added more battleships (p. 72).
3. **Performance.** This quantitative assessment compared top speed, crew complement, displacement, primary weapon, and primary sensor for five comparable ship classes (p. 73). The U.S. Navy scored higher in four of five ship classes (p. 74).
4. **Acquisition Workforce.** This qualitative assessment was based on the adequacy of training compared to job responsibilities and the level of bureaucracy and compartmentalization (p. 75). For the U.S. Navy, Lorge referred to the structured training of the DAU and the use of integrated product teams (p. 75). PLAN does not have structured training and product lines are stove-piped (p. 76). The U.S. Navy scored higher (p. 76).
5. **Contracting.** This qualitative assessment showed how well each country's contracting method held contractors responsible (p. 76). The U.S. Navy incentivizes contractors to meet targets by tying contractor profit to predetermined cost, schedule, and performance levels. Many PLAN contracts use a fixed 5% profit. The U.S. Navy scored higher (p. 77).
6. **Resource Allocation.** This quantitative assessment was based on how the country incorporated affordability into its budget decisions (p. 77). The U.S. Navy budget request to Congress includes affordability assessments.

Affordability was difficult to measure for PLAN because resources may come from multiple sources. The U.S. Navy scored higher (p. 78).

7. **Innovation.** This qualitatively assessed if the country has the technical expertise and technologies in-house to design and build all the elements for a complex system, in this case naval vessels (p. 78). The U.S. Navy does not rely on other countries; however, PLAN relies on foreign technology for elements such as electronics and propulsion. The U.S. Navy scored higher (p. 79).

8. **Industry Base.** This qualitative assessment determined whether the country has the ability to produce naval vessels, from both a capacity and a capability standpoint, to meet its military requirements (p. 79). Lorge concluded the U.S. industry base has the capability but not the capacity to meet its objectives. Conversely, China can meet the capacity but not the capability. The U.S. Navy and PLAN scored the same (p. 80).

9. **Requirements System.** The qualitative assessment focused on whether the finalized requirements document meets the strategic objective (p. 80). The U.S. Navy follows the JCIDS process which is translated to key performance parameters. Like the U.S., China requirements leverage long-range planning and strategic documents. They then go to a special committee dominated by the Chinese Communist Party that may introduce political aspects. For this reason, the U.S. Navy scores higher (p. 81).

10. **Operations and Sustainment (O&S) Costs.** This qualitative assessment is based on whether O&S costs are calculated into the total life-cycle cost of new naval vessels (p. 81). For the U.S. Navy, O&S costs are part of the total life-cycle of a program. Conversely, PLAN has different organizations responsible for research and development, procurement, and O&S. The U.S. Navy scored higher (p. 82).

Table 4 summarizes the efficiency factor, assessment method, and which country scored higher. Lorge (2018) concluded that the U.S. Navy was more efficient in the acquisition of naval battle force ships than China (p. 83).

Table 4. Summary of U.S. Navy and PLAN Efficiency Factors and Assessment: Adapted from Lorge (2018).

Efficiency Factor	Assessment Method	Scored Higher
1. Cost	Quantitative	China
2. Schedule	Quantitative	China
3. Performance	Quantitative	U.S.
4. Acquisition Workforce	Qualitative	U.S.
5. Contracting	Qualitative	U.S.
6. Resource Allocation	Qualitative	U.S.
7. Innovation	Qualitative	U.S.
8. Industrial Base	Qualitative	Same
9. Requirements System	Qualitative	U.S.
10. O&S Cost	Qualitative	U.S.

Lorge (2018) also referenced two books published by the Defense System Management College (DSMC) that compared DOD acquisitions to two sets of countries. The first book released by DSMC compared the U.S. to the U.K., Germany, and France (Kausal et al., 1999). The second book compared the U.S. to Australia, Japan, South Korea, and Singapore (Kausal & Markowski, 2000).

Both books have the same purpose, structure, and information. The difference between the books is which countries are compared. The first book focuses on European countries, while the second book selects three Asian countries plus Australia. The books begin with the countries' history, government structure and development, and military organization. Each also delves deep into topics such as the acquisition process, procurement systems, roles within organizations, and industry base. Although the books mention requirements, budgeting, and the program management processes, the comparison focuses on seven factors: value of money, level of arms exports, level of arms imports, level of collaboration, political environment, competitive environment, and acquisition structure.

Lorge summarized DSMC's comparison of the seven factors for both sets of countries. Table 5 compares the U.S. to the U.K., France, and Germany. Table 6 provides information for Australia, Japan, South Korea, and Singapore. (The United States is not repeated in this table.)

Table 5. Acquisition System of the U.S., U.K., France, and Germany. Source: Lorge (2018).

Factor	U.S.	U.K.	France	Germany
Definition of Value for Money	Primarily concerned with military capability. Also uses spending for socioeconomic goals.	Concerned with self-defense capability and ability to support collective defense.	Most likely to consider nondefense factors such as socio economic goals and exports.	Primarily concerned with self-defense and support of the local industrial base.
Level of Arms Exports	Largest in world but does not consider export value when developing weapon systems.	Significant amount but export value has limited influence on requirement development.	Very high levels, particularly to third world. Export value affects requirements.	Most restrictive policy. Exports done only in certain situations such as EU trade agreements.
Level of Arms Imports	Limited. Open to some European products but requires most manufacturing be done in U.S.	Significant, particularly from the U.S. Also imports from other European countries.	Limited imports from the U.S. and European countries. Desires to be self-sufficient.	Limited imports from the U.S. and European countries. Desires to be self-sufficient.
Level of Collaboration	Overall limited. Most projects developed independently with a few exceptions.	Significant due to the cost of independent systems. Mostly with Europe but also with U.S.	Traditionally independent but has embraced collaboration due to costs.	Most frequent participant in collaborative projects of all 4. Mostly with NATO allies.
Political Environment	Congress has the ability to make decisions on any individual program.	Parliament approves overall budget but has limited authority for specifics.	Parliament approves long-term spending plans but not annual amounts.	All large contracts must be submitted to Parliament for review to award.
Competitive Environment	Privatized industrial base. Qualified competition used in some sectors.	Privatized industrial base. Qualified competition used in some sectors.	Some companies owned by the government. Least amount of competition.	Strong preference for competition but also uses direct awards for some.
Acquisition System Structure	Decentralized system with each branch of service having its own procurement authority. Central system for joint items.	Centralized procurement agency whose main role is to maximize business value of weapon programs.	Centralized procurement agency which balances defense and social-economic requirements.	Centralized procurement agency required to maintain separation from the armed forces.

Table 6. Acquisition System of Australia, Japan, South Korea, and Singapore. Source: Lorge (2018).

Factor	Australia	Japan	South Korea	Singapore
Definition of Value for Money	Considers self-defense, support for allies, and socioeconomic factors in its decisions.	Concerned with self-defense capability and support to the economy.	Self-defense capability to counter North Korea is central to all acquisition activities.	Primarily concerned with deterring aggression and protection of economic base.
Level of Arms Exports	Moderate level of exports. Considers export value when developing requirements.	Prohibits sale of arms in most instances. Does allow some level of technology transfers.	Moderate level of exports. Considers export value when developing requirements.	Limited level of exports but does consider export value when developing requirements.
Level of Arms Imports	Moderate level from the United States but preference is to manufacture products locally.	Most equipment is developed and constructed locally. Does import some from the U.S.	Significant level of imports in order to lower development costs and lead times.	Significant level of imports in order to lower development costs and lead times.
Level of Collaboration	Significant range of cooperation. Primarily with New Zealand, the U.S., and the U.K.	Collaborative efforts are almost exclusively limited to those with the U.S.	Primary partner is the U.S. but also works with European and Asian allies.	Significant effort to leverage foreign expertise through research and development partnerships.
Political Environment	Cabinet is final decision-making authority and legislature approves topline budget.	Cabinet is final decision-making authority, with trade/finance ministers' influencers.	National Assembly can make some decisions but president is main authority.	Legislature can only approve or reject topline budget numbers and has little say in programs.
Competitive Environment	Privatized industrial base and encourages competition in order to lower program costs.	Strong, private industrial base; competition is limited with many contracts sole source.	Similar to the French model with mix of government and privately owned companies.	Privatized industrial base. Competition used for most programs but some set asides.
Acquisition System Structure	Centralized procurement agency that is independent from armed services.	Centralized procurement agency headed by civilian political appointees.	Centralized procurement agency headed by civilians but with military in key positions.	Centralized procurement agency with military members in most key positions.

These works compare DOD to other countries' military and program management competencies. This project is unique because it compares DOD to a civilian agency: NASA. Although DOD and NASA differ in size and purpose, both agencies strive to improve program management practices and address deficiencies identified by GAO. This CAP compares program management guidance at the foundational level.

IV. ANALYSIS

This analysis first compares and contrasts DOD's overarching policies to those of NASA. Selected documents, DODD 5000.01 and DODI 5000.02 for DOD and NPD 1000.5C and NPD 7140.4E for NASA, provide policies and the acquisition framework, as summarized in Chapter 2. These documents set a foundation for program managers by identifying priorities within each agency. The comparison identifies similar trends and prominent differences.

Next, this analysis delves into the similarities and differences of the DOD versus NASA information technology (IT) pathways. These two pathways map well to one another, which is why they were chosen. Figure 8 provides a visual of compared documents.

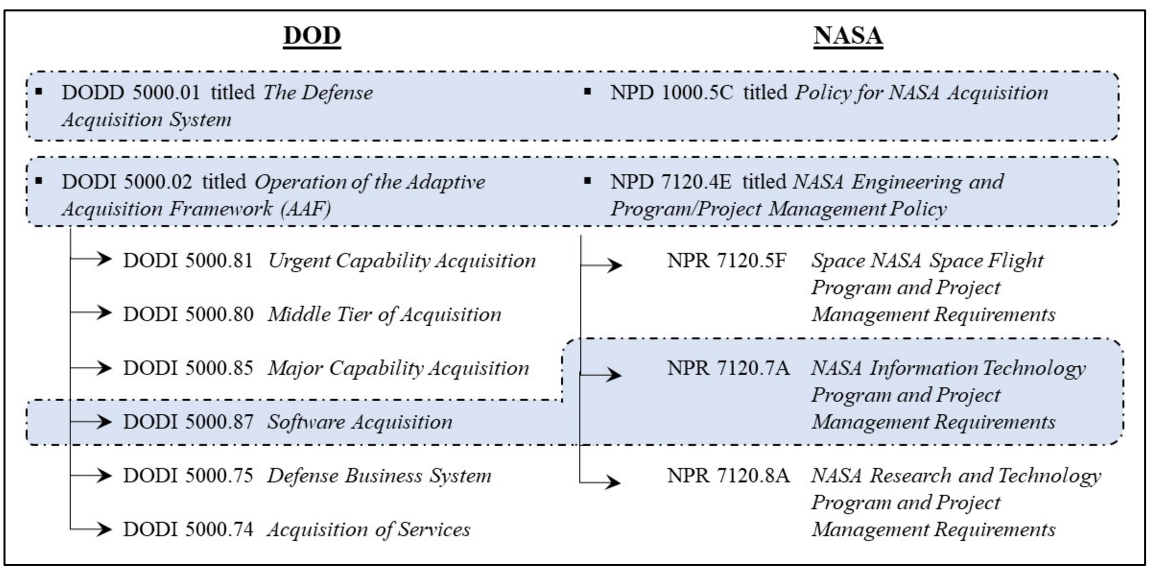

Figure 8. Compared Documents of DOD and NASA.
Adapted from DAU (n.d.a.) and NASA (n.d.).

Lastly, similarities and differences are assessed as strengths and weaknesses to inform a SWOT analysis.

A. OVERARCHING POLICY COMPARISON

DODD 5000.01 and NPD 1000.5C primarily identify policies and responsibility. The policies are identified in Chapter 2. At the next level, DODI 5000.02 discusses responsibilities and authorities and then delves into the six acquisition pathways. NPD 7120.4E discusses functional policies, responsibilities, and three acquisition pathways. This section first identifies policy similarities between DODD 5000.01 and NPD 1000.5C and then the differences. Lastly it addresses a major difference in the acquisition pathways between DODI 5000.02 and NPD 7120.4E.

1. Similarities

When comparing DOD to NASA, some policies could be directly mapped from one organization's documents to the other's. These items are specifically called out in both DOD and NASA. Other similarities, rather than being directly mapped, are common themes described within the language.

a. Policy: Direct Mapping

A **professional workforce** is the first direct mapping. Both DOD and NASA look for a skilled workforce across a range of management, technical, and business disciplines, despite a few nuances in the language. DOD mentions recruiting, developing, and maintaining a fully professional military and civilian acquisition workforce (DOD, 2022b, p. 8). NASA discusses having the appropriate skill, competencies, and certification (NASA, 2020c, p. 3). Regardless of the nuances, both DOD and NASA policies call for a professional workforce across disciplines.

Promoting competition is another direct mapping, with nuances in the language. DOD discusses how to promote competition (e.g., considering alternative systems, data rights, and modular design) (DOD, 2022b, p. 5). NASA does not provide additional information; however, it does emphasize small business participation (NASA, 2020c, p. 3). Both agencies look to promote competition.

Both DOD and NASA identify a **disciplined approach** in their policies. DOD focuses on compliance with regulations, policies, and statutes as well as adherence to program goals for cost, schedule, and performance (DOD, 2022b, p. 5). NASA focuses on a strategic management approach that addresses responsibilities, planning and execution requirements, and metric management (NASA, 2020c, p. 2). Additionally, NASA's policies have a separate item for adherence to laws and regulations as well as meeting cost, schedule, and performance requirements. Although the language is slightly different, both agencies stress a well-organized approach that follows external and internal regulations and policies.

b. Policy: Common Themes

This section delves into the remaining similar items for which there is not necessarily a direct mapping. Each DOD policy is either mapped to a NASA policy or summarized below as a difference.

DOD's first policy is to **deliver performance at the speed of relevance**. This focuses on following operating policies that include empowering program managers, tailoring and streamlining acquisitions, relying on data analysis, and managing risk (DOD, 2022b, p. 4). Common themes at NASA include tailoring and a "risk-informed decision making process" that includes analysis (NASA, 2020c, p. 3). NASA discusses roles and responsibilities for program managers but does not specifically mention empowerment.

DOD identifies **developing a culture of innovation** as a key policy (DOD, 2022b, p. 5). Oddly, NPD 1000.5C does not mention innovation, but it is mentioned several times in the *NASA Governance and Strategic Handbook* (NPD 1000.0C) and *2022 NASA Strategic Plan* (NPD 1001.0D).

DOD specifically calls out the **development and delivery of secure capabilities**, which is focused on cybersecurity, protection of technology, and other security concerns (DOD, 2022b, p. 5). NASA does not call this out, but it is embedded in their policies.

One DOD policy is the **focus on affordability**. This policy addresses preparing achievable cost estimates that balance with capability to prioritize and funding constraints (DOD, 2022b, p. 6). DOD also mentions the importance of life-cycle planning, which addresses development and production costs earlier in the life-cycle as well as operations and sustainment towards the end. Closely related are two additional DOD policies. First is to **plan for product support,** which addresses a long-term consideration to provide sustainable, affordable products for operations (DOD, 2022b, p. 7). Second is to **implement effective life-cycle management**, which addresses reaching objectives throughout the life-cycle of the project (DOD, 2022b, p. 7). NASA's policies track to these concepts with emphasis on realistic cost estimates, alignment with fiscal year budget projections, and consideration of short-term and long-term planning that spans a program or project life-cycle (NASA, 2020c, p. 3).

DOD policy addresses the **plan for coalition partners** to enable allies and partners to participate early in the design and development phase to maximize opportunities (DOD, 2022b, p. 8). NASA language differs slightly because it mentions early and continued participation by organizations with vested interest as well as the importance of maintaining relationships with partners and suppliers (NASA, 2020c, p. 3).

DOD policy to **maintain data transparency** establishes the need to maximize information flow across all DOD departments (DOD, 2022b, p. 9). Similarly, NASA references robust documentation and knowledge sharing (NASA, 2020c, p. 3).

DOD policy to **employ a collaborative process** emphasizes collaboration with DOD components and their authority (DOD, 2022b, p. 9). NASA's guidance provides for collaboration and stresses roles and responsibilities (NASA, 2020c, p. 3).

Several DOD policies address compliance with regulations. This includes 1) **employing performance based acquisition strategies,** 2) **emphasizing environment, safety, and occupational health and requirements**, 3) **compliance with statute and international agreements,** 4) **managing records effectiveness**, and 5) **planning for corrosion prevention and mitigation** (DOD, 2022b, pp. 6–9). NASA does not specifically identify these, but NASA does identify adherence to regulations, standards, policies, etc., as a policy. Both agencies are doing their due diligence to execute within the law.

2. Differences

This section first identifies the seven DODD 5000.01 policies and two NPR 1000.5C policies that are different. Then it highlights the difference in acquisition pathways of DOD and NASA.

a. Policy

Table 7 shows items that are different between the DOD 5000.01 and NPR 1000.5C policies. These policies do not map or have a close mapping to both organizations.

Table 7. DODD 5000.01 and NPD 1000.5C Unmapped Policies. Adapted from DODD (2022b) and NASA (2020c).

DOD 5000.01 Policies	NASA 1000.5C Policies
b. Conduct System of Systems (SoS) Analysis (p. 4)	13. Require disclosure of financial interests from those persons participating in the strategic acquisition process, and avoid personal conflicts of interest in all acquisitions (p. 3)
h. Manage Efficiently and Effectively (p. 6)	14. Ensure that organizational conflicts of interest are identified and resolved as early as possible in the strategic acquisition process (p. 3)
n. Implement Reliability and Maintainability by Design (p. 7)	
o. Conduct Integrated Test and Evaluation (pp. 7–8)	
p. Apply Human Systems Integration (p. 8)	
q. Deploy Interoperable Systems (p. 8)	
s. Employ Artificial Intelligence, Machine Learning, Deep Learning, and Other Related Capabilities throughout Execution of the Acquisition Process (p. 8)	

b. Acquisition Pathways

When comparing DODI 5000.02 versus NPD 7120.4E, we find that DOD identifies six acquisition pathways, while NASA only provides three. DOD's six pathways, identified in Figure 4, address various product lines as well as time constrained acquisitions. For example, DODI 5000.81 provides guidance for capabilities needed within two years. DODI 5000.80 provides guidance for rapid prototype and rapid fielding of capabilities within five years. The remaining four pathways are product specific for major capabilities, software, business systems, and services. DODI 5000.02 allows program managers to "leverage a combination of acquisition pathways to provide value not otherwise available through use of a single pathway" (DOD, 2022a, p. 10).

In spite of the fact that NASA's strategic acquisition process provides guidance to procure new or forward the development of research, services, construction, and supplies; NPD 7120.4E provides acquisition pathways for only three products which are space flight, information technology, and research and technology programs (NASA, 2017, p. 1). Other than NPR 7120.8A, which mentions the possible dual use with NPR 7120.5F, the guidance does not encourage use of multiple pathways (NASA, 2018, p. 5).

B. INFORMATION TECHNOLOGY COMPARISON

DOD provides functional policy for *Acquisition of Information Technology (IT)* (DODI 5000.82, 2020a) and an acquisition pathway for *Operation of Software Acquisition Pathway* (DODI 5000.87, 2020c). Definitions in DODI 5000.82 (2020a) describe IT as follows:

> Any equipment or interconnected system or subsystem of equipment used in the automatic acquisition, storage, analysis, evaluation, manipulation, management, movement, control, display, switching, interchange, transmission, or reception of data or information; this includes computers, ancillary equipment (including imaging peripherals, input, output, and storage devices necessary for security and surveillance), peripheral equipment designed to be controlled by the central processing unit of a computer, software, firmware and similar procedures, and services (including support services, and related resources. IT is equipment used by the DOD directly or is used by a contractor under a contract with the DOD that requires the use of that equipment. IT does not include any equipment acquired by a federal contractor incidental to a federal contract. (p. 17)

NASA has two IT specific policies. *NASA Information Technology Program and Project Management Requirements* (NPR 7120.7A) provides guidance for IT programs and projects, similar to DOD's acquisition pathway. Additionally, *NASA Software Engineering Requirements* (NPR 7150.2D) provides systems engineering guidance dedicated only to software. IT is defined by NASA almost exactly the same as it is defined by DOD as shown in Figure 9. The only exception is DOD's further clarification that IT includes equipment used by DOD or a contractor; however, that flows down at NASA.

DOD IT Definition	**NASA IT Definition**
Any equipment or interconnected system or subsystem of equipment used in the automatic acquisition, storage, analysis, evaluation, manipulation, management, movement, control, display, switching, interchange, transmission, or reception of data or information; this includes computers, ancillary equipment (including imaging peripherals, input, output, and storage devices necessary for security and surveillance), peripheral equipment designed to be controlled by the central processing unit of a computer, software, firmware and similar procedures, and services (including support services, and related resources). IT is equipment used by the DOD directly or is used by a contractor under a contract with the DOD that requires the use of that equipment. IT does not include any equipment acquired by a federal contractor incidental to a federal contract.	Any equipment or interconnected system or subsystem of equipment that is used in the automatic acquisition, storage, manipulation, management, movement, control, display, switching, interchange, transmission, or reception of data or information by an executive Agency. IT also includes computers, ancillary equipment (including imaging peripherals, input, output, and storage devices necessary for security and surveillance), peripheral equipment designed to be controlled by the central processing unit of a computer; software; firmware; and similar procedures, services (including support services), and related resources, but does not include any equipment acquired by a Federal contractor incidental to a Federal contract.

Figure 9. IT Definitions. Adapted from DOD (2020a) and NASA (2020d).

This section primarily compares DODI 5000.87 to NPR 7120.7A because the IT acquisition pathway maps well to NASA's guidance. It is not a perfect comparison because the NASA NPR addresses all IT, which includes software, while DODI provides guidance for only software, a subset of IT. Still, there is sufficient overlap to identify notable similarities and differences. Additionally, the comparison references DODI 5000.82 and NPR 7150.2D when appropriate. Figure 10 shows which DOD instruction and NASA requirement document are compared versus referenced.

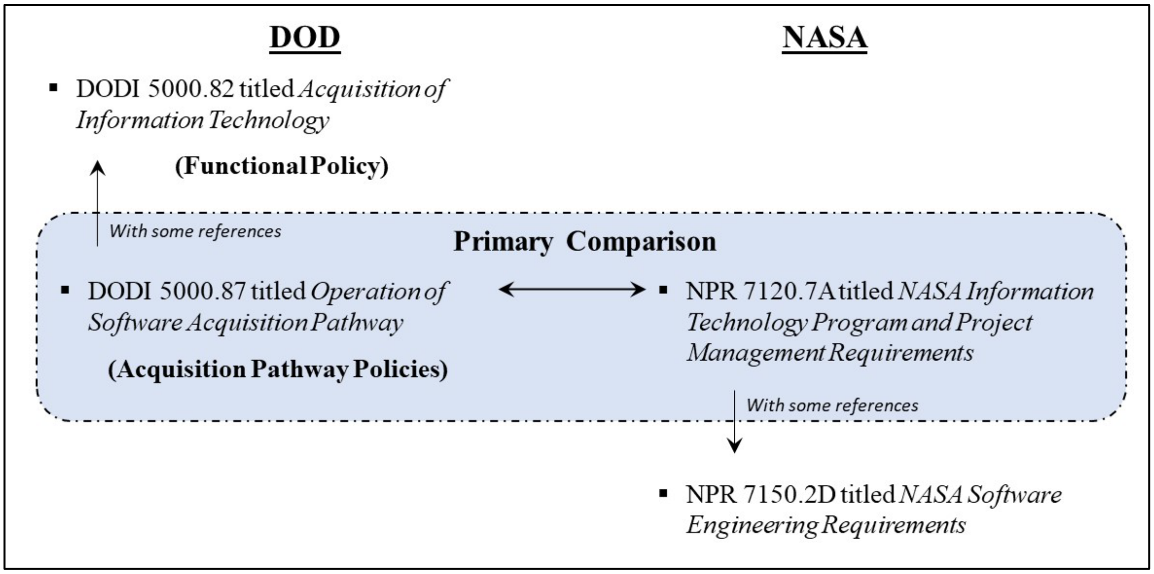

Figure 10. IT Comparison. Adapted from DAU (n.d.a.) and NASA (n.d.).

1. Similarities

Despite the fact that IT is neither DOD's nor NASA's primary mission, IT is part of almost all products. Both organizations recognize the importance of this and have dedicated program management guidance for software/IT. DOD dedicates one pathway to software acquisition while NASA dedicates one NPR to IT programs and projects. In NASA's case, there are only three NPRs for program management, yet one is exclusively for IT.

a. Categories and Exceptions

Both DOD and NASA further define software/IT as a way to categorize the investment. Both provide exceptions to using the IT guidance, even when software/IT is applicable, maximizing flexibility for the program manager.

Guidance in DODI 5000.87 breaks software into two categories: application and embedded (DOD, 2020c, p. 8). The instruction defines application as "rapid development and deployment of software running on commercial hardware, including modified hardware, and cloud computing platforms" (p. 8). Embedded is defined as "rapid development, deployment, and insertion of upgrades and improvements to software embedded in weapon systems and other military-unique hardware systems" (pp. 8–9).

The first exception is specifically called out, which is that software programs can be covered by the Defense Business Systems (DBS) pathway (DOD, 2020c, p. 3). The second exception is more subtle. DODI 5000.87 states "systems in which the software is embedded could be acquired via other acquisitions paths (e.g., major capability acquisition)" (DOD, 2020c, p. 9). The directive continues stating the decision authority "will document the decision and rationale to use the software acquisition pathway" (p. 8) or will direct the project "to use another acquisition pathway if the software acquisition pathway is not deemed appropriate" (p. 5).

NASA categorizes IT investments into three categories: IT projects, initiatives, and activities (NASA, 2020d, p. 15). They are defined in NPR 7120.7A as follows:

> An IT project is a specific investment having defined requirements, a life-cycle cost, a beginning, and an end …
>
> An IT project yields a new or revised system/service …
>
> An initiative is an effort intended to achieve stated objectives, such as improving performance, reducing costs, or analyzing capabilities …
>
> An initiative does not yield a new or revised system/service …
>
> An activity is an ongoing and repetitive effort that operates, monitors, evaluates, and modifies existing IT systems/services. (p. 15)

NASA provides an exception. IT, including software development, incorporated within space flight, space technology, or aeronautics research projects are not governed by NPR 7120.7A (NASA, 2020d, p. 3). This exception is similar to DOD's second exception. Figure 11 summarizes the definitions and exceptions discussed above.

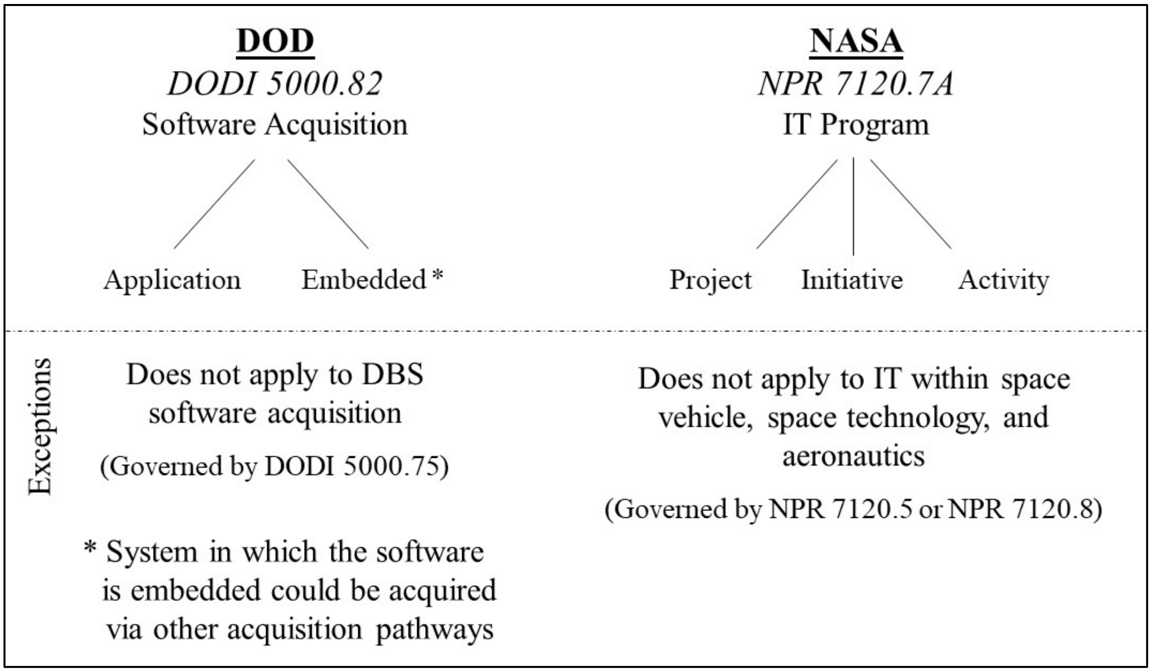

Figure 11. IT Categories and Exceptions. Adapted from DOD (2020c) and NASA (2020d).

The key takeaway is that regardless of the fact that DODI 5000.87 and NPR 7120.7A for software/IT guidance are at different levels, both provide a breakdown of categories and similar exceptions to use the pathway/NPR.

b. Tailoring

DOD and NASA provide additional information for tailoring software/IT. DODI 5000.87 mentions tailoring 11 times and provides extra guidance.

Who: For DOD, the decision authority is the component acquisition executive (CAE), unless the Under Secretary of Defense for Acquisition and Sustainment (USD(A&S)) designates the program as a special interest program (DOD, 2020c, p. 7). The CAE is encouraged to delegate decision authority and approval to the lowest level (DOD, 2020c, p. 7).

What and When: Tailoring is stressed during the planning phase to "adopt modern software development practices (e.g., lean, agile, and development, security, operations)" (DOD, 2020c, p. 12). These modern software development practices "focus on rapid, iterative development and delivery of software" (DOD, 2020c, p. 21). DODI 5000.87 specifically calls out tailoring the Acquisition Strategy, but other documents can also be tailored (DOD, 2020c, p. 11).

Limitations: Other than approval by the decision authority, DODI 5000.87 does not limit what can be tailored.

NPR 7120.7A mentions tailoring 17 times, providing additional guidance. NPR 7150.2D provides substantial guidance from a systems engineering standpoint. Various IT decision authorities are addressed below under differences.

What and When: NPR 7120.7A provides a compliance matrix to document tailoring of program and project requirements throughout the life-cycle (NASA, 2020d, p. 34). For programs, tailoring is addressed for the two phases: formulation and implementation/ operations (NASA, 2020d, pp. 47–48). For projects, tailoring is addressed from pre-formulation through concept studies (NASA, 2020d, pp. 48–49).

Tailoring for the life-cycle of the program or project is completed and approved in the beginning. For programs, it is done during the formulation phase and for projects during pre-formulation (NASA, 2020d, pp. 47–49). If updates to the compliance matrix are needed afterwards, they are presented at a subsequent KDP and require the same approval (NASA, 2020d, pp. 45–49).

Limitations: Tailoring does not apply to the IT activities or initiatives (NASA, 2020d, p. 11). This means only IT programs and projects can be tailored.

The key takeaway is both DOD and NASA encourage tailoring. DODI 5000.87 states tailoring enables "rapid and effective acquisition and delivery of software capabilities" (DOD, 2020c, p. 7). NPR 7120.7A states tailoring is "to achieve program/project success in an efficient and economical manner" (NASA, 2020d, p. 11). Both goals are the same, to streamline the process and provide software/IT services to the end users.

c. Incremental Approach

Congress passed the Federal Information Technology Acquisition Reform Act (FITARA) in 2014 requiring select agencies, which included DOD and NASA, to implement incremental development for IT investments (Federal Information Technology Acquisition

Reform Act (FITARA), 2014). Office of Management and Budget (OMB) issued additional implementation guidance. *Management and Oversight of Federal Information Technology* (M-15-14) defined adequate incremental development as follows: "For development of software or services, planned and actual delivery of new or modified technical functionality to users occurs at least every six months" (Office of Management and Budget (OMB), 2015). Both DOD and NASA acquisition pathways reference an incremental approach. DOD refers to a "rapid, interactive approach to software development" (DOD, 2020c, p. 8). NASA refers to "incremental or modular development" for software (NASA, 2020d, p. 21).

In 2017, GAO assessed 24 government agencies' policies on how well they endorse an incremental development for IT investments (Powner et al., 2017, pp. 36–38). The GAO report stated only four agencies had clearly defined policy and the remaining agencies, which included DOD and NASA, needed to develop policy or provide additional information. Figure 12 summarizes GAO's assessment.

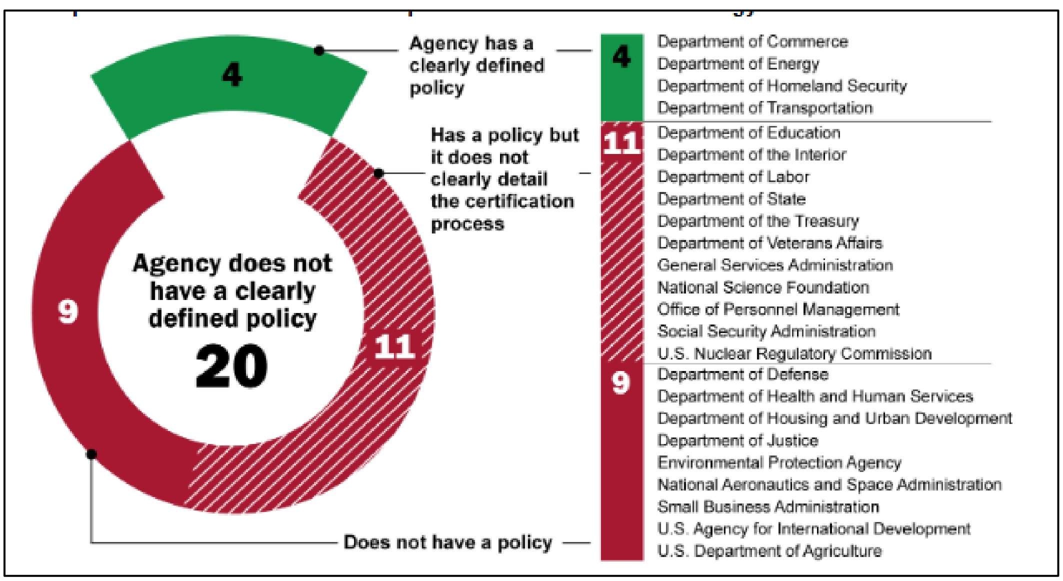

Figure 12. GAO IT Assessment. Source: Powner et al. (2017).

DOD reported no challenges with implementing incremental development; however, DOD had issues with delivering functionality every six months because IT systems were too complex (Powner et al., 2017, p. 30). NASA reported no challenges and indicated that policies will be updated (Powner et al., 2017, p. 53). The current NPR 7120.7A addresses both incremental development and its certification per FITARA as well as requires six month delivery of new or modified functionality per OMB M-15-14 (NASA, 2020d, pp. 21–22).

The key takeaway is that both DOD and NASA have incorporated and encouraged an incremental approach for software/IT.

d. Independent Assessments

Both DOD and NASA have independent assessments embedded in their program guidance. They are slightly different in nature but provide similar end results.

DODI 5000.87 requires, at minimum, annual value assessments once software is delivered. These assessments are "to determine if the mission improvements or efficiencies realized from the delivered software are timely and worth the current and future investments from the end user perspective" (DOD, 2020c, p. 9). The sponsor and user community perform these assessments and provide it to the program manager (DOD, 2020c, p. 18). The sponsor uses this to inform resource decisions. The program manager uses the value assessments to evaluate progress and update strategies, design, and the capability needs statement (DOD, 2020c, p. 18).

NASA requires periodic independent assessments to review the IT activity and provide "unbiased analysis of schedule, cost, technical risk, and performance" (NASA, 2020d, p. 13). To ensure impartial evaluation, these assessments are conducted by external individuals that are "outside the advocacy chain of the program or project" (NASA, 2020d, p. 6). This is done prior to each KDP decision to inform the future of the program or project (NASA, 2020d, p. 13).

The key takeaway is that both DOD and NASA seek outside, independent assessments on a periodic basis. Since IT projects use an incremental approach, there are built-in opportunities to assess progress and inform future planning. Both DOD and NASA use individuals outside the program and project chain. While the sponsor is part of the DOD value assessments, NASA requires people outside the advocacy chain. DOD specifies participation of end-users in the assessment. While NASA does not specify this, external participation can and should include end-users.

2. Differences

Despite the common threads, there are notable differences between DOD and NASA software/IT program guidance.

a. Life-Cycle

DODI 5000.87 identifies one life-cycle for all software development shown in Figure 13. It is an iterative approach with two phases: planning and execution. The philosophy is that "software is never done" (DOD, 2020c, p. 8). This is simple, straight-forward and applicable to software across a variety of operations.

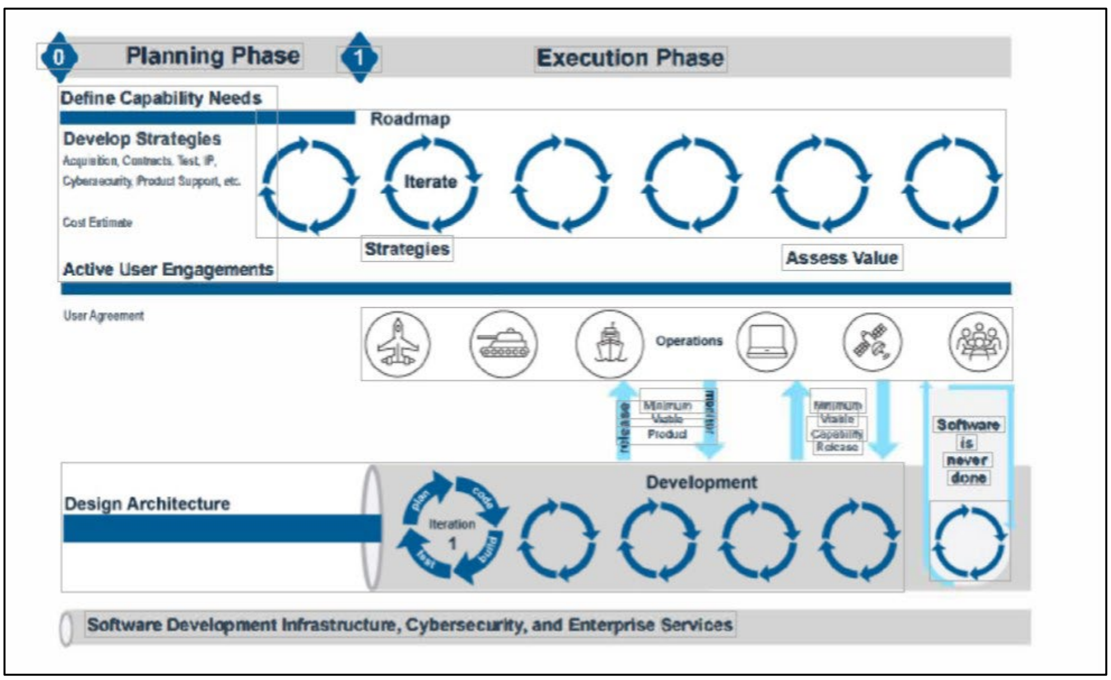

Figure 13. DOD IT Life-Cycle. Source: DOD (2020c).

Conversely, NPR 7120.7A identifies two life-cycles: one for programs and one for projects. NASA's program life-cycle, shown in Figure 14, is similar to DOD's life-cycle in that it has two phases and provides for an incremental process. NASA's two phases have different names (formulation and implementation/operations) but accomplish the same objectives. NASA's iterative approach is depicted by the phase numbers ending with phase n. One major difference is NASA programs end with a Termination Review.

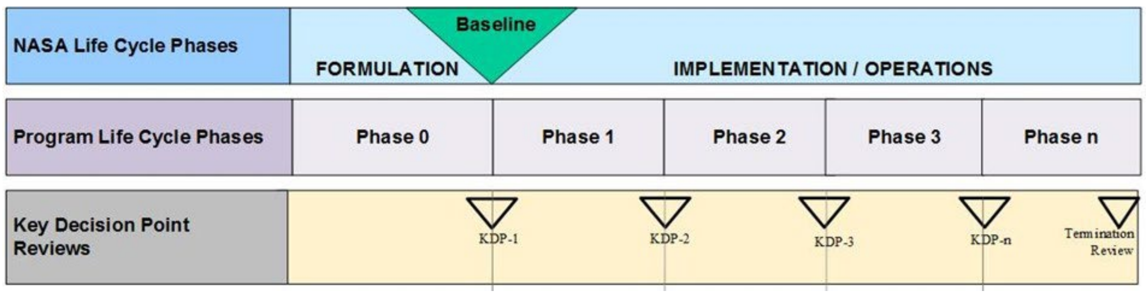

Figure 14. NASA IT Program Life-Cycle. Source: NASA (2020d).

NASA's project life-cycle depicted in Figure 15 is notably different. IT projects have a life-cycle with a beginning and end. They are divided into five phases: pre-formulation, formulation, implementation, operations, and decommission. The systems engineering reviews follow more of an end-item deliverable. But NPR 7120.7A identifies incremental development to be used in the project life-cycle phases.

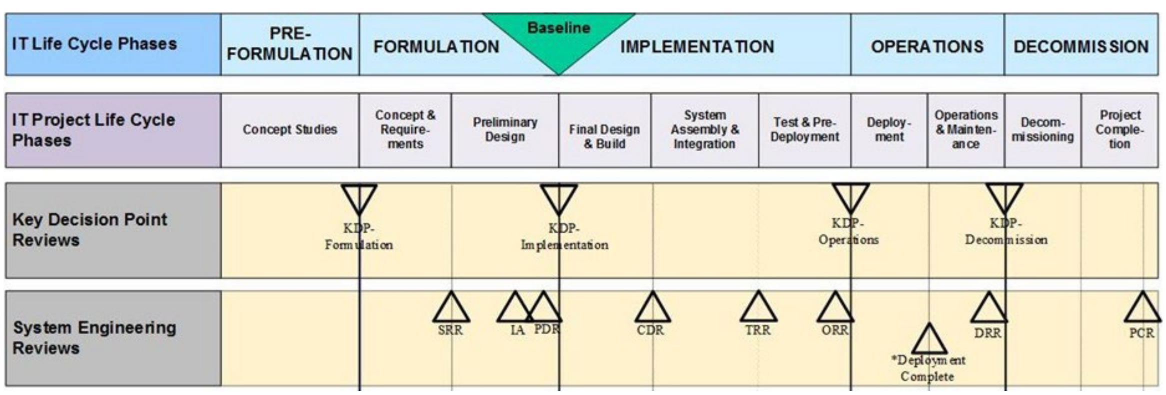

Figure 15. NASA Project IT Life-Cycle. Source: NASA (2020d).

The key takeaway is DOD approaches software development as never ending, while NASA IT programs and projects clearly provides for an end point. Despite the fact that NASA calls for incremental development, that may be missed if solely looking at the project life-cycle in Figure 15. The KDP structure and systems engineering reviews gives a structured feel rather than incremental.

b. Baselines and Rebaselines

Looking at the life-cycle of the software/IT programs and projects, one item stands out: NASA clearly identifies when the program or project baseline is set. NPR 7120.7A defines a baseline as "an agreed-to set of requirements, cost, and schedule that will have changes controlled through a formal approval and monitoring process" (NASA, 2020d, p. 34). The baseline is documented in the program or project plan and approved at KDP-1 for programs and KDP-Implementation for projects by the KDP decision authority (DA).

The baseline for programs or projects can only be redefined if certain conditions exist. NPR 7120.7A states that one or multiple of the following criteria can result in an IT program or project rebaseline:

> (1) Addition, change, or deletion of investment goals (requirements, objectives) resulting from internal or external management decisions …
>
> (2) Changes in program funding level or availability of funds (e.g., extended continuing resolution) …
>
> (3) Changes in contracting (including bid protests) …
>
> (4) The current baseline is no longer useful as a management tool for realistic performance measurement (cost, schedule, or requirements) as variances have exceeded the approved limits …
>
> (5) The program has been interrupted or put on hold …
>
> (6) The KDP DA requests a rebaseline. (pp. 16–17)

Rebaselines are presented at KDP decision points to be approved by the KDP decision authority.

Conversely, DODI 5000.87 does not identify a baseline or rebaseline process. It may organically happen at the conclusion of the planning phase, given the required documentation for the acquisition plan, test plan, roadmap, etc. Nonetheless, it is not explicitly stated and changes to the planning documentation are subject to updates.

c. Delivery

Initial delivery of software and incremental releases differ between DOD and NASA. DOD requires a roadmap that provides a minimum viable product (MVP) or minimum viable capability release (MVCR) for operations no later than one year after funds are first obligated (DOD, 2020c, p. 16). DOD's subsequent software releases to the user community are done at least annually.

NASA does not have a one-year deadline for IT investments. Rather, deployment is identified in the proposed life-cycle of the program and project. However, compliant with OMB M-15-14, NASA delivers incremental developments every six months.

d. Decision Authority

Both DODI 5000.87 and NPR 71207A clearly identify roles and responsibilities. DODI 5000.87 identifies one key decision authority, while NASA provides for two decision authorities and delegation matrices.

CAEs serve as the decision authority for software acquisitions, unless the USD(A&S) designates the effort as highly visible or delegated to another official (DOD, 2020c, p. 7). DODI 5000.87 provides responsibilities for others including Under Secretary of Defense for Research and Engineering; Under Secretary of Defense (Comptroller)/Chief Financial Officer; Chief Information Officer (CIO); Director of Operations, Test, and Evaluation; Director for Cost Assessment and Program Evaluation; and Vice Chairman of the Joint Chiefs of Staff. Their roles are identified as advising, consulting, guiding, establishing policies, or overseeing (DOD, 2020c, pp. 5–7). CAE is the one decision authority but is encouraged to delegate authority to the "lowest level practicable" (DOD, 2020c, p. 7).

NPR 7120.7A discusses various decision authorities (NASA, 2020d, pp. 9–10). Most comparable to the DODI 5000.87 authority for software is NASA's KDP decision authority. However, NPR 7120.7A also identifies a systems engineering authority for projects. The NASA CIO delegates KDP and systems engineering authority based on cost, impact to other programs or projects, visibility, impact, and risk. Figure 16 depicts delegation of KDP authority and Figure 17 depicts delegation of systems engineering authority.

Criteria	NASA CIO	Program Executive	Center CIO
IT Programs	X		
Projects with DME cost ≥ $1M or LCC ≥ $5M	X		
Projects impacting more than one IT Program	X		
Projects with high visibility, impact, or risk	X		
Projects impacting more than one Center with minimal visibility and risk		X	
Projects impacting a single Center with minimal visibility and risk			X
Pre-Formulation KDP Reviews		X	

Note: DME = Development, Modernization, and Enhancement, M = Million, and LCC = Life-Cycle Cost

Figure 16. Criteria for KDP Decision Authority. Source: NASA (2020d).

Criteria	Agency PMO Lead	Program Manager	Center PMO Lead
Projects with DME cost ≥ $1M or LCC ≥ $5M	X		
Projects impacting more than one IT Program	X		
Projects with high visibility, impact, or risk	X		
Projects impacting more than one Center with minimal visibility and risk		X	
Projects impacting a single Center with minimal visibility and risk			X

Note: DME = Development, Modernization, and Enhancement, M = Million, and LCC = Life-Cycle Cost, PMO = Program/Project Management Office

Figure 17. Criteria for Project Systems Engineering Authority. Source: NASA (2020d).

C. STRENGTHS, WEAKNESSES, OPPORTUNITIES, AND THREATS ANALYSIS

The next step is using these similarities and differences to determine if DOD or NASA can leverage one another's practices, which is accomplished by with a SWOT analysis. SWOT analyses date back to the 1960s and have been used to "identify internal and external factors that are favorable and unfavorable to achieving the objectives" (Wikipedia, n.d., para. 2). Wikipedia defines the four quadrants:

> Strengths: characteristics of the business or project that give it an advantage over others …
>
> Weaknesses: characteristics that place the business or project at a disadvantage relative to others …
>
> Opportunities: elements in the environment that the business or project could exploit to its advantage …
>
> Threats: elements in the environment that could cause trouble for the business or project. (Overview)

Wikipedia discusses that strengths and weaknesses are internal factors, whereas opportunities and weaknesses are external (Wikipedia, n.d., Internal and external factors). Internal factors are those that the organization influences and controls, such as procedures and priorities. External factors are beyond the control of the organization, for instance economic and legislative. Strengths and opportunities are helpful, while weaknesses and threats are harmful. Figure 18 depicts these relationships.

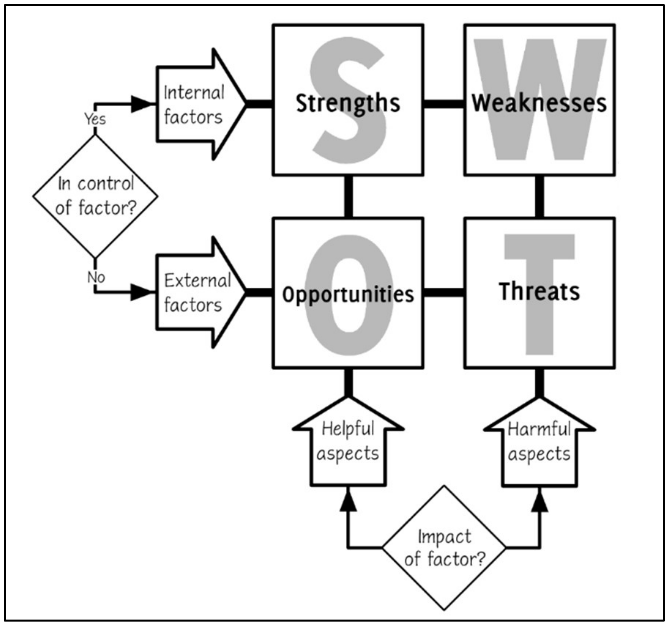

Figure 18. SWOT Analysis. Source: Sarsby (2016).

This longstanding model was originally used for a single company, but its application has grown. Helms and Nixon (2016) note that "SWOT continues to expand in usage beyond individual businesses to countries, regions, and trading blocs" including comparing two or more companies (p. 240). This project adapts the SWOT analysis to compare DOD and NASA policies.

The previous sections focused on identifying similarities and differences. This section evaluates them as helpful, which equates to a strength, or harmful, which equates to a weakness. The similarities and differences are evaluated against PMBOK's twelve program management principles. If the similarity or difference aligns with one or multiple PMBOK principles, it is considered a strength. If the similarity or difference is in conflict with a principle, a weakness is noted. If it neither aligns nor conflicts, it is considered neutral and not mentioned in the SWOT.

When comparing two entities, opportunities and threats can manifest when one entity has a notable strength from which the other company can benefit. For this comparison, differences between DOD and NASA are evaluated to determine if one can adopt a policy or practice from the other to create an opportunity. Conversely, if a weakness is identified, the analysis evaluates it to determine if there is a threat.

Section 1 summarizes the PMBOK twelve principles that are used to assess strengths and weaknesses. Section 2 discusses how the similarities and difference map to strengths or weaknesses and then opportunities or threats. Section 3 distills the key finding and completes a SWOT analysis.

1. Evaluation Criteria for Strengths and Weaknesses

PMBOK (2020) identifies twelve program management principles summarized below:

1. **"Be a diligent, respectful, and caring steward"** which includes effective and honest communications; a transparent work environment; and compliance with internal and external laws, rules, regulations, and requirements (pp. 26–27).
2. **"Create a collaborative team environment"** means management of diverse skills, clarity of roles and responsibilities, and defining processes (pp. 28–30).
3. **"Effectively engage with stakeholders"** requires effective communication at various levels to set and execute on expectations for areas such as cost, schedule, and scope (pp. 31–33).
4. **"Focus on Value"** is based on identifying business needs, project justifications, and business strategies to achieve desired outcomes (p. 35).
5. **"Recognize, evaluate, and respond to system interactions"** focuses on system level thinking across disciplines, elements, and time (pp. 37–38).
6. **"Demonstrate leadership behavior"** includes, but is not limited to, effectively setting vision, empowering others, managing conflict, and successfully communicating with others (pp. 40–43).

7. **"Tailor based on context"** is understanding unique characteristics that can customize a program's approach to maximize the outcome, such as increasing innovation (pp. 44–46).

8. **"Build quality into processes and deliverables"** means balancing aspects such as performance, reliability, efficiency, and sustainability to meet the project's objective and satisfy user needs (pp. 47–49).

9. **"Navigate complexity"** involves balancing various elements, whether influenced by systems or people, to manage through the project life-cycle (pp. 50–51).

10. **"Optimize risk responses"** focuses on managing the uncertainty of events and conditions to mitigate negative impacts (pp. 53–54).

11. **"Enable adaptability and resiliency"** allows program managers to effectively respond to unexpected events (pp. 55–56).

12. **"Enable change to achieve the envisioned future state"** relies on change management, flexibility, and forward thinking (pp. 58–59).

2. Assessment

Assessments of strengths and weaknesses are qualitative. Similarities and differences are evaluated based on whether they map to PMBOK's program management principles. For example, if an item (similarity or difference) maps to one or multiple principles, it is considered a strength. If the item is contrary to PMBOK's program management principles, it is considered a weakness.

a. Similarities

Since similarities between DOD and NASA naturally map to the same PMBOK principles, similarities are considered of equal strength or weakness unless there is a unique DOD or NASA characteristic. Although all similarities are reviewed, the final SWOT utilizes those that have unique characteristics. All differences are referenced in the SWOT.

Table 8 itemizes the similarities identified in the overarching principles and IT pathways, and then maps each item to the PMBOK principles. Lastly, if a similarity has some uniqueness in DOD or NASA policies, it is noted.

Table 8. Policy Similarities and Mapping.

Similarity	PMBOK Mapping	Unique Characteristic
Overarching Policy Similarities		
Maintain a Professional Workforce	1, 6	none
Emphasize Competition	1	none
Employ a Disciplined Approach	5, 8	none
Deliver Performance at the Speed of Relevance	8, 10	none
Develop a Culture of Innovation	7	DOD specifically calls this out, while NASA relies on higher level documentation
Develop and Deliver Secure Capabilities	1, 6	none
Focus on Affordability	3, 4	none
Plan for Product Support	3, 4	none
Implement Effective Life-Cycle Management	9	none
Plan for Coalition Partners	6	none
Maintain Data Transparency	1	none
Employ Performance Based-Acquisition Strategies	1	none
Emphasize Environment, Safety, and Occupational Health (ESOH) and Requirements Management	1	none
Comply with Statute and International Agreements	1	none
Manage Records Effectively	1	none
Plan for Corrosion Prevention and Mitigation	1	none
Employ a Collaborative Process	2	none
IT Similarities		
Categories and Exceptions	7	none
Tailoring	7	While both DOD and NASA encourage tailoring, NASA provides a compliance matrix
Incremental Approach	1, 5, 11, 12	none
Independent Assessments	1, 3, 4	none

All the similarities map to one or multiple PMBOK principles; therefore, these are all considered strengths for both DOD and NASA. With the exception of the two items with unique characteristics, the other strengths are considered equal and are not itemized in the SWOT. The two exceptions are 1) developing a culture of innovation and 2) tailoring, which are further discussed below.

Developing a culture of innovation is a common policy for both DOD and NASA. The difference is DOD prominently identifies this policy, while NASA mentions it in the higher level strategic policy directives. This may seem insignificant; however, innovation is a key aspect of program management. This is especially true for NASA, an agency at the forefront of research and technology. Gallagher (2015) states "Project management is all about breaking new ground—doing things that have never been done before. This places innovation right at the heart of what we do as project managers. In fact, innovation has become a core competency, essential to success in a rapidly shifting strategic environment" (para. 1). Therefore, although a strength for both DOD and NASA, the SWOT reflects an opportunity to strengthen the concept of innovation in lower level procedural documents such as NPR 1000.5C.

Tailoring is another common and important strength for DOD and NASA. Not only is this concept included in the *Acquisition of Information Technology (IT)* (DODI 5000.82), but it is also mentioned in each of the DOD acquisition pathways and is on the DAU website (DAU, n.d.b.). Tailoring is a prominent concept in NASA's NPRs. *NASA Information Technology Program and Project Management Requirements* (NPR 7120.7A) and *NASA Space Flight Program and Project Management Requirements* (NPR 7120.5F) provide an additional resource called a compliance matrix to document the tailoring approach for a program or project. *NASA Research and Technology Program and Project Management Requirements* (NPR 7120.8A) does not include a compliance matrix; therefore, all three NASA policies are not consistent. The advantage of the compliance matrix is that it provides a structured approach to review and tailor the program or project. It provides a historical trace of how programs and projects are tailored. The disadvantage is the time required to document the details and have it approved. Nonetheless, there is an opportunity for DOD to leverage from NASA's compliance matrix and provide a structured approach for tailoring. For NPR 7120.8A, there may be an opportunity to add a simplified compliance matrix.

b. Differences

The differences between DOD and NASA include the overarching principles identified in Table 7, the number of acquisition pathways, and those identified from the IT policies. Table 9 summarizes these differences and maps them to the PMBOK principles.

Table 9. Policy Differences and Mapping.

Differences	PMBOK Mapping	Differences	PMBOK Mapping
<u>DOD Overarching Policies</u>		**<u>NASA Overarching Policies</u>**	
Conduct System of Systems (SoS) Analysis	2, 4, 5	Not mentioned in NASA policies	
Manage Efficiently and Effectively	6	Not mentioned in NASA policies	
Implement Reliability and Maintainability by Design	11	Mentioned in other NASA policies	
Conduct Integrated Test and Evaluation	8, 9	Mentioned in other NASA policies	
Apply Human Systems Integration	7	Mentioned in other NASA policies	
Deploy Interoperable Systems	8, 9	Mentioned in other NASA policies	
Employ Artificial Intelligence, Machine Learning, Deep Learning, and Other Related Capabilities throughout Execution of the Acquisition Process.	8, 9	Mentioned in other NASA policies	
Not mentioned in DOD policies		Require disclosure of financial interests from those persons participating in the strategic acquisition process, and avoid personal conflicts of interest in all acquisitions	no mapping
Not mentioned in DOD policies		Ensure that organizational conflicts of interest are identified and resolved as early as possible in the strategic acquisition process	no mapping
Six acquisition pathways	4, 6	Three acquisition pathways	4, 6
<u>DOD IT Policy</u>		**<u>NASA IT Policies</u>**	
One software life-cycle is an iterative process	1	One life-cycle for programs and one for projects	1
Not mentioned in DOD IT guidance		NASA identifies a process to baseline and rebaseline programs and projects	3, 4
DOD delivers an initial software release in one year with annual updates	1, 8	NASA does not have a timeframe for an initial release, but releases updates every six-months	1, 8
DOD identifies one authority over software programs	2	NASA has two authorities, one for key decision points and a systems engineering authority	2

Conducting an SoS analysis is done to identify operational gaps and develop systems concepts to deliver greater capability to the field. This is in line with DOD's capability-based requirements approach and provides overlap of two interconnected circles: JCIDS and little-a. It is mapped to three PMBOK principles, therefore, considered a strength for DOD. NASA approaches requirements slightly differently. Rather than stressing capability gaps, NASA relies on meeting their six strategic goals by leveraging its roadmap to develop requirements. Since NASA has an approach for requirements development, the concept of SoS may not be as applicable to them. Therefore, this does not result in an opportunity or threat for NASA.

The DOD policy of **managing efficiently and effectively** centers around empowering program managers at DOD and giving every management level the authority to execute. Although this is mapped to only one PMBOK principle, it is important. The policy is intended to ensure every level of management is given authority to execute their responsibilities. Though NASA does not use this language, it does address roles and responsibilities and provides for delegation. Given the importance of empowering employees, this is a strength for DOD. NASA may benefit by emphasizing empowerment when they discuss roles and responsibilities in their policies.

The next four items, **implement reliability and maintainability by design, conduct integrated test and evaluation, apply human systems integration, and deploy interoperable systems**, are addressed together. These are DOD policies targeting key traits during a project life-cycle. These items address technical process requirements that take into consideration life-cycle challenges such as reliability, maintenance, and interoperability. It stresses integrated test and evaluation as well as human systems integration to achieve optimal performance. This is considered a DOD strength. Comparatively, NASA does not include this language in the program management guidance; however, it does stress these traits in the systems engineering processes. *NASA Systems Engineering Processes and Requirements* (NPR 7123.1C) mentions these approaches as key aspects to developing solid systems engineering program processes (NASA, 2020b). Since NASA does address these topics in their regulations, it is a common strength for DOD and NASA with no opportunities or threats.

DOD's last policy is to **employ artificial intelligence (AI), machine learning, deep learning, and other related capabilities throughout execution of the acquisition process**. These are technologies and innovations used to build intelligent machines and applications. In their GAO report, Ludwingson and Wright (2022) state that

> DOD has reported that AI is poised to change future battlefields and the pace of threats the U.S. faces. AI capabilities could enable machines to perform tasks that usually require human intelligence, such as identifying potential threats or targets on the battlefield. DOD designated AI a top modernization area and is investing heavily in AI tools and capabilities. Other nations are making significant investments in this area that threaten to erode the U.S. military technological and operational advantage. (Highlights).

DOD's forward thinking and commitment to innovative and quality products makes this a strength. NASA does not identify this as a primary policy; however, where appropriate, NASA leverages these practices and addresses them in other guidance. Given NASA's mission includes human space flight, AI needs to be carefully leveraged. Certainly, for DOD, this is a strength that addresses future capabilities. For NASA, since it is addressed in other regulations, it is neither an opportunity nor threat.

NASA policy mentions **disclosure of financial interest** and **organizational conflict of interest**. Although sound practices, these do not directly map to PMBOK's twelve management principles; therefore, they are not considered strengths or weaknesses.

One major difference is the number of **acquisition pathways** utilized at DOD versus NASA. DOD identifies six robust pathways that address both time-phased (e.g., less than two years, less than five years) and product-based (e.g., mid-tier, weapons, DBS, software, and services) programs. Additionally, DOD encourages tailoring programs and projects to utilize multiple pathways. This provides multiple disciplined approaches while maximizing tailoring, an important strength for DOD. Comparatively, NASA has three product acquisition pathways: space flight, information technology, and research and technology. Though NASA's pathways provide guidance to technical programs and projects, there is no guidance for other program types such as business and services. NASA NPRs do not discuss using multiple pathways other than one reference in NPR 7120.8A. Depending on lower level organization direction, a space flight program or project can use a hybrid of NPR 7120.8A and NPR 7120.5F. DOD policies provide far more options as compared with NASA; therefore, the SWOT analysis reflects a weakness for NASA. This results in opportunities for NASA to add non-technical pathways and expand tailoring options to use multiple pathways.

The IT policy comparison identifies four major differences. The first is program **life-cycles.** This is not a perfect comparison since DOD's IT policy addresses only software development, while NASA IT guidance addresses all IT acquisitions. However, policies from both DOD and NASA highlight a relevant concept which is having IT and software programs leverage incremental approaches. DOD's life-cycle clearly shows the continuous and iterative approach for software procurements (DOD, 2020c, p. 8). NASA represents two life-cycles: one for programs and one for projects. The program approach clearly identifies an incremental approach depicted by numerous phases (i.e., phase-0, phase-1, phase-2 through phase-n) (NASA, 2020d, p. 16). However, the IT project life-cycle is definite and mimics a phased approach (i.e., pre-formulation, formulation, implementation, operations, and decommission) (NASA, 2020d, p. 24). When addressing IT life-cycles, NASA has an opportunity to show the iterative and incremental approach even at the project level.

The second IT difference is that NASA's NPR 7120.7A policy outlines specific guidance for **baselining and rebaselining** IT programs and projects. A baseline includes parameters for requirements, cost, and schedule. A program or project can only rebaseline if certain criteria are met, and it is approved at a KDP review. Conversely, DODI 5000.87 does not explicitly provide a process. NASA's clarity of a baseline and rebaseline process helps track and manage program constraints and provides a clear communication path for stakeholders and program members. This is a NASA strength because it provides structure to the program/project and assists with stakeholder management. It is an opportunity for DOD to look at best practices and define a process within the DODI 5000.87 pathway.

Leveraging an incremental approach for IT, OMB M-15-14 requires **delivery** of software every six months. DOD provides an initial release at the end of one year but afterwards commits to annual releases. This is contrary to OMB policy. Conversely, NASA does not have a defined initial commitment, rather identifies the first release date as part of the planning. NASA does comply with six-month subsequent releases. Because DOD does not comply with OMB policy, this is considered a weakness and threat. For NASA, there are no notable strengths for the SWOT.

The last IT policy difference is **decision authority** definitions between NASA and DOD. DOD identifies one authority which is the CAE, who is encouraged to delegate authority to the lowest level possible. NASA has two decision authorities: KDP and systems engineering authorities. NASA clearly defines the roles and provides delegation criteria. Since both DOD and NASA clearly define roles and responsibilities for decision authority, this is considered equal strengths for both agencies and not mentioned in the SWOT.

3. Strengths, Weaknesses, Opportunities, and Threats Summary

The details in the assessment are distilled into strengths and weaknesses and how they inform opportunities and threats. This section summarizes the pertinent findings in the assessment and ends with Figure 19, the DOD/NASA SWOT analysis.

1. The first DOD strength is their policy to manage efficiently and effectively. This stresses empowering program and project managers. Although NASA clearly defines roles and responsibilities, NASA may be able to leverage this language to emphasize empowerment as an opportunity.
2. A strength for DOD and weakness for NASA are their acquisition pathways. DOD has six wide-ranging acquisition pathways for time-phased programs and product lines. Guidance encourages tailoring including use of multiple pathways. The pathways are comprehensive and robust. NASA options are more limited. NASA has only three pathways that address major technical programs. Use of multiple pathways is only mentioned in the context of research and technology that is a space flight program or project. NASA has an opportunity to revisit if additional non-technical pathways can be added and expand tailoring to allow use of multiple pathways.

3. A NASA strength is their clear, structured definition and process for baselining and rebaselining IT programs and projects. DOD's software acquisitions policy does not mention baselining or rebaselining. This may be an opportunity for DOD to add language and provide a structured approach.

4. A common strength to DOD and NASA is their culture of innovation; however, this is identified at different levels. NASA identifies it at the strategic level, but not in the program and project NPRs. This is DOD's third policy identified in DODD 5000.01. Therefore, the SWOT shows this as an opportunity for NASA to reinforce the culture of innovation in their program and project NPRs.

5. Another common strength is guidance and emphasis on tailoring programs and projects. Both DOD and NASA understand that one size does not fit all which is reflected throughout their policies at all levels. NASA provides a structured approach to identify and tailor program and project requirements using a compliance matrix. There may be opportunities for DOD to leverage this or a similar approach.

6. One weakness is identified within DOD policies and that is their non-compliance with OMB M-15-14 to deliver incremental IT every six months. DOD has committed to providing annual updates, but this may manifest as a threat of policy non-compliance.

7. The last item is an opportunity within NASA policies to reinforce incremental development within their IT projects. NASA clearly identifies an incremental approach for IT development, but the IT project life-cycle does not specifically show that. This may be administrative in nature because NASA complies with incremental development policies; nonetheless, reiterating this external requirement emphasizes its importance.

Figure 19 summarizes this in a SWOT quadrant. In the figure, the numbering tracks to the numbered list discussed above; therefore, the numbering does not appear sequential, and numbers may repeat in multiple quadrants.

SWOT	Helpful	Harmful
Internal	**DOD** **Strengths** 1. DOD policy to manage efficiently and effectively focuses on empowering program managers 2. Provides six acquisition pathways for time-phased programs and product lines **NASA** 3. Clear, structured definition for baselining and rebaselining IT programs and projects **Common to DOD and NASA** 4. Identifies a culture of innovation 5. Provides guidance and encourages tailoring for programs and project	**DOD** **Weaknesses** 6. DOD does not comply with OMB-15-14 to delivery incremental IT capability every six months **NASA** 2. NPRs have only three pathways that only address technical programs (space flight, research and development, and IT)
External	**DOD** **Opportunities** 3. Adopt a structured approach to baseline and rebaseline for software acquisitions 5. Leverage NASA's approach to document program/project tailoring (compliance matrix) **NASA** 1. Adopt DOD's language for empowerment 2. Add non-technical acquisition pathways and expand tailoring to allow using multiple pathways 4. Although already a strength, NASA can add language to program NPRs to emphasize innovation 7. Reinforce incremental development for IT project life-cycle	**DOD** **Threats** 6. Noncompliance with OMB-15-14 to delivery incremental IT capability every six months (DOD delivers yearly). **No NASA Threats**

Figure 19. SWOT Analysis.

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V. CONCLUSION

The purpose of this research was to compare and contrast foundational program and project management practices of DOD and NASA, which aligns with the primary research question. The second goal of this research was to identify strengths, weaknesses, opportunities, and threats for DOD or NASA.

Overall, the research showed more similarities in the program and project management guidance than differences. The similarities and differences were assessed against PMBOK's program management principles to identify opportunities and threats. The summary section reviews the approach, the recommendation section distills this into thoughts for DOD and NASA, and the future research section identifies ideas for other projects.

A. SUMMARY

To compare the foundational program and project management guidance between DOD and NASA, the background chapter first summarized DOD's big-A. DOD has a well-documented, structured approach. NASA does not have a big-A structure, but NASA's processes map well to DOD's three categories of requirements, budget, and acquisitions. Both agencies have an established requirements process. DOD's JCIDS guidance is based on a capability-driven process. NASA's requirements stem from the *NASA Governance and Strategic Management Handbook* and *Strategic Plan* (NASA, 2020a). To address budget, both agencies rely on their PPBE guidance. This is a calendar-driven process that results in a government-wide submission of the President's Budget to Congress. For acquisitions, DOD has a little-a process, while NASA relies on various NPDs and NPRs. DOD's little-a and NASA's NPDs and NPRs were the focus of the analysis chapter.

Figure 8 summarizes the selected DOD and NASA overarching policies and IT acquisition pathways used for this project. There are more similarities than differences between DOD and NASA policies. Twenty-one similarities were identified as summarized in Table 8 and fourteen differences were identified as summarized in Table 9. Next, using the PMBOK's twelve program management principles (2020), these similarities and differences were assessed as strengths and weaknesses which informed opportunities and threats. DOD and NASA have mutual strengths which are a culture of innovation and guidance for tailoring programs. DOD's most notable strength is their six comprehensive and robust acquisition pathways that address time-phased and product lines. The one DOD weakness identified is non-compliance with OMB M-15-14 to deliver incremental IT capability every six months. For NASA, a unique strength is their structured approach to define and manage IT program and project baselines and rebaselines. A weakness for NASA is their limited acquisition pathways. These strengths and weaknesses informed various opportunities and threats resulting in the recommendations below.

B. RECOMMENDATIONS

Recommendations for DOD include the following:

- Tailoring is a common strength for both DOD and NASA. It is encouraged at the overarching policy level and IT acquisition pathway. However, NASA provides a compliance matrix which identifies program or project requirements for the program manager to document their tailoring approach. NASA uses it for their space flight and IT pathways but not for research and technology. The advantage of the compliance matrix is that it provides a structured approach to document and approve tailoring. The disadvantage is that it can be a burdensome process. Given PMBOK's seventh program principle of tailoring, this added step would be considered a strength and hence, best practice for programs and projects.

- For IT acquisition, NASA identifies guidance for baselining and rebaselining requirements, which includes justifications and approvals. For DOD, this may happen organically through the iterations and phases of the program; however, it is not specifically required in the guidance. There may be an opportunity for DOD to improve on their process by adding structure to baselining and rebaselining programs and projects.

Recommendations for NASA include the following:

- NASA effectively has three product-driven acquisition pathways: space flight, IT, and research and technology. Conversely, DOD has six pathways (shown in Figure 4) which address both product lines and time constraints. Additionally, DOD encourages tailoring to use multiple pathways when appropriate for the program or project. Comparing these two approaches, DOD provides structured approaches that encompass a broader range of program and project types, plus they encourage maximum tailoring. NASA may be able to leverage a similar, broader approach by adding NPRs for other activities, such as services or business processes.

- NASA has opportunities to leverage already noted strengths or practices. For example, NASA documents their culture for innovation at the strategic level, but that is not reinforced at the program procedural level. Conversely, DOD emphasizes innovation at the overarching policy level. Another example is how NASA specifies using an incremental approach for IT, but this approach is not reiterated at the project level. Lastly, NASA provides program roles and responsibilities but does not emphasize empowering project managers. Conversely, DOD's overarching policy does both. These are not considered weaknesses for NASA, rather a recommendation for NASA to improve on what they are already doing well.

C. FUTURE RESEARCH

This research is limited to comparing foundational program management and software/IT acquisition pathways between DOD and NASA. Future research can delve into comparing other acquisition pathways or expand the comparison to functional policies. With additional comparisons, trends may be identified. Further research may show DOD and NASA policies continue to converge and have more similarities than differences or policies diverge and there are notable variations. Additional comparisons can either corroborate the strengths, weaknesses, opportunities, and threats identified in this project or identify others.

Alternatively, DOD or NASA program management practices can be compared with other government agencies, industry, or academia. Government agencies, industry, and academia have different characteristics but often work together for a common goal. Expanding research to include these entities would broaden the comparison and may result in the identification of other best practices.

In addition to expanding comparisons, a future project can further investigate opportunities. For example, this research showed that tailoring is a common theme emphasized by both DOD and NASA policy. Yet, each agency has slightly different approaches such as tailoring strategies, what extent programs and projects can be tailored, and how to document it. Future research can compare DOD's and NASA's use of tailoring and whether or not it has positive impacts on programs and projects.

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