Acquiring Artificial Intelligence Systems: Development Challenges, Implementation Risks, and Cost/Benefits Opportunities

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Introduction

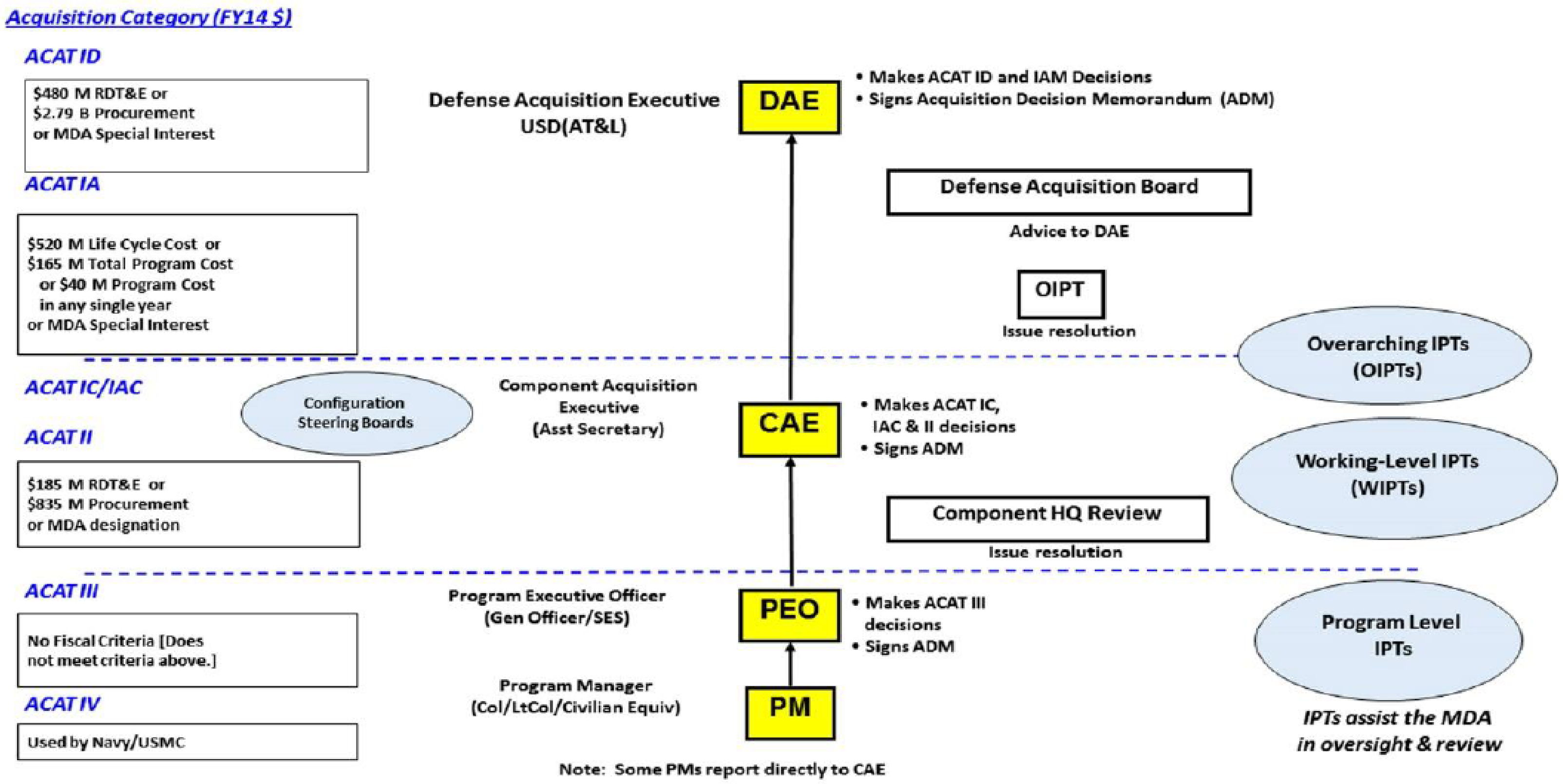
- Acquisitions of Artificial Intelligence (AI) systems is a relatively new challenge for the DoD.
- There is a high risk of failure for such system acquisitions, making it is critical that the acquisition community examines potential new approaches to help manage the AI acquisition life cycle.
- The identification, review, and recommendation for use of new acquisition methodologies, to supplement or replace existing methodologies, should help avoid costly disasters in AI system acquisitions.
- AI has been in use in various commercial and governmental domains to address a variety of decision support problems.
- However, existing DoD acquisition frameworks may not be adequate to address the unique nature of AI systems life-cycle investments.

Research Problem

- The complexity and speed of decision-making at the DoD is increasing exponentially with the advent of intelligent systems that support or actually make decisions in time-critical, high-impact problem spaces.
- Current process management and control tools supporting acquisitions do not provide adequate warning of, or sufficient information about the root causes of fiscal budgetary overruns and time schedule delays.
- PMs are unable to respond to issues in a timely manner, delaying the delivery of promised capabilities to the services.
- This study examines the strengths and weaknesses of several performance and project management methodologies: Earned Value Management (EVM), Knowledge Value Added (KVA), and Integrated Risk Management (IRM), used to strategically and tactically plan, monitor in real time, measure, and preemptively forecast the value and progress of AI acquisitions.

DoD Acquisition Categories

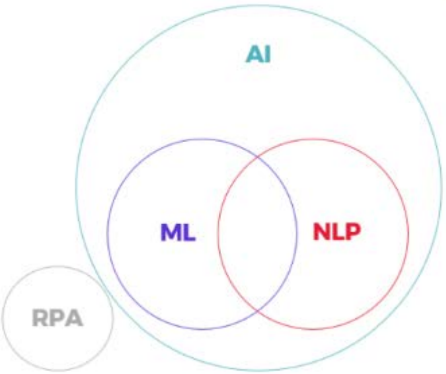
Acquisition Categories (DoD, 2017)



ACAT: Acquisition Category
ADM: Acquisition Decision Memorandum
CAE: Component Acquisition Executive
Col: Colonel
DAE: Defense Acquisition Executive
Equiv: Equivalent
HQ: Headquarters
IPT: Integrated Product Team
Lt Col: Lieutenant Colonel
M: Million

MDA: Milestone Decision Authority
PEO: Program Executive Officer
OIPTs: Overarching Integrated Product Teams
PM: Program Manager
RDT&E: Research, Development Test and Evaluation
USD(AT&L): Under Secretary of Defense for Acquisition, Technology and Logistics
USMC: U.S. Marine Corps
WIPT: Working-Level Integrated Product Team

A Quick Introduction to AI

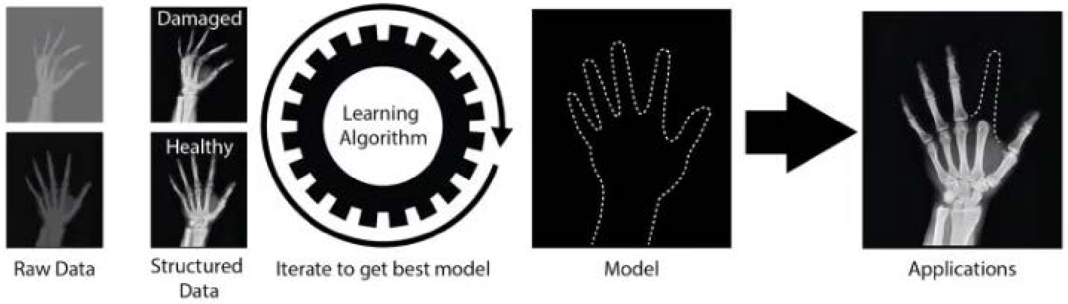


- **Artificial Intelligence (AI):** algorithms exhibiting any behavior considered 'smart'.
- **Machine Learning (ML):** algorithms that detect patterns and use them for prediction or decision making.
- **Natural Language Processing (NLP):** algorithms which can interpret, transform and generate human language.
- **Robotic Process Automation (RPA):** algorithms that mimic human actions to reduce repetive, simple tasks.

- Formally founded in 1956, the science of AI was created to determine if inorganic machines could perform human-level intelligent functions (Denning, 2019).
- It went through several hype cycles, due primarily to sensationalizing of what it might be able to do, with frequent disappointments.
- Significant enthusiasm for AI reemerged at the same time that Big Data computing power became more accessible to researchers and companies, which, in turn, could apply the science to multiple tangible applications (Haenlein & Kaplan, 2019).
- Currently, examples of commercially viable applications of AI exist in manufacturing robots, smart assistants, proactive healthcare management, disease mapping, automated financial investing, virtual travel booking agents, social media monitoring, conversational marketing bots, NLP tools, and contract management (Daley, 2019).

Machine Learning

- Intelligence is the capacity to process a certain type of information, allowing a processor to solve problems that are of consequence. The categories of intelligence include visual-spatial, linguistic-verbal, interpersonal, intrapersonal, logical-mathematical, musical, body-kinesthetic, and naturalistic.
- A computer can perform calculations based on the data provided and ultimately returns a result. It can be programed and coded to follow certain steps or algorithms repeatedly, and even to alter its findings based on its own previously calculated results through some error correction algorithms. A combination of these two steps is the basic concept of machine learning. A computer system is first fed data structured in a way that the algorithm is programmed to recognize, derive patterns from the data, and make assumptions about any unstructured data provided subsequently.
- The areas of machine learning include: supervised learning, unsupervised learning, reinforcement learning, and deep learning.



Human-Machine Partnership

- DARPA believes AI integration is critical as a human–machine symbiosis because sensor, information, and communication systems generate data at rates beyond which humans can assimilate, understand, and act on.
- As was the case in the industrial revolution, machines are better at certain activities and using machines for those activities frees humans to become productive in other areas. Humans and machines excel in separate areas of processing.
- Consider these comparisons between computers and humans: calculate versus decide; compare versus make judgments; apply logic versus empathize; unaffected by tedious monotony versus having preferences; deals with large data versus intuitional focus on what is most important (Darken, 2019). And while AI performs well in some tasks, it works better with a human partner.
- However, without proper controls, AI is a gullible learning system and can be vulnerable to being deceived by bad actors. Some studies show that AI can be fooled in a way that humans would not be due to human intuition. Other research has been able to fool a self-driving car into thinking a benignly tampered with stop sign was a speed limit sign, which would undoubtedly lead to collisions if the car were left unsupervised.

AI in the Private Sector

- To compare solutions to the DoD acquisition problem, we examine similar circumstances in the U.S. private sector.
- Lawgeex is an example of a company that is applying the AI integration process in the private industry procurement world. It demonstrated that its AI software could outperform U.S. trained lawyers on an example contract aspect, the Non-Disclosure Agreement (NDA), with an average accuracy of 94% as compared to 85% for humans.
- The study was conducted to respond to a common business problem in large companies that rely on contracts to engage with partners, suppliers, and vendors having an 83% dissatisfaction rate with their organization’s contracting processes.
- Another example is Icertis, a company that services large and commonly familiar companies such as 3M, Johnson & Johnson, and Microsoft, to list a few. Icertis provides its customers with a cloud-based AI platform that learns from contracts provided by the client, along with control measures, to create and assist in contract setup; contract operations; governance, risk, and compliance; and reporting.

Earned Value Management (EVM)

- Simplicity is a key attribute of the EVM methodology.
- The process is broken down into three main variables: money, time, and work completed.
- The key metrics managers use to assess a project are simple ratios derived from these cost and schedule parameters.
- Early warning of potential issues within a program.
- A forecast of the total cost and schedule requirements.
- CPI (cost performance index) stabilizes within a 10% range after a project reaches the 20% completion point. This early indication provides PMs a reliable prediction of the project's final costs
- The low range of the cost overrun is the current cost plus the remaining scheduled cost.
- The high end of the costs is the budgeted cost divided by the CPI, which is a more accurate estimate unless extenuating circumstances caused the overrun.
- SPI (schedule performance index) provides an indication of future cost increases. An unfavorable SPI indicates spending will grow larger than initially planned to reduce the schedule variance.

Knowledge Value Added (KVA)

- KVA is an objective, quantifiable method to measure the value produced by a system and the subprocesses within the system.
- The value measurements of each process are ratio scale numbers, allowing analysts to compare them with the values from other subprocesses to determine their relative effectiveness.
- KVA converts the outputs of all processes into common value units allowing a standard productivity performance ratio, that is, output/input across all processes. PMs can determine the value generated from the human component against the value added by AI processes.
- PMs can use these measurements to develop useful ratios in their analysis of the program's performance. Productivity ratios include return on knowledge (ROK), where the output of a process is divided by the process cost required to produce the output, and return on investment (ROI), which is the monetized output minus cost divided by cost. The ROKs and ROIs, which are always 100% correlated, give managers information about the amount of value a process generates compared to the amount of money spent to create the value. Unlike any other methodology, KVA assigns these figures to both the process and subprocesses rather than only the firm as a whole.

Integrated Risk Management (IRM)

- Technical capabilities can often fall short of expectations and project schedules are inherently uncertain, and change is normal. Therefore, we should expect changes and find the best way to deal with them. So why do projects always take longer than anticipated? One reason is inaccurate schedule estimating.
- The main shortcomings in the traditional methods of schedule estimation is the lack of uncertainty modeling.
- Monte Carlo simulation and advanced analytics can be applied to address these shortcomings.
- The Integrated Risk Management (IRM) process and techniques are related in an uncertainty decision analytical framework, within the risk analysis and risk management context.
- This IRM framework comprises eight distinct phases of a successful and comprehensive risk analysis implementation, going from a qualitative management screening process to creating clear and concise reports for management.

Comparison of Methods

- Choosing a methodology depends on the nature of the project, commitment from the organization, the desire to align strategic goals with the project, predictive capability of the methodology, flexibility required, and the time and knowledge available.
- EVM only needs the management team to track the cost and schedule of the project compared to the baseline as there is no goal alignment with the organization. While the CPI and SPI can help estimate the final cost and schedule, there is no true predictive ability associated with EVM since the assumption is that the schedule will proceed according to the baseline, regardless of previous performance.
- KVA only needs the analyst and process owner, as the subject matter expert, to determine the value of a process's output, supporting the need to align the project with an organization's productivity goals. Using this analysis, they can model the current baseline as-is process ROK and compare it with the proposed to-be process model ROK, thus offering a simple prediction of the improvement between the models. Since KVA can be used with any language of description to define the process outputs, analysts can choose whichever method is most beneficial for the particular system in question, providing flexibility.
- IRM requires organizational leadership, portfolio and project managers, and the analyst to determine how a project fits within an organization's portfolio, the uncertainties in the project estimates, and potential strategic options. By analyzing and simulating various scenarios, IRM provides a prediction of a project's likely performance, which allows managers to build in flexibility via real options at the appropriate locations within the project.

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- If the software is not complex or consists of known processes, EVM sufficiently monitors its progress.
- Integrating software and hardware is also complicated with EVM since there are numerous pieces of the program that must be combined to meet the goals, resulting in additional debugging and recoding.
- EVM is more efficient when used to manage the physical creation of systems or infrastructure. It can monitor the cost/schedule progress of software work packages but is not as useful at estimating the value of those programs until the requirements have been delivered.
- KVA can provide an objective, ratio-scale measure of value and cost for each core process and its subprocesses within any IS system. Using the two measurements, managers can then analyze productivity ratios information, such as ROK and ROI, to determine the efficiency of a process compared to the resources used to achieve the output.
- Combining the KVA results with IRM allows managers to iterate the value of the system, risks and uncertainties, while also providing strategic real options analysis of alternatives through Monte Carlo simulation and other techniques. IRM quantifies risks and forecast performance probabilities for measures of the potential success for programs and components of programs using historical and contemporaneous data.

Summary and Conclusion

- EVM remains the only program management methodology required by the U.S. government for all DoD acquisition programs with a contract value exceeding $20 million.
- However, there are significant limitations when using EVM for AI acquisitions, the major weakness being that it was not designed for managing AI acquisitions that follow a very iterative pathway.
- Organic AI acquisitions require a given level of flexibility to deal with the unknowns that arise during the development process. EVM does not provide a common unit of value metric to enable standard productivity metrics, such as ROI.
- If an AI acquisition program is trending toward cost and schedule overruns, but the resulting value added of the modifications to the original requirements provides disproportionate increases in value, EVM is not designed to recognize this increase in value.
- To remedy the shortcomings of EVM in AI acquisitions, the methodology should be combined with KVA and IRM, which can be useful during the requirements phase of EVM by ensuring that a given AI acquisition is aligned with organizational strategy and that a baseline process model has been developed for establishing current performance before acquisition of the supporting AI.
- A future process model that estimates the value added of the incorporation of the AI can also set expectations that can be measured against the baseline model after the AI has been acquired. IRM can be used to forecast the value of strategic real options flexibility that an acquired AI may provide so that leadership can select the options that best fit their desired goals for the AI in defense core processes.

Limitations and Future Research

- The current research conducted looked at AI as a whole and not specific types of AI.
- Future studies should examine if acquisition methods, strategies, and methodologies should change based on the category of AI being acquired. This is of specific interest when considering artificial intelligence and its subsets.
- Machine learning, intelligence with a specific focus or field of expertise, and general or universal intelligence would likely have different methods used in the acquisition process based on their complexity, complicated nature, undeveloped technology, and level of risk.
- The applicability of these methodologies within commercial acquisition of AI is another area of potential research. This research focused exclusively on the application of the respective techniques within the DoD acquisition process.
- Further research may indicate if these same methodologies could provide value to decision-makers in the private sector during the creation, adoption, or customization of commercial AI.
- Future research could examine other program management tools, management philosophies, analytic tools, or other methodologies and their benefit when acquiring AI. While the examined methodologies were chosen because they would likely benefit the process and support improvements in EVM, other systems may be more appropriate in certain phases or may offer additional benefits not seen in this research.