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CROWDSOURCING DEFENSE ACQUISITION PROGRAMS

December 2017

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Crowdsourcing solutions have the potential to meet the Army's modernization goals. With the rise of improved Internet access and online resources, crowdsourcing has been increasing in popularity since 2006. The benefits of crowdsourcing have been visible in commercial industry and can apply to Department of Defense (DOD) Acquisition Programs. This report identifies the overall use of crowdsourcing, looks at cases in the DOD and in industry, and analyzes strengths and weaknesses. Our findings consist of crowdsourcing strategies that can benefit the DOD and include prize competitions, open dialogue, and open-data collaboration. Integrating the crowd-force with defense contractors through online collaboration platforms can speed up the time required to find solutions and reduce program costs. Barriers include senior-level leaderships' reluctance to change, risks associated with opening up the DOD to crowdsourcing, and the DOD's unwillingness to adapt to new ways of innovation. Recommendations include that Congress pass laws directing the use of open innovation, crowdsourcing, and implementing directives across federal agencies. The best area for the DOD to implement crowdsourcing focuses on design, forecasting, and software. Lessons learned allow for better use of crowdsourcing in new modernization goals and efforts in reducing costs and fielding equipment.

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CROWDSOURCING DEFENSE ACQUISITION PROGRAMS

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ABSTRACT

Crowdsourcing solutions have the potential to meet the Army's modernization goals. With the rise of improved Internet access and online resources, crowdsourcing has been increasing in popularity since 2006. The benefits of crowdsourcing have been visible in commercial industry and can apply to Department of Defense (DOD) Acquisition Programs. This report identifies the overall use of crowdsourcing, looks at cases in the DOD and in industry, and analyzes strengths and weaknesses. Our findings consist of crowdsourcing strategies that can benefit the DOD and include prize competitions, open dialogue, and open-data collaboration. Integrating the crowd-force with defense contractors through online collaboration platforms can speed up the time required to find solutions and reduce program costs. Barriers include senior-level leaderships' reluctance to change, risks associated with opening up the DOD to crowdsourcing, and the DOD's unwillingness to adapt to new ways of innovation. Recommendations include that Congress pass laws directing the use of open innovation, crowdsourcing, and implementing directives across federal agencies. The best area for the DOD to implement crowdsourcing focuses on design, forecasting, and software. Lessons learned allow for better use of crowdsourcing in new modernization goals and efforts in reducing costs and fielding equipment.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACAT	acquisition category
ACV	amphibious combat vehicle
AVM	Adaptive Vehicle Make
CAD	computer aided design
CDD	capabilities development document
CFT	cross-functional team
CPD	capabilities production documents
DARPA	Defense Advanced Research Project Agency
DOD	Department of Defense
EMD	engineering and manufacturing development
ESP	early synthetic prototype
FANG	fast adaptable next generation ground vehicle
FCS	Future Combat System
GAO	Government Accountability Office
GCV	ground combat vehicle
GPRA	Government Performance and Results Act
GSA	General Services Administration
HUD	Department of Housing and Urban Development
ICD	initial capabilities document
JCIDS	Joint Capabilities Integrations and Development Systems
JROC	Joint Requirements Oversight Council
KPP	key performance parameters
LTC	lieutenant colonel
MDA	milestone decision authorities
MGV	manned ground vehicle
NASA	National Aeronautical and Space Administration
OSTP	Office of Science and Technology Policy
PAM	Policy Analysis Market
PEO	program executive officer
PPBE	planning, programing, budgeting, and execution

RFP	request for proposal
SES	senior executive service
SWOT	strengths, weaknesses, opportunities, and threats
UAV	unmanned aerial vehicle

I. INTRODUCTION

The chief of staff of the Army is working to implement cross-functional teams (CFTs). CFTs implement an integrated product and process development during the requirements definition process of defense acquisition, which should support program fielding with lower cost, fewer schedule problems, and an increase in requirements stability. CFTs are one of many Army initiatives aimed at improving the performance of acquisition programs. Crowdsourcing should be considered as an option. This thesis addresses the use of crowdsourcing in government programs and how this creative method has historically impacted Department of Defense (DOD) and commercial programs. DOD can use crowdsourcing at a larger scale, leveraging the innovative ideas and capabilities across a diverse and educated population. By reaching out to non-traditional sources for solutions to hard problems, the DOD can expand its potential solution space and decrease program risk in the most demanding areas. While crowdsourcing is merely one approach to improving program performance, this research seeks to investigate its ability to provide quick solutions and remain adaptable to the relevant and continuously changing ideas and trends in industry and throughout the world.

A. PROBLEM STATEMENT

To maintain our status as the world's greatest army, we depend on successful modernization programs, that incorporate smart solutions. These solutions are planned inside the military but are generally designed and built by a diverse web of traditional defense contractors. Still, this limits the potential solutions to the crowd that is willing to wade in the waters of complex regulations, bureaucratic slowness, and decreasing DOD budgets. To reach the entire solution pool, we can use crowdsourcing. This thesis focuses on the use of crowdsourcing for previous government and commercial innovations and its related strengths and weakness that can help determine the best areas of use for government programs in the future. It also looks at policies, guidance and federal acts

that have been implemented to promote affordability and the use of open innovation and crowdsourcing.

This research first entertains the idea that the DOD can benefit from crowdsourcing solutions for some DOD programs. It studies apparent connections between successful ideas from past government programs, as well as commercial ventures that have benefited. The literature review also outlines the motivation of those that contribute to crowdsourcing. Many individuals are inspired to participate and perform well, due to the same internal motivation that causes them to become experts in their specific field. To better understand the similarities in these cases, this thesis considers these connections and commonalities through an analysis of strengths, weaknesses, opportunities, and threats (SWOT). The knowledge learned from this portion of research is crucial for understanding and determining the utility of crowdsourcing for future DOD programs.

Next, this research explores the possibilities of new pathways for crowdsourcing opportunities that can be beneficial to the DOD. It focuses on methods that can aid modernization programs and motivate the solution community to assist with this process. Crowdsourcing can assist the current Army directive for the use of CFTs in an effort to reduce the amount of time to get capabilities fielded to the warfighter and reduce program costs.

B. RESEARCH QUESTIONS

The primary research question is:

- How can crowdsourcing benefit DOD programs?

The answers to this question provides the acquisition community with a basic understanding of crowdsourcing, how it has been used to solve DOD problems already, and where it could be used in the future.

The secondary research questions are:

- What are the barriers that could limit DOD personnel from using crowdsourcing.?

- What changes are necessary for the DOD to take advantage of crowdsourcing?
- What are the best areas for the DOD to capitalize on crowdsourcing?

Examining previous implementation of crowdsourcing in DOD programs and civilian programs offers new ways for addressing these questions and discovering answers. These observations and analysis can lead to new pathways between government and crowds that can provide knowledge, information and new approaches to problem solving. Once these questions are answered, their composition works to answer the primary research question.

Examining previous implementation of crowdsourcing in DOD program and civilian programs offers new ways for addressing these questions and discovering answers. These observations and analysis can lead to new pathways between government and crowds that can provide knowledge, information, and new approaches to problem solving.

C. DEFINING CROWDSOURCING

This section lists common definitions that relate to crowdsourcing. Different terms for crowdsourcing are explained providing a better understanding to the reader. Examples give a better picture of common uses that readers can identify with. Leaders in the crowdsourcing community are analyzed and provide the foundation for this thesis.

1. Definition

Following are some definitions that have been commonly used to understand crowdsourcing. The premise is to be able to use the skills or resources of the crowd to achieve a desired goal. The *Oxford English Dictionary* (n.d.) defines crowdsourcing as "the practice of obtaining information or services by soliciting input from a large number of people, typically via the Internet and often without offering compensation." Another definition is that crowdsourcing outsources to a large group of participants using open call for ideas and solutions (Howe, 2006). Some other terms for crowdsourcing include open innovation, peer production, user-powered systems, user-generated content, collaborative systems, community systems, social systems, social search, social

collaboration and human computation (Hossain & Kauranen, 2015, p. 3). This research defines the community from which acquisition crowdsourced solutions come from as the crowd-force. This definition of the community is the workforce that is the crowd, making up the participants, civilians and others, that come together to develop solutions.

2. Rise of Crowdsourcing

The use of crowdsourcing can be seen by analyzing historical examples that ask the population for information and input on how to accomplish a goal. A few examples include offering funds to determine the best and most reliable way to determine longitude back in 1714 by the British government; the *Oxford Dictionary* in 1884 used readers to catalog words, a practice that still occurs today; or Toyota and how it publicly asked for ideas in designing its new logo (Hossain & Kauranen, 2015, p. 3). More recently, the Federal Bureau of Investigation has used crowdsourcing as a way to crack into the iPhone of the San Bernardino shooter when Apple would not release the rights or capability to get into the device in 2016.

Since 2006, there has been an increased demand for crowdsourcing applications. Research and professional articles have increased due the demand of crowdsourcing with emphasis on many of the market leading countries in the world. In Figures 1 and 2, the information related to crowdsourcing authors' locations and the increase in the amount of conferences and journals publishing them shows the rise in demand for crowdsourcing.

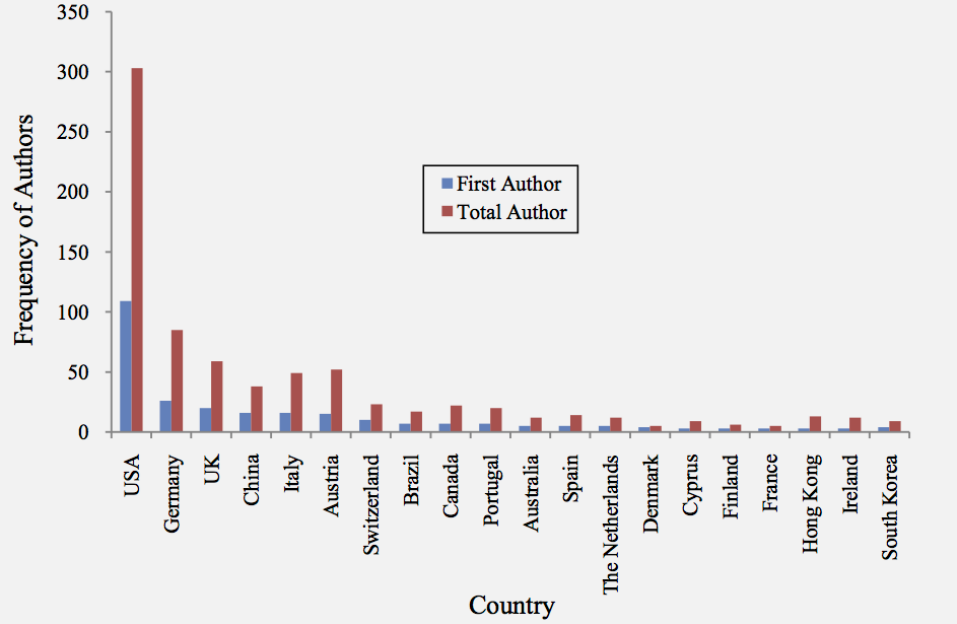

Figure 1. Top 20 Countries in Terms of First Authorship and Total Authorship. Source: Hossain and Kauranen (2015, p. 6).

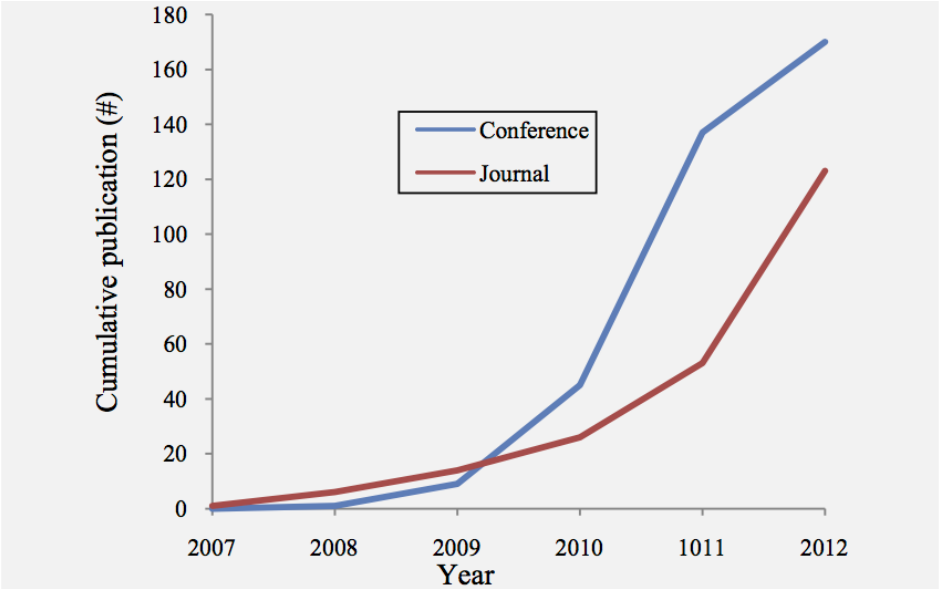

Figure 2. Cumulative Number of Journal Articles and Conference Articles on Crowdsourcing. Source: Hossain and Kauranen (2015, p. 7).

The Internet has made crowdsourcing events easier to achieve and gain access to participants around the world. Many websites promote the use of online collaboration,

bringing together individuals that have a passion, skill, and motivation to help others perfect their trade. The values that motivate the crowd-force to tackle an organization's goals can be intrinsic or extrinsic. Intrinsic meaning comes from individuals working on problems that give them purpose and fulfill their internal needs because they are experts at that task. Extrinsic value would be to have a reward or an external incentive that motivates the crowd to come up with the best solution. Altruism is another motivating factor for the "solution community." This value is the desire to help others by contributing in a way that supports with assistance to solve a problem or give unselfishly. Whatever the motivation, crowdsourcing captures the willingness of experts to share intellectual resources both inside of contracted companies and non-traditional solution communities around the world.

3. Open Source and Open Innovation

The basis for crowdsourcing comes from open source and open innovation. Open source is the precursor to the open innovation idea (Lauterbach-Hagan, 2010, p. 22). Open source started with the software company Linux and stems from their ability to develop software code for operating systems and websites developed by its users. Open source differs from open innovation based off the use of patents where they are donated by different companies to a patent pool or uses limited licenses for free use (Lauterbach-Hagan, 2010, p. 24). This allowed IBM to provide source code to other suppliers to enable them to integrate other parties' commercial applications to its consumer products.

Open innovation is for participants to be able to access knowledge inside their firms and outside (Lauterbach-Hagan, 2010, p. 22). The idea here is that a company will most likely not use all of the designs and efforts they put research and development into, but others might be able to prosper from them. The same goes for all participants, the inventions that companies come up with do not get used all the time and they sit on the shelf (Tapscott & Williams, 2008, p. 102). These ideas are key because companies spend money to develop them and by sharing them in online collaboration, a product can be born from other people's inputs.

These ideas of open sourcing and open innovation have helped companies like IBM Proctor and Gamble, Facebook, and Amazon (Tapscott & Williams, 2008). Some of the reasons behind sharing the information and looking to others for inputs is to gain solutions at a reduced cost. In Amazon's case, 30 percent of its revenue comes from 975,000 third-party retailers who leverage Amazon's e-commerce platform (Tapscott & Williams, 2008, p. 194–276). Others like Proctor and Gamble pay awards to those who can provide solutions to their research and development problems over the Internet based forums. In Brian Lauterbach-Hagans's thesis, he discusses an idea that relates to that of the Defense Advanced Research Project Agency (DARPA) initiative as well as the main thesis question proposed. He states,

> these new business strategies and Web-based applications have a strong potential to improve efficiency, and thus reduce the cost of creating and updating knowledge databases in real time, collecting and instantaneously disseminating information to pertinent personnel, and improving communication between program stakeholders. It is therefore problematic for the government to ignore this movement. (Lauterbach-Hagan, 2010, pp. 13–14)

4. Wisdom of Crowds

In the book *The Wisdom of Crowds* by James Surowiecki (2005), we identify some of the factors that make up wise crowds. These conditions include independence, diversity of opinion, decentralization and a way to aggregate the results (Surowiecki, 2005). Different groups of people are used to analyze the conditions. Surowiecki uses examples such as TV shows, stock market, and sports betting. Additionally, he mentions the use of prediction markets, which we explore latter in this thesis with an example from DARPA. These markets are an excellent method of collecting knowledge from the crowd-force and using it to make relatively accurate predictions.

Diversity is a critical aspect of wise crowds. Successful crowdsourcing requires multiple inputs from a variety of different types of members. Desirable data points include solutions from an area of expertise, age demographics, education levels, and other relevant factors that pertain to the reason for crowdsourcing. Diversity in larger groups is easier to achieve than in smaller groups in which groupthink can easily occur

(Surowiecki, 2005). Another aspect that helps individuals make large contributions with risky or unique ideas comes from the ways in which the groups connect with each other. Small groups of people tend to have more of a likelihood to influence others to conform to the ideas of the group (Surowiecki, 2005). Groups with disparity through the Internet feel less risk or do not need to conform to others ideas because their own are unique, and they have no fear of sharing (Surowiecki, 2005).

Independence of action is important for the wisdom of crowds. If all members shared a common belief, the group would be less likely to arrive at a useful answer. A topic called herding behavior addresses the issue of information cascades, whereby the initial decision is made by some members of the group, and it is accepted by more and more by other members (Surowiecki, 2005). This causes trouble when initial decisions are wrong yet continually accepted by an increasing amount of people in the group. The wisdom of crowds works best when decisions come from all members of the group at the same time, which prevents them from latching on to other individual's decisions.

Decentralization aids in the ability for people of a group to act more independently, offering the ability to participate and act in support of the groups. This can be seen in the civilian world of website development. GitHub is an online collaboration website that aids projects in finding a suitable crowd-force. GitHub develops software solutions for crowd proposed problems using its global outreach to access the crowd-force. Other crowdsource initiatives to support military applications include DARPA's website Adaptive Vehicle Make (AVM) (DARPA, n.d.) AVM is an online design collaboration website used to bring participants together to find solutions to a given design challenge. Another example of online collaboration that is mentioned by Surowiecki is the futures market, which attempts to predict future events that may occur in the Middle East and elsewhere (2005). Futures prediction is addressed late but essentially takes real-time data that can be used to predict changes in an area. A complication occurs with futures market models in that information can be inaccessible. This can occur because of lack of Internet, freedom of access regulations, and state or regional actors stifling the communication ability of the crowd-force.

The last element that is required to form the crowd-force is aggregation. This concept is important to the success of decentralization. The idea is that even though all the opinions and solutions come in from multiple participants, someone has to be the central point and make the decision (Surowiecki, 2005). This is the difference between local ideas with inputs and the global reach we can have with crowds. If the ideas of the crowd-force have no way of communicating and aggregating recommendations, then they are only as good as the smartest idea presented. The ability to aggregate ensures that the groups collective decision is smarter than even the smartest person (Surowiecki, 2005)

D. RESEARCH METHODOLOGY

The method for this research is the SWOT analysis; it provides a structure to a wide-ranging discussion of strategic programmatic elements. SWOT analysis can be effective for businesses to determine their strategic direction and can be applied to decision making for other organizations like the government. This thesis accesses SWOT through internal factors, external factors, positive factors, and negative factors, as seen in Figure 3.

> Strengths: internal factors that give an organization an advantage over others.
>
> Weaknesses: internal factors that put the organization at a disadvantage to others.
>
> Opportunities: external factors that provide possibilities for improvement.
>
> Threats: external factors that create downside risks for the organization. (Augier, 2017)

	Positive factors	Negative factors
Internal factors	Strengths	Weaknesses
External factors	Opportunities	Threats

Figure 3. SWOT Analysis Chart. Source: Augier (2017).

The SWOT analysis clarifies how the DOD can incorporate crowdsourcing solutions into programs based on their specific environment. This type of analysis can contribute to how the government builds and retains DOD strategic and competitive advantages over near peer threats and nation states, who have invested to undermine our overmatch capabilities.

Appreciative inquiry also applies a philosophical framework that does not define outcomes but helps create the conditions for them to emerge (Barrett & Fry, 2005). This research focuses on what practices are working and finds ways to apply those methods of crowdsourcing to DOD programs.

E. CHAPTER OUTLINE

Chapter I covers an introduction to this thesis; the initial problem statement and the main research question being addressed. Chapter I also describes what crowdsourcing is and defines it using various definitions observed during literature review. The wisdom of crowds helps explain the elements that aid crowdsourcing. The research methodology of SWOT analysis explains and describes how crowdsourcing is measured, allowing for determining where it can best fit in DOD programs.

Chapter II examines previously executed DOD programs that have used crowdsourcing in some capacity. These studies address crowdsourcing in programs such as ground combat vehicle (GCV), DARPA initiatives, and others found throughout the

DOD. Other artifacts that illuminate the advantages of crowdsourcing, include civilian organizations and areas of industry that have had large range of success. An overview of defense acquisitions summarizes the current environment where crowdsourcing can add benefits.

Chapter III summarizes the literature researched that shows the use of crowdsourcing throughout the government. The overview of the larger use of crowdsourcing in government includes reports from the Government Accountability Office (GAO), House resolutions, and other acts passed into law. These examples provide methods that have been used to help government agencies interact with private companies, nonprofits, academia, and citizens to collaborate on agency initiatives.

Chapter IV addresses the strengths, weaknesses, opportunities, and threats of the programs and projects in Chapter II. This thesis conducts analysis in specific areas of DOD programs, in order to identify where crowdsourcing solutions could best fit. This chapter addresses crowdsourcing in previous government programs and commercial industry. It examines multiple ways where groups of people come together in order to accomplish a goal. Some of the implementation is creative and "out of the box" type thinking providing beneficial and alternative means of solving a problem.

Chapter V provides recommendations that logically derive from SWOT analysis. These recommendations apply for DOD programs that can use the application of crowdsourcing. These programs have opportunities to reduce costs and deliver quality products to users on time. The analysis compares the previous programs and research to current programs of modernization in the Army. This chapter also provides conclusions and recommendation for future areas of study and different types of programs that might benefit from the use of crowdsourcing.

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II. BACKGROUND AND HISTORY OF CROWDSOURCING

This chapter addresses crowdsourcing in previous government programs and commercial industry. It examines multiple ways in which the crowd-force comes together to accomplish a specific goal. Some of the implementation is creative and "out of the box" type thinking that provides beneficial and alternative means of solving a problem. The chapter concludes with a summary of defense acquisitions where crowdsourcing has potential to benefit.

A. CROWDSOURCING IN PREVIOUS GOVERNMENT PROGRAMS

The purpose of this section is to analyze previous uses of crowdsourcing in DOD programs to explore different crowdsourcing environments. The first case is the GCV design challenges and how the program used one of DARPA's online collaboration tools to develop the GCV and similar platforms. The second case addresses a DARPA initiative developed to forecast future terrorist attacks in certain areas. The last case covers the area of software innovation and addresses a video game, Operation Overmatch, that the Army uses as a training and feedback tool. The primary method of collaboration in the cases addressed in this research was through web-based forums or communities enabling the sharing of ideas and knowledge, which given their online nature, makes them easy to update and analyze for effective decision making and problem solving.

1. Design Innovation, DARPA and Use of Adaptive Vehicle Make

The GCV program resulted from the restructuring of the Future Combat System (FCS) program whereby Congress cancelled the Manned Ground Vehicle (MGV) program within FCS and directed the Army to develop the GCV. Four main tenets remained in the GCV to maintain an attainable and affordable program: that the production of the system be complete within seven years, the system would carry a nine-person squad, would support full spectrum operations, and would have mine-resistant ambush protected level protection (Mortlock, 2017). The GCV concept was to be designed with the ability to accept future capabilities, incorporate mature technologies,

maintain armor protection, accept current and future network capabilities, and to be fielded by 2015 to 2017 (Feickert, 2014). Some other capabilities the Army desired were to keep the platform concept common to save logistics costs for other variants, incorporate a V-shaped hull and side armor, and that it must fit on C17 transport. According to the Congressional Research Service report by Feickert (2014), the Army left out the technical detailed specifications for the request for proposal (RFP) and aimed to get industry participants best recommendations for future vehicle designs to meet the performance requirements for the next generation of combat vehicles. This statement is somewhat inaccurate as the use of previous technical specifications from the manned ground vehicle system where used to create the GCV proposal, giving many specific details about what must be incorporated into the system.

The first RFP was canceled by the Army's Assistant Secretary of the Army for Acquisition, Logistics and Technology, Malcolm O'Neil, for multiple reasons. After a review by the Army's Red Hat team, the GCV program was found to have "too many performance requirements and capabilities to make it affordable and relied on immature technology" (Feickert, 2014, p. 4). The competition for this contract for the GCV was between three main industry teams, BAE Systems, General Dynamics, and SAIC. The new RFP the Army issued aimed for simplifications in the performance requirements compared to those of the manned ground vehicle: built in time for technology maturation, fielding timeline, and with a targeted price tag of $10 million instead of the original $20 million (Feickert, 2014). DARPA was working on ways of assisting with the timeline and the cost by standing up a crowdsourcing initiative.

Since the fall of 2010, DARPA began holding design competitions for engineers on their web-based portal called vehicleforge.com. This portal is part of a collaborative design portfolio called AVM. The goal of AVM is to be able to eliminate time consuming and costly prototyping that would use crowdsourcing to design the next fast, adaptable, next generation combat vehicle (FANG) (Bertuca, 2011). Lieutenant Colonel (LTC) Nathan Wiedenman, Deputy Program Manager for AVM, thought this program could help speed up the process and reduce expensive overhead costs incurred when using big named defense contractors. (Bertuca, 2011) Another of Wiedenman's ideas was that the

costs associated with the production of prototypes and the small teams used to create them limits participants to big companies. The capabilities of the AVM portfolio give the Army an opportunity to reach out across the entire country to a variety of participants who could help contribute to the engineering and design process. The efforts of those individuals could then be paired with those of the contractors, thus reducing the costs incurred during the design process as well as reducing the need for costly prototypes. Some of the design tools that all participants would need are available on the VehicleForge website. The website allows users to design introductory level components like drivetrains and chassis with the ability to develop full scale vehicles.

AVM is DARPA's portfolio of programs with the goal of compressing the development timelines for new systems by at least five-fold. This portfolio allows for development of systems engineering, design, manufacturing, and collaborative innovation. To apply these capabilities to relevant military systems, AVM uses programs called Vehicle Forge and FANG. AVM uses model based system design to represent, transform, and integrate numerous types of models to conduct analysis in the design and development of systems. Designers can carry out virtual performance testing using open-sourced commercial tools to create cutting edge research prototypes. To design exercises for drivetrains, suspensions, propulsion, and chassis, DARPA uses another program called iFAB Foundry. This program completes an end-to-end process flow, providing a detailed model that reduces production costs of prototypes and supplies reliable sources of data on potential products for analysis.

Some of the main differences between AVM and the use of computer aided design (CAD), which is prevalent with industry leading contractors, is the overall incorporation of the AVM designs into the design system as a whole. CAD designs physical subsystems derived by the system level requirements, but these designs are often times developed in isolation, which can lead to poor integration during testing. According to DARPA,

> AVM implements a compositional design approach that enables designers to consider the behavior of the whole system design in multiple domains throughout the design process. This ability emerges from the compositional nature of AVM component model representations of

> physical parts. The tool suite is able to reason about the geometry and behavior of an assembled system by aggregating the behavioral models of each component in all of the relevant domains (i.e., physical, thermal, vibrational, electro-magnetic, etc.). (Defense Advanced Research Project Agency [DARPA], 2017)

AVM's goal is to compress the timeline for development, design, and build for a new system. Its use of highly analytical and automated software combining the ideas from crowds to develop a solution and recommend the best production layout for manufacturing could help save costs with physical production of prototypes and save time in the schedule of a system's design and production.

The VehicleForge website resembles forums and design environments allowing participants to use web-based resources to come together and in a shared workspace. The purpose of VehicleForge in the AVM program "was to provide a common platform for design event participants to team, collaborate and submit designs for testing" (DARPA, 2017). According to DARPA, "It is also the portal for accessing design tools, manufacturability tools, component models, and generated system designs" (DARPA, 2017). VehicleForge allows participants to be able to use their expertise and unique applications to solve design problems using their own software that has access. Some of the software plugins include CAD visualization, project design trade space exploration, and scoring analysis based on virtual testing. DARPA's website notes, "The VehicleForge platform, hosted on a private cloud at Vanderbilt University, is highly scalable, fault tolerant, and flexible" (DARPA, 2017). This platform aids in the ability of DARPA to reach out to crowds and get multiple design ideas to help achieve a program's goal with reduced costs.

DARPA has the ability to conduct parallel design builds, which enables it to move into other areas such as unmanned aerial vehicles (UAVs). Crowds coming together for web enabled collaboration and unaffiliated groups of people outnumbering the industry can assemble, produces results quickly and cheaply. In the case of the GCV program, which ultimately was canceled again, cheaper quicker results were not possible; however, it was the start of DARPAs use of crowdsourcing. Since then, the online collaboration sites have improved greatly, and they have produced a combat support vehicle for

reconnaissance missions from a company called Local Motors. Other vehicles, such as the amphibious infantry fighting vehicle, have also been designed using the AVM tools. The wide range of AVM tool use includes the drive train, chassis, and full vehicle design and prototype.

The marines have seen the results of using the AVM portfolio and have analyzed the requirements for a replacement to the expeditionary fighting vehicle against the specifications output by the Amphibious Combat Vehicle (ACV) program (Evans, 2013). The DARPA results of the 2013 design challenge were not guaranteed to be incorporated into the new ACV design. AVM provided a chance to design a drivetrain that could enable the capabilities required for the ACV system. This DARPA design challenge had a budget (or prize award) of $1 million and awarded to the team with the unique, winning design. Since the Marine Corps is in charge of the ACV program and had traditional companies conducting design in parallel to the that of the DARPA design challenge, it is unclear which drive train design was used. According to an article on the Warrior Scout website, the BAE design 1.1 uses independent gear boxes for each of the wheels instead of an axel drive train to allow for more V hull armor protection underneath (Osborn, 2017). Additionally, the winning design for the ACV was wheeled and not tracked like the DARPA design. Figure 4 shows the FLYPMODE reconnaissance vehicle from Local Motors; Figure 5 shows the infantry fighting vehicle designed by DARPA; and Figure 6 shows the Marine ACV from BAE Systems.

Figure 4. FLYPMODE by Local Motors. Source: Boyle (2011).

Figure 5. DARPA Design Amphibious Infantry Fighting Vehicle. Source: Ackerman (2013).

Figure 6. BAE Design for ACV 1.1. Source: BAE Systems (n.d.).

2. Forecasting, Futures Market

The second area included in this research for crowdsourcing involves prediction markets. The use of crowds in speculative markets has proven beneficial in the past when crowds aggregate relevant information. DARPA began conducting research about prediction markets in 2001 using a small business independent research grant proposal named "Electronic Market-based Decision Support" (Hanson, 2005, p. 3). This program would later be known as FutureMAP Policy Analysis Market (PAM) and by the media as terrorism futures.

PAM was widely assumed by politicians and the media to be a betting market to learn the details of terrorist attacks. These ideas triggered fears, and many were concerned that through PAM we could be instigating terrorist attacks and wasting resources on misinformation attempts as well as about the difficulty we would have with getting inside knowledge. As part of the team hired to conduct the research and analysis, Robin Hanson is positioned to explain about PAM. He describes,

> In fact, however, PAM was not intended to forecast the details of terrorist attacks. It was instead intended to forecast aggregate measures of

> geopolitical stability in the Middle East. PAM would have used speculative markets to estimate economic growth, political stability, and military activity four times a year in each of eight nations, and how those measures would depend on each other and on various U.S. policy choices. PAMs designers thought their plan ambitious enough without also tackling the added complexities of predicting terrorism. (Hanson, 2005, p. 1)

PAM focused on eight countries in the Middle East conducting analysis of traders involved with military activity, political instability, economic growth, U.S. military activity, and U.S. financial involvement. These markets could also predict a combination of events such as troop movements in a country and the associated political effect this could cause in another or how those movements could impact oil prices. The website through which PAM launched and the participation of John Poindexter led to the program's early shutdown by members of Congress. The website portrayed pictures of leaders being overthrown or assassinated and large-scale nuclear strike scenarios. Additionally, John Poindexter's involvement with the Iran Contra case did not help the media nor Congress's confidence in the PAM program. Due to DARPAs use of the crowd-force, program costs were minimal compared to larger DOD programs. It was easy for Congress to cancel a $1 million program with very little fall out. Hanson discusses the demise of PAM,

> If PAM had been a one billion dollar project, representatives from districts where that money was spent might have considered defending the project. But there was no such incentive for a one million dollar project (spend mostly in California and London). So the safe political response was obvious: repudiate PAM, and all associated with it, especially Poindexter. (2005, p. 5)

In this case, the use of predictions market was relevant and usable, but due to moral and political reasons, PAM's use was halted. This example shows how the low cost of crowdsourcing in futures markets could have had great advantages for estimates of cause and effect with regard to economic, political, and military analysis in specific areas of the world.

3. Software Innovation, Hacking, and Operation Overmatch

The next area of research explores the use of crowds to produce solutions to software related problems. Some of the cases analyzed for this research include the use of crowdsourcing in improving hacking at the Pentagon, *Operation Overmatch* video game, and developing applications for soldier use. First, we look at bug bounties to understand how the expertise of these crowds can be incentivized to help the government.

Bug bounties incentivize individuals who are hackers to test a system and look for vulnerabilities. These activities are common in the private sector but they can be applied to the federal government too. For example, in early 2016, the DOD conducted the first ever government bug bounty called "Hack the Pentagon." This was an effort to use a creative and cost effective way to expand the reach of participants to the crowd-force and provided internal experts ways to better protect networks and systems (Ruff, 2016). The platform HackerOne was responsible for registering hackers and providing analysis to the experts to help combat the vulnerabilities. This group was at its core the best of what makes crowdsourcing possible, people who love what they do as hobby enthusiasts or as part-timers who want to contribute information and data to the security of the nation. Some of the participants enjoy it for the intrinsic values while other enjoy the prospect of receiving reward prize money for their hard work.

The Secretary of Defense, Ash Carter, both approved and supported the idea to conduct the 2016 hackathon, which came from the Defense Digital Service. The interest in the Hack the Pentagon program grew rapidly, in the first six hours of opening, 200 participants tried to find and report security problems (Mickos, 2016). An unanticipated number of over 1,400 hackers joined from all over the country and the world. The bug bounty lasted 24 days, and in the end, it resulted in the disclosure of 138 vulnerabilities, and 58 hackers earning up to thousands of dollars in awards (Mickos, 2016). With cybersecurity as one of the major concerns for current and future DOD systems, this market has the potential to help gain levels of security by an untraditional method. Marten Mickos, the head of HackerOne, says it best when he describes the outward thinking of senior DOD leaders. He explains,

> No organization is so powerful that it does not need outside help identifying security issues, and this includes the Pentagon. Top companies rely on these bug bounty programs to improve their security, like Google, Facebook, Microsoft, Uber, Github, Twitter, Yahoo, and hundreds more. To be the most powerful, you must be open about your vulnerabilities, seek the help of others, and take corrective action quickly. (Mickos, 2016)

Secretary of the Army, Eric Fanning used HackerOne and the bug bounties in November 2016. HackerOne led and implemented this in the same manner as it did the Hack the Pentagon event, but it placed limitations on the number of participants to 500. The Army event also included the same incentives, and hackers received awards for their efforts to find vulnerabilities; the size of the payments were in relationship to the level of threat the hackers could find.

Another area where the Army has used crowdsourcing is with a video game called *Operation Overmatch*. This subject is one of the chief of staff's modernization priorities, focusing on synthetic training environment that relates to improving soldier lethality. *Operation Overmatch* relates some of the prototypes previously talked about in GCV design. The game is an early synthetic prototype (ESP) of future ground vehicles, UAVs, and weapons systems. The source of the crowd for this video game comes from soldiers playing the game, and the system records all data to help analyze decisions, which can improve the weapon system. According to Dobkin in a 2017 article for *The Atlantic*, "Every shot fired and decision made, in addition to messages the players write in private forums, is a bit of information soaked up with a frequency not found in actual combat" (2017, p. 1). Researchers and analysts use the data to inform Army programs on what technologies and capabilities the warfighter desires to be effective with future systems.

The goal of *Operation Overmatch* is to shift the way we think from scientists and engineers building perceived solutions to providing soldiers with early prototypes, evaluating the solutions use and if they are even worth continued effort (Dobkin, 2017). Not everyone believes that a video game can contribute to an acquisition system; however, Major General William Hix believes that generational differences prevent people from believing that video games, and the contributions of the soldiers performing tasks as they would in combat, can make a difference in the acquisition process (Dobkin,

2017). A comment made by LTC Brian Vogt, ESP project lead with U.S. Army Capabilities Integration Center, compares our current trend with ESP to the past. He states,

> Right after World War I, we had technologies like aircraft carriers we knew were going to play an important role…. We just didn't know how to use them. That's where we are and what we're trying to do for robots. (Dobkin, 2017)

Using ESP and video games like *Overmatch* allows the Army to take hundreds of prototypes and at a fraction of the cost of what it would cost to manufacture and produce and let soldiers test them. Robert Smith from Army Tank and Automotive Command Research Development and Engineering Center has experience with large costs associated with prototypes. He mentions the following.

> In the future, programs like *Overmatch* could allow the Army to become less reliant on complex, big-ticket technologies that require large purchases, and instead allow the service to field smaller number of vehicles or weapons tailored to specific areas or individual missions. (Dobkin, 2017)

The use of ESP falls in line with modernization priorities of the chief of staff of the Army. It provides benefits to multiple programs and has the same goals as current initiatives—to decrease costs and time required to get a product in the hands of the soldier.

4. Conclusion

The previous research discusses three different cases and addresses the different areas of crowdsourcing, including design challenges, forecasting, and software. The cases include successes and failures. The research provided evidence of strengths and weaknesses from the relevant uses of crowdsourcing in the DOD. The next section addresses other forms of crowdsourcing from the private sector and its use in commercial industry.

B. CROWDSOURCING IN OTHER AREAS OF INDUSTRY

The purpose of this section is to analyze previous uses of crowdsourcing in the private sector. The first explores a company called GitHub, which uses crowds to address the development of software and other online collaboration efforts. The second case is of a crowdsourced way to analyze traffic patterns and predict the best routes from a company called Waze. In the analyzed cases, the primary method of collaboration is through web-based forums or communities that enable the sharing of ideas and knowledge, which users can easily update and analyze for decision making and problem solving.

1. GitHub

GitHub is an online software collaboration company that allows users to share and update code for anyone who participates (Juergen, 2013). This process lines up more with open source use of the crowd-force as presented earlier in Chapter I. The idea of GitHub is for users is to be part of the online forums and present questions, problems, updates, desires, and methods for how to write code or develop solutions. The website allows others to assist and reduce the workload of an individual seeking assistance or help solve a problem for a participant who did not know how to do. Many of the members have jobs that relate to code and software, and they are experts who either participate because they find value out of helping others or enjoy enhancing their skill level. These intrinsic values help makes the company popular with the participants, and others looking for unique ways to solve problems. Juergen explains,

> Tom Preston, CEO of GitHub talks about its participants accomplishing a goal. "GitHub is able to pull people together and inspire people to contribute, because they can become part of something that's bigger than themselves." (Juergen, 2013)

GitHub takes projects that someone starts and populates it on the GitHub online interface. These projects are shared with all other users, who can download the project or repository in efforts to make revisions to accomplish the code's goal. This could range from fixing a simple mistake in the code to complete code revisions. After the revisions are made, the person who made the fixes submits the project back to the person who

originally submitted the problem. He or she has the choice to merge the changes with what he or she originally submitted. The online platform also allows for real-time discussion and provides support and guidance from other users on the revisions (Juergen, 2013). There are more complex issues that arise with the use of proprietary code development and large companies using GitHub for assistance. Through specific agreements, companies can purchase solutions from users, or they can pay for a monthly subscription to access domain hosts offering certain capabilities.

GitHub's expanded user base of helps to bring in a diverse pool of talents. Large companies such as Twitter and Facebook and even defense contractors like Lockheed Martin use GitHub (Juergen, 2013). In April 2013, GitHub had 3.5 members as crowd participants and worked six million projects (Juergen, 2013). Current numbers for 2017 have grown to 24 million users with 67 million repositories across 200 countries, reaching out to 1.5 million organizations (GitHub, n.d.). From many of the world's top countries to over half of the fortune 500 companies, the extent to how far GitHub reaches is vast, benefitting its users in some capacity through collaborative software building (GitHub, n.d.).

GitHub's use of crowds has been continuously growing and providing benefits to users throughout the last four years. Its ability to spread into so many companies and business locally and around the world enables it to reach the masses and come up some of the best solutions to software problem submitted by users. One concern with the use of Github could be the number of projects opened as repositories and whether or not it is too much for people to actually look through and provide feedback.

2. Waze Application

Waze is a free mapping and turn-by-turn direction app for android and IOS devices launched in 2007 by an Israeli and a Palo Alto developer. This app is a crowdsourced app drawing its popularity and reliability from the drivers and participants who use it. The steady increase in the number of participants has grown from 30 million in 2013 to 65 million in 2017 with use in over 185 countries (Smith, 2017). The use of

crowdsourcing sets it apart from other third party apps that offer map and direction data. As Empson explains,

> Waze relies on its millions of users to act as traffic cops, field ops and cartographers, flagging and recording updates on accidents, bottlenecks and traffic as they drive. It sucks in and aggregates the realtime data,….using it to build out and refine its own maps and to calculate the best possible routes for its drivers. (2013)

The use of this app is simple, and the data that comes in from the masses is aggregated at a central point of collection. Other features of the app allow drivers to gain insight on gas prices and traffic alerts, to share points of interest, and to interact in a social environment in real-time, all of which improve the accuracy of the data drivers use and add to the reasons people participate in Waze.

The social driving experience of Waze gives users visibility into friends going to same destinations, meet up spots, pickup requests, and communicate easier while on the road. The introduction of Facebook into the app has expanded the social aspect even more, providing more ways for users to make friends and share information, all while in the background the users supply data needed to make the app more beneficial. The app also provides a level of incentive for users to provide data with goals to level up, similar to gamerism, increasing one's score as compared to others. The intrinsic nature also applies to users with the feeling of doing a good deed for their fellow drivers and Waze participants.

The popularity of the app and its unique method of map data collection is what led Google to buy the company for $1 billion in 2013. As a large company familiar with the ideas of crowdsourcing, Google appreciated the atypical method that the Israeli company used to perform the mapping and direction functions. After the purchase, Google wanted to keep the core diversity of the company in place. The flow of impressive research and development ideas coming out of Israel has enabled the tech leader to see a market base for future contributions that have gone previously unnoticed. This helps Google, and its users to benefit from the talent that come out of Israel's population.

Waze's use of crowds is what caught the attention of large companies, like Google, who sought to take control of the small company with a huge market advantage in mapping and direction data. The expansion of Google into thriving and divergent areas of the world broadened its use of the world-wide power and wisdom of crowds. Waze's centralized aggregation method ties in the four elements that make up effective crowds.

3. Conclusion

This section described two different cases of crowdsourcing: software and forecasting in the respect to data collection. The cases display many of the trends researched with a continued growth in crowdsourcing and the ability of crowd-force to contribute over web-based applications. The research provided evidence of the strengths and weaknesses from the relevant uses of crowdsourcing in the private sector. The next section presents a summary of defense acquisition.

C. OVERVIEW OF DEFENSE ACQUISITIONS

An overview of defense acquisition provides a picture of the current process for how programs are formed. The DOD has the opportunity to use crowdsourcing to improve this process to help reduce costs and field program capabilities to the warfighter. This section covers the summary of the planning, programming, budgeting, and execution (PPBE) process, the Joint Capabilities Integrations and Development Systems (JCIDS), and the Defense Acquisition System. An emphasis on Defense Acquisitions highlights how crowdsourcing can be beneficial to these. Figure 7 summarizes the Defense Acquisition System.

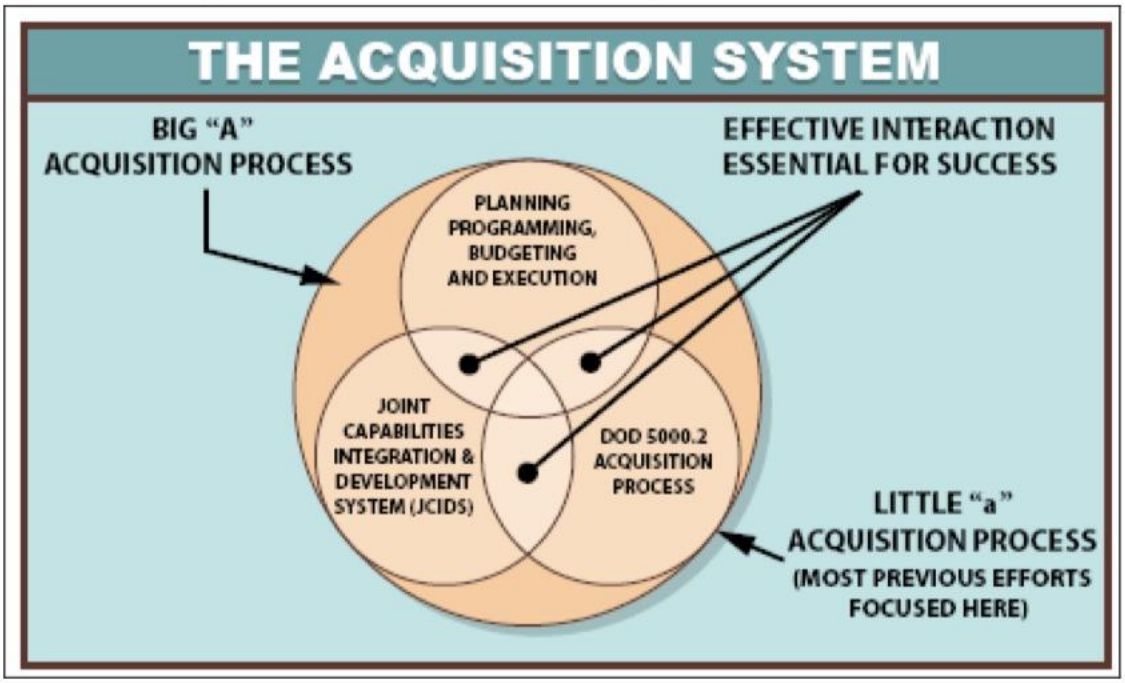

Figure 7. DOD's Defense Acquisition Structure. Source: Schwartz (2013, p. 3).

1. Planning, Programing, Budgeting, and Execution

The budget is what allows for funds to be used to pay for all aspects of our government; defense acquisition is no exception. This review summarizes the PPBE, a four-stage process, and covers the federal budget process in detail. This section concludes with a summary of the PPBE process.

a. PPBE

The PPBE is the method used to develop and propose budgets for all Major Defense Acquisition Programs as well as funding for all other agencies of the government. DOD uses this process for all purchases. It ensures that the DOD can meet the future needs of national security with regard to forces, equipment, manpower, and support that fall inside the budget for that year and forecasted out years (Schwartz, 2013).

(1) Planning

The first stage, planning includes the national security strategy and drills down into other documents, like national military strategy and the quadrennial defense review,

that support the security of our country. It results in the chair of the Joint Chiefs publication of *Joint Planning Guidance* wherein the service chiefs and Joint Staff make efforts to ensure the service components are able to meet the security requirements of our country (Schwartz, 2013). This planning phase can determine if services need new capabilities, modification or upgrades, or other methods such as training, to adhere to the published guidance (Schwartz, 2013).

(2) Programing

During this second stage, programming, government offices submit documents called program objective memorandums to the president for approval in the president's budget. These documents outline proposed or existing programs, associated expected performance goals, and estimated budget to fill national security requirements for approval in the president's budget. Additionally, these memorandums cover the areas addressed in the *Joint Planning Guidance* for defense programs (Schwartz, 2013).

(3) Budgeting

The third phase of PPBE, the budgeting process occurs concurrently to programming and is explained in more detail below. Different congressional committees deliberate on overall costs and feasibility of programs in efforts to come together on an agreement with how much money to provide to defense spending. The budgeting phase produces a budget estimate submission, which turns into the president's budget.

(4) Execution

The fourth phase of the PPBE, execution, is during a program's year of execution when program offices are purchasing requirements and conducting the business of acquisitions. The program offices are measured against the expenditure rates forecasted in the budgeting phase. The programs are evaluated to ensure the services are meeting requirements for national security.

b. Federal Budget Process

Congress is known to have the "power of the purse," which means it controls the way in which the federal government collects taxes, borrows money, and assigns the money to fund the government (National Priorities Project, 2017). These functions are granted by the U.S. Constitution and have been adapted over time. The process to approve the budget includes offices and agencies throughout the government. Submissions from these offices ultimately form the budget that goes to Congress for approval every year. There are five main steps that cover the federal budget process. These are outlined in the following subsections.

(1) Step 1: The President's Budget

The president's budget request is formed from all the offices in all branches under the federal government that will need money for the next year. These estimates come from different departments, such as the DOD, and includes the cost of acquisition programs for the coming year. These numbers are added up across all the branches, and this estimate is supposed to be sent to Congress every February for the upcoming fiscal year that starts 1 October (National Priorities Project, 2017). This budget is the president's proposal to Congress for approval, of what funding the government will need. The president's budget includes what programs need more funding, what can be cut, and how new priorities need to be funded to meet national security demands (National Priorities Project, 2017).

(2) Step 2: The House and Senate Pass Budget Resolutions

During the second step, both the Senate and the House budget committees look at the budget and review federal agencies requests (National Priorities Project, 2017). However, the two congressional groups have their separate ideas of how much funding should be authorized for these federal agencies, and they set overall spending amounts for the agencies. (National Priorities Project, 2017). The budget committees come together again after the first review to reconcile differences and vote to approve (National Priorities Project, 2017).

(3) Step 3: House and Senate Subcommittees Markup Appropriations Bills

In the third step, the Senate and the House budget committees determine the precise amount of money that is to be provided to all discretionary programs (National Priorities Project, 2017). The appropriation committees determine the need for the funding requested by talking to the federal departments, such as DOD for example, that have requested the funds. The committees ensure the dollars the departments have requested are going to be spent on necessary programs, which adhere to national defense, and then they vote on any proposed changes later. This process is done for other departments and respective committees come back together after any changes have been made (National Priorities Project, 2017).

(4) Step 4: The House and Senate Vote on Appropriations Bills and Reconcile Differences

In the fourth step of the federal budget process, the House and Senate debate and vote on the appropriations bill from each of the 12 different House and Senate subcommittees (National Priorities Project, 2017). Any differences between the separate committees are then debated until the issue has been reconciled. From here, once agreed upon the appropriation bills are voted on and go to the president (National Priorities Project, 2017)

(5) Step 5: President Signs Bill into Law

Each appropriation bill must be signed by the president for the departments to be able to use the funding legally. The president's signing of the appropriation bills signifies that the budget process has been completed (National Priorities Project, 2017). The budget then goes into effect and the process starts again next year. Figure 8 is a depiction of how the federal budget process works.

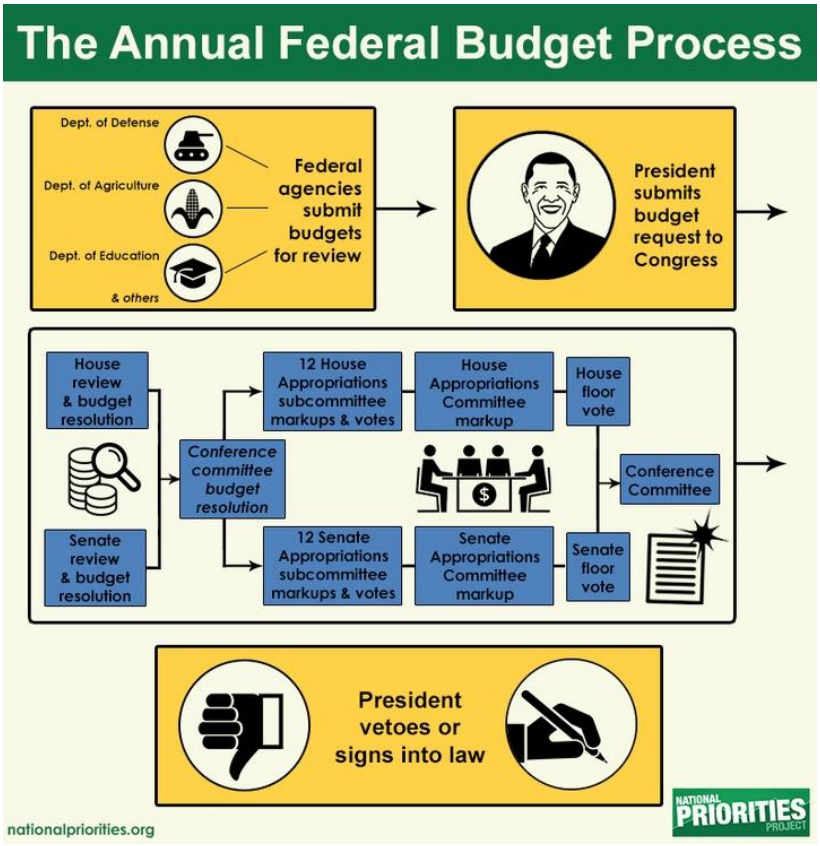

Figure 8. Budget Process. Source: National Priorities Project (2017).

c. Where the Money Comes From

The money that funds the government comes from a variety of taxes and fees that people and companies have to pay to the government each year. The three main sources of revenue for the government are income taxes, paid for by individuals, payroll taxes, and corporate taxes. Tax loopholes and deductions cost the government around 1 trillion dollars, which is almost twice of what the government has to borrow to meet its needs. This number is also close to what the discretionary benefits are for the U.S to meet the defense budget and other veteran's benefits. Figure 9 shows a breakdown of the different funding streams for the budget.

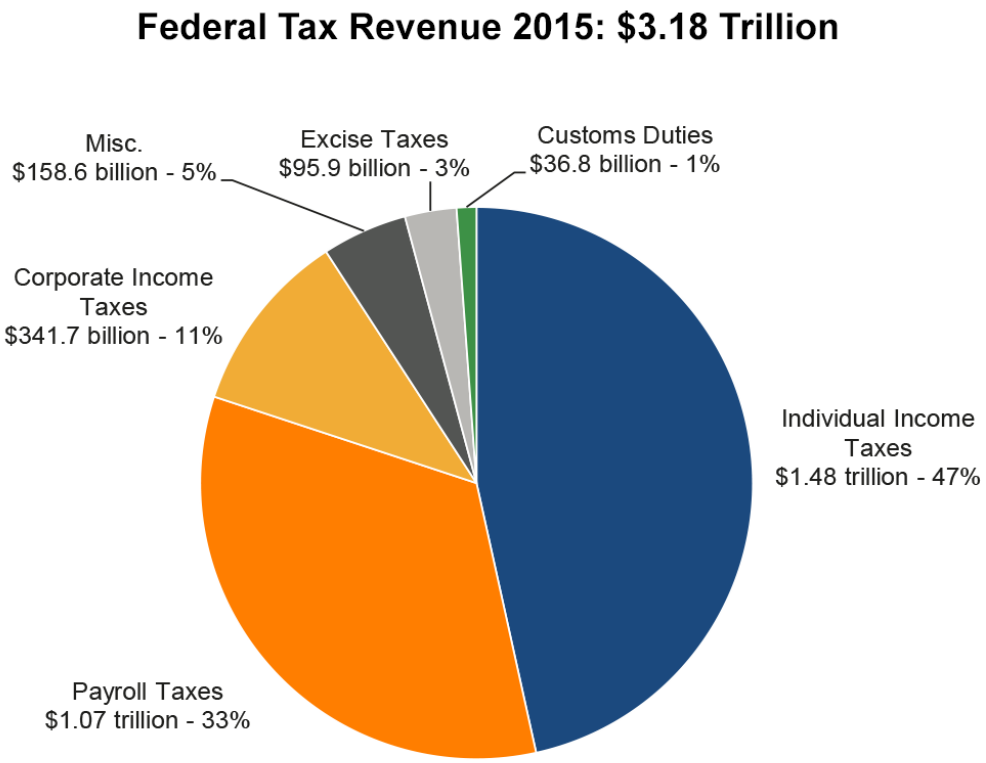

Figure 9. Where Budget Revenues Come From.
Source: National Priorities Project (2017).

d. Where the Money Goes

The approved budget goes into three basic categories. These include mandatory spending, discretionary spending, and paying down the interest on the national debt. Figure 10 depicts the amount of funds and percentages for amount of dollars spent from the budget.

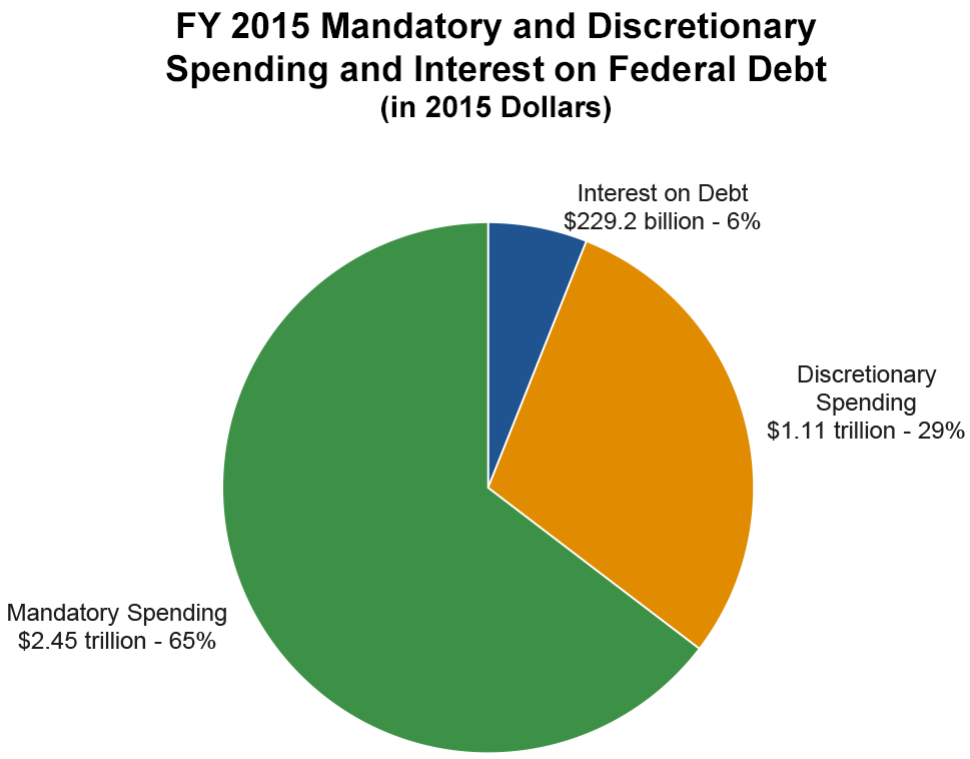

Figure 10. Spending Chart for FY15.
Source: National Priorities Project (2017).

The mandatory spending expenses include such programs as Social Security, Medicare, Supplemental Nutrition Assistance Program, Department of Transportation, and other programs that Congress decides to create where eligible individuals receive benefits (National Priorities Project, 2017). The two programs that take up the largest amount of the federal budget are Social Security and Medicare. Congress has the ability to change the eligibility rules for these programs, giving it the ability to include or exclude different categories of people, resulting a change in the amount of money spent in the budget on these programs (National Priorities Project, 2017). Congress cannot increase and decrease the mandatory budget without these types of changes to the programs qualifications (National Priorities Project, 2017).

Discretionary spending is the portion of the budget, mentioned earlier regarding programs like the DOD, wherein Congress decides on the amount of funds to appropriate.

The final section Figure 10 is the interest paid on the federal debt. This is the smallest portion of the spending and is about six percent.

2. Joint Capabilities Integrations and Development Systems

The JCIDS process is a way for the government to fulfill capability gaps that occur when strategic needs of the country have not been met by existing capabilities. Strategic guidance in the form of the *National Security Strategy*, *National Defense Strategy*, *National Military Strategy*, *Quadrennial Defense Review*, and others help prioritize the requirements that need to be filled through the JCIDS process. The Joint Requirements Oversight Council (JROC) is charged with supporting the acquisition cycle through the identification, review, and implementation of DOD capability requirements as well as shaping the force for future threats. There are four main documents of the JCIDS process that support the acquisition system.

The first one is an initial capability document (ICD). This document specifies the DOD's capability requirement and the capability gap with high operational risk levels that the requirement mitigates. The capability requirement exists dues a a lack in the government's ability to mitigate a threat, such as poor performance of a weapon system in comparison to another country. In this process, non-materiel solutions can be recommended along with a materiel one or a combination. The ICD is the entrance criteria for the material development decision.

The alternative to a materiel solution is a doctrine, organization, training, materiel, leadership and education, personnel, facilities, and policy change recommendation. The change recommendation is used to find a non-materiel solution through exploration of one of the alternatives above. Through analysis of strategic level goals and priorities, JROC identifies capability gaps that can be mitigated through other means besides costly defense acquisition programs.

The capability development document (CDD) identifies the key performance parameters, key system attributes, and additional performance attributes that the capability requirement must support. These criteria must be met to be able to produce a materiel solution that can meet the capability identified by the JROC. A draft CDD is

needed for programs to begin technology maturation and risk reduction, a process to ensure technology levels are able to meet the performance requirements. The program office needs the CDD to move forward with the Defense Acquisition System at Milestone B.

The last document for a materiel solution is the capability production document (CPD). This document supports the production of a capability the ends up meeting all the requirements to meet the capability gap previously identified. This document is required to move forward with the first increment production and Milestone C.

In summary, JCIDS ensures that the joint force has the capabilities it needs to execute the operations needed to uphold our nation's security. It works directly with the Defense Acquisition System to produce materiel solutions and analyses alternative means to cover any capability gaps in DOD. JCIDS uses the JROC to ensure our joint fighting force is postured with the means required to fight the future conflicts, improve current systems, and develop new capabilities.

3. Defense Acquisitions

Defense Acquisition System is the process that the DOD uses to procure weapons and major system requirements needed to uphold national security objectives. It is governed by the DOD Directive 5000.01 (2007), DOD Instruction 5000.022017), and the *Defense Acquisition Guidebook* (Schwartz, 2013). The process is not a cookie cutter approach for all systems, and each acquisition is unique and tailored to fit the scope of a given requirement. There is a general framework to guide all acquisitions. Figure 11 the different milestones, phases, and other requirements for programs to move through the acquisition life cycle.

The three milestones are listed below and depicted using Figure 11, which shows the overall summary of defense acquisitions.

- Milestone A: Initiates technology maturation and risk reduction
- Milestone B: Initiates engineering and manufacturing development
- Milestone C: Initiates production and deployment (Schwartz, 2013).

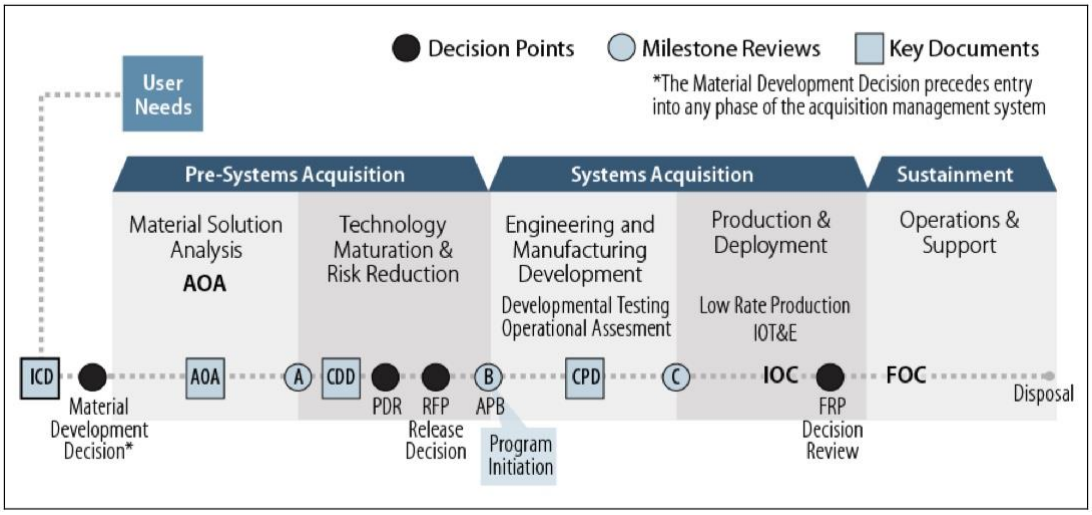

Figure 11. Defense Acquisition Milestones/Phases.
Source: Schwartz (2013, p. 7).

Milestone decision authorities (MDA) are the officials responsible for deciding when a program passes the requirements to move on to the next phase or milestone in the acquisition process. These authorities range from the undersecretary of defense to component acquisition executives. These positions are senior executive service (SES) positions, civilian personnel. The range in approval is based on the different acquisition category (ACAT) level. ACAT 1 is held for DOD level MDA and ACAT 2 and 3 have a component level SES as MDAs. Under the components, specifically the Army, are program executive officers (PEO). These individuals can be military or civilian personnel. Program managers work for the PEOs, and they are the primary officers in charge of the team executing a program's objectives. These positions can be military or civilian also, and the team consists of engineers, logisticians, contracting officers, financial managers, and testers. This structure makes up the current organization facilitating the Defense Acquisition System.

As covered earlier, requirements come from the JCIDS process and enter into the Defense Acquisition System with the ICD. The JROC determines if a materiel solution is necessary for fill the capability gap. The MDA makes a decision to approve the materiel development decision, documented in an acquisition decision memorandum (Schwartz, 2013). In this decision, the MDA ensures that a materiel solution is required, designates

the component in charge, and identifies what phase the program will enter (Schwartz, 2013).

The material solution analysis phase determines the best solution that can meet the requirements. A requirements board, like the JROC, conduct an analysis of alternatives to take all possible existing solutions and other options in development to compare and determine risk, performance, cost and availability. Program offices are selected at this point, life cycle cost estimates are estimated and technology maturation levels for performance requirements are analyzed. This phase is complete when the analysis of alternatives is completed and the program meets requirements to enter into the next appropriate milestone (Schwartz, 2013.)

The next phase is technology maturation and risk reduction phase. This phase begins with Milestone A wherein the MDA approves the acquisition strategy, and has the cost estimate, the program has full funding, and RFP is ready for release (Schwartz, 2013). The acquisition decision memorandum is updated with the MDA decisions. This phase determines whether or not technologies and designs are able to meet the requirement and to validate costs to move forward to develop the system. Competitors produce prototypes to show their design ideas and available technology. Programs collect data to develop the CDD for movement in to the next phase. The RFP is released for development decision point during this phase to ensure that contractors who bid on the development RFP understand the requirements and are able to achieve them within cost schedule and performance goals.

Milestone B is the start "to the Engineering and Manufacturing Development (EMD) phase" (Schwartz, 2013). According to Schwartz, "This is the point at which a program becomes a program of record" (2013). To pass Milestone B, the "program must have passed the development RFP decision point, requirements validated and approved, full funding established, cost estimate submitted to MDA, all risk mitigated, and MDA approve updated Acquisition Strategy" (Schwartz, 2013). At this point, the MDA approves and the program manager signs an acquisition program baseline and the This document is the basis of which the cost schedule and performance goals of the program are measured. The EMD phase fully designs and integrates the systems that meet the

capability requirements. The program office conducts early test and evaluation on systems and evaluates them to ensure the design is adequate and meets performance objectives. Tests also verify that systems can integrate and operate correctly with one another to ensure the capability can perform in an operational environment. This phase develops the CPD for entrance into Milestone C and the production and deployment phase.

To pass Milestone C,

> the production design must be stable, the system has passed developmental and operational testing, software maturity has been reached, the system is interoperable, costs are within budget, full funding is established, CPD documents are approved, and the MDA has approved the Acquisition Strategy. (Schwartz, 2013, p. 9)

Low rate initial production phase helps prepare the manufacturing process, ensure quality control, and provide test models for further operational testing (Schwartz, 2013). The MDA approves full rate production after operational testing requirements have been met and the manufacturing process is adequate to meet the demands of the producing the quality desired out of the system. Initial operating capability is achieved in this phase when the system meets the minimal useful form to the users. Full operational capability is completed when the systems are delivered to the users, and they are able to employ and maintain the system as it was designed.

The last phase in the Defense Acquisition System is the operations and support phase. This is the largest and longest phase of a system, typically making up around 70 percent of the total life cycle costs for a program. This phase includes the full operational capability of the system and the maintenance and support required to ensure its effective use. It ends with the appropriate disposal of the system after it has meet its life span or been replaced by another capability.

4. Defense Acquisition Conclusion

The Defense Acquisition System is the final component that makes up the larger acquisition process for the DOD. This section has summarized the three elements of the acquisition system, The PPBE process, JCIDS, defense acquisition process and to provide

the knowledge of the overall steps required to establish a DOD program and to develop solutions for capability requirements. Crowdsourcing can aid the acquisition system and those areas is addressed in further detail during Chapter IV in the SWOT analysis.

D. CHAPTER CONCLUSION

This chapter has analyzed different cases of crowdsourcing, including examples from government programs, such as GCV and DARPA, and commercial companies, such as GitHub and Waze. The research shows three main areas where looking to crowds can help solve problems: design challenges, futures forecasting, and software related fields. The overview of the acquisition system explains how the current process works for identifying requirements, determining funding and congressional approval, and how to build and produce a system to fill a capability gap. The next chapter covers a higher-level view of crowdsourcing with its application in the government and its increasing trend as a contributing factor in the ways we solve problems.

III. LITERATURE REVIEW

A. INTRODUCTION

The literature review includes sources that discuss crowdsourcing in the government to determine the overall use of crowdsourcing in defense programs. Three main areas stand out in the analysis of the previous cases—design competitions, futures prediction or forecasting, and software related collaboration. This continued evaluation of applicable fields allows us to explore the far reaching uses of crowdsourcing throughout the government.

The first work reviewed is a GAO report, by Mihm, (2016), on the use of *Open Innovation: Practices to Engage Citizens and Effectively Implement Federal Initiatives*. Mihm introduces the reader to the challenges that the government faces when it tries to engage with private citizens, nonprofit organizations, and other sectors that can contribute. The report identifies seven practices that agencies can use to incentivize participants from five unique strategies covered later. The report looks at different government agencies such as the Department of Energy, the Department of Housing and Urban Development (HUD), and National Aeronautics and Space Administration (NASA).

The second work is an article titled "Opening Government: Designing Open Innovation Processes to Collaborate with External Problem Solvers" by Ines Mergel (2014). The article discusses government initiatives focusing on transparency, participation, and collaboration. It addresses the needs of the government to improve efficiency. and quality of services, and products delivered by the government. Additionally, Mergel includes discussion on the America Competes Act, which promotes excellence in technology, education, and science (2014). These goals have led the government to turn to open innovation with problems using four phases, covered later, to find a solution.

The third work, "A Framework for Using Crowdsourcing in Government," and article by Clark, Zingale, Logan, and Brudney (2016) provides an overview of the

concept of crowdsourcing and examples, like in Chapter II of this work, about how crowdsourcing has been used in both the public and private sectors. Additionally, the article provides a framework for how governments can strategize and use crowdsourcing to come up with solutions to problems.

Lastly, the fourth aspect of the literature review is a look at federal acts to provide government the ability to increase the use of crowdsourcing. This includes a review of some historical acts that have helped in contracting and others that help use crowdsourcing as a solution. Many of the ideas addressed above fall in line with the introduction to crowdsourcing and the sources used to describe this idea. *The Wisdom of Crowds* (Surowiecki, 2005) and *Wikinomics* (Tapscott & Williams, 2008) are two other pieces that tie in to other works in the literature. They also add validity to the cases in Chapter II and summarize the overarching use of crowdsourcing and it roots.

B. GAO REPORT: OPEN INNOVATION—PRACTICES TO ENGAGE CITIZENS AND EFFECTIVELY IMPLEMENT FEDERAL INITIATIVES

The 2016 GAO report, *Open Innovation: Practices to Engage Citizens and Effectively Implement Federal Initiatives,* covers the use of crowdsourcing in government agencies, strategies and practices agencies use to implement crowdsourcing and supporting policy and guidance that encourages open innovation. The report looked at examples from six different government agencies and observed 15 different open innovation initiatives (Mihm, 2016). These agencies are the Department of Energy, Department of Health and Human Services, HUD, Department of Transportation, the Environmental Protection Agency, and NASA. The first section defines the five strategies and purposes. The second section looks at the multiple examples these agencies used to achieve open innovation. The third section addresses the policies and guidance the GAO analyzed to create this report.

1. Open Innovation Strategies and Purposes

The 2016 GAO report, *Open Innovation: Practices to Engage Citizens and Effectively Implement Federal Initiatives*, describes five open innovation strategies federal agencies have used. These are listed in Figure 12.

Figure 12. Description of Innovation Strategies Used by Federal Agencies. Source: Mihm (2016, p. 9).

Government agencies should be able to use the innovation strategies in Figure 12 to identify the purpose of reaching out to citizens to incorporate their feedback and solutions into projects (Mihm, 2016). Additionally, the report by Mihm identifies five main purposes to correlate with these strategies. These purposes are listed in Figure 13.

Purpose	Description
Collect information and perspectives	Agencies can collect the perspectives of a broad group of citizens and external stakeholders to identify problems or challenges, gauge perceptions of a program or service, gather reactions to proposed actions, or better understand their priorities, values and preferences. Agencies can then use this information to inform decisions about policies, plans, and the allocation of resources.
Develop and test new ideas, solutions, or products	Agencies can efficiently engage a broad range of citizens and external stakeholders in developing new ideas, solutions to specific problems, or new products ranging from software applications to physical devices. Agencies can also have them evaluate the quality and feasibility of the ideas and solutions proposed by others, or test the products that were developed. If it uses a successive or iterative process, the agency can help build the capacity of participants in these efforts to further develop or refine their ideas or products. Agencies can also use open innovation initiatives to stimulate the creation of new markets and companies that will then commercialize products and technologies developed for an initiative.
Enhance agency capacity	Agencies can leverage the time, resources, and expertise of citizens and external stakeholders to supplement their own internal resources, data, and expertise. These contributions enhance the agency's capacity, and therefore, its ability to achieve goals that would be more difficult to reach without this additional capacity or expertise. Open innovation initiatives may also allow agencies to achieve goals more efficiently and effectively than more traditional federal program types, such as grants or contracts.
Build or expand community	Agencies can establish or enhance collaboration among citizens and external stakeholders or organizations interested in an issue. This can be done, in part, by developing relationships among involved individuals and organizations. These relationships can then be leveraged to achieve common or complementary goals. Agencies can also enhance previously-established communities by using open innovation initiatives to strengthen existing relationships. This also can be done to bring new individuals and organizations into the community.
Increase public awareness	An agency can provide participants or the broader public with balanced and objective information and data to help them understand an issue or problem. Information can also be provided to help them understand opportunities and various alternatives for addressing an issue or problem.

Figure 13. Purposes that Agencies Can Use Open Innovation to Achieve.
Source: Mihm (2016, p. 11).

The GAO report collected data from 35 different federal agencies and found 171 initiatives using open innovation strategies (Mihm, 2016). This report categorizes these initiatives into innovation strategies. Second, the report examines the initiatives to identify the agency goals by using open innovation. Once Mihm, completed the examination of initiatives, he created a table to show how specific strategy could be used to achieve the five purposes. Figure 14 shows how a specific strategy could be used to achieve the five purposes but identifies what purpose had the most occurrences.

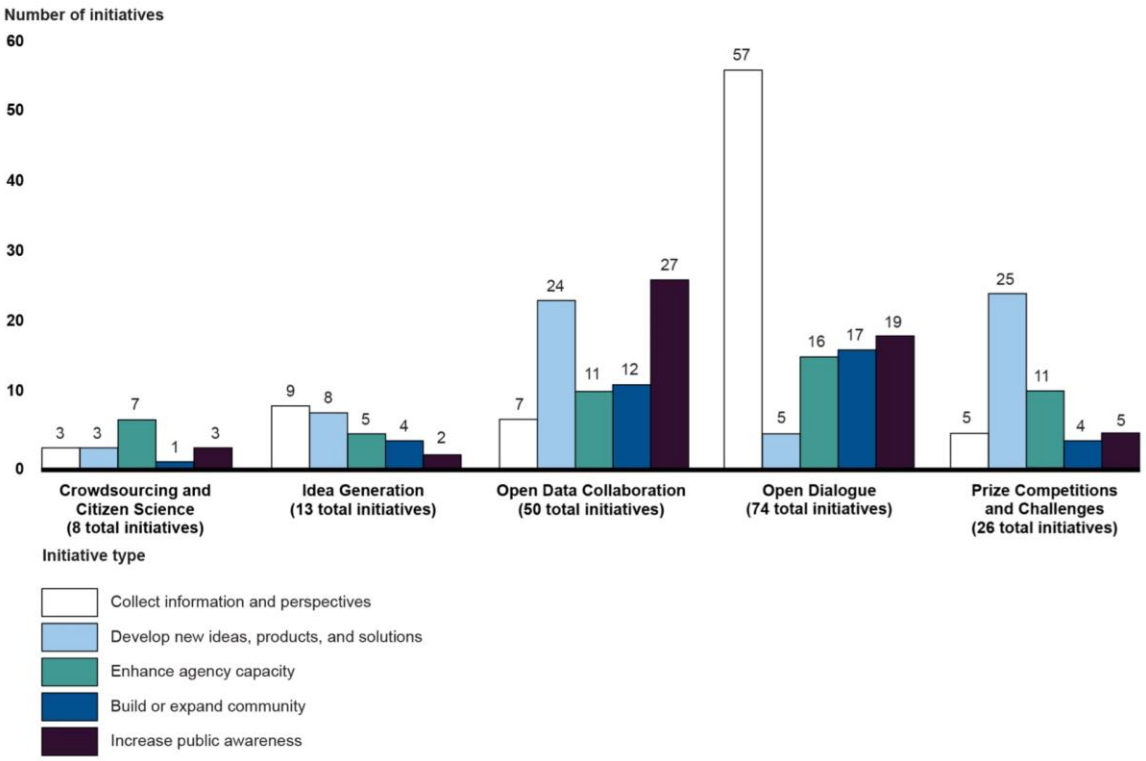

Figure 14. Purposes of Open Innovation Initiatives Identified in Agency Open Government Plans. Source: Mihm (2016, p. 13).

Figure 14 shows the that government agencies reach out more frequently at certain strategies of the given purpose than at others. One that has highest instances is using open dialog as the strategy (at 57 initiatives) for the purpose of collecting information and perspectives. The other relevant strategy is prize competitions and challenges relating most with developing new ideas, products, and solutions. This specific example is featured in the DARPA case and the Hackathon case. Mihm covered other factors that government agencies should consider when selecting an open innovation strategy. Support form an agency's leadership for the use of an open innovation strategy provides credibility, visibility, and supportability, ensuring that approvals and resources needed for the initiative can be met. Legal authorities pertain to policies, either government or agency wide, and outline requirements that have to be met prior to awarding a prize or other restrictions for the strategy (Mihm, 2016). Resource needs and availability apply to technological requirements that enable the open innovation strategy and can help lead to more accurate cost estimates for implementation.

Lastly, the agencies capacity to implement the strategy determines if the staff members available have the experience or knowledge required to successfully implement the strategy. Government agencies can use contractor support to augment existing capability or seek other experts with relevant experience (Mihm, 2016). The next section addresses some examples from the 2016 GAO report.

2. Open Innovation Agency Examples

The first example of open innovation is a challenge strategy that NASA uses to identify asteroids that could have potential threats to Earth. NASA's Tournament Lab, an office that works with the execution of prize competitions and challenges, issued the Asteroid Grand Challenge (Mihm, 2016). The grand challenge, which became known as the Asteroid Data Hunter Challenge, aimed to improve collaboration and the algorithm accuracy for tracking potential threats to Earth. In April 2014, a report of the progress of the challenge over the course of 10 months found that more than 1,200 participants submitted 700 potential solutions for improving the accuracy of the tracking algorithm (Mihm, 2016). According to Mihm, "The improved algorithm led to faster and more accurate asteroid detection resulting in a 15% increase in positive identification of new asteroids at the cos of $200k, around what it would cost to hire one engineer" (2016). The benefits of this challenge and the results it yielded were worth the efforts to reach out to citizens for input and suggestions to improve critical capabilities for NASA.

The next example is an idea generation strategy that HUD successfully implemented. HUD's use of an online idea generator called Switchboard to collect ideas from citizens, stakeholders, and HUD staff to improve its processes and programs (Mihm, 2016). The organization developed a team to review the ideas and respond to the people who submitted suggestions. The platform also hosts discussion forums on specific issues and includes the ability to target specific segments of the public to get the desired participation (Mihm, 2016). The result enabled HUD to incorporate and use participant feedback to inform its policy and budget requests.

More examples cover the different strategy areas such as the Department of Health and Human Services collecting feedback from users to make changes on a data

platform called OpenFDA. OpenFDA provides information that gives researchers and developers easier access to its data (Mihm, 2016). As the platform reached testing and progressed toward release, the department opened it up to potential users and got feedback that helped it make changes and modifications to the system to be more appealing to the user community (Mihm, 2016) Numerous other examples include many instances of prize challenges from designing a way to collect wave energy from the ocean to challenges in how to best rebuild communities after Hurricane Sandy.

3. Policies and Guidance

Recent involvement from the president and Congress have aimed to improve the use of open innovation across federal agencies. Memorandums and directives, such as the *Presidential Memorandum on Transparency and Open Government* as well as the Office of Management and Budget's Open Government Directive have directed agencies on how to use feedback, technology, and other innovation methods (Mihm, 2016). In 2011, President Obama signed into law the America Competes Reauthorization Act, which gives "government wide authority for the executive branch agencies to use prize competitions to advance their goals" (Mihm, 2016, p. 2). Congress has introduced and passed other bills, some of which are addressed later, such as the Crowdsourcing and Citizen Science Act of 2016, the American Innovation and Competitiveness Act, and the Aeronautics Innovation Act (Mihm, 2016). The Government Performance and Results Act (GPRA) of 1993, updated in 2010 to the GPRA Modernization Act, outlines how agencies are to identify strategies and resources they will use for open innovation and how the implementation affects the agencies (Mihm, 2016). These policies and guidance were aimed at instructing agencies to plan and update innovative methods to use outside parties and increase public participation. Three examples from Office of Management and Budget, Office of Science and Technology Policy (OSTP), and General Services Administration (GSA) illustrate the implementation of this guidance.

These agencies have developed specific policies and guidance documents that support open innovation strategies and facilitate through shard knowledge and websites (Mihm, 2016). GSA uses a website called Challenge.gov to help different government

agencies find participants to sign up for prize competitions and challenges (Mihm, 2016). GSA meets quarterly to discuss best practices and ideas that help further this strategy. Since from 2010, when GSA first launched Challenge.gov, to October of 2016, agencies have conducted over 700 prize competitions or challenges (Mihm, 2016). In 2013, the Office of Management and Budget followed guidance from a presidential executive order about open data policy to ensure the use of open formats to maximize accessibility to the public for agency information systems (Mihm, 2016). In 2014, GSA released and Open Data Action Plan tasking agencies to use online and in-person mechanisms to release data sets and ensure ease of use by individuals outside the agency (Mihm, 2016). In 2015, OSTP issued a memorandum that listed out principles and methods to build strategies that should be followed when conducting crowdsourcing initiatives (Mihm, 2016). OSTP also released a Citizen Science toolkit highlighting best practices, lessons learned, and case studies. GSA established a central repository, called Citizenscience.gov, to support these initiatives, and as of September 2016, it has over 303 active crowdsourcing projects with participation from 25 agencies (Mihm, 2016).

The literature review for this report covered the strategies and purposes used to promote open innovation. Additionally, it explored examples of agencies that have implemented open innovation initiatives with success. This summary includes a brief overview of the laws and policies directing the increased access and ability for the public to participate in challenges, feedback, idea collaboration, and other means of open innovation.

C. OPENING GOVERNMENT: DESIGNING OPEN INNOVATION PROCESS TO COLLABORATE WITH EXTERNAL PROBLEM SOLVERS

Open innovation focuses on three main points: transparency, participation, and collaboration. Federal agencies use collaboration less than the other aspects, but efforts to include outsiders to come together to solve problems is part of the open innovation concept (Mergel, 2014). policies and directives, discussed in this research and articles such as Mergel's, further influences and stresses the use of open innovation to federal agencies. Mergel's 2014 article, "Opening Government: Designing Open Innovation

Process to Collaborate with External Problem Solvers," addresses the current views of government and how we need to have a paradigm shift so as to better facilitate open innovation to reach crowds, which as they have done for the private sector, may provide benefits to the government. Mergel also covers a different approach to the open innovation process.

Open innovation in the government aims to move away from the paradigm of using predetermined contractors, which conduct the majority of the development and production of government systems or services (Mergel, 2014). This paradigm shift includes the policies, directives, and acts that strive to improve the ability for federal agencies to collaborate with and encourage new participants to help solve problems. Some of the examples expressed in Mergel's article follow the same strategies mentioned in the 2016 GAO report. This includes idea generation, prize competitions, and challenges. Both Mergel and the GAO report use similar cases addressing the success of hackathons and some of the NASA challenges and also review the use of peer production in crowdsourcing. This idea comes from breaking down a large project into smaller workable segments that groups of people can solve with a combination of all the pieces to develop the solution (Mergel, 2014). Similar applications like this were evaluated in the case of GitHub.

Many open innovation ideas have been previously addressed in this thesis and this article highlights the same main points. For open innovation in government to be successful, there must to be transparency, participation, and collaboration, and policies and directives to achieve the paradigm shift. One topic similar to innovation strategy with a different approach is the phases of open innovation process.

Phase 1 of the open innovation consists of general idea collection whereby an agency publishes a problem to the public to begin collecting ideas with no predetermined solution (Mergel, 2014). This idea gets away from the organization's manager, who has a specific solution in mind, and opens idea generation up to the crowds. This ties in one of the main purposes from the 2016 GAO report, increasing public awareness. This phase solicits "a broad sweep of ideas to open up communication between government and citizens" and collecting submissions to move to the next phase (Mergel, 2014).

Phase 2 is the selection of ideas and judging of winners where agencies use three different approaches to determine the best ideas (Mergel, 2014). These approaches are an internal review, citizen vote, and judges with subject matter expertise (Mergel, 2014). Agencies use internal review of general idea submissions to review ideas to determine if they have a direct application for a specific task of that agency or if the agency can use the ideas for a more strategic purpose (Mergel, 2014). The citizen vote takes the crowd-force solutions to a problem and invites the participants to vote on ideas; the ideas with the most votes move to the final decision makers for approval (Mergel, 2014). The judging option provides more publicity for an event and includes government officials to speed up the process with more awareness and visibility into what matters to the citizens (Mergel, 2014).

Phase 3 is the implementation of the open innovation outcome. This phase takes the citizen innovation and moves it into action, including improvements to a service provided, design solution, or general information and data flow. Mergel's article states that phase 3 is very rarely seen by the participants (2014). While the other two phases have a noticeable achievement, some ideas do not tend to go forward (Mergel, 2014). One example can be observed in the development of the Marine Corps ACV, where in the DARPA challenge sought designs for the make the suspension and drivetrain. While DARPA awarded a winner, the program manager ultimately used a different design, which was more suitable in meeting the performance requirements of the project.

Mergel's article adds validity to the government's desire to improve open innovation and the use of crowdsourcing. The article also shown some weaknesses previously identified and uses many federal agencies to draw it conclusions. Other literature in this review looks into policies and laws that help promote more access to crowdsourcing for the government.

D. A FRAMEWORK FOR USING CROWDSOURCING IN GOVERNMENT

The 2016 article by Clark et al., titled, "A Framework for Using Crowdsourcing in Government," addresses crowdsourcing and provides more examples of how it has been effectively used in private industry. The article includes insight into crowdsourcing

for the government through an analytical framework to develop strategies to engage with citizens. The framework and the typology described in this article ties in the work of James Surowiecki and his book *The Wisdom of Crowds* (2005).

The framework described by Clark et al. helps to integrate and engage crowdsourcing methods (see Figure 15). First, it looks at the scope of the problem, ranging from simple to complex (2016). Secondly, the framework takes into account the knowledge and expertise of in house ability to solve a problem (Clark et al., 2016). Lastly, the framework takes into consideration the diversity of thought to achieve solutions, taking into account different perspectives, backgrounds, and points of view (Clark et al., 2016).

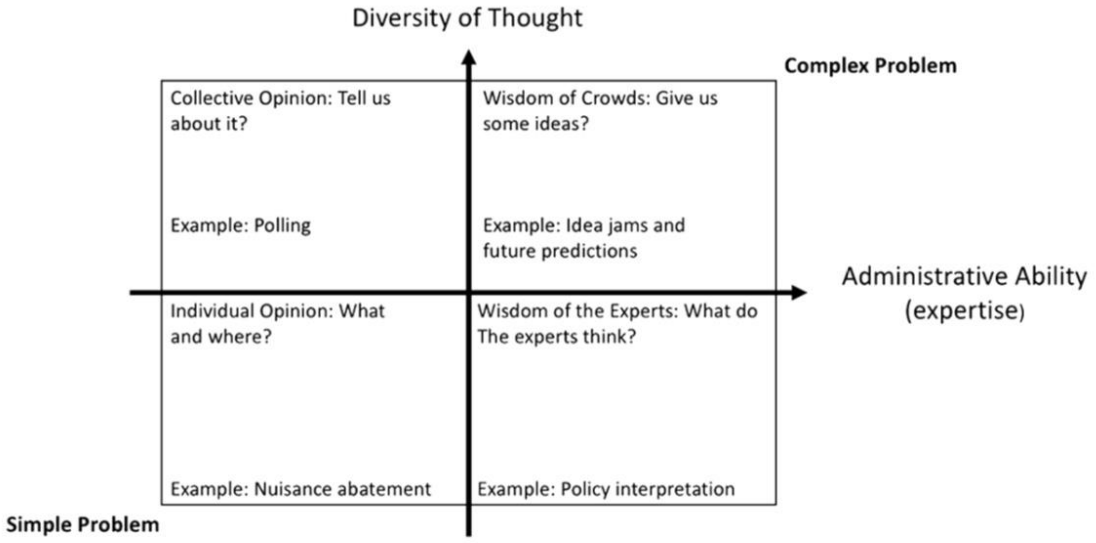

Figure 15. Analytical Framework. Source: Clark et al. (2016, p. 63).

The left-hand side of the framework in Figure 15 shows how problems relate to opinions of individuals or of groups, while the right-hand side shows the need for greater expertise in the organization (Clark et al., 2016). The top part of Figure 15 shows the need to involve a greater number of participants, while the bottom shows demand for individual knowledge in specific areas (Clark et al., 2016). Surowiecki's idea of *The Wisdom of Crowds* (2005) comes into play at the top-right portion of Figure 15— the

idea that larger groups off people can come up with a better solution than individual experts.

Similarly, Figure 16 shows crowdsourcing problem types for government and uses Brabham's typology included with the framework covered above. This typology is problem based so users can assess what they need to solve, whether crowdsourcing can help, and what approach would be most useful. The types of problems line up with the purposes listed in the 2016 GAO report.

Brabham's Origianal Typology			Our Additions to the Typology	
Type	How it Works	Kinds of Problems	Our Analytical Framework	Administrative Expertise (AE) and Diversity of Thought (DT)
Knowledge Discovery and Management	Organization tasks crowd with finding and collecting information into a common location and format	Ideal for information gathering, organization, and reporting problems, such as the creation of collective resources	Individual Opinion	Lower DT Lower AE
Distributed Human Intelligence Tasking	Organization tasks crowd with analyzing large amounts of information	Ideal for large-scale data analysis where human intelligence is more efficient or effective than computer analysis	Collective Opinion	Higher DT Lower AE
Broadcast Search	Organization tasks crowd with solving empirical problems	Ideal for ideation problems with empirically provable solutions, such as scientific problems	Wisdom of the Experts	Lower DT Higher AE
Peer-Vetted Creative Production	Organization tasks crowd with crating and selecting creative ideas	Ideal for ideation problems where solutions are matters of taste or market support, such as design or aesthetic problems	Wisdom of the Crowd	Higher DT Higher AE

Figure 16. Brabham's Modified Typology. Source: Clark et al. (2016, p. 63).

In Figure 16 the wisdom of crowds is in the fourth row and the associated problems for government are covered in the far-left column. Type one, knowledge discovery and management, relates to the purposes of increase public awareness and build community. Type two, distributed human intelligence tasking, is similar to collect

information and perspectives. Type three, broadcast search, compares to enhance agency capacity. Type four, peer vetted creative production, relates to develop and test new ideas, solutions, or products.

Clark et al.'s article (2016) provides a broader look at a framework of crowdsourcing for government than that of other works reviewed. This review observes the relationships between the academics, who established the main principles for crowdsourcing, and the recent policies to influence new innovation efforts in federal agencies. The effectiveness seen in private business examples helps to define ways forward for government in how we develop policy and directives to enable the same success.

E. ACTS AND INITIATIVES ENCOURAGING THE USE OF CROWDSOURCING

In his thesis from 2010 titled *Innovations in e-Business: Can Government Contracting Be Adapted to Use Crowdsourcing and Open Innovation*, Brian Lauterbach-Hagan's examines acts that have helped innovation for crowdsourcing in the past. The acts he researched are best summarized in his own words. He explains,

> the Clinger-Cohen Act authorizes the government bureaucracy to develop and use technology in order to help improve efficiency and reduce the cost of government. In addition, the E-government Act establishes the framework for promoting interagency cooperation and using Internet technology for this purpose. Further, the Bayh-Dole Act sets parameters for competitive patenting of university research, which prompted some in the scientific community to promote and advance Open Source development. The legal framework is further refined through a series of federal acts such as the National Cooperative Research Act, the Federal Technology Transfer Act, the National Cooperative Research and Production Act and the Cooperative Research and Technology Enhancement Act. They promote the government and commercial industries to enter joint and collaborative research agreements as well as transfer agreements. They also changed ownership and patent law. Finally, the Antideficiency Act restricts government agencies from using "free" volunteer labor that is rendered with the implicit expectation that there is a guarantee of future revenues. Since Crowdsourcing is driven by volunteers, government users must be aware of the boundaries surrounding the use of free labor. (Lauterbach-Hagan, 2010, p.79)

This thesis takes the work of Brian Lauterbach-Hagan and carries it forward, applying it seven years later by looking at new laws and policies the government has enacted to continue to advance innovation. This research reviews three main acts that have recently been passed by or introduced to Congress to improve access to crowds for the government and the participation from the citizens it is trying to reach.

The first act is America COMPETES Reauthorization Act of 2010. This act "gives government wide authority for the executive branch agencies to use prize competitions to advance their goals" (Mihm, 2016). Each of the following acts use this act to justify giving more power to federal agencies to improve innovation. The prize competitions and challenges have proved very beneficial for federal agencies and have seen wide use in the DOD as illustrated by the numerous examples cited in this research. The ability for the government to be able to reach the masses online and provide incentives to participants improves our capabilities across any section of government that implements the crowdsourcing ideas and strategies as a solution. Cost savings seen in this research's examples show some of the benefits of the America COMPETES Reauthorization Act.

The next act is a House resolution from 2016, titled the Crowdsourcing and Citizen Science Act, and it uses the previous America COMPETES Act to support its goals. The act is meant to "increase the use of crowdsourcing and citizen science methods within the federal government in order to advance and accelerate scientific research, literacy, diplomacy and other purposes" (Crowdsourcing and Citizen Science Act [Crowdsourcing Act], 2016). Crowdsourcing in this act is defined as "obtaining needs and services by soliciting voluntary contributions from a group of individuals or organizations, especially from and online community" (Crowdsourcing Act, 2016). Citizen Science is defined as "open collaboration in which individuals or organizations participate in the scientific process to include formulation of research questions, refining project design, conducting scientific experiments, collecting and analyzing data, developing technologies, and solving problems" (Crowdsourcing Act, 2016). These resources aim to bring together participants from these two communities and the government to capitalize on similar benefits seen in previous acts. The act grants "Federal

science agencies the direct, explicit authority to use crowdsourcing and citizen science to encourage appropriate use to advance federal missions and stimulate participation in the innovation process" (Crowdsourcing Act, 2016).

The final act relevant to crowdsourcing is the American Innovation and Competitiveness Act of 2017. This act is "to invest in innovation through research and development, and to improve the competitiveness of the United States" (American Innovation and Competitiveness Act, 2017). Passed in January 2017, the act is the most recent document found during this research process. It also includes many updates to the America COMPETES Reauthorization Act and includes the Crowdsourcing and Citizen Science Act. The American Innovation and Competitiveness Act is largely focused on science and technology institutions with the aim to maintain the transparency and accountability as seen from the 2016 GAO report by Mihm and the practices that GSA and other organizations have implemented. This act includes a section on prize competitions for the science sector as well as a section on improving government partnerships with manufacturing. Many of the goals look to improving innovation relationships with science partners and academia to increase U.S. economic competiveness and advance the health and welfare of the United States of America (American Innovation and Competitiveness Act, 2017).

The ideas from these acts are made into law to increase our nation's strength and to establish regulation on how to best implement crowdsourcing. Many of the current acts aim to achieve more involvement from citizens and sections of the economy to provide the input needed for our country to achieve technological breakthroughs. They further expand on some of the recent successful guidance to federal agencies to enable better capabilities to crowdsource. The activities of the government to continue updates to acts and to pass as law, showing the importance that crowdsourcing will play in the near future.

F. CONCLUSION

This literature review evaluated the larger reach of crowdsourcing through our government. The review covers the GAO report, articles, and federal acts, all relating to

the implementation of crowdsourcing by the government. The 2016 GAO report provided strategies and practices that government agencies should use when attempting to use a crowdsourcing solution. The article by Mergel spoke of very similar strategies and broke the use of implementation down into phases. The third article showed a framework that tied in Surowiecki's *Wisdom of Crowds* (2005). Federal acts gave the historical aspect of where crowdsourcing was back in 2010 and how current laws have been established to support the innovation concept through federal agencies. Numerous examples were provided to explain key approaches and ideas to crowdsourcing from each of the sources. The practices of different government agencies outside of the DOD shows similarities in strategies used for design innovation and prize challenges offered to crowds in exchange for providing solutions.

IV. SWOT ANALYSIS OF CROWDSOURCING

A. INTRODUCTION

This chapter addresses the research method used to conduct the analysis of this thesis. The SWOT analysis provides a way to structure the topic of crowdsourcing that evaluates positive and negative factors in relationship to internal and external factors. The SWOT analysis can help show how to incorporate DOD programs with initiatives that best support the use of crowdsourcing (see Table 1). This type of analysis can contribute to how the government builds and retains DOD strategic and competitive advantages over near peer threats and nation states. The areas that have potential impact for crowdsourcing in DOD programs are design competition, forecasting, and software related fields.

Table 1. SWOT Analysis Chart

	Positive	**Negative**
Internal	Strengths - Experience - Challenges / prize comps - Data collection - Cost savings - Access to web	Weaknesses - Platform design issues - Too many solutions or ideas - Old paradigm, use defense KTRs
External	Opportunities - Strategies and purposes - Top down emphasis - Integration of primes and crowds	Threats - Adversary knowledge of systems - Drive out innovation

B. STRENGTHS

The DOD has had experience in the past with performing crowdsourcing initiatives. Some of the more successful examples come from programs that have used citizen participation in software related fields and idea generation and data collection or

forecasting. Our experiences have also helped to identify some of the weaknesses and opportunities that have been analyzed during the course of this research discussed in the next two sections. In this section, the strengths of using crowdsourcing are identified and explained based off the information gathered.

1. Evaluations

From the examples provided pertaining to the DOD, crowdsourcing has been used in the past seven years in efforts for new combat vehicle designs, futures forecasting, and software related fields with success in each area. The two areas that stand out the most are forecasting or data collection and software related fields. Design will be addressed later, but strengths were noted that could provide benefits to the DOD if used differently in the future. Forecasting and software are both largely successful due to the types of crowds that are attracted and their ability to gain access to provide feedback. An additional positive attribute observed was the ability for these two areas to have ideal conditions learned from *The Wisdom of Crowds* by Surowiecki (2005). The conditions are "independence diversity of opinion, decentralization, and a way to aggregate the results" (Surowiecki, 2005). This idea relates also to the observation of failures in his article "Opening government: Designing Open Innovation Process to Collaborate with External Problem Solvers." Mergel refers to the phases of crowdsourcing addressing failure to move forward or poor implementation of crowdsourcing (2014). The last condition that is so important to the success of crowdsourcing is the aggregate of the results where the combined solutions are greater than that of any one expert.

The first observation of strengths is evident in the examples of prize competitions and challenges reviewed during the previous chapters and throughout the research process. This strategy provides the most incentive for citizens to participate in an initiative and help achieve a goal of the DOD or other federal agencies. Examples such as the Hackathons and NASA's Asteroid Hunter program were successful because of their ability to use web based resources to reach out and communicate with large amounts of individuals all around the world. This ties into the crowdsourcing framework and applies to complex problems trying to include a wide-ranging diversity of thought in order to best

solve a problem. Prizes, such as monetary payments, seem to be a big motivational aspect for participation in crowdsourcing. In some instances, not every participant received a monetary donation or prize but individuals still participated. For these reasons, we can infer that largely in DOD programs most participants choose to contribute for monetary benefits that they can obtain, therefore placing this more into the extrinsic category. Even though legislative acts have been passed into law enabling federal agencies use of funds for these innovation strategies, the costs associated are much less than traditional methods. NASA's use of crowds to develop modifications to the algorithm to find asteroids cost as much as one engineer position for a year. Instead of getting one smart guy's feedback NASA used that same amount of money to receive over 1,000 different peoples' inputs to develop a solution.

The second area that is a strength is seen from data collection and includes futures forecasting. Observations from DARPAs futures program, the video game using ESP for user feedback, and the Waze application provide support for this strength. This area also relies heavily on the experiences of the people that are providing the information to the websites or online collaboration forums. The ability to have access to communications resources such as the Internet and other infrastructure supports information sharing in the crowd-force. The use of ESP to get feedback and collect data that can be included early on in a programs life cycle reduces costs in future potential rework that would be needed to meet user demands. Driving down costs by using innovative testing methods through ESP and early performance feedback lines up well with the Army's modernization priorities. The main goals are aimed at reducing cost and speeding up the time required to field a solution.

DOD program offices can use crowdsourcing strategies to reach modernization goals. The strengths center around the DODs ability to reach the crowd force, experiences learned from previous crowdsourcing efforts, and potential cost savings with increased use of crowdsourcing. The strengths apply to Army directive, creating CFTs that focus on documentation, testing and research required to advance a materiel solution from early stages of defense acquisition to a program office for production and fielding. The strengths of crowdsourcing can reduce the time it takes to field a solution by

bringing together greater testing capabilities in virtual environments and improving collaboration between all stakeholders. The CFTs aim to do this early on using key personnel from every organization that will have visibility on a program later on in the acquisition process. Surprises and unknowns can be mitigated earlier on in the life-cycle achieving reduced costs and quicker fielding.

There are opportunities to expand crowdsourcing in the DOD using external observations from other government organizations and civilian companies. Those opportunities are addressed in the upcoming section.

2. Conclusion

The strengths of crowdsourcing include the experiences that the DOD and other government agencies have had in the recent past. This include what types of strategies work the best with the use of prize competitions and challenges being among the most popular. Additional strengths noted were the data collection and feedback enabling better forecasting leading to programs that can use real-time data for more reliable system. The last factor is cost saving of crowdsourcing. This observation was noted throughout all the cases and examples researched. Even in the events of strategies that issued prize money, the saving in comparison to traditional methods of developing solutions was notable. Next aspect to cover is some of the weaknesses that stand out with the use of crowdsourcing.

C. WEAKNESSES

The three main weaknesses that were evaluated throughout the research process include issues with vehicle design, the occurrence of too many crowdsourcing solutions, and paradigm shifts. The weaknesses relate to the internal observations from the DOD examples as well as civilian observations that were relevant. The applications of the weaknesses were evaluated based on the three areas of potential use for crowdsourcing in the DOD: design, forecasting, and software.

1. Evaluations

The first weakness concerns the use of crowds to conduct DOD vehicle designs. Although the use of prize challenges is an effective method to conduct design challenges, the solutions gained from the crowd-force do not meet performance needs of the program offices. Vehicle design is performed by some of the few companies in the United States that are able to produce and manufacture combat vehicles. Designs submitted by the crowd-force are able to be developed more rapidly but also do not hold the same level of expert knowledge needed to have long term success. The crowd-force is able to create rapid design such as the FLYPMODE reconnaissance vehicle due to extensive online collaboration and virtual testing of system components. These advancements in virtual testing are seen through extensive knowledge gained by DARPA over years of research and continual improvements in their databases. The use of production fabrication software allows the crowd to determine the ideal setup for manufacturing plants. The FLYPMODE was able to be designed by the crowd-force over virtual collaboration with a prototype produced in less time compared to traditional program development. The design did not meet performance requirements required to guarantee Soldier protection but proved a possible method to design vehicles and production facilities.

The research noted that vehicle design is best conducted by experts that specialize in this area of industry. Leading contractors are able to produce designs that are capable of being manufactured and meet performance requirements of the user. In this case strategies for crowdsourcing do not line up well with achieving vehicle design for the DOD. Some aspects of systems are going to be better left to experts who have more experience and knowledge of certain DOD systems.

The second weakness demonstrates that too many solutions can occur, causing little contribution to a solution. As seen with the GitHub example, there are over 67 million repositories or open projects looking for solutions, leading to participants' inability to find a solution for every problem. The DOD could have similar issues if they opened up crowdsourcing in the same manner. The weakness of getting too many responses or having too many open projects can lead to poor proposed solutions from the crowd-force or wasted time in the search to find other options. The DOD has followed

directions to increase the use of prize competitions and challenges as prescribed in policy and guidance. These directions push government agencies to make crowdsourcing more accessible to the crowd-force. Using the lessons learned from struggles in commercial industry can prevent the DOD from making similar mistakes. Recent efforts at minimizing the number of participants in hackathon challenges have proved beneficial for limiting the amount of quality solutions provided to the government.

The last weakness observed concerns a paradigm shift needed to open the doors for crowdsourcing ideas to thrive. The use of the video game *Operation Overmatch* and the increase of policy directives focused on crowdsourcing demonstrates a desire to change old practices. *Operation Overmatch* addresses the use of a video game to provide early feedback about combat platforms to prevent their extensive, costly rework in the future. Many senior ranking government officials find the use of video games ineffective. Individuals who are used to the old practices see prime contractors as the only source of good information for solutions. The change of strategies of collecting data and challenge solutions from the crowd-force will help drive costs down and promote innovative ideas. Congress and the executive branch are now placing more emphasis in crowdsourcing reflecting the positive trends of the civilian sector. In efforts to change paradigms, recent laws from 2017 have been passed to force government agencies to promote innovation and to seek ideas and solutions from the crowd-force.

2. Conclusion

The weaknesses of crowdsourcing include design for any major system in the DOD where expert knowledge and expertise are vital, the occurrence of too many solutions, and paradigm shifts. Experts are needed to ensure user requirements for DOD systems are reached. The crowd-force is not the best solution for every aspect of DOD systems but can be applied to some. Crowdsourced solutions have some opportunities addressed in the next section. The overabundance of solutions generated from the crowd-force can occur in the DOD as it has in commercial business. The government must be aware that too many solutions can occur, thus offering no benefits. Practices learned from civilian companies, as well as best uses from agencies such as NASA, need to be

evaluated when conducting future crowdsourcing efforts. We need a paradigm shift to catapult us past our historical views of relying solely on experts to the benefits gained with the use of crowd-force. The strengths of many civilian companies come from the diversity of their crowds. The government can achieve similar strengths, resulting in achievement of overmatch, and reaching modernization goals.

D. OPPORTUNITIES

During the research process three observations for opportunities for crowdsourcing in the DOD were noticed. The observations include; strategies and purposes, top down emphasis, and the integration of prime contractors and the crowd-force. These opportunities are external to the DOD that can result in positive effects for modernization priorities. The three areas that were researched are design, forecasting and software. This section of the SWOT looks closely at design opportunities and apply to strategies that can aid forecasting and software efforts.

1. Evaluations

The first opportunity consists of recent strategies and purposes implemented by federal agencies. The strategies that consist of crowdsourcing and citizen science, idea generation, open data collaboration, open dialogue, and price competitions, provide a starting point for a crowdsourced solution. The five strategies have been used with some success in the past by the DOD. The strategy most commonly used is prize competitions and challenges. Federal agencies outside the DOD have had success with open dialogue and open data collaboration. Open data collaboration can be used to improve forecasting initiatives as well as improve capabilities in software related fields. Other strategies outside of prize competitions can benefit the DOD and are cheaper in cost. The research noted that the purposes with the most usefulness are collecting information and perspectives, and develop new ideas, products and solutions. These two purposes were successful in federal agencies crowdsourcing efforts and can be beneficial when used in the DOD. The strategies and purposes should be implemented as a policy for DOD programs to maximize the use of the crowd-force in efforts to achieve cost effective and timely product solutions.

The second opportunity is top down emphasis, meaning the amount of attention the idea of crowdsourcing receives from Congress and the executive branch. The most recent acts that have been passed into law show the level of emphasis placed on improving innovation. Crowdsourcing is a method that has now been published into law as a directive to federal agencies for generating solutions. The GAO report addresses the directives aimed at government agencies to create open innovation opportunities for the crowd-force. Laws, such as the American Innovation and Competitiveness Act, emphasize crowdsourcing to achieve improved innovation. This opportunity, having Congress and the president place emphasis on an innovation method, can be used to develop new policy for the DOD. Providing CFTs with crowdsourcing guidance, using policy letters and directives, will help them achieve their goals to reduce costs and produce and feasible materiel solution. Giving CFTs the ability to use successful practices can lead to improved methods for conducting the acquisition process with inclusion of the crowd-force.

The third opportunity involves the integration of the crowd-force and the prime contractors. Traditionally designs and ideas for innovation and modernization have come from large companies in the commercial industry such as Lockheed Martin, Boeing and others known as prime contractors. The opportunity for the government to leverage the knowledge and expertise of the crowd-force can be applied to the current acquisition process. Primes can be instructed to use a certain percentage of crowdsourcing for their proposals to the government. The idea for this opportunity relates to current methods for small business set asides. The government can direct prime contractors to use small business for a certain percentage of the contract. A similar policy can be implemented to enforce an increased use of crowdsourcing efforts. Prime contractors can take the ideas of the crowd-force and use them as a means for idea generation, information and product solutions. Incorporation of the crowd-force can reduce costs that are normally associated with using the traditional methods of contracting with large companies, relying on their expert personnel for advice and input. The NASA case, Asteroid Hunter, used the crowd-force to produce results in updating tracking algorithms at the same cost of one full time

position. This opportunity is used successfully in industry and other government agencies and can provide benefits to the DOD.

2. Conclusion

The opportunities of crowdsourcing include strategies and purposes, top down emphasis, and integration of primes and the crowd-force. These opportunities can help the DOD improve the use of the crowd-force. CFTs can be directed to use prize competitions and challenges that have had large success in the past. Additional strategies from federal agencies can be applied to improve idea generation and product solutions. A policy letter describing the strategies for use by the DOD can be the foundation for aligning goals of the modernization program and the methods in which they tend to achieve the goals. The inclusion of crowd-force and prime contractors can leverage the best of both resources. The opportunities listed will help the DOD to achieve modernization priorities as well as reduce the overall cost associated with program execution.

E. THREATS

During the research process two observations were observed as threats. The threats of crowdsourcing for the DOD include adversary knowledge of systems and driving out innovation. Since many methods for crowdsourcing require the use of websites for online collaboration and access to systems, there is concern that bad actors can gain valuable information. Issues have been observed in the past with DOD programs prime contractor outsourcing work to countries like China. Other vulnerabilities exist with opening up a hackathon to participants who have motives other than trying to identify weaknesses in a system. The security of our countries combat platforms and information systems needs to be maintained as we open up to opportunities for crowdsourcing. The DOD can apply crowdsourcing to certain programs to mitigate the impact on driving out innovation.

1. Evaluations

DOD programs have measures in place to ensure that systems vulnerabilities are not known by our adversaries. The increased emphasis, placed on innovation and the use of crowdsourcing, opens the door to potential leaks or sharing of knowledge with participants that intend to do harm to the United States. In the case of forecasting with DARPAs terrorism futures market, misinformation provided to the forecasting model could have led to misinformation campaigns. Other concerns include designing the next generation combat vehicle. Crowdsourced knowledge of how a combat platform is built can lead to the discover of vulnerabilities that could ultimately result in the loss of lives in combat. Careful considerations of the crowd-force need to be evaluated as selection criteria when allowing participation during crowdsourcing efforts. Some DOD programs might have very limited crowd-force involvement such as vehicle design. Other areas like software fields and forecasting can use the crowd-force with appropriate security measure in place.

While being secure and ensuring the safety of programs, the DOD does not desire to drive out innovation. Taking precautions and allowing for participation is a risk that is weighed against the reward. The DOD runs the risk of reducing competition to a smaller number of contractors by not looking to the crowds for innovative ideas. While the caution in warranted, never using a crowd-force idea in the implementation phases can cause a lack of future participation. Many of the federal agencies have had large amount of innovation come from the crowd-force. During the research process, it was observed that one aspect noted by the crowd-force was the lack of solutions generated making to the implementation phase. The DOD can take lessons learned from other agencies innovation efforts to avoid similar mistakes.

2. Conclusion

The threats of crowdsourcing come from external negative impacts that were observed during the research process. The two main threats include adversary knowledge of a system and driving out innovation. These threats were explained using examples from the research conducted. The crowd-force does not require full knowledge of DOD

systems. Weapons capabilities, system design vulnerabilities, and other sensitive information need to be controlled for authorized users only. Too many risks are observed to warrant the complete integration of the crowd-force and the DOD. Some aspects of design with crowd force and primes was noted as an opportunity. With the appropriate risk mitigation that remains true. Complete disregard for the crowd's ideas during the implementation phase will lead to reduction in the crowd-force efforts. The DOD needs to remain cognizant of soliciting the crowd-force for ideas and solutions and the implementation of those recommendations. Good communication is needed to ensure the innovation efforts of both the DOD and the crowd-force, remain constant with our national security objectives.

F. CONCLUSION

In conclusion, this chapter addresses the SWOT analysis of crowdsourcing government programs. It answers the main research question describing how crowdsourcing can benefit the DOD. The SWOT analysis of crowdsourcing provides a tool to observe where to DOD has had success in the past and where it can be used in the future. This chapter addresses the secondary research questions identifying barriers, changes necessary, and best areas for use of crowdsourcing. The next chapter summarizes the knowledge gained, applying it to current modernization efforts and recommendations for future research.

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V. SUMMARY, RECOMMENDATIONS, AND AREAS OF FUTURE RESEARCH

A. INTRODUCTION

This chapter summarizes the research and analysis of crowdsourcing DOD programs. The chapter also addresses the three areas that can apply crowdsourcing to DOD. The SWOT analysis shows aspects of crowdsourcing that are beneficial and risky for government programs. These aspects should be considered for further research and analysis, continuing the goals of better innovation for the purpose of improving national security.

B. SUMMARY

This thesis begins with an introduction into crowdsourcing and proposes the idea that crowdsourcing can be a solution to the Army's modernization goals. The research questions focus the thesis on DOD crowdsourcing benefits, barriers, changes, and areas. The introduction explains how crowdsourcing has been around throughout history, and gives examples from British trade ships to Federal Bureau of Investigation hacking challenges. Definitions of crowdsourcing and similar terms provide better context for the rest of the thesis. The crowd-force describes the participants who are the source of solutions for crowdsourced problems. This chapter concludes with showing the increasing trend of crowdsourcing from 2006 and reveals the importance of the crowd-force in the future.

The next section covers the three areas that have importance in the DOD. These areas include design, forecasting, and software. GCV, DARPA, and Hackathons are examples of programs in these DOD areas. DOD programs offer some insight to strengths and weaknesses, including civilian companies provides more knowledge of crowdsourcing. The two companies researched include GitHub and Waze. Both of these companies are wide users of the crowd-force and have seen benefits from the use of crowdsourcing. The areas they fall into are forecasting and software. These examples provide a more detailed look into how crowdsourcing has been used in the past and give insight to what the future

holds. This chapter also includes an explanation of the acquisition process for readers to understand where crowdsourcing can apply.

The third chapter addresses the larger picture of open innovation and crowdsourcing throughout all government programs. Laws, policy's, and directives are used to govern federal agencies implementation of the crowd-force. GAO reports address the requirement they have to continue to monitor and update congress on the progress of agency improvements that incorporate the crowd. Crowdsourcing examples from NASA, GSA and other agencies are provided, showing methods and practices that are successful. A framework provides strategies and purposes that best align goals of crowdsourcing with methods to develop a solution.

Chapter IV shows the SWOT analysis describing the findings of the research. The strengths include DOD experience in the past with crowdsourcing efforts, the potential for cost savings and strategies that work best. Weaknesses include concerns with valid platform design, abundance of solutions, and changing paradigms. Opportunities exist to develop guidance and policies derived from senior leadership to groom DOD crowdsourcing efforts. Additionally, bringing together contractors and the crowd-force can provide better products at a cheaper price. Threats include risks that adversaries could gain knowledge on DOD combat systems. This risk could prevent the DOD from using the crowd-force, adding to the threats by driving out innovation. This analysis is used to answer the research questions in the next section.

C. RECOMMENDATIONS

Answering the research questions provides the best recommendations for the research conducted on this thesis. The questions below are pulled from the beginning of the thesis. The questions combine the research and analysis in relationship to modernization goals; reduce costs and speed up delivery of quality products.

1. How Can Crowdsourcing Benefit DOD Programs?

Crowdsourcing has benefitted the DOD in the past and can be improved upon to reach modernization goals. The three areas of design, forecasting, and software can benefit

from crowdsourcing by using strategies that have been successful in the past. The strategies of prize competitions and challenges, open dialogue, and open data collaboration have the most popularity and participation from the crowd-force. Including the crowd-force in aspects of design process with integration of the prime contractors can reduce program costs. The DOD can leverage the crowd-force capabilities in online collaboration platforms, speeding up the time it takes to get solutions. The solutions can apply to any of the three areas. These benefits are from successful uses of crowdsourcing in government agencies and civilian industry.

2. What Are Barriers That Could Limit DOD Personnel from Using Crowdsourcing?

Barriers that exist include higher level leadership conforming to the old ways, not taking advantage of innovation strategies that have been proved successful. Other barriers include the risk associated with opening up DOD programs to the crow-force. Security measures need to be in place to maintain system security, ensuring capabilities and vulnerabilities remain secret.

3. What Changes Are Necessary for the DOD to Take Advantage of Crowdsourcing?

Changes at the highest level are already passed into law. Other government agencies have been including crowdsourcing in multiple strategy methods. Policies or directives for the DOD can be the next step for improving the use of crowdsourcing. The CFT directive is a perfect opportunity for an innovative team, dedicated to reducing costs and fielding quality products, to use crowdsourcing. Prize competitions and challenges have been used in the past with success and should be continued. Spreading out to employing different strategies can help to reduce costs and meet modernization goals

4. What Are the Best Areas for the DOD to Capitalize on Crowdsourcing?

The best areas for the DOD to capitalize on crowdsourcing consist of the three addressed throughout the thesis; design, forecasting, and software. The DOD has great experience using strategy methods for incentivizing the crowd-force with prize

competitions. The next best return would be for open idea and open collaboration improvements. Incentivizing the crowd-force to participate with design ideas or information collaboration without prize money would be optimal. The knowledge of the crowd-force is far better than one expert.

D. AREAS OF FUTURE RESEARCH

Future research can build off the foundation of this thesis and others that have provided pertinent information. This thesis uses the recommendations as a means to further crowdsourcing benefits across the DOD. Below are three areas that future research can be applied.

1. Areas of modernization can be researched in depth for each service. For the Army, each of the modernization categories can be focused on to create a guide or strategy for best methods of crowdsourcing.
2. Online collaboration websites that promote lessons learned for the DOD. The GAO report listed lessons learned from federal agencies and how they share that information. A similar capability could be useful for the DOD. The collaboration platform could be service specific or joint, ultimately getting knowledge shared about practices that work and areas to avoid.
3. How other countries use crowdsourcing. Other countries have been using crowdsourcing for a while. Actors like China just won an Artificial Intelligence competition as one of the participants of a prize challenge. Other countries have different capabilities than the United States. Their capabilities could prove useful to furthering the DOD innovation goals.

E. CONCLUSION

In conclusion, this thesis began with the idea that crowdsourcing can help solve modernization problems. The identification of the crowd-force and its effective implementation rely on sound strategy and appealing to incentives that motivate the crowd. Crowdsourcing has been around for a long time. Recent trends have seen an increase in the use of crowdsourcing. Modern day capabilities such as the Internet and real-time ability to share information create the perfect environment for worldwide participation. The result is a far greater solution from the crowd-force than that of the experts. This thesis provides the research and analysis that support the use of crowdsourcing in DOD programs, with the goal of reducing costs and getting quality products to the warfighter.

LIST OF REFERENCES

Ackerman, S. (2013, April 22). This is the million dollar design for DARPA's crowdsourced swimming tank. *Wired.* Retrieved from https://www.wired.com/2013/04/darpa-fang-winner/

Augier, M. (2017, April 10). SWOT analysis chart. GB4014: Strategic Management. Naval Postgraduate School, Monterey, CA.

America COMPETES Reauthorization Act of 2010, 42 U.S.C. § (2010).

American Innovation and Competitiveness Act, 42 U.S.C. (2017).

BAE Systems. (n.d.). Amphibious combat vehicle 11 ACV 11. Retrieved October 15, 2017, from http://www.baesystems.com/cs/Satellite?c=BAEMedia_C&childpagename=US%2FBAELayout&cid=1434555233452&pagename=USWrapper

Barrett, F. J., & Fry, R. E. (2005). *Appreciative inquiry: a positive approach to building cooperative capacity*. Chagrin Falls, OH: Taos Institute Publications.

Bertuca, T. (2011). *DARPA continues crowd-sourcing vehicles with an eye toward its own GCV*. Arlington, VA: Inside Defense.

Boyle, R. (2011, June 30). How The first crowdsourced military vehicle can remake the future of defense manufacturing. *Popular Science*. https://www.popsci.com/cars/article/2011-06/how-first-crowdsourced-military-car-can-remake-future-defense-manufacturing

Clark, B., Zingale, N., Logan, J., & Brudney, J. (2016). A framework for using crowdsourcing in government. *International Journal of Public Administration in the Digital Age 3*(4), 57–75. doi:10.4018/IJPADA.2016100105

Coultas, B. (2015). *Crowdsourcing intelligence to combat terrorism: Harnessing bottom-up collection to prevent lone wolf terror attacks* (Master's thesis). Retrieved from https://calhoun.nps.edu/handle/10945/45174

Crowdsourcing. (n.d.). In *Oxford English Dictionary*. Retrieved April 29, 2017, from http://www.oed.com/view/Entry/376403?redirectedFrom=crowdsourcing#eid

Crowdsourcing and Citizen Science Act, 42 U.S.C. (2015).

Dobkin, A. (2017, October 26). The video game that could shape the future of war. *The Atlantic*. Retrieved from https://www.theatlantic.com/technology/archive/2017/10/operation-overmatch/544062/

Empson, R. (2013, June 11). WTF is Waze and why did Google just pay a billion for it? Retrieved November 7, 2017, from https://techcrunch.com/2013/06/11/behind-the-maps-whats-in-a-waze-and-why-did-google-just-pay-a-billion-for-it/

Evans, G. (2013, March 23). FANG—Crowd-sourcing brings DARPA's "swimming tank" to life. Retrieved from http://www.army-technology.com/features/featurefang-crowd-sourcing-darpa-swimming-tank/

Feickert, A. (2014). *The Army's ground combat vehicle (GCV) program: Background and issues for Congress* (CRS Report No. R41597). Washington, DC: Congressional Research Service.

GitHub. (n.d.). The state of the octoverse 2017. Retrieved November 13, 2017, from https://octoverse.github.com

Hanson, R. (2005, August). *Designing real terrorism futures*. Fairfax, VA: George Mason University. Retrieved November 5, 2017, from http://mason.gmu.edu/~rhanson/realterf.pdf

Hossain, M., & Kauranen, I. (2015). Crowdsourcing: a comprehensive literature review. *Strategic Outsourcing: An International Journal 8*(1), 2–22. doi:10.1108/SO-12-2014-0029

Howe, J. (2006). The rise of crowdsourcing. *Wired 14*(6), 1–4.

Juergen, M. (2013, June). GitHub is helping companies work together by crowdsourcing software. Retrieved November 7, 2017, from https://www.entrepreneur.com/article/226707#

Lauterbach-Hagan, B. (2010, September). *Innovations in e-business: Can government contracting be adapted to use crowdsourcing and open innovation?* Retrieved from https://calhoun.nps.edu/bitstream/handle/10945/10563/10Sep%255FLauterbach%255FHagan%255FJAP.pdf?sequence=1&isAllowed=y

Mergel, I. (2014). Opening government: Designing open innovation processes to collaborate with external problem solvers. *Social Science Computer Review 33*(5), 599–612. journals.sagepub.com/doi/pdf/10.1177/0894439314560851.

Mickos, M. (2016, June 17). What was it like to hack the pentagon? [Blog post] Retrieved November 6, 2017, from https://www.hackerone.com/blog/hack-the-pentagon-results

Mihm, C. (2016). Open innovation: practices to engage citizens and effectively implement federal initiatives (GAO-17-14). Washington, DC: U.S. Government Accountability Office. Retrieved from http://www.gao.gov/products/GAO-17-14

Mortlock, R. (2017, March 15). Manned ground vehicle (MGV) program. Class notes for MN3384: Principles of Acquisition Production and Quality Management. Naval Postgraduate School, Monterey, CA.

National Priorities Project. (n.d.). Budget process: Federal budget 101. Retrieved October 15, 2017, from https://www.nationalpriorities.org/budget-basics/federal-budget-101/federal-budget-process/

Osborn, K. (2017, June 25). Corps gets new amphibious combat vehicle. Retrieved from https://scout.com/military/warrior/Article/Marine-Corps-Receives-First-New-More-Lethal-Amphibious-Combat-Ve-101458136

Ruff, T. (2016, October 4). 6 must haves for fed bug bounty programs. *Federal Times*. Retrieved from https://www.federaltimes.com/2016/10/04/6-must-haves-for-fed-bug-bounty-programs/

Schwartz, M. (2013). *Defense acquisitions: How DOD acquires weapon systems and recent efforts to reform the process* (CRS Report No. RL34026). Washington, DC: Congressional Research Service. Retrieved from https://fas.org/sgp/crs/natsec/RL34026.pdf

Surowiecki, J. (2005). *The wisdom of crowds why the many are smarter than the few*. London: Abacus.

Smith, C. (2017, August 12). 9 interesting Waze statistics and facts. Retrieved from https://expandedramblings.com/index.php/waze-statistics-facts/

Tapscott, D., & Williams, A. D. (2008). *Wikinomics: How mass collaboration changes everything*. London: Atlantic Books.

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