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Growing an Artificial Intelligence Capability: Challenges and Opportunities

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ABSTRACT

Artificial Intelligence's (AI) potential to augment or auto-mate human decision making has caught the attention of many within the Department of Defense (DoD). Effective AI implementations, originating from well-scoped use cases, require the alignment of people, processes, and technologies. While many focus on the opportunities that these systems provide for leap ahead improvements to the future state of DoD business processes and warfighting capabilities, the challenges that must be overcome must not be under-estimated and expectations should be man-aged appropriately with an understanding that achieving the desired end state will be a long term endeavor. This paper provides a brief overview of some of the challenges that must be overcome in order to realize the opportunities presented by AI systems.

Keywords: Artificial Intelligence, Data, Data Strategy, AI Systems, Department of Defense, Data Science.

1. INTRODUCTION

The field of AI has a longer history than most would suspect, with initial work originating in the 1940's.[1] However, AI investment and capability development has been historically volatile, going through several periods of what Gartner's Hype Cycle concept would describe as "inflated expectations".[2] Ultimately, various setbacks would end excitement, resulting in a period of limited interest and advancement. These historical issues included things such as a lack of affordable computing power and storage, data availability, and capricious government and private sector investors that granted and retracted funding as AI excitement rose and fell.[3] Those aware of this history may question the current renaissance in AI, but the prime limiter of previous advancements, computational power, storage, and affordability, have faded.[3] Advances in complementary analytic methods have enabled successes in machine learning, deep learning, computer vision, and more to the point that we are now "entering the age of deployed AI".[4]

The U.S. Department of Defense (DoD) seeks to continuously modernize and update its business processes and warfighting capabilities in order to efficiently and effectively safeguard the nation in an uncertain world. The explosion of data in the 2000's, along with advances in computational power and storage, brought data science and analytics to the forefront of civilian and defense related activities. Greater volumes of data existed in the DoD with the potential to inform decisions than could be examined by human analysts to inform operational or institutional decisions.[5] However, this data was largely collected in disparate silos with few early efforts at aggregation. The belief that additional insight could be gained if this data could be accessed and analyzed in a timely manner motivated the adoption of data science techniques by operations research analysts within the defense community. However, limited access to data and tools prevented early endeavors from applying these methods to problems beyond limited, niche use cases. These efforts required support from external contractors as knowledge and expertise were scarce.

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Newer organizations, such as those standing up capabilities in the cyber domain, embraced data science tools and methods from their inception and took a more systematic approach to realize an operational capability.[6] This includes the building of organic data science teams who could respond quickly based on operational needs. Organizations across DoD are reexamining the way they store, manage, and gain value from their data and are beginning to embrace change through operationally focused data strategies.

As the DoD pushes to adopt AI capabilities, it is critical for organizations to understand what AI is. Additionally, there is also a requirement to understand the people, processes, and technologies required to realize the capability. Organizations can then consider the use cases for which an AI application would provide the greatest benefit.

Adopting AI encompasses a focused, enterprise-wide effort, which is a transformation rife with challenges. Overcoming these, though, will present significant opportunities for the advancement of future DoD-capabilities and operating concepts such as Multi-Domain Operations (MDO).[7]

2. BACKGROUND

The US Department of Defense (DoD) has, at times, been a historical participant in the advancement of AI and an interested customer.[8,9] As a result of the recent explosion of data and computational capabilities in the 2000's, data science and analytics permeate civilian and defense related activities. Enabling this is a DoD culture more reliant than ever on curating and leveraging large data sets with the potential to inform decisions at the strategic, operational, and tactical levels.[10]

While the DoD continues to rework, leverage, and enjoy the enhancements brought forth via data and data analytics, the DoD is now looking to move to the next logical step: the adoption of more advanced AI techniques. This necessitates a reexamination of the way DoD organizations store, manage, and gain value from their data as they seek to restructure enterprises for the future; this is evident in restructuring such as the Army Futures Command, the Joint Artificial Intelligence Center (JAIC), as well as the emergence of DoD AI and data strategies.[11,12]

AI researchers seek to develop software agents to augment or automate human decision making.[1] AI consists of too many sub-fields to list here, but examples include topics such as machine learning, expert systems, cognitive architectures, and natural language processing. With the current interest in AI being primed by the recent revolution in data science, most people commonly think about the application of machine learning techniques when AI is mentioned. The machine learning subfield of AI focuses on developing algorithms that use statistical pattern matching to improve performance on tasks such as prediction and classification.

These machine learning techniques are often applied in data science workflows. Data science focuses on the collection, processing, and transformation of data into insights using a variety of methods.[13] This interdisciplinary field relies on team members with backgrounds in computer science and information technology, operations research and statistics, and the problem domain under study. However, the data workforce also includes lower skilled personnel such as data analysts and data labelers. These team members are part of an organization, not a material developer, and work at the operational level.

Instead of long procurement cycles, AI and data science products are intended to be built and deployed quickly, customized to the needs of current mission. The most commonly used process for executing a data science project is the Cross Industry Standard Process for Data Mining (CRISP-DM), which has been in use since the 1990's.[14] The data science community relies heavily on open source development tools, such as R and python, to provide user focused applications to develop insights which drive decisions for well-scoped use cases.

The training and equipping of data teams is still an open issue with minimal formalization in the DoD.[13] Most training is not done via typical military channels, instead it is more common that traditional academic credentials are required, such as Master's or Doctorate's within related fields. This approach has led to a diverse set of abilities and tool preferences within teams.

DoD organizations have also been working to improve the manner in which they use and store data - note the proliferation of data strategies and recent cloud initiatives such as JEDI.[15] This enabling step, still in progress across government, begins to create opportunities for the utilization of machine learning techniques by data science practitioners and the application of more advanced techniques from machine learning and other AI subfields.

In addition, DoD researchers from organizations such as the Army Research Laboratory (ARL) have contributed to the body of knowledge and sought opportunities to insert AI technologies into combat systems as technology matures.[16] Now, with public press releases describing AI capability gaps between nations, the DoD has a renewed interest in adopting these techniques and a sense of urgency that is driving resource allocation and organizational change in this area.

Multi-Domain Operations, the emerging operating concept, requires the integration of data from multiple sensors and platforms in real-time to enable decision making.[7,11,12] This will require the integration of AI capabilities in combat platforms and command and control systems across services so as to streamline decision making capabilities and provide global situational awareness. The development of AI capabilities across DoD necessitates both top-down emphasis through specialized organizations such as the Joint Artificial Intelligence Center (JAIC) and bottom-up feedback from traditional, operational organizations. The convergence of insight from both directions will yield the core use cases for the adoption and execution of AI-enabled processes.

3. WHAT DOES AN AI CAPABILITY REQUIRE?

As organizations begin to adapt to take advantage of the potential of AI technologies, the first considerations typically center on the understanding of resources required to realize an enterprise capability. AI systems are designed to augment or automate human decision making[1]. Some of the functions required to establish an AI capability would include: identify use cases, access data, develop algorithms, design interfaces, deploy systems, and measure effectiveness. Depending on the organization's size, development and deployment requires an organic team with expertise in AI methods, technologies, and the specific use cases. The team must also interact with existing data managers and information technology managers.

Developing and deploying AI capabilities into an organization requires three primary functions; data engineering, data science, and software development. Figure I depicts how these efforts are related.

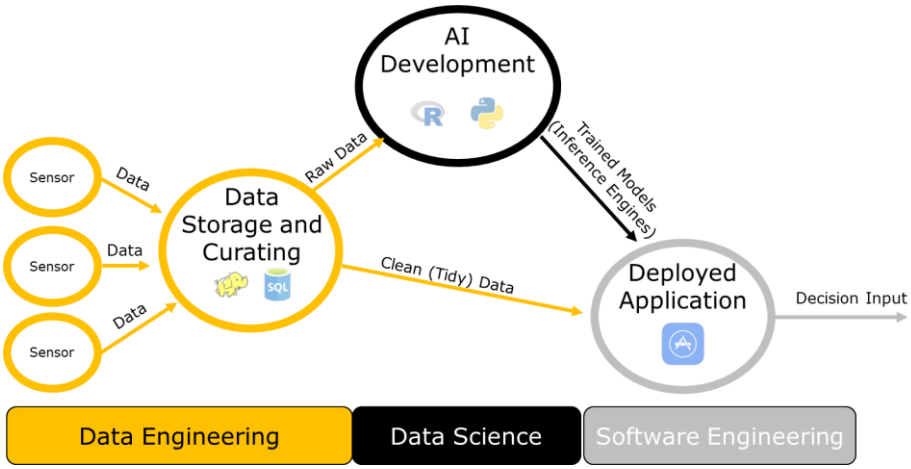

Figure I. Functional Requirements for AI Development and Deployment.

Data is collected from an array of sensors and stored in an accessible repository. These are data generated from activities which may range from physical devices to recording meta-data from business process. AI development uses data from this repository; however, AI development occurs off-line in a different eco-system with specialized tools. Once a product is

ready for deployment, it is integrated into a software application specific to the use case of interest. This process is continuous, resulting in AI enabled software that is constantly updating. This process is often referred to as Development Operations or DevOps.[17]

Understanding business processes and organizing data to support the development of use cases is key to enabling an AI capability. Figure II gives an example functional decomposition of an enterprise AI system. This requires team members that understand the organization's core functions and who also have access to data which might provide insights to decisions. Providing access to this data often requires resource and governance process adjustments. For example, if a data strategy, endorsed by organizational leaders, is not in place, it can greatly slow the development and fielding of AI systems.[18,19]

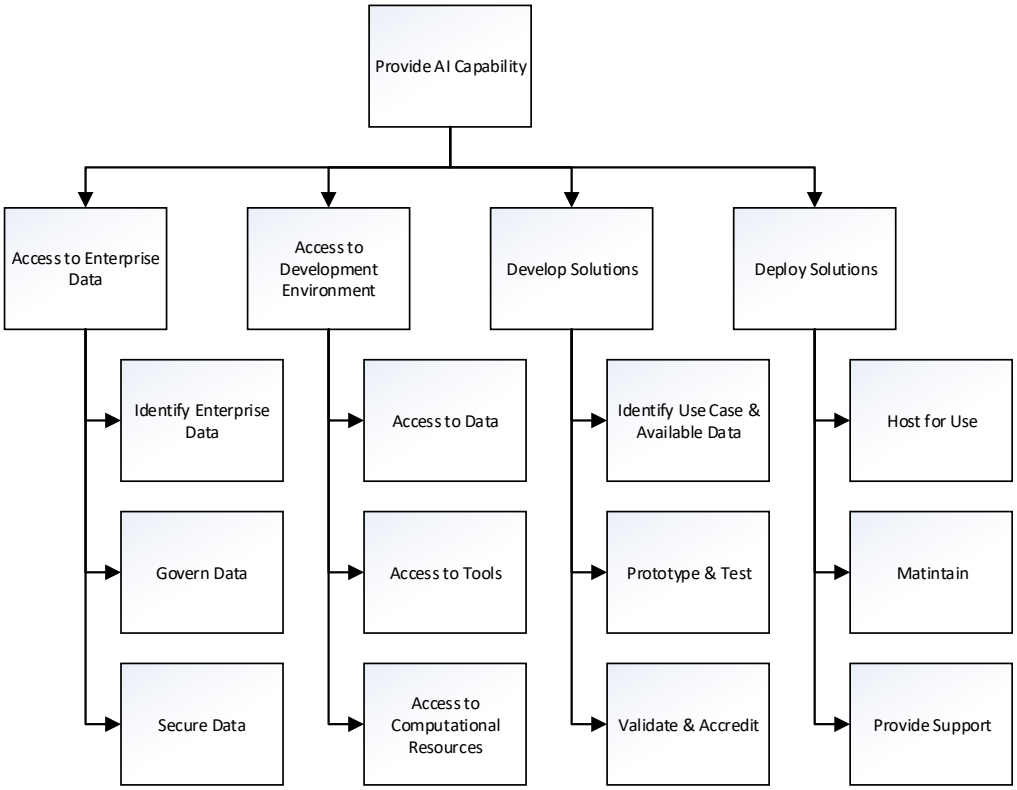

Figure II. Sample High-level Functional Decomposition of Enterprise AI System.

Data managers tasked with organizing, securing, and protecting organizational data need directive guidance, in the form of a data strategy and data governance policies, which incentivize them to work with AI system developers to realize the organization's vision for the use of data. Once these conditions are in place, the AI team can begin to show value through the initiation of well targeted pilot projects.

4. AI ENTERPRISE OPERATING CONCEPT

The initial set of projects selected should be of obvious value to the organization, regardless of the level of interest or complexity required to solve the problem.[20] An AI capability relies on the existence of computer science and network capabilities. This implies sound, existing IT architectures, infrastructures, hardware and software development capabilities, and domain expertise in management and implementation of the preceding. Computing capabilities provide the platform upon which modern, big data analytics occur, to include operations research, statistics, advanced engineering and design, and ultimately data science. These capabilities are necessary and, in many situations, hard pre-requisites for any organization wishing to explore AI development and capabilities.

Organizations can capture the need for these functions as part of an overarching data strategy that lays a vision for how the organization will use data to enable its business processes. This requires a firm understanding of the organization's processes and the identification of well-scoped use cases for the integration of data-driven decision making, enabled by AI capabilities.

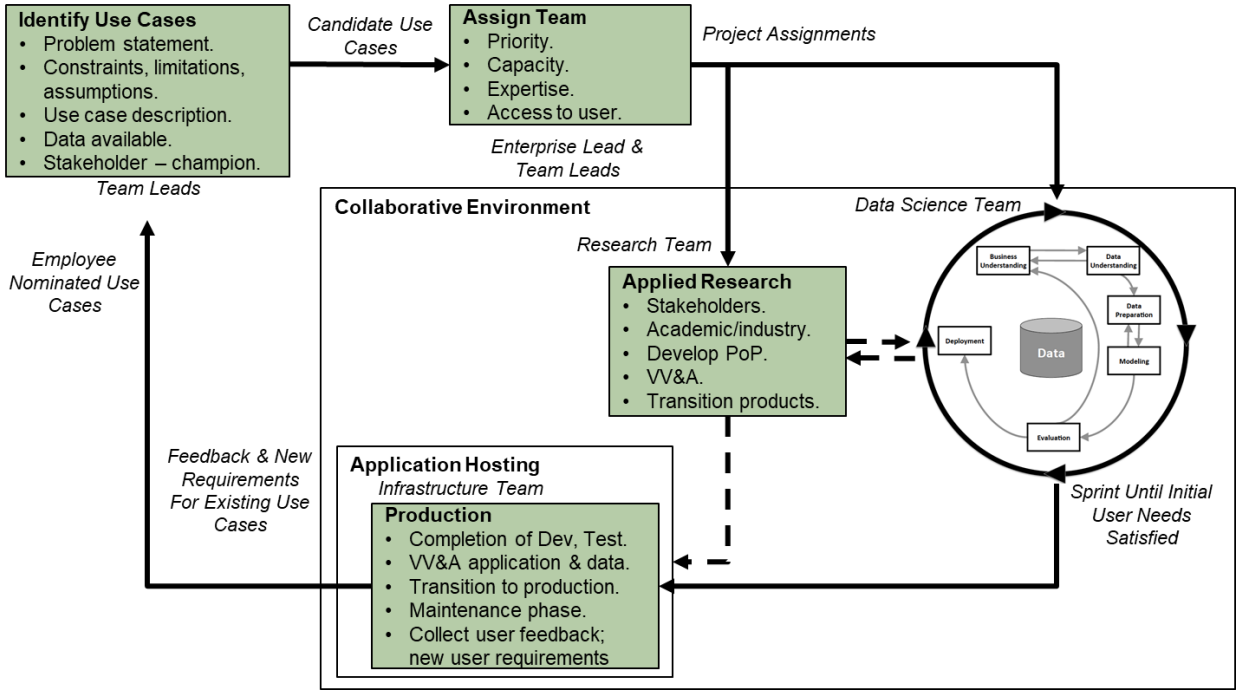

Figure III. AI Enterprise Operating Concept with CRISP-DM

5. CHALLENGES

The typical challenges associated with organizational change, along with some that are unique to the adoption of AI, will present themselves as government entities begin to adapt. Adjustments to the status quo that are required to align people, processes, training, and technology to achieve an operational AI capability will require planning, resourcing, and leadership that can create a shared vision of the future.

Recruiting and retaining talent in this competitive field within the government might require a re-examination of what is feasible given government hiring and incentive constraints. Flexible schedules and remote telework, used extensively in the civilian sector in this field, might have to be re-examined by the government – particularly in areas where opportunities for individuals with these skills is competitive. Once talented individuals are in the system, retention will require managers to examine their work environments and how they empower them to accomplish their objectives. Talented individuals that want to serve but have options outside of government are likely to leave if they perceive their skills are underutilized. Access to modern technology, sometimes a challenge within government, is also a key consideration for talent retention.

Training and development of a diverse set of skills required to build AI products requires formalization. Relying on skills acquired externally is not maintainable or reliable.[21,22] The DoD must codify the required skill sets and create common tools. This standardization necessitates a training pipeline and related career advancement opportunities.

Processes concerned with governance, use, access, storage, and provisioning of data require adjustment to enable the development and fielding of AI systems. The importance of a data strategy to facilitate this change for the long term cannot be understated. The establishment of processes for capturing user feedback, maintaining existing applications, and providing support to the user community must occur to support application development. Nomination and selection processes for AI projects require prior establishment as well as prioritization of applicable use cases in order to augment or automate critical business functions.

The organization's first challenge is the successful establishment of processes to allow members of the workforce with appropriate knowledge, skills, and abilities access to data to support the development of an AI system. The next challenge is to ensure workers have access to modern technology, particularly development environments provisioned with open source tools used by the broader community. Attracting highly talented employees and providing them access to data, but failing to allow them to employ state of the art tools, will likely result in frustration, employee attrition, and a disenchantment with AI by the organization.

6. OPPORTUNITIES

Despite the challenges outlined above, the benefits associated with opportunities to apply AI within the government make it worth the effort. The use of data to objectively inform decision-making can result in more efficient processes, greater transparency and accountability, and ultimately more effective allocation of resources.

Use cases associated with information retrieval exist across multiple organizations – simply being able to effectively search internal drives and storage can have a tremendous impact. The ability to objectively screen documents and materials rather than relying on manual methods, can aide in the aggregation and synthesis of data as well as assist in minimizing human bias in processes currently adjudicated by a human. The use of computer vision to identify objects within imagery can enable target identification or the identification of those in need of aid during disaster recovery.

Well scoped, human-centered AI systems can enable humans in a variety of settings to accomplish their work more efficiently while considering more relevant data than a human could manually inspect – allowing the human to spend more time focusing doing what they are best at -- applying their judgement to cases that do not lend themselves to automation (user centered design ref). Use cases with the potential to leverage AI systems exist in all area of the DoD from recruiting and retention to target recognition within combat systems. In order to capitalize on these opportunities, the DoD must simultaneously identify pilot projects that can show value in the short term and address foundational issues associated with the challenge areas.

7. CONCLUSION

"Artificial intelligence holds tremendous promise to benefit nearly all aspects of society." – National Artificial Intelligence Research and Development Strategic Plan: 2019.[23]

As the DoD pushes to advance the adoption of AI throughout its business processes and within its combat systems, leaders at all levels must develop a basic understanding of the technology and its potential, while also understanding the limitations and challenges. This requires the development and communication of a shared vision for AI at each level of operations and deliberate educational programs at the appropriate level with technical depth for a variety of roles to enable decision makers to transform their organizations and formations. The foundation for the development of AI systems must be established, along with processes to verify, validate, and accredit these systems for appropriate use cases. The governance of these systems and the development of rules for their appropriate use, the ethics of AI, must be addressed and reconciled with our national values and military ethics.[24] The adoption of AI systems should be viewed as a long term endeavor. While pressure exists to innovate and modernize rapidly, the challenges of adopting an AI enabled force will only be fully addressed over a span of years. However, through gains in efficiency and improved warfighting performance the potential long term rewards make it an investment worth pursuing.[25]

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