



INVENTION

INNOVATION

A Disruptive Game Changer to Achieve DoD Austerity

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Deputy Secretary of Defense Ashton Carter's recent challenge to "improve tradecraft in services acquisition" as part of his Better Buying Power initiatives appears aimed at the software engineering function and the prime contractors who struggle to comply with the Recruit-Train-Retain objectives laid out in the 2008 National Defense Authorization Act. As a result, there remain unclaimed benefits and unmet needs stemming from earlier neglect.

The Challenge of Competition

One of the AT&L challenges is to promote real competition. Currently, the defense industry enterprises devote extensive resources and management attention to complying with the Capability Maturity Model Integration (CMMI). The CMMI provides structures to house and control managers. This initiative fosters a culture of compliance but not one of innovation and competitiveness. Despite a two-decade history of capability maturity model improvement, software problems continue to impact defense programs. In addition, the CMMI has not

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kept pace with contemporary issues, such as cybersecurity, global supply-chain management, and team innovation management. Earlier, the CMM and CMMI led from the front and were viewed as necessary and sufficient. Today, the CMMI is a lagging indicator that is viewed as necessary but not sufficient. Competition and innovation, like process improvement, demand continuous improvement.

Instead of being content with compliance, these defense industry enterprises should strive to achieve global software competitiveness characterized by controlling the supplier, controlling the customer, controlling the competition, and controlling threat events.

- Supplier control is achieved by establishing an attractive workplace culture, achieving maturity in process and skills, deepening industry relationships, and retaining personnel.
- Customer control is achieved by deepening customer relationships, balancing business factors, and achieving total customer satisfaction.
- Competitor control is achieved by deepening community relationships, fielding superior products, and setting the direction for the niche.
- Event threat control is achieved by guarding against government intrusion, applying strategic software management, performing due diligence, and understanding reality.

Operationally, the stages of competitiveness include make and sell, sense and respond, and anticipate and lead.

- In *make and sell*, the goals are to achieve process efficiency and deliver quality products. This is the current state to which the defense industry aspires.
- In *sense and respond*, the goals are to listen to the voice of the customer and to deliver satisfying solutions. Too often this is a failed state.

To borrow criteria from the USPTO, innovation involves applying creativity and inventiveness in ways that are novel, useful, and a non-obvious extension of prior art.

- In *anticipate and lead*, the goals are to understand the deep needs of the customer and to deliver transforming innovations. This represents the game changing state to which defense industry enterprises need to aspire and for which the Department of Defense needs to structure incentives to achieve.

The Challenge of Innovation

Another of the AT&L challenges mentioned incentives for innovation. William Brody, former president of Johns Hopkins University, said, "The calculus of innovation is really quite simple: knowledge drives innovation, innovation drives productivity, productivity drives our economic growth." Innovation occurs at the intersection of invention and insight. It is not just something new; it is not just the inventiveness. To borrow criteria from the USPTO, innovation involves applying creativity and inventiveness in ways that are novel, useful, and a non-obvious extension of prior art.

How is innovation achieved? An organization can get lucky or it can be good. In getting lucky, ideas originate from the producer, and changes are directional—that is, moving in the direction the producer is already traveling. In being good, ideas originate in the cross-discipline collaboration and culture clash between producer and consumer, and changes are intersectional, that is, moving in a new direction under the combined influence of both producer and consumer. These changes are transformational.

Since software is the carrier for innovation, an unmet need involves systematically sparking intersectional ideas between systems engineers and software engineers. However, traditional program culture, organizational structures, and supply chain management practices erect barriers and obstacles that interfere with this opportunity. As noted earlier, one of these barriers is an excessive culture of compliance.

The Challenge of Fixed Price

The Department of Defense needs to ensure that defense industry senior executives are committed to meeting the AT&L challenges and are accountable for demonstrating game-changing progress towards solving these challenges.

For example, the most significant game changer a defense industry senior executive can deliver is an "all in" commitment to accept fixed price contracts on large software-intensive programs along with a convincing capability to deliver that reflecting an understanding of the cultural changes required. This self-medicating measure requires that both the Department of Defense and the defense industry populate a tool kit of capabilities for successfully engaging in fixed price contracts and for evaluating the challenges and benefits of doing so.

Reluctance to accept fixed price contracts within the defense industry community is based on risk and fear of failure in cost, schedule, and quality performance. This reluctance can be offset by DoD incentives based on technical performance measures designed to tilt the risk calculation in favor of fixed price for those capable of delivering.

GPS: A Fixed Price Success

An example of how a fixed price contract can result in a win-win outcome was turned in by IBM's Federal Systems Division performance on the Global Positioning System (GPS) Ground Station, a \$150 million fixed price program. GPS is a high assurance real-time system that provides continuous and accurate positioning information to properly equipped users. So naturally, incentives were tied to achieving accuracy of results and a high availability operation.

As the IBM FSD software development manager for GPS, I managed a team of 70 software engineers who produced the system of 500,000 source lines of code. I experienced first-hand the challenges and benefits that come with a fixed price contract.

- The first challenge was to convince John Akers, the president of IBM, that we could successfully perform a sizable fixed price contract. A comprehensive set of technical performance measurement incentives organized around the accuracy of results was instrumental in securing that approval.
- The second challenge was the commitment to systems engineering and software engineering collaboration needed to obtain the deepest possible user domain awareness. This was done through early operations analysis and simulation in order to integrate the needs of the systems, software, and user in the best possible way. Every eyeball was trained on accuracy and high availability incentives.
- The third challenge was to structure the software development plan as an incremental development, with four well-specified design levels, each with fine-grained cost accounts, formal software inspections of design-level artifacts, careful management and visibility of systems-engineering "to be determined" items, and a relentless focus on the innovation needed to meet or exceed the accuracy incentives. Designs were recorded in a program design language, and by the end of design, level 4 represented a 1:4 ratio of design language to estimated sources lines of code. Design levels

1 and 2 supported the systems engineering preliminary design review (PDR), with intended functions of components, interface specifications, and software architecture rules of construction; design levels 3 and 4 comprised the basis for the software engineering critical design review (CDR) with provably correct, stepwise refined elaborations of functionality.

- The fourth challenge was to apply strict accountability and control of cost accounts and work packages based on a work breakdown structure and work responsibility matrix. Cross-charging was prohibited—that is, systems engineers were prohibited from charging software engineering work packages. Work packages were opened only when the entry gates had been either met or waived by explicit decision. Work packages were closed only when and as soon as the work package had achieved 100 percent earned value, so that unexpended funds in completed work packages were not used to offset work packages that were over budget. An estimate to complete (ETC) was made for each work package each month. Where actuals to date combined with the ETC for a work package exceeded the budget at completion (BAC), a corrective action plan was initiated, if possible.

Software Doctrine

The preferred organization software doctrine for large-scale, software-intensive systems development on fixed price contracts features the following tenets. Table 1 shows the fixed price doctrine tenets and their focus on project management, process management, and product engineering.

Table 1. Fixed Price Doctrine Tenets

Fixed Price Doctrine Tenets	Project Management	Process Management	Product Engineering
Requirements and incentives known from the beginning			■
Software engineering reports directly to the program manager	■		
Commitment to the deepest possible domain awareness			■
Explicit project goals and readiness to perform and deliver	■	■	■
Strict cost accountability based on work responsibility matrix	■	■	
Software development planning based on design levels and staged increments	■	■	■
Software product release frequency planned, managed, and controlled	■	■	■
Joint team innovation management of ideas generated, selected, and used	■	■	■

DoD must now impose austerity on the defense industry by requiring, demanding, and expecting the defense industry to accept fixed price contracting and by supplying incentives as the lubricant for its acceptance.

- Requirements and the technical performance incentives for their achievements are fully known at the beginning and managed and controlled throughout the life cycle.
- The software engineering organization reports directly to the program manager.
- Both the systems engineering and software engineering functions are jointly committed to obtain the deepest possible user domain awareness.
- Project goals for schedule, cost, and quality are explicitly stated and matched by both the readiness to perform and actual performance.
- Strict accountability and control of cost accounts and work packages are applied based on a work breakdown structure and work responsibility matrix.
- Software development planning is based on multiple design levels and staged incremental deliveries.
- The frequency of software product releases is planned, managed, and controlled.
- Joint systems engineering and software engineering team innovation management results in new ideas that are generated, selected, and used in new product releases.

Conclusion

Commercial enterprises are finding ways to do more with less. DoD must do the same. Austerity has been imposed on DoD. DoD must now impose austerity on the defense industry by requiring, demanding, and expecting the defense industry to accept fixed price contracting and by supplying incentives as the lubricant for its acceptance. Improved competitiveness and innovation are the outcomes sought. Accomplishing this is essential to the sustainability of the defense software industry. 

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