Department of Defense

Prototyping Guidebook

Office of the Under Secretary of Defense for Research and Engineering

Prototypes and Experiments

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Record of Changes

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05/17/2019	1.1	Updated definition of OUSD(R&E) Rapid Prototyping Fund	7.2.8
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		Modified definition of prototype to align with Section 4	Appendix 2: Definitions
		Added reference, "Defense Acquisition University. 'Procurement for Experimental Purposes (10 USC 2373).'"	Appendix 4: References

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1 Forward

Components of the U.S. military have benefited from the use of prototyping for decades. Many of these organizations and their subject matter experts (SMEs) have developed processes, methods, and tools that have helped them succeed in their efforts. This prototyping guidebook attempts to capture and consolidate these approaches, best practices, and recommendations into a single reference document for the Department of Defense (DoD). It is a living document and will be updated periodically to ensure that direction captured from governing documents is current and best practices are fresh.

This guidebook is not policy, nor should it be understood as directive in nature. Rather, the guidebook is designed to complement DoD, Military Service, and defense agency policy pertaining to acquisitions and prototyping, providing the reader with discretionary best practices that should be tailored to each prototyping project.

To draft this guidebook, the authors conducted an extensive literature review, gleaning information from legal, congressional, academic, and regulatory documents and reports. The authors further developed this information through interviews of research and acquisition professionals across the DoD who provided insights into processes and best practices developed and learned during previous prototyping efforts. This approach to developing the guidebook resulted in a product with broad applicability to the defense prototyping community.

2 Introduction

The current pace at which the U.S. develops advanced warfighting capability is being eclipsed by those nations that pose the greatest threat to our security. Additionally, the increasing cost of our major weapon systems has placed at risk our ability to acquire and sustain these systems at sufficient levels. According to the 2018 National Defense Strategy (NDS), "Current processes are not responsive to need; the Department is over-optimized for exceptional performance at the expense of providing timely decisions, policies, and capabilities to the Joint warfighter." Our overreliance on these processes is seen as a major contributor to this decrease in warfighting dominance.[1]

The Section 809 Panel echoes the NDS' assertion. In Section 809 of the Fiscal Year (FY) 2016 National Defense Authorization Act (NDAA), Congress directed the Secretary of Defense to

"Deliver performance at the speed of relevance"[2]

2018 National Defense Strategy

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[1] James N. Mattis, Secretary of Defense, *Summary of the 2018 National Defense Strategy of the United States of America: Sharpening the American Military's Competitive Edge* (Washington, DC: Department of Defense, 2018), 10, https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf.
[2] Mattis, 10.

establish an independent advisory panel to review the Department's acquisition regulations and provide recommendations to streamline and improve the efficiency and effectiveness of the defense acquisition process.[3] The May 2017 "Section 809 Panel Interim Report" summarizes Senator John McCain's assessment of the current state of DoD acquisitions as follows:

> "The way the DoD buys what it needs to equip its warfighters is from another era, one in which the global strategic landscape was entirely different. Today the United States' ability to maintain technological, military, and economic superiority is being challenged because its adversaries are rapidly modernizing their militaries with an eye toward exploiting U.S. vulnerabilities and negating traditional U.S. advantages. DoD has not fully adjusted to the pace of this environment, nor has it adjusted to a marketplace that bears no resemblance to that of just a few decades ago."[4]

Dr. Michael D. Griffin, Under Secretary of Defense for Research and Engineering (USD(R&E)) acknowledged these challenges and highlighted the key need for speed in DoD capability development in his April 18, 2018 testimony to the Senate Armed Services Committee's Subcommittee on Emerging Threats and Capabilities:

> "We are in constant competition, and the pace of that competition is increasing. In a world where everyone pretty much today has equal access to technology, innovation is important, and it will always be important, but speed becomes the differentiating factor. How quickly we can translate technology into fielded capability is where we can achieve and maintain our technological edge. It is not just about speed of discovery. It is about speed of delivery to the field."[5]

To address these challenges, the NDS emphasizes adopting a risk-tolerant approach to capability development through the extensive use of prototyping and experimentation to drive down technical and integration risk, validate designs, gain warfighter feedback and better inform achievable and affordable requirements, with the ultimate goal of delivering capabilities to the Joint warfighter at the speed of relevance.[6] In order to retain U.S. global technological dominance, DoD must adopt and mature this approach quickly, using all existing authorities at its disposal and new authorities provided by Congress in recent law.

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[3] National Defense Authorization Act for Fiscal Year 2016, Pub. L. No. 114-92 § 809, 129 Stat. 889 (2015). https://section809panel.org/wp-content/uploads/2017/12/809-Panel-Charter-As-Amended-by-FY2018-NDAA.docx.
[4] John McCain, *Restoring American Power: Recommendations for the FY 2018-FY 2022 Defense Budget*, accessed January 27, 2017, https://www.mccain.senate.gov/public/_cache/files/25bff0ec-481e-466a-843f-68ba5619e6d8/restoring-american-power-7.pdf, summarized in Section 809 Panel: Advisory Panel on Streamlining and Codifying Acquisition Regulations, *Section 809 Panel Interim Report*, (Washington, DC: Author, 2017), 2, https://section809panel.org/wp-content/uploads/2017/05/Sec809Panel_Interim-Report_May2017_FINAL-for-web.pdf.
[5] *Accelerating New Technologies to Meet Emerging Threats: Testimony before the U.S. Senate Subcommittee on Emerging Threats and Capabilities of the Committee on Armed Services,* 115th Cong. (2018) (testimony of Michael D. Griffin, Under Secretary of Defense for Research and Engineering (USD(R&E)), 7-8, https://www.armed-services.senate.gov/imo/media/doc/18-40_04-18-18.pdf.
[6] Mattis, 11.

3 Purpose and Scope

Components of the U.S. military have benefited from the use of prototyping for decades. Many of these organizations and their SMEs have developed processes, methods, and tools that have helped them succeed in their efforts. This prototyping guidebook attempts to capture and consolidate these approaches, best practices, and recommendations into a single reference document for the DoD. It is a living document and will be updated periodically to ensure that direction captured from governing documents is current and best practices are fresh.

This guidebook is intended to be used by DoD research and acquisition professionals conducting prototyping projects along the full spectrums of the science and technology (S&T), research and development (R&D), and acquisition lifecycle domains, including those inside DoD programs of record (PoR), in support of DoD PoRs, and independent of DoD PoRs. This guidebook is also intended to be used as an introductory and reference document by staff officers seeking to increase their knowledge of prototyping.

This guidebook is not policy or directive in nature, and it does not supersede DoD, Military Service, or defense agency policy pertaining to acquisitions or prototyping. It is not a substitute for Defense Acquisition University (DAU) training and it does not describe every activity necessary to be effective.

4 Prototyping Basics

The term "prototype" is defined in numerous ways in DoD, defense industry, commercial industry, and academic literature. All of the definitions have merit, and, not surprisingly, all of them are similar. For the purposes of this guidebook, please use the following definition:

> *Prototype: a model (e.g. physical, digital, conceptual, and analytical) built to evaluate and inform its feasibility or usefulness*

Definitions of other terms pertinent to this guidebook are found in Appendix 2.

4.1 Types of Prototypes.
Prototyping literature discusses numerous types of prototypes—too numerous, in fact, for this guidebook to adequately describe each. The literature also often presents and discusses the types of prototypes in groupings based on specific characteristics of the prototype or the prototyping project. For example, some groupings of prototypes describe their location in a program's life cycle—e.g., conceptual, developmental, production, and operational prototypes. Others describe the level of technology development of the prototyping project—e.g., system-level, subsystem-level, component-level, and technology prototypes. Still others describe the expected final disposition of the prototype itself—e.g., deployable prototypes and disposable prototypes. Regardless of how a prototype is characterized and grouped, the fundamental activities associated with the prototyping process are typically consistent across all types of prototypes. As a result, rather than attempting to address each of these different types of prototypes individually, the guidebook attempts to describe the ubiquitous activities associated with most (if not all) types of prototypes.

4.2   Why Prototype?

4.2.1   Purpose for Prototyping.

A review of prototyping literature reveals a nearly endless list of reasons why S&T, R&D, and acquisition professionals conduct prototyping projects. Table 1 lists a select subset of relevant reasons found in literature. All of these reasons can be synthesized into one fundamental purpose: to generate information that supports a decision.

Table 1: Example Reasons in Literature for Prototyping

- Reduce technical risk
- Validate designs and feasibility of design concepts
- Obtain early feedback from warfighter
- Refine performance requirements
- Identify cost drivers and obtain information on potential costs
- Investigate integration challenges
- Identify potential reliability and sustainability issues
- Validate new ways of using fielded equipment and technologies
- Validate changes to how systems are employed
- Verify analytical models

These decisions take place along the full spectrums of the S&T, R&D, and acquisition lifecycle domains. Some decisions occur at formal milestones while others are simply made by program and project managers (referred to as PMs for the remainder of the guidebook) in the course of managing their projects. These decisions are often expressed in the form of a question, or directly

Table 2: Example Questions that Prototyping Projects Answer

- Are the requirements technically feasible?
- What are the necessary or potential tradeoffs required between requirements?
- Is this technology ready to move to the next phase of development or production?
- Can the end item be manufactured affordably?
- Is the Concept of Operations (CONOPS) valid?
- Can we rely on the model? Do we have confidence that the model accurately reflects reality?
- Is the technology (or capability) ready to become a PoR or be integrated with an existing PoR?

supported by an answer to a question, and cover a wide spectrum of topics, including decisions related to the prototype's technology, program management challenges, and how the technology is to be employed. Examples of some of these questions can be found in Table 2. Prototyping projects should be designed to generate data sets that support a specific decision.

4.2.2   Benefits of Prototyping.

In addition to the reasons S&T, R&D, and acquisition professionals choose to prototype, the literature also identifies numerous benefits that can be recognized from prototyping.

4.2.2.1   Rapid Learning.

Prototyping can enhance rapid learning through the use of the "test-analyze-fix-test" (TAFT) approach to capability development. Using this approach, prototypes undergo repetitive iterations of the TAFT process as long as funding and schedule permit or until the desired performance is achieved or the purpose is realized. This approach helps reveal problems early and enables developers to evaluate the modifications they make to mitigate the problems.

4.2.2.2   Accelerated Demonstration.

Prototyping can be used to demonstrate the value of new concepts, technologies, components, systems, and applications earlier in the technology development process than would have been possible if the final development article was used for testing.

4.2.2.3 Rapid Delivery of Capability to the Field

Prototyping can also be used to develop and demonstrate solutions to existing and emerging operational capability gaps. When these prototypes are deemed viable solutions, they are often left in the field to be used by operators as solutions to their pressing needs.

4.2.2.4 Fail Fast, Fail Cheap to Learn Fast and Save Money.

"Fail Fast, Fail Cheap" is a term of art that the prototyping community uses to describe the great value of prototyping. Dr. Griffin echoed that philosophy in his April 18, 2018 statement to Congress. Rather than avoiding failure, Dr. Griffin encourages the Department to adopt a "willingness to learn from failure" as it uses prototyping and experimentation to quickly deliver innovative solutions.[7] This philosophy seeks to use the simplest and least expensive representative model possible (rather than an expensive final development article) to quickly determine the value of an approach, concept, or technology through incremental development and evaluation. When testing reveals something isn't working as expected or desired (i.e., a "failure"), the prototype design can either be modified and reevaluated, or decision makers can pivot to a different approach. The faster prototyping "fails," the faster learning can occur, and the faster decisions can be made regarding the next appropriate step in the development or innovation process. "Failing fast" with prototyping enables the DoD to drive down technical risk, inform requirements, and ensure an integrated and interoperable capability before either weighing down the research and engineering phase of an acquisition with costly procurement decisions or weighing down a procurement program with costly technical risk.

4.3 Prototyping Tools.

The increased use of prototyping within and outside of DoD in recent years is partially attributable to the tools and methods available today that enable the rapid building, testing, rework, and retesting of prototypes as many as several times each day. The following are brief summaries of some of the common tools that can be used for physical and virtual prototypes.

4.3.1 Prototyping Tools for Physical Prototypes.

4.3.1.1 Additive Manufacturing (AM).

Often referred to as three-dimensional (3D) printing, AM reads in data from a Computer-Aided Design (CAD) file and adds successive layers of liquid, powder, or other material layer-by-layer to build a 3D object. Common materials used for AM include plastic, metal, and concrete.

4.3.1.2 Computer-Aided Design (CAD).

Mainly used for detailed engineering of 3D models or 2D drawings of physical components, CAD enables designers to use computer systems to help them design products. Benefits of CAD include lower product development costs and a shortened design cycle.

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[7] *Technology Transfer and the Valley of Death: Statement Before the U.S. Senate Subcommittee on Emerging Threats and Capabilities of the Committee on Armed Services,* 115th Cong. (2018) (statement by Michael D. Griffin, Under Secretary of Defense for Research and Engineering (USD(R&E)), 1, https://www.armed-services.senate.gov/imo/media/doc/Griffin_04-18-18.pdf.

4.3.1.3 Hardware-In-The-Loop.

Hardware-In-The-Loop is a tool that uses simulation to test physical prototypes. Real signals from the prototype are transmitted through input/output devices of a test system that simulates a fully assembled product, enabling test and design cycles to occur as though the real-world system is being used.

4.3.2 Prototyping Tools for Virtual Prototypes.

4.3.2.1 Advanced Modeling and Simulation (AMS).

AMS is a tool that uses advanced computing capabilities to create models and simulations that closely align with actual physical systems. AMS allows the user to not only observe physical processes in order to gain a better understanding of what happens and how it happens, but it also creates new ways of studying the physical processes that occur.

4.3.2.2 Artificial Intelligence (AI).

AI is the science pertaining to machines mimicking cognitive functions that are typically associated with the human mind, such as "learning" and "problem solving". AI works by combining large amounts of data with fast, iterative processing and intelligent algorithms that allows the software to learn automatically from patterns or features in the data, making it possible for machines to learn from experience, adjust to new inputs, and perform human-like tasks.

4.3.2.3 Machine Learning (ML).

ML is a type of AI that is based on software programming of statistical techniques that give computer systems the ability to "learn" with data and build analytical models, with minimal human intervention. ML enables users to automatically produce models that can quickly and accurately analyze large, complex sets of data.

4.3.2.4 Augmented Reality (AR).

AR is an interactive experience that layers virtual information over a live camera feed into a headset or through a smartphone or tablet device giving the user the ability to view 3D computer-generated images superimposed on the physical world. AR can also be used to identify changes needed in the system design, CONOPS, or other inputs without the need to manufacture a physical prototype.

4.3.2.5 Mixed Reality (MR).

MR brings together real-world and digital elements that allow the user to see and immerse themselves in the physical world around them as they interact with a virtual environment. With MR systems, the user interacts with and manipulates both physical and virtual items and environments using next-generation sensing and imaging technologies.

4.3.2.6 Virtual Reality (VR).

VR is an interactive computer-generated experience that takes place within a simulated environment, providing users with visual, auditory, and other types of sensory feedback on the use of a simulated system. Similar to AR, VR can be used to identify changes needed in the system design, CONOPS, or other inputs without the need to manufacture a physical prototype.

4.4 Cultural Implications for Prototyping.

While prototyping is a useful tool in the S&T, R&D, and acquisition professionals' toolbox when used appropriately, concepts such as "Fail Fast, Fail Cheap" run counter to the culture of success within DoD's acquisition community. The NDS points out that DoD's over-optimized processes hinder timely delivery of capability to the Joint warfighter. These processes have inculcated a level of risk aversion that hampers the use of prototyping to inform decisions.[8] In its report, "Weapon Systems: Prototyping Has Benefited Acquisition Programs, but More Can Be Done to Support Innovation Initiatives" (GAO-17-309), the Government Accountability Office (GAO) states that "DoD has become increasingly risk averse" and further asserts that risk aversion stifles innovation.[9]

One way of mitigating this risk-averse culture is institutionalizing a new definition of what constitutes prototyping "success" and "failure." Quite simply, since at its core prototyping is meant to generate a data set to inform a future decision, a prototyping project "succeeds" if it provides that data set—even if the prototype itself does not work as it was intended to work. Likewise, a prototyping project that does not generate a data set to inform a future decision "fails." Perspectives of "success" and "failure" in prototyping should

> *"Everyone wants innovation, but innovation is messy. If the department is really going to succeed at innovating, we are going to have to get comfortable with people making mistakes."[10]*
>
> *Patrick M. Shanahan, Deputy Secretary of Defense*

have less to do with the prototype itself and more to do with the data that the prototyping project generates. The reality is that, by their nature, prototypes should be expected to "fail" frequently—that's part of the prototyping and learning process. Some might question then: what is the benefit of developing something that fails? It is the concept of "Fail Fast, Fail Cheap" that provides the justification for exploring technology development that subsequently fails to perform.

Consider the following example of a successful prototyping project designed to "fail fast" and "fail cheap." In the 1970s, IBM was exploring the development of speech-to-text technologies; however, the computer hardware of the time lacked the computing power to even build a rudimentary functioning prototype. So, before making the substantial investments required to accelerate the hardware development, they first needed to answer the fundamental question: would consumers find the technology useful enough to pay for it? In order to answer that question, the developers designed a very simple prototype. First, they placed a computer

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[8] Mattis, 10.

[9] Michael J. Sullivan, *Weapon Systems: Prototyping Has Benefited Acquisition Programs, but More Can Be Done to Support Innovation Initiatives,* GAO-17-309 (Washington, DC: U.S. Government Accountability Office, 2017), 22. https://www.gao.gov/assets/690/685478.pdf.

[10] Patrick M. Shanahan, Deputy Secretary of Defense, quoted in *Accelerating New Technologies to Meet Emerging Threats: Testimony before the U.S. Senate Subcommittee on Emerging Threats and Capabilities of the Committee on Armed Services,* 115th Cong. (2018) (testimony of Michael D. Griffin, Under Secretary of Defense for Research and Engineering (USD(R&E)), 9-10, https://www.armed-services.senate.gov/imo/media/doc/18-40_04-18-18.pdf.

monitor and a microphone in a room. In a second room, they placed the microphone's speaker alongside a typist with a keyboard that was connected to the monitor in the first room. They then asked random IBM employees to speak into the microphone and observe the monitor. The typist in the second room typed what they said, and the text appeared on the monitor in the room with the IBM employee. The employee was then asked the question: If they had a device in their office that could automatically do what just happened, would they find that useful in their daily activities? The answer was a resounding yes, a response validated by the now ubiquitous nature of speech recognition applications throughout our day-to-day lives. While admittedly this example did not fail, it was still very fast and very cheap; and it helped justify the subsequent investments made in the technology.

In order to show that prototyping projects that fail to deliver a capability actually succeed in their intended purpose, developers must clearly identify up front the purpose of the prototyping project, what information is going to be learned, and the value of that information. That way, even if the prototype fails, the developer can point to the metrics of success identified during the planning process to justify the expenditure and demonstrate how, while the prototype may have failed,

> *"All too often, we punish program managers because they take something out to the desert and they flight test it and it breaks. Until I was 40, I was closely involved with hardware development. I will tell you, it is really hard to get it right the first time. You have to have that freedom to take on new challenges, take new risks, let things break, figure out why, and move on to the next step without punishing the young folks who you want to learn all those lessons. There is no more critical step than that to me, sir. That is how we can establish a new culture of speed and innovation."* [11]
>
> *Dr. Michael D. Griffin, USD(R&E)*

the prototyping project succeeded. For instance, consider a development effort that calls for a missile propulsion system to deliver the same speed with a 15% reduction in size. Full development of the propulsion system is estimated at $10M and will take one year; but the developers believe they can build a benchtop model using existing systems to assess technical feasibility for $1M and in four months. While the developers state that the benchtop model will have no additional use (it will be disposed of), they also estimate that, if the benchtop model succeeds, the lessons learned will help accelerate development of the full propulsion system by two to three months. Based on these parameters, if the benchtop model fails, the program will save $9M in cost avoidance and eight months development time. However, if the model succeeds, while the cost increases to $11M and the schedule by one to two months, the prototype significantly reduced performance risk by better ensuring successful development of the full system.

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[11] Griffin, testimony on *Accelerating New Technologies*, 21-22.

Institutionalizing new definitions of what constitutes prototyping "success" and "failure" and adopting the "Fail Fast, Fail Cheap" approach to prototyping is foundational to "foster[ing] [the] culture of experimentation and calculated risk-taking" called for in the NDS.[12]

5 Prototyping Activities

Even though every prototyping project is unique, there are several fundamental activities that must be addressed to ensure that any prototyping project achieves its purpose. These fundamental activities also apply to projects that follow traditional acquisition processes. However, due to the accelerated time-horizons that prototyping projects strive to satisfy and that are called for in new congressional authorities, these activities will often be much more abbreviated for prototyping projects (e.g., in documentation content and in duration of time). This section describes each of these activities and provides recommendations for each based on best practices captured from organizations in the prototyping community.

5.1 Identifying Military Capability Gaps for Prototyping Projects.
Prototyping should start with a clear understanding of why the prototype is being developed. For projects in which the objective is to push the boundaries of technology, the purpose could come in the form of a statement of intent by the researcher or an emerging need not yet formally recognized by the Department. However, for projects seeking to directly support an operational mission, the purposes will come in the form of an identified existing or emerging military capability gap.

Military capability gaps can be obtained from numerous sources. Certainly, the most obvious are validated requirements that are documented through formal processes. Examples include requirements listed in approved Joint Capabilities Integration and Development System (JCIDS) documents and strategic needs recorded in the following documents:

- The 2018 National Defense Strategy;
- The USD(R&E)'s Road to Dominance modernization priorities;
- The Chairman's Risk Assessment; and
- The Joint Requirements Oversight Council-led Capability Gap Assessment.

Formal requirements also include capability gaps that have been validated by Components or the Joint Staff (JS) and documented by Joint or Military Services' requirements processes, such as Integrated Priority Lists (IPL) and Initial Capability Documents. In addition, for urgent requirements, warfighters can use their Components' urgent needs processes or work through the JS' urgent needs process in which Combatant Commands (CCMD), the Chairman of the Joint Chiefs of Staff, or the Vice Chairman of the Joint Chiefs of Staff can submit Joint Urgent Operational Needs Statements and Joint Emergent Operational Needs Statements.

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[12] Mattis, 7.

Unlike formal acquisition programs, however, prototyping is often not bound by traditional Joint or Military Service requirements processes. In fact, the NDS encourages the use of prototyping prior to defining requirements. In these cases, prototyping projects can be initiated using military capability gaps identified and provided by the warfighter, outside of Joint and Military Services' requirements processes. Sources for these gaps include critical intelligence parameter breaches; emerging needs that are identified through threat, intelligence, and risk assessments; and offsetting or disruptive needs that are identified through experiments, demonstrations, and exercises.

5.1.1   Best Practices for Identifying Military Capability Gaps for Prototyping Projects.
The following are best practices noted by SMEs that pertain to identifying military capability gaps for prototyping projects:

- Not only is it important to understand the military capability gap identified, but PMs should also strive to understand why the gap was identified. This additional level of understanding will help ensure the warfighter's intent is understood, and that the capability developed will fully satisfy the stated capability gap.
- Regardless of whether the project is based on validated and documented requirements or on less formal military capability gaps, nearly all prototyping SMEs agree that close collaboration with members of the requirements community is critical and should begin as early in the project planning phase as possible. This collaboration is important for several reasons. First, personnel in the requirements community can help define, organize, and clarify the project's capability gap. Second, personnel in the requirements community can help identify existing validated requirements that may pertain to the project. Finally, enabling requirements personnel to document the initial capability gaps and refine them as the project progresses can expedite the process if formal requirements are determined to be needed at some point in the future for follow-on production and fielding efforts.

5.2   Planning Prototyping Projects.
Successful prototyping begins with effective planning. For traditional acquisition programs, that usually begins with an acquisition strategy and an acquisition plan. Prototyping projects, however, are not obligated to comply with the same documentation requirements as traditional acquisition programs, and not all of the traditional acquisition content is essential for prototyping projects. Instead, plans for prototyping projects should include only the planning content necessary to effectively execute and manage the project.

The most critical element of a prototyping project plan is a clear, unambiguous purpose statement for the project. This statement should include a clear articulation of the problem/need to be addressed, a description of the future decision to be made, the data set that will be generated by the project, and an explanation of how that data will be used to inform the decision. Often, PMs and approval authorities make the mistake of identifying too many variables for a prototyping project to focus on. Instead, prototyping projects should be designed to focus on answering one question at a time. When that question is answered, if appropriate, the process can be repeated to answer additional questions as many times as time and budget permits. Focusing on multiple questions at one time introduces unnecessary concurrent risks to the project and may result in data that are inaccurately applied to answer the questions.

After the purpose statement is defined, the following foundational planning topics should be considered for the plan:

- **Prototype Description**
- **Funding and Cost:** funding source and execution plan
- **Schedule:** project schedule, including technical stage gates and "go/no-go" criteria
- **Risks:** project risks and plans to mitigate the risks

5.2.1   Best Practices for Planning Prototyping Project.

Prototyping SMEs suggested the following additional topics and considerations for prototyping project plans:

- **Cross-Functional Team (CFT).** At a minimum, decision-makers, operators who identified the capability need, technology experts, and the transition partner should be identified. Points of contact from the requirements, contracting, finance, and developmental and operational testing communities should also be considered.
- **Evaluation Discussion.** A discussion of how the prototype will be evaluated in a relevant environment should be addressed. The evaluation criteria that will be used to determine if the project has accomplished its purpose should also be included.
- **Integration with Existing Systems.** If the project is conducted in support of an existing major defense acquisition program (MDAP) or fielded PoR, the plan should address how the prototype will integrate with the MDAP acquisition strategy or the configuration of a fielded PoR.
- **Intellectual Property and Data Rights.** A clear description of DoD rights to any intellectual property or data generated from the project should be included.
- **Sustainment Considerations.** Sustainment considerations should be addressed for projects that expect to leave a residual capability in the field.
- **Transition Plan.** A discussion of what will happen with the prototype at the conclusion of the project if the project accomplishes its stated purpose should be included. The transition plan should include as much detail as is available, especially the transition partner if known.
- **Waivers and Delegations.** A listing of recommended waivers and delegations required to effectively execute the prototyping project in the shortest possible timeframe while ensuring sufficient project management rigor and oversight should be discussed.

The following are examples of the criteria that three DoD organizations within the Office of the Under Secretary of Defense for Research and Engineering (OUSD(R&E)) use in planning their prototyping projects:

- The Defense Advanced Research Projects Agency (DARPA) uses a set of questions crafted by a former DARPA director, George H. Heilmeier, to help Agency officials think through and evaluate proposed research programs. A slightly modified set of the questions, known as the "Heilmeier Catechism," follow:
    - What are you trying to do? What problem are you trying to solve? (Articulate your objectives using absolutely no jargon.)
    - How is it done today? Who does it? What are the limits of current practice?

- o What is new about your approach? Why do you think you can be successful at this time? (Have you done a first-order analysis of your approach?)
  - o Who cares? If you are successful, what difference will it make?
  - o What are the risks?
  - o How long will it take? How much will it cost? What are the mid-term and final "exams" to check for success?
    - ▪ What does success look like and how will you demonstrate it?
    - ▪ What is your execution plan? How will you measure progress? What are your milestones/metrics? How will your results transition?
- The Rapid Reaction Technology Office (RRTO) uses a high-level prototyping project planning template for its projects. This 3-page template includes the following elements:
  - o Project Description
  - o Objective and Value
  - o Key Participants
  - o Metrics
  - o Project Schedule, Task Descriptions, and Deliverables
  - o Risk Assessment
  - o Spend Plan
- The Joint Capability Technology Demonstration (JCTD) office uses a robust planning process for their projects. Their plans consist of two primary sections (see Table 3). The first, an Implementation Directive, acts as a "contract" among stakeholders. The second section is the Management Plan, a living document that is updated throughout the life of the project.[13]

Table 3: Contents of JCTD's Prototype Plan

Implementation Directive		
• Purpose of the JCTD • Resource commitments • Key objectives	• Roles and responsibilities of parties • Program schedule	• Deliverables • Transition strategy
Management Plan		
• Description • Objective	• Transition strategy	• Risk assessment
Overall Approach • Operational need • Technical approach and system description • CONOPS • Roles and responsibilities of participating organizations • Schedules and critical events • Funding source • Spend plan	**Development Strategy** • Development objectives and goals • Key yearly deliverables • Contracting strategy	**Assessment Strategy** • Demonstration objectives • CONOPS • Demonstration and assessment plan • Critical operating issues and measures of performance • Training requirements • Safety/hazard/ environmental assessments

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[13] Defense Acquisition University, "Joint Capabilities Technology Demonstration: JCTD Project Execution." (briefing charts for JCTD Process and Execution Overview Course, Defense Acquisition University, August 16-18, 2018), 9-11.

5.3 Soliciting Prototyping Project Proposals.

The need to solicit for proposals depends on the dynamics of the project. When a technology or concept solution is already known, this step is not needed. However, as often is the case, the problem statement is drafted without a specific solution in mind. In these cases, reaching out to other DoD sources, industry, academia, and defense labs for solutions to the problem affords the opportunity to uncover potential solutions heretofore untapped. Once the capability need is clearly defined and the prototyping project plan is drafted, the next major activity is soliciting technology solutions that meet the stated need. Prototyping solutions can be obtained from a number of different sources. PMs or Program Executive Officers of other programs may be able to offer solutions. Many national laboratories, defense laboratories, centers of excellence, and other DoD organizations (e.g., U.S. Army's Prototyping Integration Facilities) have organic prototyping capability that should be considered. Another approach is reaching out to DoD Federally Funded Research and Development Centers (FFRDC) and University Affiliated Research Centers that develop prototypes. Finally, industry and other academic institutions are also great sources of innovation and prototypes.

Occasionally, solicitation is unnecessary, as industry and other offerors use internal independent research and development (IRAD) funding or other non-DoD funding sources to develop and submit prototypes to DoD as unsolicited proposals. These proposals should be taken seriously and be evaluated for their applicability in satisfying warfighter gaps.

5.3.1 Soliciting Via FedBizOpps.

When soliciting solutions for warfighting gaps is necessary, however, the Federal Acquisition Regulation (FAR) requires non-sole source business opportunities greater than $25,000 to be accessible electronically by the public through a single government-wide point of entry (GPE).[14] The FAR further instructs contracting officers to access the GPE via the internet using the Federal Business Opportunities website, also known as (aka) FedBizOpps (https://www.fbo.gov)[15]. In addition to common solicitations (e.g., requests for information, requests for proposal, etc.), posting special notices, Broad Agency Announcements, Commercial Area Announcements, and Commercial Solutions Opening (CSO)[16] solicitations to this website is a great way to get solution needs known to the traditional defense industry and traditional academic partners. However, to cast a wider net to include nontraditional defense contractors, FedBizOpps is not sufficient. In discussions with DoD Components that routinely pursue prototyping projects, a number of other options were suggested.

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[14] U. S. General Services Administration, *Federal Acquisition Regulation* (Washington DC: U. S. General Services Administration, 2018), Part 5, Subpart 5.101(a)(1), https://www.acquisition.gov/browsefar.

[15] U. S. General Services Administration, *Federal Acquisition Regulation*, Part 5, Subpart 5.201(d).

[16] Office of the Secretary of Defense, Defense Innovation Unit (DIU), *Commercial Solutions Opening (CSO)*, (Washington DC, 2018), https://www.diu.mil/download/datasets/1988/DIU_CSO_-_2018_Update.pdf.

5.3.2   Soliciting Nontraditional Sources.

5.3.2.1   Defense Innovation Unit (DIU).

DIU is a Joint DoD organization in OUSD(R&E) that connects commercial innovators with defense organizations to rapidly meet Joint warfighter needs. DIU uses their CSO model to solicit solutions from nontraditional vendors. DIU works with its DoD partners to develop short (from a few sentences to a paragraph), broad Areas of Interest (AoI) in laymen's terms that it posts to its website. Interested companies respond directly to DIU with solution briefs in the form of papers (five pages or less) or slide decks (fifteen slides or less).[17] The CSO model is available for use by other DoD components as well. Ultimately, however, the key to DIU's success is the networks they have cultivated that help them identify and encourage nontraditional vendors to respond to DoD AoIs.

5.3.2.2   Defense Consortia.

Defense Consortia are collaborative partnerships between the U.S. Government and a consortium of industry (large and small, traditional and nontraditional companies), non-profit organizations, research institutes, and academic institutions. Consortia are open to any U.S. entity and, depending on the consortium, may include as many as 500 organizations. A consortium is typically focused on a specific technology area or problem set and is managed by a consortium management firm that acts as the primary interface between the government and consortium members. The consortium management firm will work with a government partner to collaboratively develop a needs statement that it will communicate to its members and will assist in the proposal development and contracting actions of its members.

5.3.2.3   Partnership Intermediary Agreements.

Partnership Intermediary Agreements are agreements between the Federal Government and State or local government agencies or nonprofit entities (i.e., intermediaries) that provide intermediary services between a Federal Government organization and small businesses, educational institutions, and laboratories. These public-facing intermediaries help government organizations find, collaborate with, and contract with industry, labs, and academic partners to discover and develop innovative solutions to solve problems that the organization is trying to solve. A good example of a partnership intermediary is SOFWERX, established through a partnership intermediary agreement between the U.S. Special Operations Command and the non-profit Doolittle Institute.[18] Other partnership intermediaries include the Virginia Tech Applied Research Corporation;[19] Defensewerx;[20] the Center for Technology, Research, and

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[17] Office of the Secretary of Defense, Defense Innovation Unit (DIU), *Commercial Solutions Opening (CSO)*, (Washington DC, 2018), 5, https://www.diu.mil/download/datasets/1988/DIU_CSO_-_2018_Update.pdf.

[18] For more information regarding the Doolittle Institute, please refer to https://doolittleinstitute.org/.

[19] For more information regarding the Virginia Tech Applied Research Corporation, please refer to https://vt-arc.org/.

[20] For more information regarding the Defensewerx, please refer to https://defensewerx.org/.

Commercialization;[21] Innovation and Modernization Patuxent River;[22] and the Wright Brothers Institute.[23]

5.3.2.4 Tradeshows, Conventions, and Industry Associations.

Tradeshows, conventions, and industry associations offer great opportunities to discuss problems and mission needs and to announce new requirements, interest in new technologies, and rapid acquisition plans for the procurement of commercial-off-the-shelf technology, prototypes, or services.

5.3.2.5 Social Media and On-Line Resources.

Several SMEs recommended the use of social media and on-line resources as solicitation venues. Social media outlet user groups (e.g., LinkedIn, Facebook, etc.) offer great access to targeted technology networks where nontraditional innovators may have a presence. Posting solicitations to these groups may generate solutions from innovators who otherwise would not have responded to traditional DoD solicitation approaches. Another option is to use crowd-sourcing sites (e.g., InnoCentive) to generate innovative ideas. These approaches may produce some very viable innovative solutions, but they may also spawn unrealistic or unfeasible solutions. PMs must perform their due diligence in evaluating these potential solutions before investing any resources.

5.3.3 Best Practices for Soliciting Prototyping Project Proposals.

Several SMEs offered the following best practices for soliciting solutions for warfighter gaps:

- When developing solicitations, it is important to remember their intended audiences— especially when pursuing nontraditional defense contractors and academia. PMs should make an effort to translate the warfighter gaps from typical military terminology to technical needs that can be understood by all potential recipients. Any metrics included in the solicitation should also be drafted with the same vocabulary considerations.
- Before publishing solicitations, operations security analyses and public release reviews should be conducted to protect For Official Use Only or other sensitive information from being released to the public.
- Solicitations should include a request that respondents provide whatever data sets they have that support their solution or approach. These data sets will assist in determining the feasibility of the proposed solution.
- If applicable, solicitations should include a statement addressing the possibility of follow-on production.
- PMs should consider binning the needs into functional areas and having technical SMEs in those functional areas put together outlines of things they need to see from vendors for each functional area. These outlines can then be provided as part of the solicitation.

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[21] For more information regarding the Center for Technology, Research, and Commercialization, please refer to https://www.c-trac.org/.

[22] For more information regarding Innovation and Modernization Patuxent River, please refer to https://impax.tech/.

[23] For more information regarding the Wright Brothers Institute, please refer to https://www.wbi-innovates.com/.

- The targeted commercial marketplace should be researched to identify venues and techniques typically used by that marketplace for soliciting specific needs. Potential venues and techniques include catalogs, product directories, trade journals, seminars, professional organizations, contractor briefings, meetings and conversations with companies, in-house experts, on-line resources, social media, and vendor surveys.

5.4   Selecting Prototyping Projects.

Selecting the right prototyping project to pursue is the next step in the process. To identify the most promising, innovative, and cost effective prototyping project, selection criteria that clearly address the purpose or objective of the project should be established. Prototyping projects should use criteria that address the future decision to be made and the data needed to make that decision. Selection criteria common to most projects include some variation of cost (e.g., are the costs reasonable?), schedule (e.g., how long will this project take to complete?), and performance measures (e.g., is the technical approach achievable?). These criteria can be tailored and other criteria added as appropriate to meet the needs of the project.

5.4.1   Best Practices for Selecting Prototyping Projects.

The following are examples of selection criteria that defense organizations have used to select prototyping projects.

- The Joint Special Operations Command (JSOC) Capability and Technology Evaluation (JCTE) team annually invites industry to submit solutions that address JSOC's Technology Interest Areas and compete for Cooperative Research and Development Agreements (CRADA). The JCTE Team uses the following major criteria areas to assess submissions. Each of these major criteria areas has six possible responses, weighted 0-5.[24]
    - Operational Relevance: Does the submission address a known gap?
    - Technical Merit: What level of supporting data accompanies the submission?
    - Deliverable: Will this be a paper product or a product for operational use?
    - Internal IRAD-to-Date: What level of funding has been invested in this proposed project to date?
    - Planned Future IRAD: What level of IRAD funding is planned to complete the project?
    - Schedule: Will this project be completed in less than 6 months or will it take longer than 24 months?
- The Rapid Prototyping Program (RPP) established criteria according to three guidelines—strategic, implied, and other guidelines. Their specific criteria are found in Table 4.

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[24] "JCTE 2017 CRADA Assessment Criteria" (working paper, 2017).

Table 4: RPP Selection Criteria

Strategic Guidelines	Implied Guidelines	Other Guidelines
- Is the proposal aligned to strategic guidance (NDS, Capability Gap Analysis, "Blueprint")? - Does the proposal improve core Service/Agency competencies? - Does proposal inform requirements for existing or future PoRs? - Does the proposal reduce or drive down technical and integration risk?	- Is the proposal innovative? - Are risk and reward balanced? - Are the cost and schedule realistic for the proposed performance? - Does the proposal provide a clear transition path/post prototyping plan? - Does the proposal have real warfighters for CONOPS development?	- Is the proposal joint or crosscutting? - Does the proposal involve multi-domain implementation? - Does it have partner contribution? - Will the proposal improve core competencies?

5.5   Project Management.

Once selected, prototyping projects and their risks must be effectively managed. Specific guidance on project management and risk management methods and tools can be found in DAU's Defense Acquisition Guidebook and other program management resources.[25]

5.6   Evaluating Prototypes.

In most cases, the most important step in the prototyping process is evaluating the prototype. In fact, prototypes are often built specifically for the evaluation activity, and will be discarded after the evaluation. Evaluations should be designed and conducted in a way that addresses the purpose of the prototyping project. Evaluations typically come in three forms: demonstrations, experimentation, and red teaming. The following paragraphs summarize each evaluation form. For prototypes that transition or integrate into MDAPs, FAR requirements for developmental testing and operational testing still apply.

5.6.1   Demonstrations.

Demonstrations are evaluations specifically designed to determine if a prototype can do what it was developed to do. The desired outcome of a demonstration may be a "ready to fight" capability for the warfighter.

5.6.2   Experimentation.

Experimentation is an evaluation method that uses prototypes to test hypotheses. Rather than simply demonstrating that a capability meets the need it was built to meet, experimentation stresses the technology to identify its full capability and limitations. In addition to evaluating the technical feasibility of a prototype, experimentation can also verify military utility and help in the development of preliminary CONOPS and Tactics, Techniques, and Procedures (TTPs) for emerging technological capabilities. Modeling and simulation is an excellent tool for experimentation.

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[25] Defense Acquisition University, *Defense Acquisition Guidebook*, Defense Acquisition University, 2018, https://www.dau.mil/tools/dag.

5.6.3 Red Teaming.

Red teaming is an effort, often performed by an independent organization, to identify potential vulnerabilities to the U.S. warfighter and to seek ways to make emerging technologies more secure. Red teaming is typically used for the following purposes:

- To identify an adversary's vulnerabilities and develop approaches to exploit them.
- To investigate how an adversary might use emerging and trending technologies. This approach can help identify vulnerabilities of U.S. CONOPS and technology, but can also be used to identify ways of defeating emerging technologies.
- To inform design choices early in a technology's development cycle in an attempt to minimize vulnerabilities of U.S. systems or take advantage of the vulnerabilities of adversary systems.
- To discover unconventional approaches that an adversary may use to counter DoD technologies and CONOPS. This includes not only technological adaptation, but also potential changes to their TTPs that could have cascading effects on our TTPs.

5.6.4 Relevant Environment.

All evaluations should be conducted in a manner and at a venue that provides an environment relevant to the decision that the prototyping project is intended to inform. Not all relevant environments are operational environments. Depending on the decision, the relevant environment could be a laboratory bench, a wind tunnel, a test and evaluation facility, a VR environment, a commercial environment, or an operational field exercise—to name just a few. The key is to ensure the environment is relevant to the decision being informed. However, if the ultimate plan is to transition the prototype to operational use by the warfighter, the relevant environment must include putting the prototype in the hands of a warfighter in an operationally representative environment. This ensures that the prototype can be successfully used by a warfighter in an operational context to meet their capability need. In fact, Congress mandated that fieldable prototypes developed under the authorities in Section 804 of the FY16 NDAA (referred to as "Middle Tier Acquisition" authorities for the remainder of the document) be demonstrated in an operational environment.[26]

5.6.5 Cost of Organizing and Hosting Prototype Evaluations.

The type of evaluation conducted and the level of realism pursued will determine the effort and cost associated with the evaluation. The more realistic the environment simulating the capability gap for which a prototype is being evaluated, the greater the effort and higher the cost of organizing and hosting the evaluation. In some cases, organizations will offer evaluation events to a large number of technology projects seeking to be transitioned to operational use by the warfighter in order to maximize the efficiency of the event as well as to ensure that the evaluation addresses as many of the doctrine, organization, training, materiel, leadership and

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[26] National Defense Authorization Act for Fiscal Year 2016, Pub. L. No. 114-92 § 804, 129 Stat. 883 (2015). https://www.gpo.gov/fdsys/pkg/PLAW-114publ92/pdf/PLAW-114publ92.pdf.

education, personnel, facilities, and policy (DOTMLPF-P) domains of the warfighter's capability gap as possible.

5.6.6   Best Practices for Evaluating Prototypes.
This subsection captures best practices recommended for evaluating prototypes.

- Planning evaluations should begin as early in the planning process as possible to ensure that the type of evaluation and the environment will provide the data and information needed to satisfy the prototyping project's purpose.
- The end user of the prototype and testing professionals should be included in developing the scope, objectives, approach, and schedule of the prototype project evaluation.
- Including independent assessors to help plan and conduct evaluations and/or analyze the data generated should be considered.
- For prototypes that are intended for transition to operational use, product quality and risk factors should be assessed.

5.6.7   Examples of DoD Evaluation Venues.
This subsection provides a representative sample of DoD evaluation venues. Participants in these events are typically responsible for covering their own costs.

5.6.7.1   Advanced Naval Technology Exercise (ANTX).
The Naval Undersea Warfare Center Division Newport conducts the annual ANTX, which provides a maritime demonstration and experimentation environment that targets specific technology focus areas or emerging warfighting concepts with a goal of getting potential capabilities out to the warfighter in 12 to 18 months. ANTXs are low-barrier-to-entry, loosely scripted experimentation events where technologists and warfighters are encouraged to explore alternate tactics and technology pairings in a field or simulated environment. Participants receive feedback from government technologists and operational SMEs. ANTXs are hosted by labs and warfare centers from across the naval R&D establishment.

5.6.7.2   Army Expeditionary Warrior Experiment (AEWE).
The Army Maneuver Center of Excellence conducts an annual AEWE campaign of experimentation to identify concepts and capabilities that enhance the effectiveness of the current and future forces by putting new technology in the hands of Soldiers. AEWE is executed in three phases—live fire, non-networked, and force-on-force—providing participants the opportunity to examine emerging technologies of promise, experiment with small unit concepts and capabilities, and help determine DOTMLPF-P implications of new capabilities.

5.6.7.3   Chemical Biological Operational Assessment (CBOA).
CBOAs are scenario-based events that support vulnerability and system limitation analysis of emerging capabilities in chemically- and biologically-contested environments. These live field experiments, conducted at operationally relevant venues, provide an opportunity for technology developers to interact with operational personnel and determine how their efforts might support military capability gaps and high priority mission deficiencies. CBOAs are sponsored by the Defense Threat Reduction Agency's Research and Development-Chemical and Biological Warfighter Integration Division.

5.6.7.4 [Hanscom Collaboration and Innovation Center (HCIC) PlugTests](#).

The Hanscom Air Force Base HCIC provides a custom-built Hanscom milCloud environment that enables the Air Force to evaluate cutting-edge advances in defense applications, cyber security, public safety, and information technology. PlugTests conducted at the HCIC enable vendors to demonstrate their systems on accessible military networks and make modifications in real-time. PlugTests also place prototypes directly in the hands of the operators, facilitating operator feedback prior to a contract award.

5.6.7.5 [Joint Interagency Field Experimentation (JIFX)](#).

The JIFX program conducts quarterly collaborative experimentation in an operational field environment using established infrastructure at Camp Roberts and San Clemente Island. JIFX experiments provide an environment where DoD and other organizations can conduct concept experimentation using surrogate systems, demonstrate and evaluate new technologies, and incorporate emerging technologies into their operations. JIFX is run by the Naval Postgraduate School.

5.6.7.6 [Joint Warfighting Assessment (JWA)](#).

JWA is an annual exercise that seeks warfighter feedback on concepts and emergent capabilities required for the Joint Force. JWA focuses on experimentation of technologies and operational concepts in the Joint warfighting environment.

5.6.7.7 [Simulation Experiment (SIMEX)](#).

SIMEX is a virtual environment for early stage experimentation that uses real Command and Control systems, simulated weapons and sensors, and real military and civilian operators executing various crisis action scenarios to explore technology, system interoperability, CONOPS, and TTPs. SIMEX is run by an FFRDC.

5.6.7.8 [Stiletto](#).

Stiletto is a flexible and responsive maritime platform that provides short notice demonstration and experimentation capability for innovators to use in evaluating operational utility and performance of new concepts and prototypes in coastal and riverine warfare. It is sponsored by RRTO and operated by Naval Surface Warfare/Combatant Craft Division at Little Creek, VA.

5.6.7.9 [Thunderstorm](#).

Thunderstorm is a demonstration and experimentation venue that enables innovators to demonstrate their technologies in a realistic scripted or unscripted environment and facilitates interaction between innovators and warfighters around a specific technology or warfighter use case. Thunderstorm is sponsored by RRTO.

5.7 Transitioning Prototypes.

5.7.1 Transition Pathways.

The measure of a successful prototyping project is whether or not the project generates the information necessary to support a specific decision. If the project does not successfully generate the necessary information, two transition pathways exist:

- The prototype is returned to the technology base for further development and evaluation.

- The prototyping project is terminated, lessons learned are documented, and the prototype is discarded.

However, if the project does successfully generate the necessary information, most SMEs agree on the transition pathways described in subsections below.

5.7.1.1 Prototype is Discarded.
Most often, the prototype built is a minimum viable product—the simplest and least expensive prototype possible that answers the required question. These prototypes will have limited utility after the project is completed and will, therefore, be discarded at the conclusion of the project, and the prototyping project will be terminated.

5.7.1.2 Prototype is Returned to the Technology Base.
Some prototypes that successfully generate the data sets needed to answer a question can be modified or reused to answer other questions. These prototypes will be returned to the technology base for modification and further evaluation. Other successful prototypes may demonstrate operational utility, but are not needed immediately for operations. These prototypes should be returned to the technology base and catalogued for potential future operational use.

5.7.1.3 Transition to Operational Use.
In some cases, at the conclusion of the project, prototypes will transition to operational use to address an existing critical warfighter capability gap. This fielded capability can either be an interim solution (i.e., until a PoR capability is fielded) or a final capability solution. In these situations, early collaboration between the innovator, PM, and warfighter is essential to clearly understand the operational need, establish the criteria that defines a successful demonstration in an operational environment, and develop an appropriate sustainment package (e.g., standard operating procedures, training requirements, etc.) to be delivered with the prototype. Identification of the transition partner and collaboration with them at the start of the planning phase and throughout the project is critical to success.

5.7.1.4 Transition to Rapid Fielding.
The Middle Tier Acquisition pathway authorizes a rapid fielding pathway for prototypes that meet the following criteria:

- The prototype meets a high-priority warfighter need or reduces the lifecycle cost of a weapon system.
- The original prototyping project was successfully completed.
- The prototype was demonstrated in a relevant environment.

Production, using this pathway, is expected to begin within six months and be completed within five years of the development of an approved requirement.[27]

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[27] National Defense Authorization Act for Fiscal Year 2016, § 804, 129 Stat. 883.

5.7.1.5 Integration Into an Existing Program.

Some prototyping projects are designed to develop new technology that will integrate into an MDAP or an existing fielded PoR as a component or subcomponent of the larger system. In these situations, early collaboration between the prototyping project PM, the PM of the receiving MDAP or PoR, and the innovator is essential to ensure integration and interoperability success.

5.7.1.6 Transition Technology to a New Acquisition Program.

Some prototyping projects will transition into their own FAR-based acquisition programs. These new programs will most likely be subject to the tailorable requirements of DoD Instruction (DoDI) 5000.02 and the JCIDS process. If this pathway is expected from the outset of prototyping project planning, it would be prudent to begin planning and coordinating the transition as early as possible with appropriate DoD and Military Services process owners and drafting the appropriate artifacts required by traditional acquisition processes.

5.7.2 Transition Planning.

Planning the transition should be initiated as early as possible. Early employment of CFTs, discussed in the "Prototyping Project Planning" section, can also help bridge the "valley of death" (the gap between technology development and production where promising technologies often "die" due to inappropriate or insufficient funding) by ensuring necessary resources are identified to facilitate the transition of high-priority programs. Transition plans should include, as appropriate, the transition approach, the transition partner, supportability requirements, data rights, funding approach, and specific testing or demonstration criteria required by the transition partner. This plan should be updated in collaboration with the transition partner throughout the project's period of performance.

5.7.3 Best Practices for Transitioning Prototypes.

The following best practices were recommended for transitioning prototypes:

- To increase the likelihood that a prototyping project will transition as planned, a transition agreement between the PM and the transition partner should be drafted within the first year of the project and all affected parties should sign the agreement.
- PMs that transition prototypes to operational use or rapid fielding should ensure the capability is safe for the warfighter, suitable for the mission, and supportable.
- A configuration baseline (e.g., level 2 drawings) should be established for prototypes that transition to rapid fielding.

6 Legally-Binding Agreement Vehicles for Prototyping Projects

The 2018 NDS identifies prototyping as a tool that can help streamline the process of developing capabilities and delivering them to the warfighter. An advantage to prototyping (especially when using the Middle Tier Acquisition authorities and the authorities in Section 806 of the FY17 NDAA (referred to as "Acquisition Agility" authorities for the remainder of the guidebook)) is

the speed at which innovation can be delivered to meet a warfighter need.[28] One of the impediments to speed, though, is the length of time it typically takes to get an effort on contract using traditional FAR-based contracting practices.

While significant improvements have recently been made in accelerating contracting actions, the most straightforward means of mitigating the schedule risk associated with traditional contracting is to avoid the contracting process altogether by seeking prototyping solutions from other Federal Government organizations (e.g., program offices, national laboratories, defense laboratories, centers of excellence, and other DoD organizations (e.g., Army's Prototyping Integration Facilities)). When this route is not feasible or the technology under consideration is not available from a Federal Government organization, other legally binding agreement vehicles should be considered to mitigate this risk. This section explores a number of expedited contracting and non-contracting vehicles that are available for contracting officers to use on prototyping projects.

PMs should express the urgency of their project to their contracting authority and work with them to structure an appropriate contracting strategy for their effort.

6.1   Other Transaction (OT) Authorities.

OTs are legally binding vehicles that can be used to carry out prototyping projects that meet the stipulations set forth in the law. OT authorities allow the Government to enter into flexible and innovative agreements other than procurement contracts, grants, or cooperative agreements. There are two OT authorities:

- 10 U.S. Code (U.S.C.) § 2371 – The FY90/91 NDAA (Public Law 101-189) authorized the use of OTs to carry out basic, applied, and advanced research projects (aka OTs for Research or Technology Investment Agreements).[29]
- 10 U.S.C. § 2371b – In the FY16 NDAA, Congress expanded the authority to include prototyping projects that are directly relevant to enhancing the mission effectiveness of military personnel and the supporting platforms, systems, components, or materials proposed to be acquired or developed by DoD, or to improvement of platforms, systems, components, or materials in use by the armed forces (aka OTs for Prototypes).[30]

Agreements under both authorities are generally not subject to the federal laws and regulations governing procurement contracts or assistance arrangements. As such, they are not required to comply with the FAR, its supplements, or laws that are limited in applicability to procurement

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[28] National Defense Authorization Act for Fiscal Year 2017, Pub. L. No. 114-328 § 806, 130 Stat. 2256 (2016). https://www.congress.gov/114/plaws/publ328/PLAW-114publ328.pdf.
[29] National Defense Authorization Act for Fiscal Years 1990 and 1991, 10 U.S.C. § 2371 (1989). https://www.law.cornell.edu/uscode/text/10/2371.
[30] National Defense Authorization Act for Fiscal Year 2016, 10 U.S.C. § 2371b (2015). https://www.law.cornell.edu/uscode/text/10/2371b.

contracts, grants, or cooperative agreements and can usually be exercised quickly and with less complexity than traditional contracts.[31]

Congress also authorized the use of follow-on production OTs for prototypes that are developed and successfully completed under the authorities detailed in 10 U.S.C. § 2371b.[32]

6.2   Procurement for Experimental Purposes.

10 U.S.C. § 2373 provides the Secretary of Defense and the Secretaries of the Military Departments the authority to buy parts, accessories, designs, and other supplies for ordnance, signal, chemical activity, transportation, energy, medical, space-flight, and aeronautical systems needed for experimental or test purposes.[33] The FAR and DFARS do not apply to this procurement authority, and contracts or agreements can be competitively or non-competitively awarded.[34]

6.3   Indefinite Delivery, Indefinite Quantity (IDIQ) Contract.

An IDIQ vehicle provides contracting officers with the flexibility needed when the exact quantity of a product or service is not known at the award of the contract. With "multiple award" IDIQs, multiple vendors are awarded the opportunity to compete for work that is added to the contract through task orders. Contracting officers can award task orders to a single awardee under specific exceptions covered in the FAR. IDIQs are popular contracting vehicles for defense S&T laboratories due to their flexibility and agility. If an innovator's prototyping project fits within the scope of an existing IDIQ contract of which the innovator is an awardee, the contracting officer can rapidly add a task order to the contract and award the new task order quickly.

6.4   Small Business Innovation Research (SBIR).

SBIR is a highly competitive three-phase program that funds small businesses to conduct cutting-edge R&D for DoD. The program is intended to encourage U.S. small business innovators to develop and deliver technology that meets warfighter capability needs.

SBIR Phase III is especially beneficial for simplifying the prototyping procurement timeline. The purpose of Phase III is to transition a company's SBIR effort into hardware or software products that benefit the DoD acquisition community or the private sector. Once a company has received a Phase I or II award, Phase III awards can be made at any time to the company using a non-competitive, sole-source process, since competition requirements were satisfied under Phase I or Phase II.

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[31] Claire M. Grady, Director, Defense Procurement and Acquisition Policy, *Other Transactions Guide for Prototype Projects* (Washington DC: Department of Defense, 2017), i. http://www.acqnotes.com/wp-content/uploads/2014/09/Tab-5-OSD-OTA_Guide-17-Jan-2017-DPAP-signature-FINAL-002.pdf.

[32] National Defense Authorization Act for Fiscal Year 2016, 10 U.S.C. § 2371b

[33] National Defense Authorization Act for Fiscal Year 1994, 10 U.S.C. § 2373 (1993), https://www.law.cornell.edu/uscode/text/10/2373.

[34] "Procurement for Experimental Purposes (10 USC 2373)," Defense Acquisition University, accessed May 15, 2019, https://aaf.dau.mil/contracting-cone/10usc2373/.

6.5 Cooperative Research and Development Agreement (CRADA).
CRADAs are written agreements between one or more federal laboratories and one or more non-federal parties under which the government, through its laboratories, provides personnel, facilities, equipment or other resources with or without reimbursement (but not funds) to non-federal parties. The non-federal parties provide personnel, funds, services, facilities, equipment or other resources to conduct specific research or development efforts that are consistent with the mission of the laboratory. This option is a particularly effective tool for partners that are willing to contribute their own IRAD funding for the effort.

6.6 Other FAR-Based Authorities.
A number of other FAR-based authorities exist that allow agencies to reduce transaction costs by reshaping existing processes while still operating within the confines of existing laws and regulations. These pathways can be executed quickly to obtain prototypes. Commercial Item Procurement under FAR Part 12,[35] Micro-Purchases and Simplified Acquisition Procedures under FAR Part 13,[36] and challenges and prize competitions authorized by the 2010 America COMPETES Reauthorization Act[37] and the FY00 NDAA,[38] are tools that can be used for securing innovation and prototypes. Examples of challenge/prize competitions include the following:

- The "incentive prize" tool uses the authorities provided by the America COMPETES Reauthorization Act of 2010 to enable an agency to run a competition where the winner receives a prize for developing a viable solution to solve a government need.
- The "milestone-based competition" process allows agencies to enter into contractual relationships with a qualified pool of contractors and to issue task orders for a series of clear, technically feasible milestones, each with an assigned deadline and monetary value.
- The "rapid technology prototyping" model involves issuance of several contracts for small, inexpensive prototypes to be built within a short period of time (i.e., several months) and then tested in a relevant demonstration scenario to assess the viability of each prior to making a substantial investment.
- The "challenge-based acquisition" model is designed to explore the market and pay only for a successful solution, but is geared towards projects where solutions are likely to already exist as opposed to having to be developed. The key differentiator between challenge-based acquisition and a traditional performance based acquisition is the firm requirement to demonstrate product performance in real-world conditions prior to a major commitment of resources for full production.

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[35] U. S. General Services Administration, *Federal Acquisition Regulation*, Part 12.
[36] U. S. General Services Administration, *Federal Acquisition Regulation*, Part 13.
[37] America COMPETES Reauthorization Act of 2010, Pub. L. No. 111–358 § 105, 124 Stat. 3989 (2011). https://www.congress.gov/111/plaws/publ358/PLAW-111publ358.pdf.
[38] National Defense Authorization Act for Fiscal Year 2000, 10 U.S.C. § 2374a (1999). https://www.law.cornell.edu/uscode/text/10/2374a.

- The "staged contract" method utilizes short concept papers to enable agencies to identify vendors who are most likely to receive an award and to help those who are less likely to receive an award avoid the cost of developing a detailed proposal.

7 Funding Prototyping Projects

Possibly the biggest challenge to experimentation is securing funding for the experiment or to apply the recommendations resulting from the experiment. When the initiation of a prototyping project is stymied or the developed prototype never makes it past the "valley of death" due to inappropriate or unavailable funds, the transformative effect of prototyping can be lost. In its report, "Weapon Systems: Prototyping Has Benefited Acquisition Programs, but More Can Be Done to Support Innovation Initiatives" (GAO-17-309), GAO points out that DoD's funding structure and budget process create challenges both for obtaining funding to start projects and for transitioning projects to the acquisition domain at the conclusion of the project.[39] DoD's rigid funding structure regulates the type of technology development that an organization can pursue.

Likewise, DoD's Planning, Programming, Budgeting, and Execution (PPBE) process makes it difficult for prototyping projects to obtain necessary funding when it's needed. The PPBE process takes nearly two years from the time a funding need is identified to the time funding is available. In the fast-paced world of technology development, this lag in funding can prevent the timely development and deployment of a capability needed to address an emerging threat. DoD is working on developing a more strategic approach to funding innovation. Until that is in place, however, Congress has provided authorities and funded some accounts outside of acquisition programs that can be tapped into for prototyping projects. The following is a summary of some of the funding vehicles and DoD offices that can be looked into as potential funding sources for their prototyping projects.

7.1 Potential Funding Sources.

7.1.1 Department of the Air Force Experimentation Initiative.
The Air Force's Experimentation Initiative conducts experiments to develop operational concepts and investment priorities through wargames, simulation, and field experimentation.

7.1.2 Department of the Army Technology Maturation Initiative (TMI).
TMI funds early prototyping of advanced technologies in support of priority experimentation efforts and future systems acquisition. TMI efforts are intended to mature critical technologies into advanced subsystem/system demonstrators and experimental prototypes that inform requirements document development, analyses of alternatives, and planning for major systems acquisitions.

7.1.3 Department of the Navy Technology Innovation Games.
The Navy established the Technology Innovation Games to conduct Navy-specific experimentation that addresses future challenges. Navy experimenters employ a progression

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[39] Sullivan, 22.

from workshops through various types of wargames and field experiments to fully address the challenge.

7.1.4 Military Services' Rapid Prototyping Fund (RPF).

Congress authorized the Secretaries of each Military Service (including the U.S. Marine Corps (USMC)) to establish department-specific RPF accounts to fund programs that fall under Middle Tier Acquisition rapid fielding and prototyping pathways. To date, these accounts have not received any appropriated funds.

7.1.5 Special Operations Forces (SOF) Advanced Concept Technology Demonstration (ACTD).

ACTDs are capability demonstration and evaluation programs in which the development and employment of technology and innovative operational concepts by military users is the primary focus. ACTDs are intended to exploit mature and maturing technologies to solve important military problems and to concurrently develop the associated CONOPS to permit the technologies to be fully exploited.

7.1.6 SOF Advanced Technology Demonstration (ATD).

The SOF ATD program funds rapid prototyping and ATDs to demonstrate and evaluate the utility of emerging advanced technologies in a realistic operational environment by SOF users.

7.1.7 JS/J7 Warfighting Lab Incentive Fund (WLIF).

WLIF supports field experiments and demonstrations that analyze and provide insight into more effective ways of using current capabilities and to identify new ways to incorporate technologies into future operations and organizations. WLIF was created to support the development and refinement of new Military Service and Joint CONOPS that address emerging warfighting challenges.

7.1.8 JS/J8 Wargaming Incentive Fund (WIF).

WIF grants are used to support analytical wargames such as tabletop exercises, seminars, workshops, and turn-based wargames that directly support senior leader priorities. WIF is managed by J8's Studies, Analysis, and Gaming Division. The division also manages a Wargaming Repository that serves as a great resource for analysts who are developing new wargames.

7.1.9 Office of the Director, Operational Test & Evaluation Joint Test & Evaluation (JT&E) Program.

JT&E assesses Service interoperability in Joint operations and explores potential solutions to identified problems. The goal is to provide non-materiel solutions, such as TTP changes, to solve Joint operational issues in existing capabilities.

7.1.10 Office of the Under Secretary of Defense for Acquisition and Sustainment (OUSD(A&S)) Small Business Innovation Research (SBIR) Program.

By funding small business innovation, the SBIR program encourages small businesses to engage in DoD's R&D efforts. The SBIR budget represents over $1 billion in research funds annually. The SBIR program is managed by the Office of the Under Secretary of Defense for Acquisition and Sustainment's (OUSD(A&S)) Office of Small Business Programs.

7.1.11 OUSD(R&E) Rapid Innovation Fund (RIF).
The purpose of the RIF program is to fund small business innovative technologies that address operational challenges and transition them into defense acquisition programs. The RIF program seeks input from DoD offices to establish the requirements that are included in their annual solicitation. These programs are targeted to cost less than $3 million and complete within 24 months. RIF is administered by OUSD(R&E) and the DoD Office of Small Business Programs.

7.1.12 OUSD(R&E)/Developmental Test, Evaluation & Prototyping (DTEP) Funding Elements
OUSD(R&E)/DTEP has authority over five funding elements focused on identifying, developing, and rapidly delivering prototype capabilities to meet DoD needs. DTEP established a single call for proposals to ease the burden on Service and CCMD staffs seeking solutions to existing and emerging military capability gaps. DTEP manages its prototyping portfolio through a Joint Mission Forum and the Prototyping Senior Steering Group (PSSG) and leverages existing JS processes via the Joint Force Integration Cell (JFIC) to inform stakeholders on DoD-wide prototyping activities within specific mission domains. The PSSG provides recommendations and includes participation from the JS, CCMDs, Services, Agencies, and OUSD(R&E) Assistant Directors for the DoD modernization areas. The programs that follow are managed within OUSD(R&E)'s Prototypes and Experiments office.

7.1.12.1 OUSD(R&E)/DTEP Emerging Capabilities Technology Development (ECTD).
The ECTD program pursues risk-reducing technology prototypes and demonstrations of cutting-edge land, sea, air, and space systems for the Joint warfighter across four lines of efforts: concept development, Joint experimentation, Joint prototyping, and red-teaming. These projects can start any time during the year and are targeted to cost less than $6 million and complete within 36 months. Additionally, the ECTD program funds venues where new technologies and concepts can be evaluated.

7.1.12.2 OUSD(R&E)/DTEP Joint Capability Technology Demonstration (JCTD).
JCTD funds innovative prototyping projects that provide the Joint Force with a decisive technical advantage. The goal of the program is to rapidly develop, assess operational utility of, and transition needed capability to the Joint warfighter. These projects are targeted to cost less than $100 million and to complete within 48 months.

7.1.12.3 OUSD(R&E)/DTEP Quick Reaction Special Projects (QRSP).
The QRSP program funds projects that mature emerging technologies to address immediate conventional and irregular warfare needs of the Joint warfighter. These projects can start any time during the year and are targeted to cost less than $2 million and complete within 18 months.

7.1.12.4 OUSD(R&E)/DTEP Rapid Prototyping Fund (RPF).
The RPF seeks endorsed proposals from DoD Component headquarters for prototyping projects that deliver innovative capability in support of USD(R&E)'s "DoD Road-to-Dominance" modernization priorities. RPF funds projects of significant scope and complexity in the $20M range that are targeted to complete within 5 years. Proposals must demonstrate new capabilities that meet emerging military needs, be demonstrated in an operational environment, and provide a warfighter with residual operational capability.

7.1.12.5 OUSD(R&E)/DTEP Rapid Prototyping Program (RPP).

RPP funds projects that rapidly develop, demonstrate, and deliver fieldable prototypes to meet existing and emergent Joint warfighter needs; drive down technical and integration risk; and generate Joint warfighter feedback that results in affordable and realistic requirements. These projects are targeted to complete within 12 months.

7.2   Defense Offices that Conduct Prototyping.

7.2.1   Department of the Army's Rapid Equipping Force (REF).

REF harnesses current and emerging technologies to provide immediate solutions to the urgent challenges of U.S. Army Forces deployed globally. It also supports priority equipping efforts over a wide range of challenges including solutions for subterranean operations, electronic warfare, unmanned and counter-unmanned aerial systems, intelligence, and expeditionary force protection. Finally, while leveraging existing technologies to meet urgent needs, REF also informs materiel development for the future force.

7.2.2   Military Services' Rapid Capabilities Offices.

All Military Services (including USMC) have been organized with a funded Rapid Capabilities Office (the Navy's is called the Maritime Accelerated Capabilities Office) to expedite the development and delivery of emergent and disruptive prototype capabilities to the field to meet the Military Services' and Combatant Commanders' operational needs.

7.2.3   DARPA's Adaptive Capabilities Office (ACO).

ACO works with the military services to define architectural solutions that combine emerging technologies with new warfighting constructs to address critical national security challenges. These architectures are vetted using a combination of modeling and simulation and a robust campaign of experimentation in order to realize new doctrine, concepts of operations, and technologies that will enable Joint, highly integrated capability sets.

7.2.4   DoD Laboratories.

Referred to as Section 219 authority, Section 219 of the FY09 NDAA (last revised by the FY19 NDAA) provides discretionary spending authority to directors of DoD laboratories enabling them to use a small percentage of their budget to conduct special R&D and technology transfer projects.[40]

7.2.5   Office of the Under Secretary of Defense for Policy Combating Terrorism Technical Support Office (CTTSO).

In collaboration with interagency and international users, CTTSO develops and prioritizes mission requirements to combat terrorism, annually solicits novel rapid prototyping solutions from industry and academia, funds and manages those solutions, and delivers capabilities to accomplish the mission.

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[40] National Defense Authorization Act for Fiscal Year 2009, Pub. L. No. 110-417 § 219, 122 Stat. 4389 (2018), https://www.gpo.gov/fdsys/pkg/PLAW-110publ417/pdf/PLAW-110publ417.pdf.

7.2.6 OUSD(A&S) Joint Rapid Acquisition Cell (JRAC).

Congress gave the Secretary of Defense and Deputy Secretary of Defense statutory authority to rapidly acquire and deploy items to respond to combat emergencies and certain urgent operational needs for emergent or ongoing contingency operations. Congress extended this authority in the FY17 NDAA to include rapid fielding and rapid prototyping. This authority grants the Secretary of Defense and Deputy Secretary of Defense the ability to use funds for higher priority requirements without undertaking a reprogramming action or use of a transfer authority. Up to $200 million in authority is available per FY to DoD Components to support a compelling national security need requiring the immediate initiation of a project under the Middle Tier Acquisition authorities. This authority is administered by OUSD(A&S)'s JRAC.

7.2.7 OUSD(A&S) Office of Small Business Programs.

The Office of Small Business Programs is DoD's champion for small businesses in their effort to contribute to U.S. national security. The Office of Small Business Programs manages the RIF and SBIR programs that can be used to reach small businesses for prototyping and experimentation.

7.2.8 OUSD(R&E) Defense Innovation Unit (DIU).

DIU is a Joint DoD organization that connects commercial innovators with defense organizations to rapidly meet Joint warfighter needs. DIU selects projects based on a number of key factors including the disruptive nature of the technology or methodology and its applicability across the Department.

7.2.9 OUSD(R&E) Rapid Reaction Technology Office (RRTO).

Leveraging traditional and non-traditional sources of innovation, RRTO develops prototypes and hosts technology demonstrations to counter emerging and anticipated threats and increase the speed from idea to developed capability.

7.2.10 OUSD(R&E) Strategic Capabilities Office (SCO).

The SCO works closely with the Military Departments, CCMDs, defense agencies, and the Intelligence Community to identify, analyze, and accelerate disruptive and asymmetric applications of existing commercial and government systems. The SCO prototypes candidate capabilities and conducts demonstrations and experiments to reduce risk on potentially game-changing concepts that can be fielded in less than five years.

8 Summary

The NDS states, "The security environment is…affected by *rapid technological advancements and the changing character of war*. The drive to develop new technologies is relentless, expanding to more actors with lower barriers of entry, and moving at accelerating speed."[41] To retain global dominance, the U.S. must adjust how it develops and acquires new capabilities. Prototyping is a key tool the Department can use to more rapidly mature technology. The information and best practices provided in this guidebook are designed to help decision-makers,

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[41] Mattis, 3.

PMs, and acquisition authorities most effectively use prototyping to inform decisions, supporting the ultimate goal of delivering capabilities to the Joint warfighter at the speed of relevance.

Appendix 1:   Acronyms

3D	Three-Dimensional
ACO	Adaptive Capabilities Office
ACTD	Advanced Concept Technology Demonstration
AEWE	Army Expeditionary Warrior Experiment
AI	Artificial Intelligence
aka	also known as
AM	Additive Manufacturing
AMS	Advanced Modeling and Simulation
ANTX	Advanced Naval Technology Exercise
AoI	Area of Interest
AR	Augmented Reality
ATD	Advanced Technology Demonstration
CAD	Computer-Aided Design
CBOA	Chemical Biological Operational Assessment
CCMD	Combatant Command
CFT	Cross-Functional Team
CONOPS	Concept of Operations
CRADA	Cooperative Research and Development Agreement
CSO	Commercial Solutions Opening
CTTSO	Combating Terrorism Technical Support Office
DARPA	Defense Advanced Research Projects Agency
DAU	Defense Acquisition University
DIU	Defense Innovation Unit
DoD	Department of Defense

DoDI	DoD Instruction
DOTMLPF-P	Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, Facilities, and Policy
DTEP	Developmental Test, Evaluation & Prototyping
ECTD	Emerging Capabilities Technology Development
FAR	Federal Acquisition Regulation
FFRDC	Federally Funded Research and Development Center
FY	Fiscal Year
GAO	Government Accountability Office
GPE	Government-Wide Point of Entry
HCIC	Hanscom Collaboration and Innovation Center
IDIQ	Indefinite Delivery, Indefinite Quantity
IPL	Integrated Priority Lists
IRAD	Independent Research and Development
JCIDS	Joint Capabilities Integration and Development System
JCTD	Joint Capability Technology Demonstration
JCTE	(JSOC) Capability and Technology Evaluation
JFIC	Joint Force Integration Cell
JIFX	Joint Interagency Field Experimentation
JRAC	Joint Rapid Acquisition Cell
JS	Joint Staff
JSOC	Joint Special Operations Command
JT&E	Joint Test & Evaluation
JWA	Joint Warfighting Assessment
MDAP	Major Defense Acquisition Program
ML	Machine Learning

MR	Mixed Reality
NDAA	National Defense Authorization Act
NDS	National Defense Strategy
OT	Other Transaction
OUSD(A&S)	Office of the Under Secretary of Defense for Acquisition and Sustainment
OUSD(R&E)	Office of the Under Secretary of Defense for Research and Engineering
PM	Project Manager or Program Manager
PoR	Program of Record
PPBE	Planning, Programming, Budgeting, and Execution
PSSG	Prototyping Senior Steering Group
QRSP	Quick Reaction Special Projects
R&D	Research and Development
REF	Rapid Equipping Force
RIF	Rapid Innovation Fund
RPF	Rapid Prototyping Fund
RPP	Rapid Prototyping Program
RRTO	Rapid Reaction Technology Office
S&T	Science and Technology
SBIR	Small Business Innovation Research
SCO	Strategic Capabilities Office
SIMEX	Simulation Experiment
SME	Subject Matter Expert
SOF	Special Operations Forces
TAFT	Test-Analyze-Fix-Test
TMI	Technology Maturation Initiative

TTPs	Tactics, Techniques, and Procedures
U.S.C.	U.S. Code
USD(R&E)	Under Secretary of Defense for Research and Engineering
USMC	U.S. Marine Corps
VR	Virtual Reality
WIF	Wargaming Incentive Fund
WLIF	Warfighting Lab Incentive Fund

Appendix 2: Definitions

Acquisition Agility. Programs that use prototyping authorities in Section 806 of the FY17 NDAA to integrate a new capability (as a new technology or weapon system component) into an MDAP platform or to reduce cost. Acquisition Agility programs are limited to two years duration.

Competitive Prototyping. When two or more teams develop prototypes of the same component, subsystem, or system, or to address the same problem, challenge, or capability need.

Middle Tier Acquisition Programs. Programs that use the rapid prototyping authorities in Section 804 of the FY16 NDAA to fill the gap between traditional PoRs and urgent operational needs. Rapid prototyping must be completed within a period of five years, production started within six months, and rapid fielding completed within another five years to meet the Middle Tier Acquisition criteria for Rapid Prototyping and Rapid Fielding.[42]

Military Capability Gap. Needs or capability gaps in meeting national defense strategies that are generated by the user or user-representative to address mission area deficiencies, evolving threats, emerging technologies, or weapon system cost improvements. For the purposes of prototyping and rapid fielding, military capability gaps include both formal requirements listed in approved JCIDS documents as well as other needs identified through the CCMD IPL accepted into the Chairman's Capability Gap Assessment process, critical intelligence parameter breaches, and emerging needs identified through formal threat, intelligence, and risk assessments.

Nontraditional Defense Contractor. An entity that is not currently performing and has not performed, for at least the one-year period preceding the solicitation of sources by the DoD for the procurement or transaction, any contract or subcontract for the DoD that is subject to full coverage under the cost accounting standards prescribed pursuant to section 1502 of title 41 and the regulations implementing such section.[43]

Other Transaction Authorities. Authorities granted to the Secretary of Defense and the Secretaries of the Military Departments by Section 2371 of Title 10, U.S.C. to enter into agreements other than contracts, cooperative agreements, and grants to conduct basic, applied, and advanced research projects, to include prototyping, in accordance with Section 2371b of Title 10, U.S.C.

Prototype. A model (e.g. physical, digital, conceptual, and analytical) built to evaluate and inform its feasibility or usefulness.

Rapid Prototyping. A prototyping pathway using non-traditional acquisition processes to rapidly develop and deploy prototypes of innovative technologies. It is the intent that these

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[42] National Defense Authorization Act for Fiscal Year 2016, § 804, 129 Stat. 882-883.
[43] National Defense Authorization Act for Fiscal Year 2016, 10 U.S.C. § 2302(9) (2015). https://www.law.cornell.edu/uscode/text/10/2302.

technologies provide new capabilities to meet emerging military needs, are demonstrated in an operational environment, and provide a residual operational capability within five years of project approval.

Technology Base. The development efforts in basic and applied research.

Appendix 3:   Governing Documents

Instructions on how DoD professionals are to conduct prototyping projects are captured in U.S. law and DoD governing documents. This section presents the most relevant current directions and authorities pertaining to prototyping.

New Congressional Authorities. Beginning with the FY16 NDAA, Congress provided several new authorities and tools that enable DoD to acquire innovative technology and weapon systems in an expedited and streamlined manner. These authorities increase program flexibility and agility, provide more responsibility to Military Services, and encourage the use of nontraditional defense contractors, in order to facilitate the rapid, iterative approach to affordable capability development called for in the NDS. The following paragraphs summarize the five most significant new authorities.

Section 804.[44] Section 804 of the FY16 NDAA provides an expedited acquisition pathway to rapidly develop fieldable prototypes and deliver innovative technology and weapon systems to the warfighter. This Middle Tier Acquisition pathway will demonstrate new capabilities that meet existing and emerging warfighter needs within five years through rapid prototyping. Unless directed otherwise, Middle Tier Acquisition programs are exempt from the JCIDS Manual and the DoD Directive 5000.02 and are not funding limited. Programs following this Middle Tier Acquisition rapid prototyping pathway must use a merit-based process for selecting prototyping projects that meet warfighter needs, develop and follow acquisition and funding strategies for the program, demonstrate the prototype in an operational environment, and transition successful prototypes. The Middle Tier Acquisition pathway also authorizes a rapid fielding pathway for prototypes that meet the following criteria:

- The prototype meets a high-priority warfighter need or reduces the lifecycle cost of a weapon system.
- The original prototyping project was successfully completed.
- The prototype was demonstrated in a relevant environment. If a competitive process was used to select the developer of the original prototype, Section 806 authorizes awarding of a sole source follow-on contract.

Production, using this pathway, is expected to begin within six months of contract award and complete fielding within five years.

Section 815.[45] Section 815 of the FY16 NDAA authorizes officials designated by the Secretary of Defense to use OTs to conduct prototyping projects directly relevant to enhancing the mission effectiveness of military personnel, platforms, systems, components, or materials used by the armed forces.

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[44] National Defense Authorization Act for Fiscal Year 2016, § 804, 129 Stat. 882.
[45] National Defense Authorization Act for Fiscal Year 2016, Pub. L. No. 114-92 § 815, 129 Stat. 893 (2015). https://www.gpo.gov/fdsys/pkg/PLAW-114publ92/pdf/PLAW-114publ92.pdf.

Section 233.[46] Section 233 of the FY17 NDAA allows selected DoD Science and Technology Reinvention Laboratories to propose and implement alternative and innovative methods of effective management and operations of eligible centers, rapid project delivery, support, experimentation, prototyping, and partnership with universities and private sector entities for the purpose of:

- Generating greater value and efficiencies in R&D activities;
- Enable more efficient and effective operations of supporting activities; and
- Enable more rapid deployment of warfighter capabilities.

During the period of this pilot program, heads of eligible centers are authorized to waive any regulation, restriction, requirement, guidance, policy, procedure, or departmental instruction that would affect the implementation of a proposed method, unless implementation of the method would be prohibited by a provision of Federal statue or common law.

Section 806.[47] Section 806 of the FY17 NDAA provides an Acquisition Agility pathway for developing component prototypes outside of, but parallel to, the traditional acquisition process. These projects are intended to be integrated into an MDAP when the capability is ready. Section 806 projects must address one or more of the following elements pertaining to major weapon systems: high priority warfighter needs, capability gaps or readiness issues, opportunities to integrate new components, or opportunities to reduce operation and support costs. These projects are to be completed within two years of initiation, may not exceed $10 million (waiverable to $50 million by the Secretary of the military department or designee), must be selected using a merit-based process, and must be successfully demonstrated in a relevant environment. The law further states that prototyping projects that exceed the duration and funding limits of section 806 should be pursued under the rapid prototyping process established by section 804 of the FY16 NDAA, discussed above.

Section 867.[48] Section 867 of the FY18 NDAA strengthens Section 815 of the FY16 NDAA by stating that transactions other than contracts, cooperative agreements, and grants are preferred tools to be used in the execution of S&T and prototyping programs.

DoD Instruction (DoDI) 5000.02.[49] DoDI 5000.02, "Operation of the Defense Acquisition System," discusses the use of prototyping in the traditional defense acquisition system as part of a program's approach to managing and mitigating risk. Early in program planning, DoDI 5000.02 instructs PMs to work with appropriate stakeholders to determine if prototypes are necessary for their programs and include that determination in the Acquisition Strategy. DoDI

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[46] National Defense Authorization Act for Fiscal Year 2017, Pub. L. No. 114-328 § 233, 130 Stat. 2061 (2016). https://www.congress.gov/114/plaws/publ328/PLAW-114publ328.pdf.
[47] National Defense Authorization Act for Fiscal Year 2017, § 806, 130 Stat. 2256.
[48] National Defense Authorization Act for Fiscal Year 2018, Pub. L. No. 115-91 § 867, 131 Stat. 1495 (2017). https://www.congress.gov/115/plaws/publ91/PLAW-115publ91.pdf.
[49] Department of Defense, *Operation of the Defense Acquisition System*, DoD Instruction 5000.02 (Washington, DC: Author, 2017). https://www.dau.mil/guidebooks/Shared%20Documents/DoDI%205000.02.pdf.

5000.02 also instructs PMs to consider using prototypes for risk reduction during the Technology Maturation & Risk Reduction (TMRR) and Engineering & Manufacturing Development phases. PMs are expected to use competitive prototyping (or single prototypes if competitive prototyping is not feasible) in the TMRR phase unless specifically waived by the Milestone Decision Authority. However, if the technology cannot be developed in the program with a high degree of confidence that it will not delay fielding, 10 U.S.C. § 2366a(b) specifies that the technology shall be developed and demonstrated separate from the program using another pathway (e.g., Section 804 or 806 authorities above) and have an effective plan for adoption or insertion of the capability by the relevant program.[50]

DoD Policy and Strategy on Prototyping. DoD is currently developing policy and strategy documents pertaining to prototyping. In response to FY16 NDAA Section 804 direction, OUSD(R&E) is drafting a DoDI to establish policy, assign responsibilities, and prescribe procedures pertaining to prototyping, rapid prototyping, and rapid fielding. In addition, in response to one of the recommendations made in the GAO report, "Weapon Systems: Prototyping Has Benefited Acquisition Programs, but More Can Be Done to Support Innovation Initiatives" (GAO-17-309), OUSD(R&E) is drafting a broad DoD Research and Engineering strategy that will include strategies pertaining to prototyping and innovation.[51] As stated in the introduction, this guidebook is a living document. When the DoDI and the DoD Research and Engineering Strategy are completed, the guidebook will be updated to reflect these two documents.

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[50] National Defense Authorization Act for Fiscal Years 2017, 10 U.S.C. § 2366a(b)(8) (2016). https://www.law.cornell.edu/uscode/text/10/2366a.
[51] Sullivan, 67.

Appendix 4:   References

Accelerating New Technologies to Meet Emerging Threats: Testimony before the U.S. Senate Subcommittee on Emerging Threats and Capabilities of the Committee on Armed Services. 115th Cong., 2018 (testimony of Michael D. Griffin, Under Secretary of Defense for Research and Engineering (USD(R&E)). https://www.armed-services.senate.gov/imo/media/doc/18-40_04-18-18.pdf.

America COMPETES Reauthorization Act of 2010. Pub. L. No. 111–358 § 105, 124 Stat. 3989, 2011. https://www.congress.gov/111/plaws/publ358/PLAW-111publ358.pdf.

Defense Acquisition University. *Defense Acquisition Guidebook*, 2018. https://www.dau.mil/tools/dag.

Defense Acquisition University. "Joint Capabilities Technology Demonstration: JCTD Project Execution." Briefing charts for JCTD Process and Execution Overview Course, Defense Acquisition University, 2018.

Defense Acquisition University. "Procurement for Experimental Purposes (10 USC 2373)." Accessed May 15, 2019. https://aaf.dau.mil/contracting-cone/10usc2373/.

Department of Defense. *Operation of the Defense Acquisition System.* DoD Instruction 5000.02. Washington, DC: Department of Defense, 2017. https://www.dau.mil/guidebooks/Shared%20Documents/DoDI%205000.02.pdf.

Grady, C. M., Director, Defense Procurement and Acquisition Policy. *Other Transactions Guide for Prototype Projects*. Washington DC: Department of Defense, 2017. http://www.acqnotes.com/wp-content/uploads/2014/09/Tab-5-OSD-OTA_Guide-17-Jan-2017-DPAP-signature-FINAL-002.pdf.

JCTE 2017 CRADA Assessment Criteria [Working Paper].

Mattis, James N., Secretary of Defense. *Summary of the 2018 National Defense Strategy of the United States of America: Sharpening the American Military's Competitive Edge.* Washington, DC: Department of Defense, 2018. https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf.

National Defense Authorization Act for Fiscal Years 1990 and 1991. 10 U.S.C. § 2371. Washington, DC, 1989. https://www.law.cornell.edu/uscode/text/10/2371.

National Defense Authorization Act for Fiscal Year 1994. 10 U.S.C. § 2373. Washington, DC, 1993. https://www.law.cornell.edu/uscode/text/10/2373.

National Defense Authorization Act for Fiscal Year 2000. 10 U.S.C. § 2374a. Washington, DC, 1999. https://www.law.cornell.edu/uscode/text/10/2374a.

National Defense Authorization Act for Fiscal Year 2009. Pub. L. No. 110-417 § 219, 122 Stat. 4389. Washington, DC, 2018. https://www.gpo.gov/fdsys/pkg/PLAW-110publ417/pdf/PLAW-110publ417.pdf.

National Defense Authorization Act for Fiscal Year 2016. 10 U.S.C. § 2302(9). Washington, DC, 2015. https://www.law.cornell.edu/uscode/text/10/2302.

National Defense Authorization Act for Fiscal Year 2016. 10 U.S.C. § 2371b. Washington, DC, 2015. https://www.law.cornell.edu/uscode/text/10/2371b.

National Defense Authorization Act for Fiscal Year 2016. Pub. L. No. 114-92 § 804, 129 Stat. 882. Washington, DC, 2015. https://www.gpo.gov/fdsys/pkg/PLAW-114publ92/pdf/PLAW-114publ92.pdf.

National Defense Authorization Act for Fiscal Year 2016. Pub. L. No. 114-92 § 809, 129 Stat. 889. Washington, DC, 2015. https://section809panel.org/wp-content/uploads/2017/12/809-Panel-Charter-As-Amended-by-FY2018-NDAA.docx.

National Defense Authorization Act for Fiscal Year 2016. Pub. L. No. 114-92 § 815, 129 Stat. 893. Washington, DC, 2015. https://www.gpo.gov/fdsys/pkg/PLAW-114publ92/pdf/PLAW-114publ92.pdf.

National Defense Authorization Act for Fiscal Year 2017. 10 U.S.C. § 2366a(b)(8). Washington, DC, 2016. https://www.law.cornell.edu/uscode/text/10/2366a.

National Defense Authorization Act for Fiscal Year 2017. Pub. L. No. 114-328 § 233, 130 Stat. 2061. Washington, DC, 2016. https://www.congress.gov/114/plaws/publ328/PLAW-114publ328.pdf.

National Defense Authorization Act for Fiscal Year 2017. Pub. L. No. 114-328 § 806, 130 Stat. 2256. Washington, DC, 2016. https://www.congress.gov/114/plaws/publ328/PLAW-114publ328.pdf.

National Defense Authorization Act for Fiscal Year 2018. Pub. L. No. 115-91 § 867, 131 Stat. 1495. Washington, DC, 2017. https://www.congress.gov/115/plaws/publ91/PLAW-115publ91.pdf.

Office of the Secretary of Defense, Defense Innovation Unit (DIU). *Commercial Solutions Opening (CSO)*. Washington DC: Office of the Secretary of Defense, 2018. https://www.diu.mil/download/datasets/1988/DIU_CSO_-_2018_Update.pdf.

Section 809 Panel: Advisory Panel on Streamlining and Codifying Acquisition Regulations. *Section 809 Panel Interim Report*. Washington DC: Section 809 Panel, 2017. https://section809panel.org/wp-content/uploads/2017/05/Sec809Panel_Interim-Report_May2017_FINAL-for-web.pdf.

Sullivan, Michael J. *Weapon Systems: Prototyping Has Benefited Acquisition Programs, but More Can Be Done to Support Innovation Initiatives*. GAO-17-309. Washington, DC: U.S. Government Accountability Office, 2017. https://www.gao.gov/assets/690/685478.pdf.

Technology Transfer and the Valley of Death: Statement Before the U.S. Senate Subcommittee on Emerging Threats and Capabilities of the Committee on Armed Services. 115th Cong., 2018 (statement by Michael D. Griffin, Under Secretary of Defense for Research and Engineering (USD(R&E)). https://www.armed-services.senate.gov/imo/media/doc/Griffin_04-18-18.pdf.

U.S. General Services Administration. *Federal Acquisition Regulation.* Washington DC: U.S. General Services Administration, 2018. https://www.acquisition.gov/browsefar.