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Recent AI Adoption in the U.S. Government

Alexander Daly
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With contributions from Vipul Agrawal,
Brent Baker, Joe Biron, Jesse Blankenship,
Mike Campbell, Ed Cuoco, Francois Lamy,
Chris MacDonald, Leslie Paulson,
and Kevin Wrenn.

Introduction

The pace of U.S. government adoption of Artificial Intelligence (AI) is heating up. Year-over-year funding for AI in the Pentagon alone has more than doubled to $4B in FY 2020.[1] In September 2018, Accenture published research that indicated over 66% of U.S. federal agencies planned to make investments in AI technologies in the next year. Another finding from the same report indicated 82% of federal executives agreed with the statement "AI will work next to humans in my organization, as a co-worker, collaborator, and trusted advisor" in the next 2 years.[2]

As an interesting parallel from the private sector, consider DeepMind's recent advances with AI in Go, the ancient Chinese strategy board game. Despite Go being infinitely more complex than Chess, the progress has been breathtaking: In March 2016, DeepMind's AlphaGo machine defeated the Korean grandmaster of Go, Lee Sedol, in 4 out of 5 games. In May 2017, AlphaGo went on to defeat the #1 ranked Go player in the world, Ke Jie, in 3 out of 3 games.[3] Just a few months after that stunning victory, DeepMind's successor to AlphaGo, called AlphaGoZero, played its own predecessor (machine vs. machine) in 100 games. In that matchup, AlphaGoZero won every single game.[4]

Similarly, the U.S. government's recent adoption wave of AI has turned the heads of many experts who had anticipated a more moderately-paced rollout. Brendon McCord, who played a significant role in authoring the DoD strategy on AI, recently commented that the DoD has more than 600 active AI projects.[5] In May of 2019, then Deputy DARPA Director (now Acting Director) Dr. Peter Highnam estimated over 30% of DARPA's 250 active projects involve AI in some way "in all domains from biology to space." [6] That number will only be increasing over time.

And yet despite the DoD more than doubling its year-over-year investment in AI, many are wondering if this already breakneck pace is fast enough. In a November 2019 report, the National Security Commission on AI (NSCAI) noted "China, our most serious strategic competitor, has declared its intent to become the world leader in AI by 2030 as part of a broader strategy that will challenge America's military and economic position in Asia and beyond."[7] In January 2020, the White House Office of Science and Technology Policy issued 10 principals that U.S. government agencies should adhere to when creating their own AI regulations. Limiting regulatory overreach is one of the main focuses of this policy guidance.[8] Both within the Executive Branch and the policy-influencing bodies on its periphery, a change is forming on the horizon; one that will be shifting the U.S. government from a relatively reserved decades-long posture regarding AI adoption to one of immediate action and at-scale deployments in the operational realm.

What follows in these pages is an exploration of this grand pivot. It is a mostly DoD-focused summary of the U.S. government's AI adoption, along with the

> "China, our most serious strategic competitor, has declared its intent to become the world leader in AI by 2030 as part of a broader strategy that will challenge America's military and economic position in Asia and beyond."[7]
>
> *– NSCAI, November 2019 Report*

recommendations of influencing organizations, as well as key people and funding levels. Also included is a PTC perspective on the myriad ways in which AI is invigorating the industrial software sector. While there is some discussion of the use cases that have been released publicly, this paper focuses less on the technical "how" of government AI adoption, in favor of "who", "where" and "by how much"?

Third Wave of AI Adoption in DoD

There have been three main waves of the DoD's adoption of AI over the last several decades. Over 50 years ago, DARPA began funding a series of rule-based systems in what is considered the "First Wave" of AI adoption. These systems were highly-focused, but only capable of limited tasks.[9] Highnam recently categorized the theme of this initial phase as "describe". For example, the underlying technology from this phase later became the foundation of software products like TurboTax; highly descriptive for a particular function but of little use outside that task set.[10]

The "Second Wave" came in the 1990s and continues to the present. It ushered in AI machine learning with pattern recognition using large data sets. It also included capability for natural language comprehension and problem solving but still with substantial limitations. Namely, these "black box" AI systems simply aren't capable of adapting to new conditions, nor can they give users explanations for how they arrived at their results. [11] Highnam classifies the theme of this phase as "recognize". [12] An AI that can sift through hundreds of millions of photos to correctly decipher skin cancers vs. benign moles is one example.

The "Third Wave" of AI adoption (alternatively referred to as "Wave 3") is beginning now with the goal to enable AI to adapt to changing situations-a concept called "contextual adaption". The former Director of DARPA, Dr. Steven Walker, recently commented, "Today, machines lack contextual reasoning capabilities, and their training must cover every eventuality, which is not only costly, but ultimately impossible. We want to explore

how machines can acquire human-like communication and reasoning capabilities, with the ability to recognize new situations and environments and adapt to them." [13] Highnam classifies the theme of this phase as "explain". [14]

This decades-long arc of maturing AI technologies from merely describing a narrowly-defined task, to recognizing trends to explaining results is the basis of the three waves of adoption. [15]

DARPA's Latest Moves

DARPA's $2B "AI Next" Campaign-As the cornerstone of Third Wave adoption, DARPA is allocating $2B over 5 years to foster AI innovation in a number of areas including "automating critical DoD business processes, such as security clearance vetting or accrediting software systems for operational deployment; improving the robustness and reliability of AI systems; enhancing the security and resiliency of machine learning and AI technologies; reducing power, data, and performance inefficiencies; and pioneering the next generation of AI algorithms and applications, such as 'explainability' and common sense reasoning." [16]

DARPA's "AIE" Program-In July 2018, DARPA announced the Artificial Intelligence Exploration (AIE) program, designed to quickly translate good ideas into practice. AIE constitutes a series of potentially high payoff projects allowing researchers to establish the feasibility of new AI concepts within 18 months of award. Leveraging streamlined contracting procedures and funding mechanisms will enable these efforts to move from proposal to project kick-off within 3 months of an opportunity announcement. [17]

Joint Artificial Intelligence Center (JAIC)

In 2016 an organization called the Defense Innovation Board (DIB) was created to bring the best high-tech innovation ideas from Silicon Valley to the DoD. This is a small group of leaders in tech, science and media making recommendations on military adoption of compelling new forms of innovation.[18] Former Google / Alphabet Chairman Eric Schmidt is the current DIB Chairman.[19] In October 2016, the DIB urged the SECDEF to "establish a DoD center for studying artificial intelligence (AI) and machine learning (ML)."[20]

The Joint Artificial Intelligence Center, or JAIC (pronounced 'Jake'), was officially established with $70M in initial funding in June 2018 and reports to the DoD's Chief Information Officer, Dana Deasy.[21] In the FY 2020 President's Budget Request (PBR) the JAIC budget was increased to $209M.[22] Specific functions for the JAIC are summarized on the next page.[23]

In the policy discussions, the government makes a distinction between NMIs (national mission initiatives) and CMIs (component level initiatives). NMIs are broad-based AI use cases that have applicability beyond just the DoD. For example, the DoD is working on two NMIs already; one for predictive maintenance (automated diagnostics, predicting

Specific Functions for JAIC

- **Identifying Prototypes**-Select "national mission initiatives" (NMIs) and "component mission initiatives" (CMIs) to deploy AI in cross-functional teams made up of JAIC personnel and SMEs from respective functional areas

- **Sharing Lessons Learned**-Sharing repeatable and standardized processes for data, testing, evaluation, and cybersecurity

- **Scaling Successful Prototypes**-In concert with the DoD's adoption of cloud, edge computing and other technology, scale AI prototypes throughout the DoD

- **Ongoing Support**-As the individual services scale up the new mission initiatives, the JAIC will strengthen the efforts of the Military Departments and Services and other independent teams across DoD

- **Military Ethics and AI Safety**-Using AI to reduce unintentional harm via improved situational awareness. Share guidelines and procedures for safety by other nations

failures, provisioning spares) and another for disaster relief (floods and wildfires). Both have applicability across the entire government. By contrast, CMIs will only happen inside the DoD (its 'components'), focusing on using AI to solve specific problems.[24]

A third NMI is focused on cybersecurity. To help refine and train future AI algorithms, in September 2019, the JAIC announced it will be working with CYBERCOM and the NSA to standardize the way the government collects cybersecurity data. Standardization in data collection hasn't been as much of an issue for other AI use cases, but is necessary for the cyber mission. Lt Gen Shanahan who runs the JAIC, recently commented "What does normal look like? If we're trying to detect anomalous behavior, I have to know what the baseline is…[That's] much more challenging on cyber than it is on full-motion video or predictive maintenance or even in our humanitarian assistance [efforts]."[25]

DoD's AI Strategy

In February 2018, the DoD issued a strategy document for AI adoption. It calls for JAIC and DARPA to both play key roles. The five-part strategy is summarized below.[26]

Five-part Strategy

- **Key Missions**-Situational awareness, decision-making, equipment safety, predictive maintenance

- **Scaling**-Learning to scale good ideas directly from users at the "forward edge" vs. an over emphasis on centralized labs…best practices for shared data, tools, frameworks and standards, and cloud and edge services

- **Workforce Development**-A twofold path of AI training and recruiting

- **Partnerships**-Entice the best academics and industry partnerships to invest in research through adequate funding.

- **Ethics and Safety**-Consult with leaders from across academia, industry, and the international community to advance military AI ethics and safety.

Air Force AI Strategy-In September 2019, the Air Force released its own AI strategy document in line with the DoD's overall strategy and the JAIC. Among its goals are to: lower adoption barriers by partnering with commercial tech firms, to treat data as a strategic asset by using it to train AI, democratizing access to AI, development of the AI workforce, and instilling transparency to ensure moral, legal AI adoption.[27] The Army and Navy will likely be releasing their own AI strategies shortly.

Funding

'American AI Initiative' $850M in FY 2020-In February 2019, the President signed Executive Order (EO) 13,859 launching the American AI Initiative, designed to accelerate U.S. leadership in the AI domain. The FY 2020 Budget funding for this Initiative includes approximately $850M across the DOE, NIH, NIST, and NSF. DoD funding for AI is separate from this particular initiative.[29]

DoD Funding for AI $4B in FY 2020-According to Bloomberg Government, the Pentagon spent $1.4B in FY 2019 on AI-related efforts. That number is going to $4B based on the FY 2020 PBR, a shocking 185% increase. Over 70% of this funding is spread among the top 4 DoD organizations below [30]

Largest DoD Recipients of AI Funding

- Office of the SECDEF (OSD)-32% / $1.3B
- Navy-22% / $886M
- DARPA-12% / $506M
- JAIC-5% / $209M

White House Summits

There have been two White House AI Summits to date. The first in May of 2018 focused on AI adoption in American industry. Key focus areas included the national R&D ecosystem, workforce development, deregulation, and application across multiple industry sectors. [31] The second in September 2019 focused on the government as a user of AI. NIH, HHS and DoD all made presentations of use cases. [32]

"Third Offset" Strategy

In a military context, an "offset" means changing the game to overcome a disadvantage rather than fighting an opponent in an area of relative weakness. For example, in the 1950s, the U.S. offset strategy was to achieve a deterrent with nuclear weapons such that we could avoid spending in other areas of the military. This was the "First Offset". In the 1970s and 1980s, the DoD's "Second Offset" Strategy was about achieving technological superiority in precision strike / logistics, which would overcome the U.S. having a fewer number of forces than a competing military. In 2014, a "Third Offset" strategy was announced by the DoD, emphasizing a reliance on unmanned systems, robotics, miniaturization and other technologies.[33]

In December 2015, then Deputy Secretary of Defense Robert Work (now Vice Chairman of the National Security Commission on AI, NSCAI), outlined more detailed themes of the Third Offset, amid a warning for how adversaries are embracing these same capabilities, "We know that China is already investing heavily in robotics and autonomy and the Russian Chief of General Staff (Valery Vasilevich) Gerasimov recently said that

the Russian military is preparing to fight on a roboticized battlefield."[34]

Mr. Work did not directly address AI itself in that presentation, but at the middle of the Third Offset will be IoT data flowing to and from sensors, machines, and other humans, so it will eventually play a critical role.

National Security Commission on AI (NSCAI)

In addition to running the Defense Innovation Board (DIB), Eric Schmidt also chairs the National Security Commission on AI, (NSCAI) an organization created by Congress to make recommendations for development of AI for national defense purposes.[35] Like the DIB, the Commission is led by a group from government, academia and industry. The list includes NASA JPL, InQTel, Georgetown University, Google, Microsoft, Amazon Web Services (AWS) and Oracle, among others. Incidentally, Google and Microsoft have representatives on both the DIB and NSCAI.

The Commission is scheduled to issue its final report to Congress in March 2021. The most recent interim report, published in November 2019, touches on several core principals including: maintaining the U.S.'s global leadership in AI, shared responsibility between government and the private sector and an emphasis on human capital development, ethics and rule of law. As the Commission prepares its final report, it is recommending five distinct "lines of effort" that will be necessary for successful AI adoption for national defense:

"Lines of Effort"

- **Invest in R&D**-Even the recent uptick in AI funding won't be enough to give the U.S. an AI advantage, the Commission argues. Overall Federal R&D as a percentage of GDP has been on a steady decline in the U.S. for several decades. Unlike many Cold-War Era technologies that sprang from significant military R&D investments (stealth, GPS, the Internet, advanced microchips), it is now the private sector - not the government - that is leading in AI-related R&D investment. The Commission argues that without the government leading the way with significant R&D investments, the U.S. will lose AI pre-eminence to near peer competitor nations, like China and Russia. The report states "Investments that are multiple times greater than current levels are needed."[36]

- **Apply AI for National Security Missions-**Per the section above on the "Third Offset" Strategy, the Commission notes that near peer competitors of the U.S. have already reached parity in nuclear and precision strike weapons. Central to the new struggle for dominance will be the "Third Offset", in which AI will feature prominently, especially for missions in which reaction time is of the essence, such as cybersecurity and missile defense. But this will only happen if bureaucratic impediments are addressed through rapid acquisition and fielding with modernized infrastructure.[37]

- **Train and Recruit AI Talent-**One recommendation of the Commission is for the government to reassess the requirements for securing an improved AI workforce. Another is to enhance the tracking of the AI related skills that are already in-house and even reward coding like any other foreign language skill (with incentive pay). The Commission also recommends utilizing internship programs, fellowships, incentive structures and other practices typically used in the private sector for hiring the next generation AI workforce. Regarding U.S. universities, the Commission noted that demand for computer sciences degrees is vastly outstripping the number of professors able to teach it, and that the U.S. badly needs students and workers from overseas.[38]

- **Protect and Build Upon U.S. Technology Advantages-**The Commission recommends the U.S. to use export controls for the protection of AI-related hardware advantages, especially semiconductors. It also suggests moving away from the current export paradigm - which only bans individual items - to instead focus on who the end users of the technology are and for what purpose. Third, while the openness of the U.S. is central to American identity, the Commission recommends law enforcement should still take measures to curb espionage by foreign governments on American campuses to prevent "…direct or indirect assistance to China's military and intelligence apparatus." [39]

- **Marshall Global AI Cooperation-**TThe Commission argues that the crux of American competitiveness in AI will be to take the lead in establishing a network of allied nations for data sharing, R&D, talent exchange and military cooperation. It also recommends American leadership in "establishing a positive agenda for cooperation with all nations on AI advances that promise to benefit humanity". This includes possible diplomatic cooperation with China and Russia to promote AI safety and stability.[40]

PTC Perspective on AI

PTC is a leader in industrial software, unleashing innovation that occurs at the convergence of the physical, digital and human worlds. AI will eventually touch every aspect of the Digital Thread, including how products are designed, manufactured, operated and maintained. This has important implications for PTC's customers in the Federal Aerospace and Defense sector.

"National Security has been a leader in recognizing the value and potential of AI while also grounded in the critical, if less exciting, practical considerations for implementation of this technology at scale" says Ed Cuoco, PTC's Vice President of AI Strategy. "The use of AI in understanding and protecting our confidential information, measuring the performance of the military and its equipment, as well as the wide-ranging, futuristic vision of human/machine seamless interaction should always be considered in concert with questions of "how, specifically" and "what infrastructure would need to exist to make this more than a pet project or demo".

Cuoco added, "The Interim Report to Congress written by the National Security Commission on AI mentions the cumulative weight of R&D contributions from the U.S. private sector ("2000 AI startups" and "roughly half of the AI unicorns") as outpacing the U.S. government.[41] While that is true, and accelerating the use of AI in the government is a laudable goal, it is also true that more traditional firms in the private sector - like core industrials - are just now entering the AI adoption curve and playing catch-up behind both Silicon Valley and the DoD. Further, those AI companies referenced in the Interim Report often deploy their capabilities in environments that are far more controlled and homogeneous than both the government and the U.S. Industrial sector at large. AI is typically developed and deployed in climate-controlled offices with dependable infrastructure in advanced urban settings that have deep pools of data science experts. But when the same technology or techniques need to be applied in more austere military or industrial environments outside of that (either because the spaces are rougher or because infrastructure cannot be assured) then questions of practicality become even more important. All that said, the industrial sector can take a valuable lesson from both the AI startup community and the government regarding how the combination of vision and practicality will guide their focus."

Chris MacDonald, Head of PTC's Analytics Solutions Center of Excellence agrees "My organization specializes in helping our customers derive insight and action from data using comprehensive analytics. Many of the topics discussed daily with the organizations we support are not just "data science", but also address logistics, infrastructure and end user needs. Our Defense customers and partners are relentlessly focused on ensuring data is treated as a first-class citizen in their IT environment. None of the near- or long-term objectives would be possible without a relentless focus on framing analytics questions, beginning with being able to find, move and model data at scale."

Brent Baker, Sr., Maj Gen (Ret), USAF is Vice President of Federal Aerospace and Defense at PTC. "Increasingly, our customers in government and industry are seeking mindshare for ways AI can be applied to help address the most persistent challenges in the product lifecycle, namely design through sustainment. There are also important process and personnel implications to consider. Because its impacts will be fundamental and ubiquitous, AI is already squarely rooted as a key part of any Offset Strategy," he said.

As a few examples, below are several AI-related use cases PTC is currently working on. Each will impact the product lifecycle in unique ways

Product Design-One concept on the near-term horizon is "generative design", in which AI algorithms - in conjunction with human beings - will be designing the products of tomorrow. A design engineer will issue requirements and intent, and the AI will explore and create multiple, optimized solutions based on those requirements. As one example, a design engineer can specify if a given part needs to be cast, milled, forged etc. and the generative design will model itself under those constraints. The AI has no human biases, which means a step function for innovation with designs that meet requirements in entirely new ways. To amplify the capability even further, consider generative design in conjunction with real time simulation and additive manufacturing. These systems use the outcomes from real-time multiphysics simulation to test and refine designs of the AI's own making, then print only the most optimized ones. Finally, there is an equalizing effect with generative design in that the AI can give lesser trained personnel the ability to produce highly complex structures quickly. This could mean part and assembly replacement in theater at the site of a mishap, printed by non-experts. For these reasons and more, the impact of generative design on product development and sustainment will be immense, both for the defense industrial base and inside the DoD.

PLM-There are also important implications for AI on PLM itself. It will mean a capability to comprehensively leverage large PLM data sets in seconds for product development insights supported by natural language processing. This will translate to product and process knowledge capture and re-use in support of change prediction and impact analysis. There will also be quality and reliability improvements when this capability is coupled with field data and prescriptive analytics to support multi-domain engineering scenarios such as tooling cost and manufacturing processes. AI can even be used to improve PLM system performance and operation including security through global usage analysis and monitoring. Finally, from a Digital Thread perspective, additive manufacturing will drive the need for enhanced PLM capability through linkages to certified 3D parts libraries or configuration management of the printers themselves. Such smart PLM systems will have an awareness built-in that quickens product development times and improves quality.

Industrial Internet of Things (IIoT)-Joe Biron, CTO of PTC's ThingWorx Business Unit, which focuses on the IIoT, recently commented "Analytics informed by AI are

so foundational to the IIoT that they should be thought of as a baseline capability set for any solution. Predictive maintenance, asset optimization, enhanced service, supply chain management and KPI management rely on AI and deep analytics, either embedded in software platforms or enterprise solutions. As one example from the factory floor, consider being able to pull real time data from CNC machines, analyze it, and link the outputs to an ERP system. This one act migrates a manufacturer away from an "after-the-fact" analysis paradigm, to one that proactively augments human reasoning to optimize production scheduling with real time data."

Computer Vision (CV) and Augmented Reality (AR)-In addition to CAD, PLM and IoT platforms, PTC is also a market leader in AR for manufacturing, training and maintenance functions. The idea is to scan an assembly on a piece of equipment and create a dynamic visual experience based on product data artifacts associated with it (engineering documents, work instructions, animated repair procedures, warranty history etc.). The classical CV approach is to scan a bar or QR code to access this data. But because it is impossible to physically attach a code to every single assembly on a piece of equipment, this approach has natural limitations on its inputs. For this reason, PTC is now focused on training AI algorithms to auto detect assemblies or equipment through neural networks built from an "inferenced" model that uses CAD data for its inputs.[42] Knowing exactly where the assembly is in the camera image and matching it with the underlying CAD model allows a system to provide any available information associated with that assembly or larger piece of equipment. And while AI and CAD are not used for individual part recognition yet, the combination of these two capabilities is able to recognize larger assemblies and augment any information on any part of that recognized assembly. In theory, an AI could use CAD for deep learning to recognize all the assemblies on an aircraft, ship, or ground vehicle - making any geometry instantly scannable by a technician at the point of service. Additionally, the inputs will be coming from inside the system itself (not from humans), so the ingestion of the learning materials for the AI would operate at machine speed. A capability like this could usher in a new world in the equipment maintenance domain alone.

Service Parts Management-The Service Parts Management (SPM) product of PTC Servigistics has a rich history of pioneering data science (Statistics, Operations Research and Machine Learning) based solutions to optimize large-scale service supply chains. Servigistics is an enterprise prescriptive analytics system that predicts future service parts needs and decides what to stock where, and what to move, procure and repair, to achieve the highest equipment uptime and mission capability for limited budgets. "The most natural use case of AI is to utilize sensor data from equipment and extend the concept of predictive maintenance (as mentioned in the IIoT section above) to get signals for future part failures and use them to position the right parts in the right place at the right time. AI is also being explored for analyzing planner actions to decipher rules not in the planning system," said Leslie Paulson, GM, PTC Servigistics. Continuing its legacy of data science-based innovation, Servigistics envisions an AI powered autonomous planning system that improves its recommendations based on planner actions, and actual service and inventory performance in the field. To fulfill that vision,

Servigistics has added Performance Analytics and Intelligence module, complementing its forecasting and inventory optimization engines. This module historicizes supply chain data, measures and analyzes performance and has an AI platform to develop intelligence for supply chain improvement.

Key Leaders in Government-Related AI

Below are several individuals frequently cited in the media regarding AI adoption in the government..

Leaders in Government Related AI

- **Mark Beall**-Director of Strategic Engagement and Policy, Joint Artificial Intelligence Center (JAIC)

- **Danny Ray Brouillette**-Secretary of Energy

- **Michael Brown**-Director Defense Innovation Unit (DIU)

- **Paul Dabbar**-DOE Undersecretary for Science (oversees the new Artificial Intelligence Technology Office)

- **Dana Deasy**-DoD CIO

- **Donna Dodson**-Chief Cybersecurity Advisor, NIST Information Technology Laboratory

- **Kelvin Droegemeier**-Office of Science and Technology Policy Director, White House

- **Peter Highnam**-DARPA Director (Acting)

- **Stephen Homeyer**-Deputy Director, JAIC (Joint Artificial Intelligence Center)

- **Suzette Kent**-U.S. CIO

- **Michael Kratsios**-US CTO and Deputy Assistant to the President for the White House Office of Science and Technology Policy (OSTP)

- **Chris Lidell**-Deputy Chief of Staff for Policy Coordination, White House

- **Brendon McCord**-Head of Machine Learning at Defense Innovation Unit (DIU)

- **Lynne Parker**-U.S. Deputy CTO, White House Office of Science and Technology Policy (OSTP)

- **Eric Schmidt**-Defense Innovation Board Chairman, National Security Commission on AI Chairman and former CEO / Executive Chairman of Google / Alphabet

- **Lt. Gen. Jack Shanahan**-Director, JAIC (Joint Artificial Intelligence Center)

- **Danielle Tarraf**-Senior Information Scientist, The RAND Corporation

- **Robert Work**-National Security Commission on AI Vice-Chairman and former Deputy Secretary of Defense

U.S. Government Use Cases

From the Professional Services Council Foundation and other sources, there are several govt use cases of AI currently underway or being considered. This is by no means a comprehensive list - these are just a small fraction of the use cases that have been released publicly.

Government Use-cases

- **DoD**-Plan deployments during crisis[43]/ Humanitarian Missions[44]/ Automating review of video surveillance[45]/ Monitoring military air traffic in the Pacific[46]/ Target and weapon selection and placement[47]

- **CYBERCOM AND NSA**-Standardize cybersecurity data collection[48]

- **GSA**-Track invoicing and payments[49]

- **HHS**-Consolidating contract vehicles[50]

- **NASA**-Aid in finance and procurement[51]

- **NIH**-Enhanced search results for PubMed[52]

- **USDA**-Natural language chatbots at call centers[53]

- **USPTO**-Route patent applications more effectively[54]

- **VA**-Improve customer/ patient experience[55]

Conclusion

In what amounts to a global game of "catch-up", especially with China, the U.S. government has rotated from a primarily R&D posture regarding Third Wave Artificial Intelligence to one focused on preparing for immediate action in the operational realm. As this shift in the tectonic plates of government ushers in a new era of contextual adaption, a few factors are at top of mind.

First, the Pentagon is at the center of U.S. government AI investment. For FY 2020, the DoD has nearly 5x the funding for AI as all civilian government agencies combined ($4B vs. $850M).[56] And this is just what is known publicly. The classified budget for AI capability in support of the DoD and the Intelligence Community may very well be significantly higher. In the near term, the DoD will clearly be setting the pace for AI adoption both for national defense purposes and for many functions in non-defense. And within the DoD, the JAIC may get most of the media attention, but it is the Office of the SECDEF (OSD) itself that has 6x the AI funding the JAIC has ($1.3B vs. $209M).[57] Indeed, in an independent research piece on the DoD's AI strategy released in December 2019, The RAND Corporation concluded that the JAIC needed more funding. "The DoD recognizes that AI could be a game-changer and has set up organizational structures focusing on AI," commented Danielle Tarraf, Senior Information Scientist, The RAND Corporation. "But currently the JAIC doesn't have the authorities or resources it needs to carry out its mission. The authorities and resources of the AI organizations within the Services are also unclear."[58] Downstream from the DoD, the defense industry often emulates the technology platforms of its end customers in government, so the policy and acquisition decisions being made by the DoD on AI now will have multiplier effects in the private sector lasting decades.

Another consideration is raw computing power, which along with access to semiconductor manufacturing technology, will accelerate advances in AI. The U.S. Dept of Energy houses some of the most advanced computing capability in the world. As Congressional appropriators begin planning for FY 2021 and beyond, it is reasonable to expect a rising role for the DOE in AI, especially with quantum computing. In

September 2019, the DOE stood up a small organization, called the Artificial Intelligence Technology Office (AITO).[59] Details are scant on the organization at this early stage, but given the DOE's access to supercomputing resources, it will likely be collaborating with the DoD on multiple AI fronts. Corresponding funding lines will surely follow.

Third is the DoD's plan for enterprise cloud adoption, which will have a direct impact on developing its AI capability. The DoD has several cloud projects in flight, including DEOS and milCloud 2.0. But by far the highest profile cloud effort in the DoD to date has been JEDI (Joint Enterprise Defense Initiative), a contract potentially worth $10B over a decade. An award was expected for either Microsoft or AWS in September 2019 when the DoD suddenly announced it was hitting a temporary pause to do further reviews. Shortly afterward, Lt. Gen Shanahan (JAIC Director) issued a quote underscoring the importance of JEDI to its AI efforts "An enterprise cloud allows AI cycle speeds that can be measured in updates and across an entire enterprise in hours as opposed to in months, six months or maybe even a year."[60] AIC applications are slated to be among the first DoD capabilities to migrate to JEDI.[61] In late October 2019, JEDI was awarded to Microsoft.[62]

Finally-and although not the specific focus of this whitepaper-to say that there will be profound moral and ethical questions arising along the adoption curve for AI is the understatement of the century. This has been a focal point in the government's planning to date-and rightfully so. Author Sam Harris recently commented on the potential future coexistence of humans with Artificial General Intelligence (AGI) "Set it humming for a week, and it would perform 20,000 years of human-level intellectual work."[63] Simultaneously a blessing and a curse, a capability differential that stark has important implications for national security.

For example, replace the game of Go with a military scenario in which a group of humans is pitted against an AGI in a naval battle. For 1 hour of human time, the AGI could perform 119 years of intellectual work; formulating strategy and tactics informed by fusing the insight of every naval commander since the time of the ancient Phoenicians with current-day product data, maintenance logs and repair procedures. It might also consider millions of scenarios to find unbeatable combinations of fleet asset placement, given supply chain, weather and cyber warfare constraints.

For better or worse, the possibilities are infinite. And for every move the humans make, the AGI would have the equivalent of a century to consider its response-ingesting, formulating, adapting - always. It wouldn't be a fair fight, which explains the U.S. government's urgent impulse to be first to this strategic square of the chessboard with technology as fundamentally game changing as this. From the designer's desktop, to the factory floor, to operating environments on land, air, sea and space-the government digital thread is being stretched across the entire national security landscape. And with ever increasing frequency, the authors and consumers on both ends of it will not be human.

Author

Alexander Daly leads PTC's Federal Aerospace and Defense efforts for DoD programs to government and industry customers. In this role, he creates strategies for improving processes around product design, manufacture, operations and support through the application of software platforms from PTC. Mr. Daly also leads PTC's government relations efforts on Capitol Hill.

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