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Exploring Program Archetypes to Simplify Digital Transformation

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Abstract

In the U.S. Department of Defense (DoD), evidence across the Services and industry has affirmed that digital transformation is critical for successful acquisition in an environment of increasing global challenges, dynamic threats, rapidly evolving technologies, and increasing life expectancy of systems currently in operation (Zimmerman et al., 2019). The DoD must continue to practice systems engineering efficiently and effectively to provide the best advantage for successful acquisitions and sustainment. Digital transformation will require the update of both acquisition and systems engineering practices to take full advantage of the digital power of computation, visualization, and communication throughout the life cycle.

There are a wide variety of variables that shape the profile of a program: What type of acquisition is being done? What is the risk profile of the program? What is the balance of the acquisition in terms of fidelity versus abstraction of data? The research described in this paper is intended to build a set of program archetypes that will help to template the considerations for programs that need to utilize digital acquisition approaches, whether they be existing programs transitioning to digital or new programs.

Research Issue Statement

Program offices across the Department are faced with the challenge of digital transformation. For some, this is the challenge of starting a program in a digital way. For many others, it is a challenge of taking the approaches and processes currently being used and updating them and their staff to take advantage of digital approaches. Though each of the Services is working to create reference models and best practices, this digital transformation process is often hindered by the workforce's understanding of how to tailor approaches to fit the program's needs.

This research theorizes that though there are many characteristics of a program—size, scope, acquisition pathway, novelty, risk, etc.—there is likely a smaller number of archetypes or commonly-occurring patterns. The researchers will develop a framework to characterize programs then gather data from existing programs in order to refine that framework and identify the most frequent archetypes. With this information, the team will work to document the flavors of digital engineering that are most commonly required based on archetype, including common templates, considerations for the environment, etc.

Methodology

This section highlights the frameworks the researchers are using to characterize programs. The team is working on gathering data from existing and recently-completed programs across the Department and classifying each program with respect to these variables. The team hypothesizes that though there are hundreds of potential program archetypes across all of the combinations of these variables, the data for actual programs will likely cluster around a few common profiles or archetypes. The team's goal is to first identify and classify these archetypes. Then, following up with additional data and, where possible, data collection from these programs, identify what DE approaches are working for each profile as well as common challenges. The team's objective is to develop a framework that links program archetypes with the common DE approaches, methods, tools, templates, etc. that are likely to be best suited to their needs. This is intended to get to the "70%–80% solution" space, giving programs a head start on developing their DE approaches while still leaving room for tailoring.

Program Characteristics

Within the scope of DoD acquisition, there are several different ways that programs can be characterized:

- Type of acquisition
- Complexity
- Novelty
- Technology
- Pace
- Scope
- Greenfield vs. brownfield
- Life cycle approach

For each of these, frameworks already exist for classification, and the team plans to utilize these existing frameworks in the characterization of programs and development of archetypes.

Type of Acquisition: Adaptive Acquisition Framework

The Adaptive Acquisition Framework (AAF) was defined in DoD 5000.02 (2022) and classifies programs based on the type of acquisition to be performed (all definitions from DAU [2023]):

- **Urgent capability acquisition**—is intended to "field capabilities to fulfill urgent existing and/or emerging operational needs or quick reactions in less than 2 years. Though the pathway did not exist at the time, the mine-resistant ambush protected (MRAP) vehicle developed during operations Iraqi Freedom and Enduring Freedom is an example of the type of capability that would fall into this category."

- **Middle tier of acquisition** (also called mid-tier acquisition)—is focused around rapid prototyping and is "intended to rapidly develop fieldable prototypes within an acquisition program to demonstrate new capabilities and/or rapidly field production quantities of systems with proven technologies that require minimal development." In general, these are programs that are intended to be fielded in less than five years.
- **Major capability acquisition** (also called MCA)—is intended to "acquire and modernize military unique programs that provide enduring capability." The F-35, Littoral Combat Ship, and the Griffin II light tank are examples of the types of systems that would be acquired through the MCA pathway.
- **Software acquisition**—is intended to "facilitate rapid and iterative delivery of software capability to the user" for software-intensive systems. In general, this pathway uses incremental delivery/continuous improvement processes for software systems. Within a larger program, the software acquisition pathway can be used to rapidly develop and deliver the software components of a system.
- **Defense business systems**—is intended to "acquire information systems that support DoD business operations." This applies to all defense business capabilities and their supporting business systems, such as: financial and financial data feeders; contracting; logistics; planning and budgeting; installation management; human resources management; and training and readiness systems. This pathway may also be used to acquire non-developmental, software-intensive programs that are not business systems.
- **Acquisition of services**—is intended to support the "acquisition of contracted services with a total estimated value at or above the simplified acquisition threshold (SAT)." The SAT changes year to year. In Fiscal Year (FY) 2023, that amount is $250,000, meaning that for acquisitions at or under this amount, the processes required are greatly simplified. In FY 2018, 49.0% of the Department's contract spend, or $123.9 billion, was spent on acquiring services.

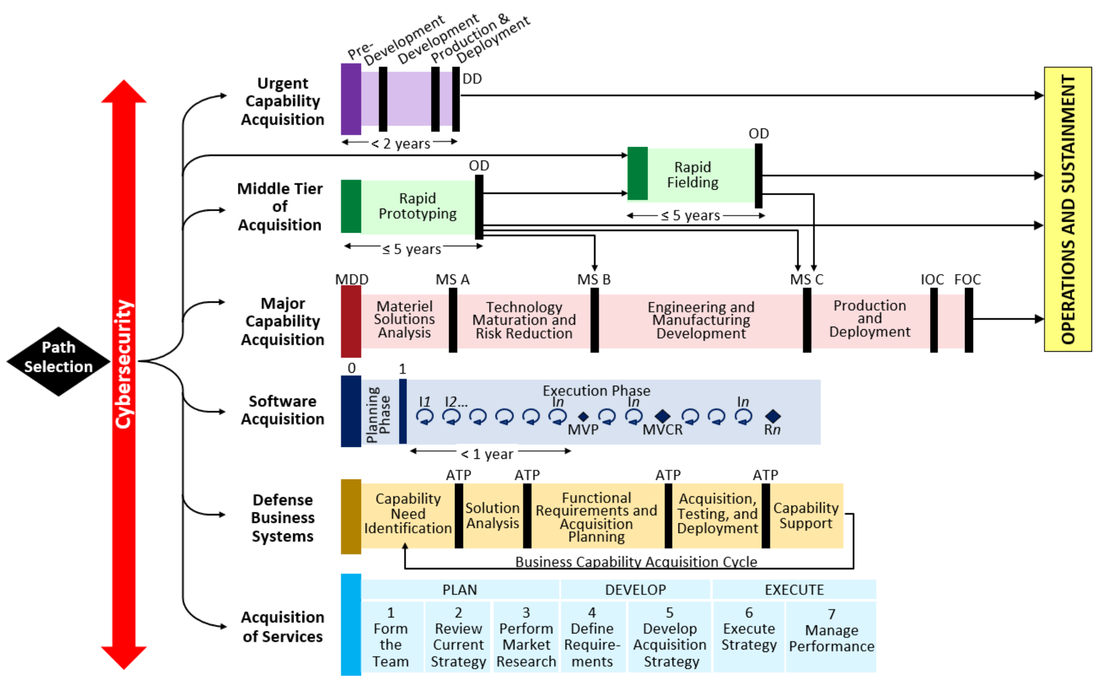

Figure 1. Adaptive Acquisition Framework (AAF)
(DAU, 2023, public domain)

Because the framework being developed is intended to be useful to programs across the DoD portfolio, the acquisition pathway is a critical characteristic of the program. It also gives insight into the type and scope of the system being developed and the level of complexity expected.

Shenhar and Dvir's Diamond Project Profile

In their 2007 book *Reinventing Project Management*, Shenhar and Dvir created a framework for classifying programs based on four characteristics: complexity, novelty, pace, and technology, as illustrated in Figure 2.

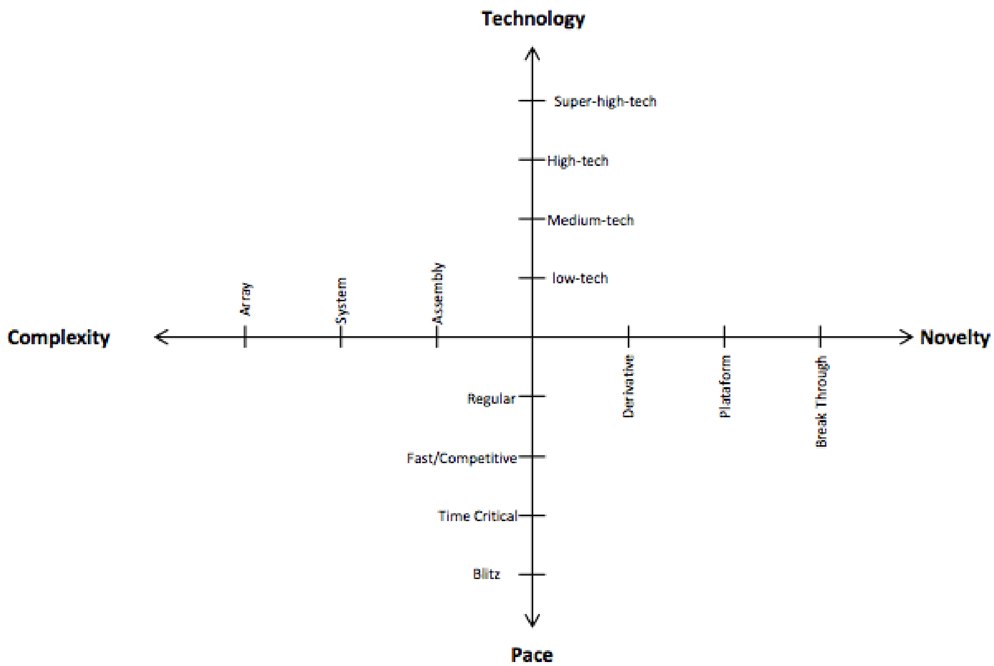

Figure 2. Shenhar and Dvir's Diamond Profile

Their classification system is relatively simple, with only three to four "bins" for each category, as outlined in Table 1 (data from Shenhar and Dvir [2007]).

Table 1. Shenhar and Dvir Classification System

Area	Level	Definition
Technology	Low-tech	Uses only existing, well-established, and mature technologies.
	Medium-tech	Mostly existing technologies; limited new technology or a new feature.
	High-tech	Uses many new, recently developed, and existing technologies.
	Super-High-Tech	Key project technologies do not exist at the time of project initiation.
Novelty	Derivative	Extending or improving existing products or services.
	Platform	Developing and producing new generations of existing product lines or new types of services to existing or new markets and customers.
	Breakthrough	Introducing a new-to-the-world product or concept, a new idea, or a new use of a product that customers have never seen before.
Pace	Regular	Time not critical to organizational success.
	Fast/Competitive	Project completion on time is important for company's competitive advantage and/or the organization's leadership position.
	Time-Critical	Meeting time goal is critical for project success; any delay means project failure.
	Blitz	Crisis projects; utmost urgency; project should be completed as soon as possible.
Complexity	Component	A fundamental element of a subsystem that never works alone.
	Assembly (or sub-system)	A collection of components and modules combined into one unit and performing a single function of a limited scale.
	System	A complex collection of units, subsystems, and assemblies performing multiple functions.
	Platform of systems	A single structure used as a base for other installed systems that are serving the platform's mission.
	Array (or system of systems)	A large, widespread collection or network of systems functioning together to achieve a common mission.

Note that with respect to "technology," it is really a measure of technological uncertainly, which can be highly coupled with risk and has implications for complexity.

With respect to "novelty," the definition aligns with commonly used greenfield, brownfield, and bluefield approaches:

- **Greenfield** approach is a clean slate approach, assuming no legacy implications.
- **Brownfield** approach is utilized when an organization (or program) has a significant history of valuable project data they wish to retain while transforming their technology systems. As many DoD programs have some legacy components, at least some aspects of most DoD programs are expected to have brownfield approaches.
- **Bluefield** approach is somewhat of a hybrid between the greenfield and brownfield, which either take the view of scrapping everything to start fresh or upgrading everything, respectively. Bluefield is a careful consideration of which existing systems should be evolved and which should be scrapped for entirely new capabilities.

With respect to “complexity,” the definitions in Shenhar and Dvir refer more specifically to the scope and scale of a project. The *Systems Engineering Body of Knowledge (SEBoK)* uses similar terms: product, service, enterprise, and system of system. However, there is a more nuanced approach to complexity that is useful for building program archetypes.

Cynefin Framework

In 2007, Snowden and Boone published the Cynefin framework, which defines complexity with respect to behavior.

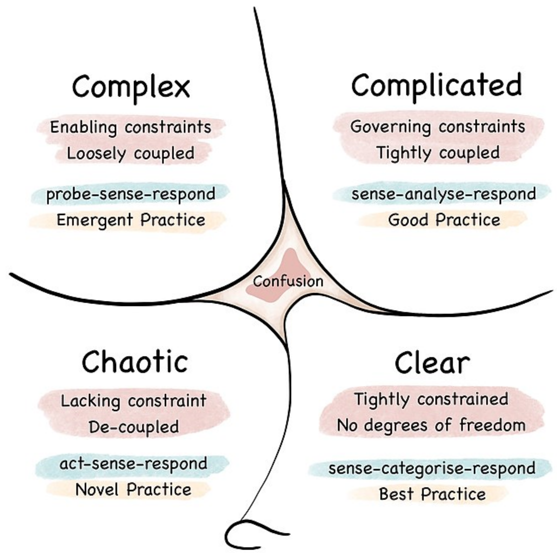

Figure 3. Snowden and Boone’s Cynefin framework.
(Snowden & Boone, 2007).

The framework classifies programs or systems into four bins:

- Clear (or simple or obvious) represents the “known knowns” and indicates that a system or program is functioning in a space with clear and established rules. Importantly in terms of behavior, there is clear cause and effect in this condition, with predictable outcomes (i.e., less uncertainty).
- Complicated represents the “known unknowns.” Cause and effect can be discerned through data collection and analysis, but often requires expertise for correct interpretation. This is the realm of engineers where the correct answer starts with, “It depends.”
- Complex represents the “unknown unknowns” or a high degree of uncertainty. Cause and effect may be identified in retrospect, though these insights are less likely to be clear causal relationships and more likely to emerge as useful patterns.
- Chaotic represents conditions where cause and effect are completely unclear. In these systems or programs, individuals must first act to try bring some order to the situation.

There is also a “center of confusion” or disorder, which generally indicates that there is not enough known to classify a program.

Clear and simple programs can often rely on established processes, even those that have a fair amount of bureaucratic overhead, because the “tried and true” approaches will eventually yield appropriate results. The more uncertain a program becomes, however, the more effective incremental approaches become.

System Scope and Type

Several of the frameworks discussed include ways of looking at systems scope. Shenhar and Dvir's complexity metric identifies a program's system of interest on a spectrum from a component to a system of systems (or a mission system in the DoD). The SEBoK highlights system types as product, service, enterprise, or system of systems. Clearly, there is a direct relationship between some system types and acquisition pathways. For example, services would be achieved through a service acquisition pathway. Many ACAT 1 programs are, in fact, developing complex systems of systems. However, the team wants to look at data across as many existing programs as possible to determine whether or not there are additional useful correlations.

Life Cycle Approach

This leads to the question of life cycle. There are clear relationships between the acquisition pathway and the level of complexity with the life cycle approach. For example, traditional waterfall methods are unlikely to be effective in a complex or chaotic environment (and many studies and examples have borne this out). A program in the software acquisition pathway will likely relay on continuous development/continuous improvement (CD/CI) approaches, for example agile or DevSecOps methodologies.

Outside of these obvious areas of alignment, however, the team will look to the data to highlight any correlations between lifecycle approaches and other factors.

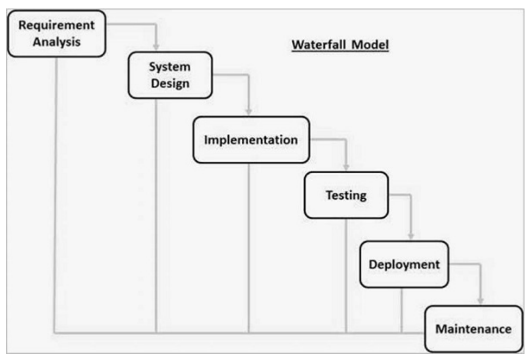

Figure 4. Generic Representation of the Waterfall Life Cycle Model

For the sake of this study, four main life cycle approaches will be considered: waterfall, Vee, incremental/spiral, and CD/CI/agile.

- Waterfall: This should be a very familiar life cycle approach to anyone in DoD acquisition. In general, it lays out the life cycle in a very linear fashion, starting with requirements through to deployment and maintenance.
- Vee: "The technical aspect of the project cycle is envisioned as a 'Vee,' starting with user needs on the upper left and ending with a user-validated system on the upper right" (Forsberg & Mooz, 1991). The Vee model is an evolution of waterfall. It incorporates the same general life cycle activities, but better embraces the relationships and feedback between the different phases.

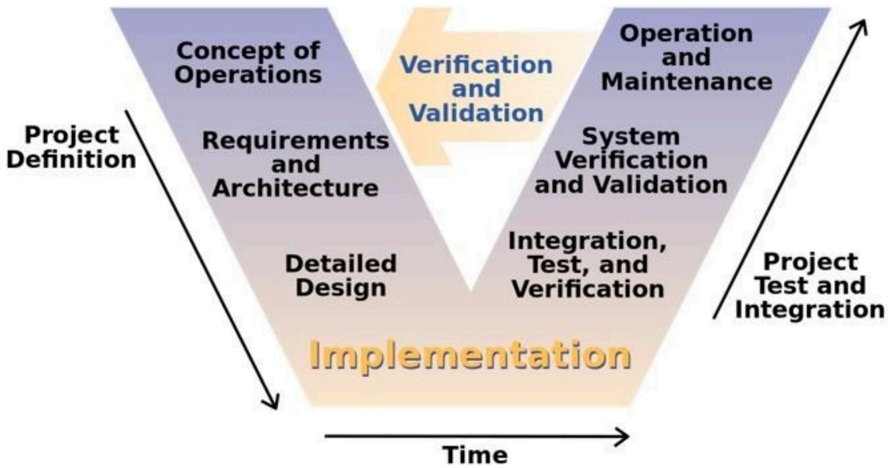

Figure 5. Generalized Vee Model.
(Osborn et al., 2005, public domain).

- Incremental/Spiral: This model was first described by Barry Boehm in 1986. The concept, overall, is the application of the lifecycle approach to a small increment of a system—in Boehm's original model, specifically a software product. Risk is reduced because there is a prototype that delivers some functionality at the end of each increment. This is different from waterfall for Vee, as the full capability is really only delivered at the end for these.

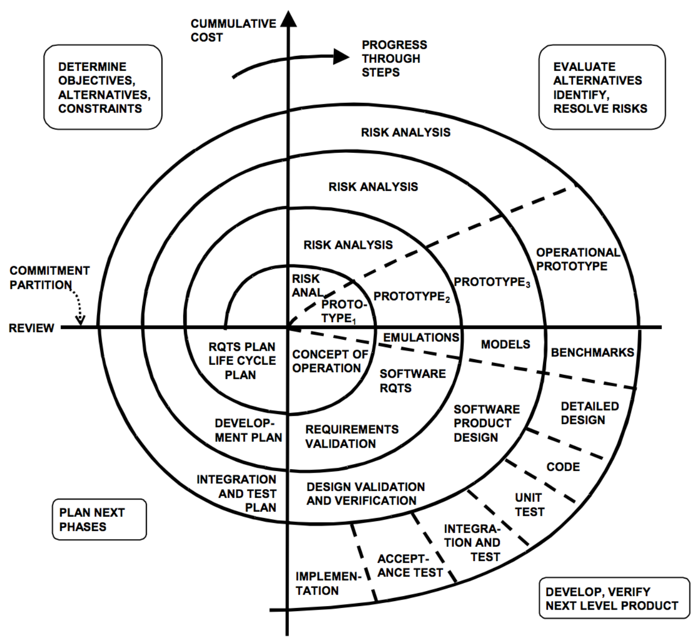

Figure 6. Spiral Development Model.
(Boehm, 1986).

- Continuous development/continuous integration: In the DoD the most commonly discussed CD/CI approach is DevSecOps (Development Security Operations).

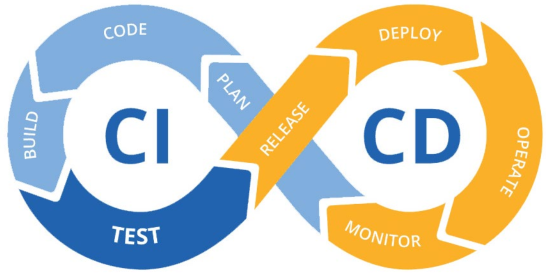

Figure 7. Generic Representation of the CI/CD (or DevSecOps) Approach

There is an overlap between life cycle models. For example, one could use an Agile approach, delivering continuously into an operational environment and integrating the principles of DevSecOps. Likewise, it is possible software development in a program may follow an incremental approach while the physical aspects of a system follow more of a Vee-model. Understanding the primary life cycle approach for a program will provide some insights.

The team is particularly interested in available data that could indicate the overlap or nesting of life cycle models as this likely will have specific implications for how a digital program environment would be developed and maintained.

Data

The researchers are in the process of collecting data. Currently, data with respect to ACAT 1 programs is more readily available than for smaller programs.

Expected Results

The team hopes to look at data from as many programs as possible—ideally a minimum of 200 programs across the spectrum. Grounded theory will be used to identify archetypes based on how the program data clusters.

For each archetype, the team will analyze available data, supplemented by subject matter expert insights into the available and appropriate DE methods, processes, tools, templates, etc. for each archetype. Figure 8 provides a conceptual example of the planned results, with specific patterns of characteristics defining the most common archetypes and recommendations for each archetype based on the programmatic and systems characteristics paired with available resources.

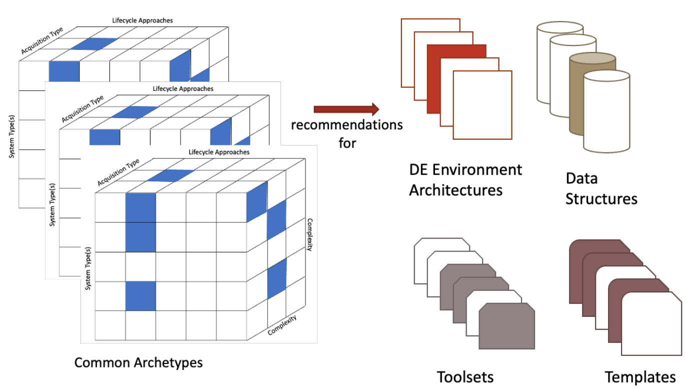

Figure 8. Conceptualization of the Proposed Framework

Conclusion

This framework is intended to provide programs that are beginning their transition to digital engineering and new programs that are being stood up in a digital engineering environment a place to start. This is meant to provide roughly a 70%–80% solution that will allow a program to quickly set up a digital engineering environment that is “good enough” to begin work, with the caveat that program specific tailoring is expected. Likewise, like most systems, the starting point is not the end. Programs will still need to evolve their digital engineering capabilities as the program grows and changes. However, this framework should provide guidance that will be applicable throughout that journey.

Participation

While the researchers are exploring available data sources such as the Defense Acquisition Visibility Environment (DAVE), the researchers are also working to make contacts across a variety of programs to supplement the data and have the opportunity to gather additional data that is not as readily available, such as the specifics of digital engineering implementation in different programs.

If you would like to participate in the study, please contact Nicole Hutchison (hicole.hutchison@stevens.edu).

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