ARMY SCIENCE BOARD

Report of Fiscal Year 2019 Study

March 2020

Army Futures Command (AFC)

The Army Science Board (ASB), organized under the Federal Advisory Committee Act (FACA) in 1977, provides the Army with independent advice and recommendations on matters relating to the Army's scientific, technological, manufacturing, acquisition, logistics and business management functions, as well as other matters the Secretary of the Army deems important to the Department of the Army.

ASB members and consultants are eminent authorities in the disciplines of science, technology, engineering, math, social science, business and governance. The Board also draws upon the expertise of senior retired military officers from all branches of service. All are dedicated experts who volunteer their time to provide independent assessments to Army civilian and military leadership.

The following report is a product of the ASB. The statements, opinions, conclusions, and recommendations contained in this report are those of the ASB study members and do not necessarily reflect the official position of the United States Army or the Department of Defense.

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PREFACE

The Army Futures Command (AFC) was established in June 2018 to provide greater speed and efficiency to the modernization enterprise. The Army Science Board (ASB) was asked to support AFC as it stood up its organization, specifically to look at internal processes to ensure the new command performed its mission.

The study team found several challenges to meeting this goal:

1. AFC's organization as constructed produces difficulties associated with integrating disparate organizations spread across numerous geographic locations. This report describes industry best practices to overcome such issues and provides recommendations to:

    - Establish one or more Boards of Advisors
    - Establish processes to unify AFC's vertical and horizontal culture
    - Improve core competencies by adding systems engineering and additive manufacturing

2. Even if the AFC organization were optimal, some aspects of the Army acquisition process would limit the potential value of its outputs to the warfighter. To "fix" the acquisition process, the study team recommended that the following practices be implemented:

    - Assure continuity of leadership; establish a Special Task Force to produce Milestone (MS) B documents
    - Require development programs be at Technology Readiness Level (TRL) 7 before achieving MS B; encourage multiple prototyping
    - Enforce the practice of requiring 90% drawings release before Critical Design Review

These topics are discussed in greater detail in this report. If the measures are adopted, the future force will be equipped for success against current and future adversaries.

EXECUTIVE SUMMARY

In January 2019, the Secretary of the Army (SECARMY) requested that the Army Science Board (ASB) conduct a study to develop recommendations for internal processes on how Army Futures Command (AFC) should operate in order to achieve the outcomes described in General Order 2018-10 (Establishment of United States Army Futures Command):

> "AFC leads the Army's future force modernization enterprise. AFC assesses and integrates the future operational environment, emerging threats, and technologies to develop and deliver concepts, requirements, future force designs, and supports the delivery of modernization solutions." [1]

The Secretary asked the study to focus on best practices within the command to ensure that AFC matures advanced systems concepts, technology, and materiel solutions into deployed systems.

The ASB established a team comprised of highly qualified former senior officers, senior government civilians, and industry leaders.

The information required to address the specified tasks was obtained during numerous visits to AFC organizations as well as other Army and DoD organizations. Significant information was also found in reports from the Army, the General Accountability Office (GAO), and academia.

In March 2019, the SECARMY and Chef of Staff, Army (CSA) testified to the importance of AFC to the future Army:

> "Last year, the Army made its most significant organizational change in over 40 years by establishing the Army Futures Command (AFC). We stood up AFC in the innovation hub of Austin, Texas with a focus on providing unity of command and unity of effort for the modernization enterprise. For the first time, one commander is driving concept development, requirements determination, organizational design, science and technology research, and solution development. …. AFC will identify and deliver new capabilities with greater speed and more efficient use of our resources."[2]

The study considered two main topics: the AFC organization and the Army acquisition process.

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[1] Headquarters Department of the Army, General Orders 2018-10: "Establishment of United States Army Futures Command," 4 June 2018, https://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/ARN11199_GO1810_FINAL.pdf

[2] Statement by The Honorable Mark T. Esper, Secretary of the Army, and GEN Mark A. Milley, Chief of Staff US Army before the Senate Armed Services Committee, 26 Mar 2019. https://www.army.mil/e2/downloads/rv7/aps/aps_2019.pdf

AFC Organization

In accordance with its charter to go from a strategic understanding of the future operational environment (OE) to fielded, effective operational capabilities, AFC organized around three main components and a headquarters element (Fig. E.1; section 2 of the report provides additional details).

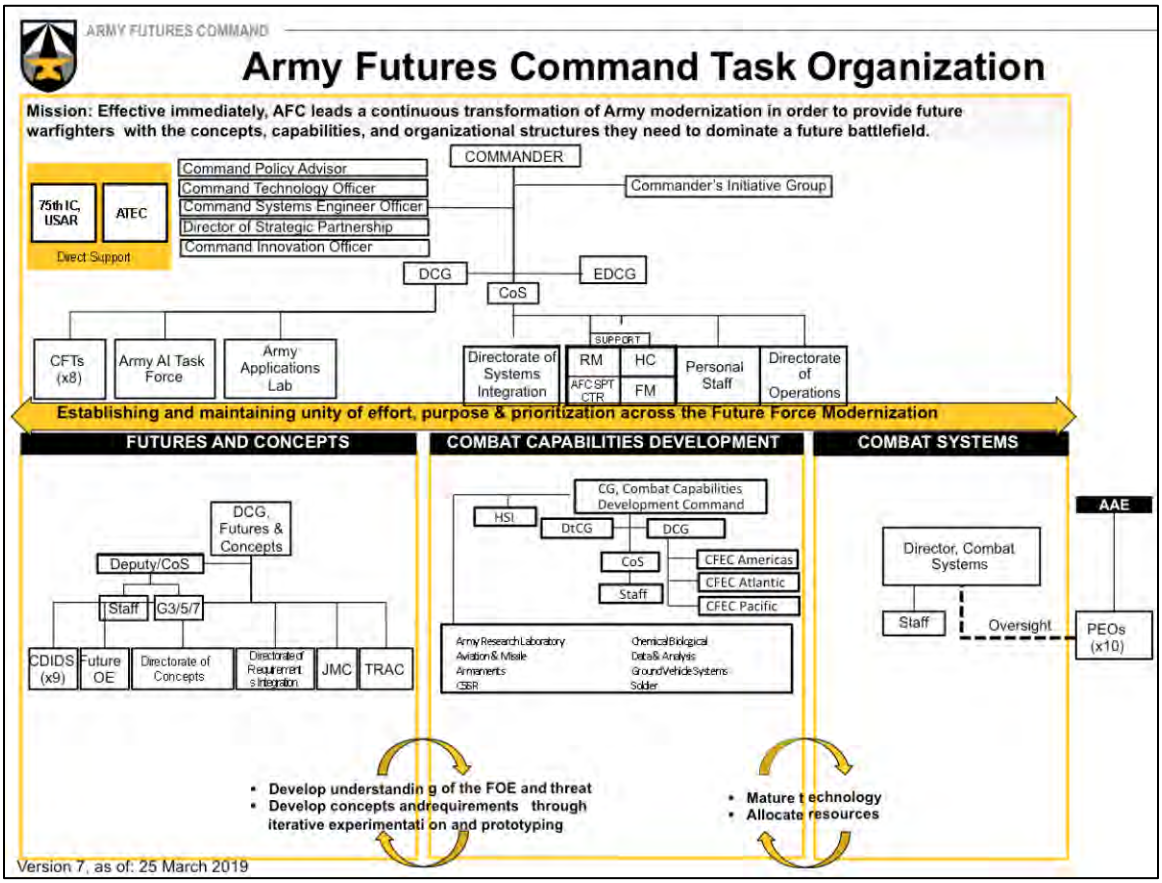


Figure E.1 AFC Organizational Chart

The AFC components have distinct roles but must collaborate to achieve success.

- The Headquarters in Austin, TX sets strategic direction, orchestrates the Army's modernization enterprise, sets capability priorities, aligns resources to priorities and maintains accountability.

- Futures and Concepts Center (FCC) in Fort Eustis, VA assesses the threat and Future OE, develops future concepts and the Army Modernization Strategy, and determines requirements to drive new capabilities and formations.

- Combat Capabilities Development Command (CCDC) in Aberdeen, MD conceptualizes, develops and transitions operationally relevant solutions and knowledge through research, engineering, testing and analysis.

- Combat Systems Directorate (CSD), also in Austin, TX, advises the AFC CG, especially pertaining to research, development, acquisition, and contracting; ensures that PEOs and PMs prioritize Army modernization efforts and maximizes cooperation, urgency, and unity of effort.

From its data gathering, the ASB developed findings and recommendations to ensure AFC established best practices similar to those adopted by industry and other government organizations.

Advisory Boards: The team recommends that one or more advisory boards comprised of high-level individuals from external elements be formed to provide the AFC commander early and relevant insights on technological and cultural developments and their potential impacts not available from internal sources.

Organization Unity – Vertical and Horizontal Integration: Edwards Deming was a pioneer in establishing techniques for creating organizations that, while large, behaved as smaller organizations where employees act together to maximize output (additional details are provided in Section 3). These industry practices and the need for AFC unity led to a set of recommendations for CG AFC to establish processes to:

- Empower employees through a top-down communication strategy

- Empower employees through an email suggestion box

- Broaden employees through developmental assignments internal to AFC

- Broaden employees through developmental assignments external to AFC

Army Core Competencies: A review of the FY 2013 ASB Study "Army Science and Technology (S&T) Essential Core Competencies" led to three sets of findings and recommendations:

- An industry best practice involves the Chief Executive Officer (CEO) to identify core competencies within his/her organization since s/he is best positioned to understand the priorities of the entire organization. Therefore, it's recommended that CG AFC establish a top-down process to identify AFC core competencies (discussed in greater detail in Section 4).

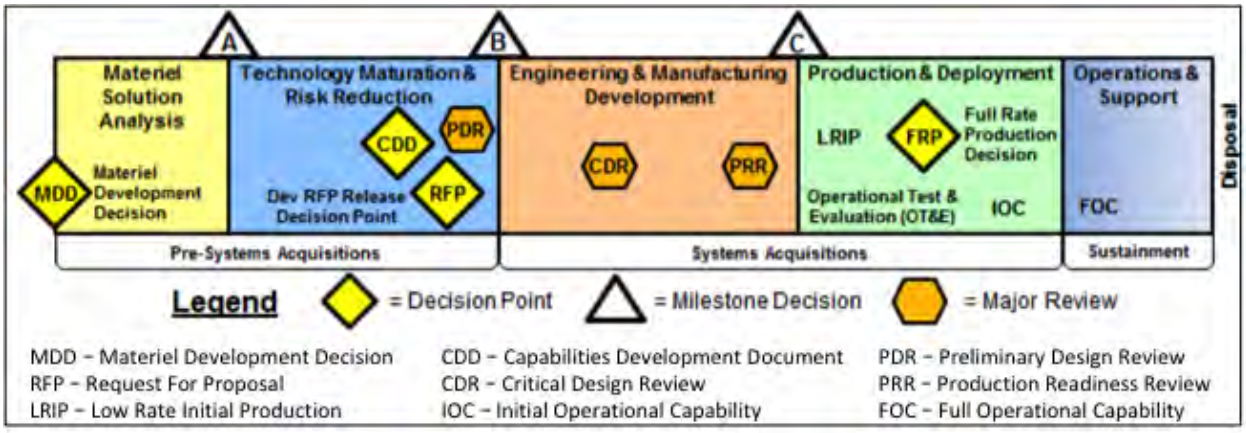
- The team identified two areas in which AFC appeared to be deficient in its ability to achieve its core competencies: systems engineering and additive manufacturing:

  – There don't appear to be enough systems engineers to meet the stated needs of AFC to build comprehensive development programs. Systems engineers are vital to complex problem solving since they view solutions as a whole and don't focus on specific details. The study team couldn't rule out the possibility that systems engineers are being undercounted within AFC and recommended that system engineers be identified throughout the command with steps taken to ensure that the personnel on hand match the requirement.

  – CCDC seems to be weak in its ability to use additive manufacturing as a tool to develop capabilities that can't be realized through other manufacturing techniques. The study recommends that additive manufacturing be designated a core competency of CCDC and that the ongoing research efforts at the Army Research Laboratory be augmented.

Army Acquisition Process The team found that, independent of AFC, the Army acquisition process needs to be fixed if AFC is to be successful in its task of developing future Army capabilities for the warfighter in a timely and efficient manner.

There are numerous phases and milestones for in the DoD acquisition process, along with key documents and reviews required to pass from one milestone to the next (Fig. E.2; section 5 provides additional details).



Source: acqnotes.com

Figure E.2 The DoD Acquisition Process

AFC has primary responsibility prior to the Materiel Development Decision (MDD) and is involved in the phases that follow. In analyzing the subsequent phases, the team found several changes that need to be made to the acquisition process in order to make it more efficient and effective (described in detail in Section 6).

Continuity of Leadership: The study recommends that an Integrated Product Team (IPT) be established to manage the acquisition process from cradle to grave. Continuity of leadership throughout the acquisition process leads to increased attention to user needs and a better understanding of program capabilities since key personnel from all phases are involved throughout the process. The IPT would be chaired by FCC up to and through MDD, then transitioned to a system concept manager from CCDC, and eventually to a board-selected PM from the acquisition community.

The Army has had previous success in high priority programs such as the Second Generation Forward Looking Infrared Radar (FLIR) Horizontal Technology Integration Program and Army Digitization through the formation and use of a Headquarters, Department of the Army (HQDA) Special Task Forces (STF). The STFs improved program effectiveness and efficiency through concurrent (i.e., with the prime contractor) development of all the analyses and documents required for MS B. The success of the task forces led to a recommendation that the SECARMY or CSA establish an STF.

Technology Maturity: Several studies by GAO[3] and academic institutions have reported that the likelihood of achieving major program success is increased by requiring greater technical maturity prior to the decision to enter Engineering and Manufacturing Development (EMD) at MS B and by requiring greater design maturity prior to the Critical Design Review (CDR). For example, in an MIT Sloan School report stated:

> A study of 62 US Department of Defense programs found that those programs which reached TRL 7 or higher by the start of system development at MS B finished practically on time and on budget, whereas those programs with technologies below a TRL 7 at MS B showed, on average, development cost growth of 32%, acquisition unit cost increase of 30%, and schedule delay of 20 months.[4]

From interviews with officials from 12 programs that used competitive prototyping, a 2017 GAO report found that using multiple system prototyping approaches was worth the investment, even though it did create additional administrative burdens.

[3] GAO, "Weapon Systems – Prototyping Has Benefited Acquisition Programs, but More Can Be Done to Support Innovation Initiatives," GAO-17-309, June 2017;
GAO, "Best Practices – Better Management of Technology Development Can Improve Weapon System Outcomes," GAO/NSIAD-99-162, July 1999; and
GAO, "Best Practices – Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes," GAO-02-701, July 2002.

[4] Alison Olechowski, Steven D. Eppinger, and Nitin Joglekar, "Technology Readiness Levels at 40: A Study of State-of-the-Art Use, Challenges and Opportunities," MIT Sloan School, 2015 Proceedings of PICMET'15, April 2015, https://web.mit.edu/eppinger/www/pdf/Eppinger_PICMET2015.pdf

Finally, a 2015 report found that if at least 90% of design drawings were releasable at the CDR (between MS B and C), cost growth and schedule slippage were less likely to occur during the EMD Phase.[5]

These considerations led the study to recommend that SECARMY adjust the acquisition process to require:

- Technology Readiness Level (TRL) 7 prior to MS B
- Multiple prototypes prior to MS B
- 90% Drawing Release prior to Critical Design Review (CDR)

Decker-Wagner: The study team reviewed the 2010 Army Acquisition Review, "Army Strong: Equipped, Trained and Ready," also known as the Decker-Wagner Report. In March 2013, the Army deemed 13 of the 76 recommendations from this study to be inconsistent with DoD and Army acquisition policy at that time, or otherwise redundant to ongoing institutional reform efforts, and therefore chose not to implement them.

The ASB team recommends that those 13 recommendations be reviewed again to determine if changes that have occurred since 2013 make it worthwhile to implement any of those recommendations now (further discussed in Section 7).

The point to reviewing the Decker-Wagner recommendations is to avoid schedule slippage, cost overruns, and performance shortfalls by encouraging cooperation and unity among AFC organizations. Implementing these recommendations will help AFC accomplish improved acquisition results and avoid the pitfalls leading to program cancellations.

Measures of Effectiveness

The study team recommended Measures of Effectiveness to monitor progress in implementing study recommendations (further detailed in Section 8):

- After 6 months, have CG AFC and SA directed implementation of the recommendations provided in this report?
- At the end of Year 1, have the recommendations assigned to CG AFC and/or to SA been implemented?

[5] Katz et al, "The Relationship of Technology and Design Maturity to DoD Weapon System Cost Change and Schedule Change During Engineering and Manufacturing Development," Systems Engineering Vol 18, No 1, 2015. https://onlinelibrary.wiley.com/doi/abs/10.1111/sys.21281.

- At the end of Year 2 and annually thereafter, have all programs continued to follow recommendations?

Based on history, if measures of effectiveness are not established and tracked, recommendations are unlikely to be implemented.

Complete texts of the study team's findings and recommendations are provided in Appendix A.

1. INTRODUCTION

The Secretary of the Army (SECARMY) established the U. S. Army Futures Command (AFC) on 1 July 2018 to lead the Army's future force modernization enterprise.[6]

In January 2019, SECARMY requested that the Army Science Board (ASB) conduct a study entitled "Army Futures Command," to develop recommendations for internal processes on how AFC should operate to achieve the outcomes described in the Department of the Army General Order 2018-10 (Establishment of United States Army Futures Command):

> AFC leads the Army's future force modernization enterprise. AFC assesses and integrates the future operational environment, emerging threats, and technologies to develop and deliver concepts, requirements, future force designs, and supports the delivery of modernization solutions.

Specifically, the study focused on establishing best practices within the command to ensure that AFC matures advanced systems concepts, technology, and materiel solutions into deployed systems based on the future threat and operational environment.

This report describes the conduct of the study and provides findings and recommendations regarding AFC. A comprehensive briefing on the study was presented and the findings and recommendations were approved by a vote of the members of the ASB in July 2019.

1.1 TERMS OF REFERENCE

The Terms of Reference (TOR) signed by SECARMY (Appendix B), specified five tasks for the study team:

- Recommend process and procedure changes deemed necessary to achieve AFC objectives. These changes may range from making semantic shifts, such as adopting business terms in favor of Government acquisition terms, to adopting commercial organizational structures that ensure integration across the command, to reinterpreting the Federal Acquisition Regulation more in line with other Services and DoD agencies.

- Recommend the incorporation of selected best practices from large commercial, public service, and other Government organizations that have demonstrated success either driving or surviving continuous, disruptive change.

- Assess the current implementation of recommendations from the following Army-commissioned reports:

[6] HQDA General Orders 2018-10: "Establishment of United States Army Futures Command," 4 June 2018, https://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/ARN11199_GO1810_FINAL.pdf

  - 2010 Army Acquisition Review, "Army Strong, Equipped, Trained and Ready" (Decker-Wagner Report)

  - ASB FY 2013 study titled "Army Science and Technology (S&T) Essential Core Competencies"

- Examine the relationships with industry required to ensure that the Army focuses on core competencies and leverages the best available outside talent to create a fast moving, innovative, and future-thinking organization.

- Recommend measures of effectiveness (MOE) that will clearly enable success and help to articulate that success in strategic communication. Metrics must be value based, output oriented, and geared toward describing what AFC, as an organization, does differently.

1.2 STUDY TEAM AND DATA GATHERING

The study team established to address these tasks (Appendix C) was comprised of former senior officers, senior government civilian, and industry leaders. Several team members have doctoral degrees with an average of over 20 years' experience working in defense policy and programs. ASB team members have significant technical expertise and experience in a wide range of disciplines, including:

- Directed energy systems
- Cyber
- C4ISR
- Intelligence
- Missile defense
- Artificial Intelligence
- Surveillance systems
- Weapons systems
- Aviation systems
- Operations Analysis
- Systems Engineering
- Physics
- Acquisition
- Defense Policy
- R&D Programs
- Technology Transition

To obtain the information required to address the specified tasks, members of the study team developed lines of inquiry and made numerous visits to AFC organizations as well as other Army and DoD organizations (Appendix D).

Significant information was found in various reports from the Army, the General Accountability Office (GAO), and academic organizations (bibliography provided in Appendix K).

2. AFC STATUS – ORGANIZATION AND PROCESSES

Beginning in September 2017, the acting SECARMY signed a series of directives focused on:

- Acquisition reform (Army Dir 2017-22)[7]
- Designation of six modernization priorities for the Army to include creation of Cross Functional Teams (CFT) to drive them (Army Dir 2017-24)[8]
- Establishment of a three-star task force to recommend a restructuring of the Army's modernization enterprise (Army 2017-33)[9]

These initiatives culminated in Army General Order (GO) 2018-10 signed by the SECARMY in June 2018 that established AFC on 1 July 2018 with Full Operating Capability (FOC) planned for 1 July 2019.[10]

In his January 2019 report to Congress, Secretary Esper delineated the responsibilities of AFC and ASA(ALT):[11]

> The Commanding General, AFC, leads and is responsible for the Army's future force modernization enterprise. As the Army's Chief Futures Modernization Investment Officer, the Commanding General, in consultation with the Assistant Secretary of the Army (Acquisition, Logistics and Technology) (ASA(ALT)), will prioritize, direct, integrate, and synchronize science and technology efforts, operations, and organizations across the Army's modernization enterprise.
>
> AFC assesses and integrates the future operational environment, emerging threats, and technologies to develop and deliver concepts, requirements, and future force designs, while also supporting the delivery of modernization solutions. AFC postures the Army for the future by setting strategic direction, integrating the Army's future force modernization enterprise, and aligning resources to priorities. The Commanding General, AFC is accountable to the Secretary of the Army and Chief of Staff of the Army for Army future force modernization and will coordinate with the ASA(ALT) on all matters pertaining to research, development, and acquisition.

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[7] Secretary of the Army, Army Directive 2017-22 (Implementation of Acquisition Reform Initiatives 1 and 2), 12 Sep 2017, https://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/ARN5858_AD2017-22_FinalWeb.pdf
[8] Secretary of the Army, Army Directive 2017-24 (Cross-Functional Team Pilot in Support of Materiel Development), 06 Oct 2017, https://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/ARN6101_AD2017-24_Web_Final.pdf
[9] Secretary of the Army, Army Directive 2017-33 (Enabling the Army Modernization Task Force), 7 Nov 2017, https://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/ARN6391_AD2017-33_Web_Final.pdf
[10] Army GO 2018-10, op cit, p1.
[11] Secretary of the Army, The Army Plan for the Establishment of U.S. Army Futures Command, Report to Congressional Committees, 1 Jan 2019.

> The ASA(ALT) is responsible for overseeing the acquisition, logistics, and technology matters of the Department of the Army. The ASA(ALT) is also the Army's chief scientist. As the Army Acquisition Executive, the ASA(ALT) is responsible for the management and control of the Army acquisition system.

The Army GO 2018-10 is more explicit and expansive:

> AFC leads the Army's future force modernization enterprise. AFC assesses and integrates the future operational environment, emerging threats, and technologies to develop and deliver concepts, requirements, future force designs, and supports the delivery of modernization solutions. AFC postures the Army for the future by setting strategic direction, integrating the Army's future force modernization enterprise, aligning resources to priorities, and maintaining accountability for modernization solutions.

Per the GO, the formation of AFC began officially in July 2018 and was executed in overlapping phases corresponding to the final organization as laid out in AFC OPORD 002-19:[12]

- Phase I: Establishment of the Headquarters and the Army Applications Lab in Austin, TX.

- Phase II: Establishment of Futures and Concepts Center (FCC) based on the assignment of the Army Capabilities Integration Center (ARCIC), the TRADOC Analysis Center (TRAC), the Capabilities Development and Integration Directorates (CDIDs) and Human Systems Integration to AFC.

- Phase III: Establishment of Combat Capabilities Development Command (CCDC) based on the assignment to AFC of the former Research, Development and Engineering Command (RDECOM) including the Army Research Lab and the Army Material System Analysis Activity.

- Phase IV: Establishment of the Combat Systems Directorate (CSD). This organization was essentially created out of whole cloth and the activities of this phase of the OPORD are focused on defining its relationships with the AFC HQ's Directorate of Systems Integration (DSI) and the ASA(ALT), Program Executive Offices (PEOs) and Program/ Project/Product Managers (PMs).

- Phase V: This phase is oriented on the enduring strategic role of AFC and is of indefinite duration.

[12] Army Futures Command, "Implementation OPORD," OPORD 002-19, 16 January 2019.

With regard to the relationship between AFC and ASA(ALT), Secretary Esper defined their responsibilities in the Jan 2019 report to Congress:[13]

> The Commanding General, AFC, leads and is responsible for the Army's future force modernization enterprise. As the Army's Chief Futures Modernization Investment Officer, the Commanding General, in consultation with the Assistant Secretary of the Army (Acquisition, Logistics and Technology) (ASA(ALT)), will prioritize, direct, integrate, and synchronize science and technology efforts, operations, and organizations across the Army's modernization enterprise. AFC assesses and integrates the future operational environment, emerging threats, and technologies to develop and deliver concepts, requirements, and future force designs, while also supporting the delivery of modernization solutions. AFC postures the Army for the future by setting strategic direction, integrating the Army's future force modernization enterprise, and aligning resources to priorities. The Commanding General, AFC is accountable to the Secretary of the Army and Chief of Staff of the Army for Army future force modernization and will coordinate with the ASA(ALT) on all matters pertaining to research, development, and acquisition.
>
> The ASA(ALT) is responsible for overseeing the acquisition, logistics, and technology matters of the Department of the Army. The ASA(ALT) is also the Army's chief scientist. As the Army Acquisition Executive, the ASA(ALT) is responsible for the management and control of the Army acquisition system. The Army Acquisition Executive is the milestone decision authority for major defense acquisition programs with the Chief of Staff of the Army's agreement. The Army Acquisition Executive, or designated program executive officer, is the milestone decision authority for non-major defense acquisition program-level programs. The Commanding General, AFC will coordinate with the ASA(ALT) on all matters pertaining to research, development, and acquisition.

2.1 AFC ORGANIZATION

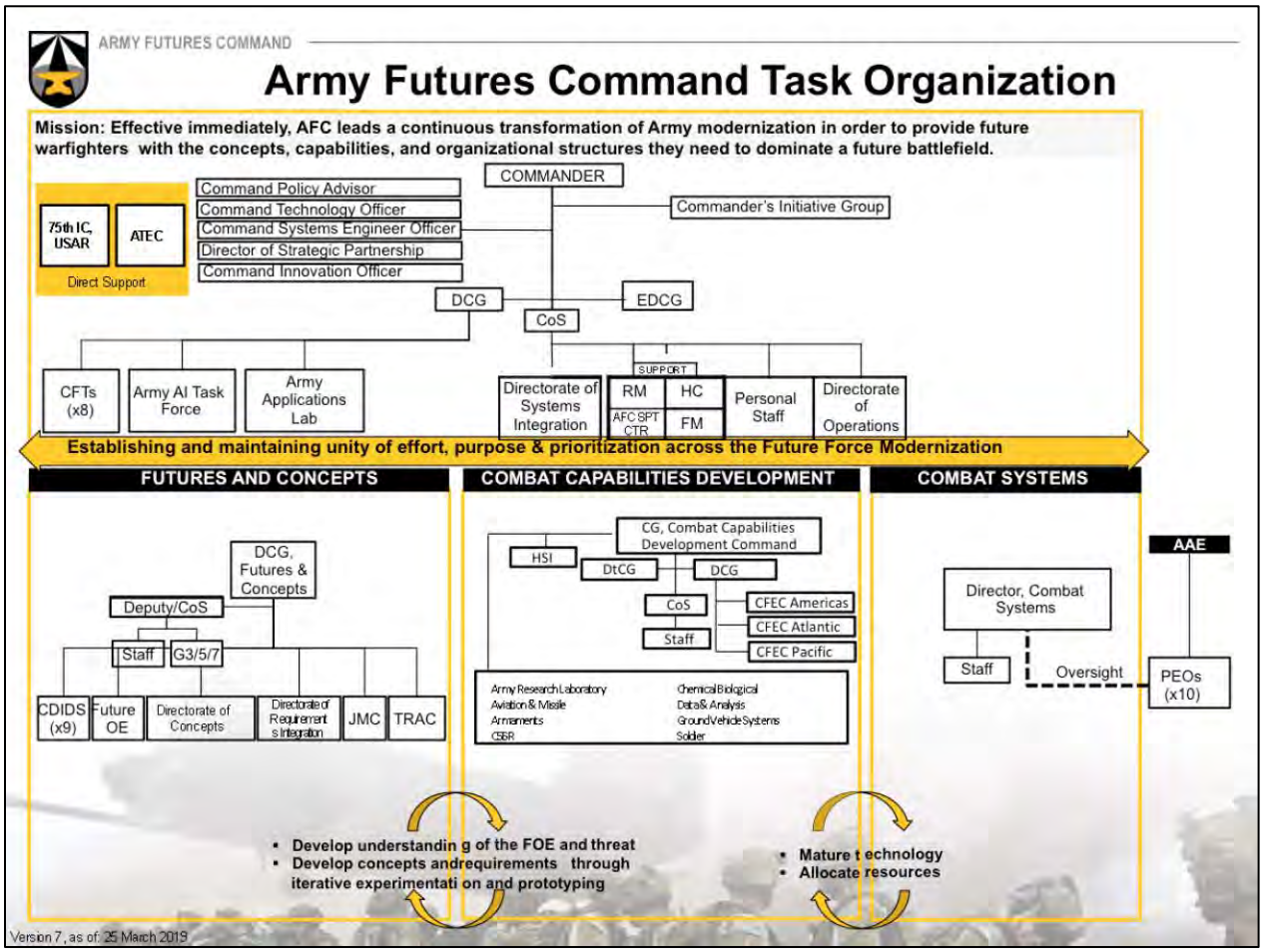
AFC is organized around a headquarters element and three main components in accordance with its charter to turn a strategic understanding of the future into fielded operational capabilities (Fig. 2.1).

- The **Headquarters** "sets strategic direction, orchestrates the Army's modernization enterprise, sets capability priorities, aligns resources to priorities and maintains accountability." Supporting the four-star commander, the HQ anticipates to grow to 500 (100 military and 400 civilian) personnel.[14] According to GAO analysis, about one third of

[13] Secretary of the Army, The Army Plan for the Establishment of U.S. Army Futures Command, Report to Congressional Committees, 1 Jan 2019.
[14] GAO, "Army Modernization: Army Should Take Steps to Reduce Risk", GAO-19-502T, May 2019, https://www.gao.gov/reports-testimonies/

the staff is involved directly in modernization efforts, including engineers and operations specialists, while two thirds execute support functions such as legal counsel and contracting.

- **Futures and Concepts Center (FCC)** assesses the threat and Future OE, develops future concepts and the Army Modernization Strategy, and determines requirements to drive new capabilities and formations. FCC is located in Fort Eustis, VA under the command of a three-star officer. FCC was formed by subsuming the ARCIC and the TRAC.



Source: US Army Combat Capabilities Development Command

Figure 2.1 AFC Organization Chart as of March 2019

- **Combat Capabilities Development Command (CCDC)** is headquartered in Aberdeen, MD with a workforce of 26,539 personnel including 166 military, 14,113 civilian employees and 12,260 contractor personnel under the command of a two-star officer. CCDC "conceptualizes, develops and transitions operationally relevant solutions and knowledge through research, engineering, testing and analysis."

- **Combat Systems Directorate (CSD)** located in Austin, TX under the command of a two-star officer, advises the AFC CG, especially pertaining to research, development,

acquisition, and contracting; ensures that PEOs and PMs prioritize Army modernization efforts and maximizes cooperation, urgency, and unity of effort.

2.2 AFC PROCESS

An internal AFC document, "Top-Down Futures Development Process" dated 3 June 2019 describes the emerging AFC process to identify, prioritize and develop required Army capabilities that clearly align with strategic guidance, addressing threats and conditions in the Future OE.

This is the most current and comprehensive description of how AFC works and was the basis for the Rehearsal of Concept (ROC) drill conducted in June 2019 that enabled the AFC HQ to assert Full Operational Capability in July 2019. As of the date of this report, however, the document has not yet been formally translated into an AFC order or directive.

The Top-Down process addresses Future Force Modernization Enterprise (FFME) activities leading to a Materiel Development Decision (MDD) or a decision to implement a DOTMLPF-P Change Request (DCR). This process involves multiple organizations internal and external to AFC. Prior to MDD, FCC has the dominant role and CCDC provides information on technology options. Following MDD, CCDC will take a larger role focused on capability development.

3. RECOMMENDATIONS TO IMPROVE AFC ORGANIZATION

3.1 BOARDS OF ADVISORS

AFC's success is premised on providing continuous inputs between rapidly developing commercial and government technology, the future needs of the Army, and the Army components who are involved in implementing the new technology and ideas.

Location of the HQ in the innovation hub of Austin, TX was specifically intended to provide this window. Additionally, several offices have been embedded within AFC Headquarters with an external focus, e.g., Command Technology Officer, Director of Strategic Partnerships, and the Army Applications Laboratory. However, best practices would indicate that the Commander would also benefit from scheduled meetings to provide input from various outside contributors and benefactors of the AFC output.

One or more high-level advisory boards comprised of people from external elements could provide the AFC commander early and relevant insights on technological and cultural developments and their potential impacts.

Finding #1 – Board of Advisors Industry best practices include establishing a Board of Advisors to help the CEO on strategic matters beyond routine governance.
Recommendation #1 – Board of Advisors SA establish a Future Force Modernization Enterprise Board of Advisors chaired by CG AFC that includes at a minimum: • COCOMs • ASA(ALT) • TRADOC • AMC • FORSCOM • External (to Army) Purpose is to conduct strategic discussions on future needs and operational requirements.

3.2 UNIFYING CULTURE

AFC is premised on realigning multiple existing organizations, combining them with some newer components, and unifying the entire enterprise under a single, focused command. The vast majority of AFC personnel have not changed locations. The command is now spread over more than 40 locations in the U.S. (Fig. 3.1) as well as international locations. Unifying the culture is an essential but difficult challenge that requires a focused effort by top management.

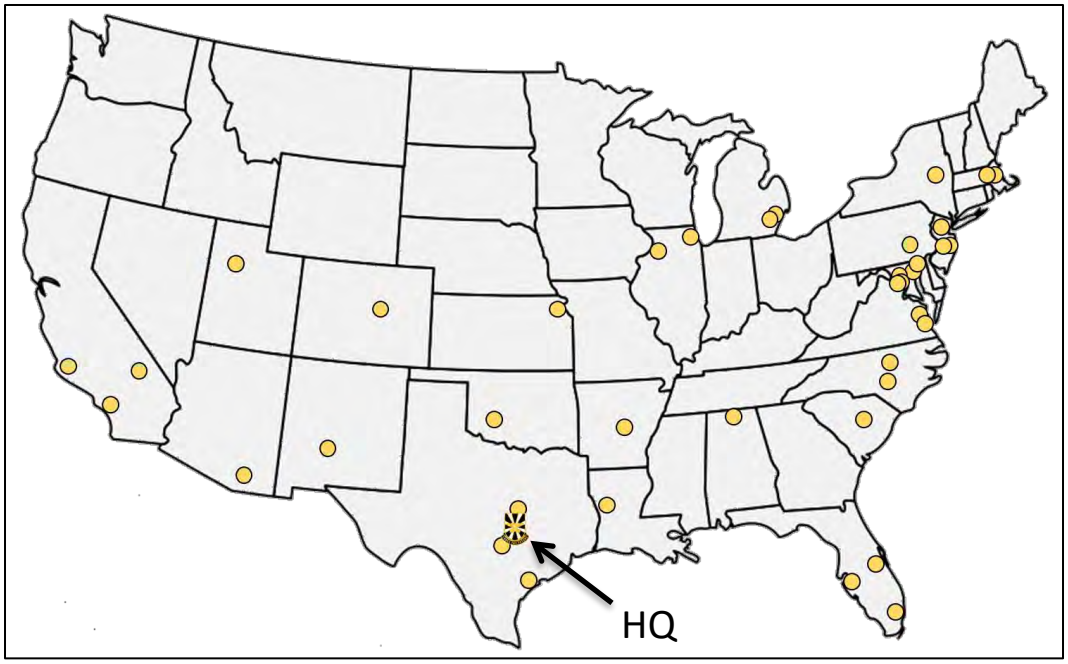


Figure 3.1 AFC Locations

On 7 December 2018, ARCIC was transitioned from TRADOC to AFC to become the FCC. On 3 February 2019 RDECOM transitioned from Army Materiel Command to AFC to become CCDC. Several other organizations have been transitioned to AFC (Fig. 3.2)

Prior Organization	Current Organization in AFC
Army Capabilities Integration Center (ARCIC) in TRADOC	Futures and Concepts Center (FCC)
Capability Development and Integration Directorates (CDIDs) and associated Battle Labs in TRADOC	Part of FCC
TRADOC Analysis Center (TRAC) in TRADOC	Part of FCC
Research, Development, and Engineering Command (RDECOM) in AMC	Combat Capabilities Development Command (CCDC)
Army Materiel Systems Analysis Activity (AMSAA) in RDECOM	CCDC Data & Analysis Center
Survivability Lethality Analysis Directorate (SLAD) in ARL	Part of CCDC Data & Analysis Center
Armament RDEC (ARDEC) in RDECOM	CCDC Armaments Center
Aviation and Missile RDEC (AMRDEC) in RDECOM	CCDC Aviation & Missile Center
Communications-Electronics RDEC (CERDEC) in RDECOM	CCDC C5ISR (Command, Control, Computers, Communications, Cyber, ISR) Center
Edgewood Chemical Biological Center (ECBC) in RDECOM	CCDC Chemical Biological Center
Natick Soldier RDEC (NSRDEC) in RDECOM	CCDC Soldier Center
Tank & Automotive RDEC (TARDEC) in RDECOM	CCDC Ground Vehicle Systems Center
Army Research Laboratory (ARL) in RDECOM	Army Research Laboratory in CCDC

Figure 3.2 Linkage of Previous Organizations to AFC Organizations

Effective communication from headquarters to the staff is essential to keep employees informed and engaged. Communications must be consistent and timely. An initial

communication from AFC HQ, "Thoughts and Guidance Memo #1," dated 15 January 2019, did not reach some employees for over eight weeks. While the memo emphasized communication and feedback, its delivery fell short.

There have been many who have proposed techniques for integrating organizations vertically and horizontally. One of the best was Edward Deming, a pioneer in establishing techniques for creating organizations that while large, behaved like smaller enterprises where employees worked together to maximize output. Deming's techniques created organization structures that were vertically and horizontally integrated, allowing the organization to operate very effectively (see Appendix H).

The study team identified these challenges and suggested that industry best practices offer potential solutions to these challenges.

Finding #2 – Unifying Culture

- Geography challenges inhibit making AFC a single unified organization.
  - AFC dispersed over 40 locations
  - Messages from headquarters are not reaching lower level staff in a timely manner
- What AFC is trying to accomplish organizationally is done by private industry on a regular basis.
- Industry best practices include:
  - Establish a culture where employees feel empowered and involved in the transformation
  - Foster relationships across sub-organizations to promote an inclusive culture

3.2.1 EMPOWERING EMPLOYEES – VERTICAL INTEGRATION

The most effective organizations are those where employees from the very bottom of the organization to the very top all feel that they are important and that their inputs are valued. At Ford Motor Company, Deming created an organization where people on the production line believed that the very top of the organization listened and valued their inputs. For example, messages from the very top reached them within hours. In addition, Ford created a system where ideas from the line level on how to create better quality automobiles at less cost could reach the top leadership quickly and would be addressed.

AFC needs to create a similar communication system that assures that messages from the top of the organization reach all employees the same day. Given that all employees are connected via email, there should not be a problem doing this.

One of the catch phases used by the warfighting part of the Army is that the people who really know what is needed are those at the "pointy end of the spear." The same is true for that part of the Army developing and building new capabilities. They are the ones who recognize challenges to meeting goals and/or identifying what can be done more effectively and

efficiently. Typically, the elements of the Army involved in the development process have no easy way to bring their knowledge to those who can effect changes. AFC needs to transform that dynamic by creating a system that mirrors the top-down message system for people at the bottom of the organization. Anyone with ideas on what needs to be changed should be able to reach those who can make the change.

The following recommendations implement vertical integration solutions:

Recommendation #2A – Unifying Culture (Empowering Employees) CG AFC establish a communication strategy to create shared expectations and report related progress. Communications from CG AFC to staff should reach everyone, including lower level staff, the same day. • Ensure consistency of message • Encourage two-way communication • Provide information to meet specific needs of employees
Recommendation #2B – Unifying Culture (Empowering Employees) CG AFC establish a process to involve all employees to obtain their ideas and gain their ownership for the transformation. Establish an email suggestion box where anyone who has an idea to make the Army better can send it directly to CG AFC special email. • Involve employees in planning and sharing performance information • Incorporate employee feedback into new policies and procedures

3.2.2 ORGANIZATIONAL NETWORKING AND BROADENING – HORIZONTAL INTEGRATION

AFC is very large, scattered across the U.S., and comprised of people coming from different organizations. As they're now part of the same organization with a larger footprint and new objectives, success will require a horizontal integration that allows employees in various parts to understand each other's roles and to reach out to tap each other's capabilities.

While organizational charts show hierarchies and reporting relationships, actual workflow rarely follows the org chart. Instead, people operate through networks: informal webs of relationships that people instinctively form in the workplace.[15] Such networks enable employees to improve processes, solve problems, and complete work.

Developmental assignments can be used to help employees establish informal networks with other AFC employees in different parts of the organization. Developmental assignments enable employees to engage in tasks outside their current job assignment but within their functional area. While a developmental assignment doesn't come with a promotion, the increased skills, knowledge, and experience are good for career advancement. Both the employee and the organization benefit from the developmental assignment program. Employees gain new skills

[15] Maya Townsend, "New Leadership Tools: Finding Direction Through Network Maps: Mini Case #1," Partnering Resources, May 2017, https://partneringresources.com/leadership-tools-network-maps-mini-case-1/

and experiences and organizations benefit because employees return with increased knowledge and capabilities.[16]

The following recommendations promote horizontal integration in AFC using developmental assignment both internal to AFC and with other organizations outside AFC:

Recommendation #2C – Unifying Culture (Networking and Broadening) CG AFC establish developmental assignments in which technical people who are interested in learning about other technologies can be integrated at another organization **inside AFC** for long enough (9 months?) to establish social and technical networks and better understand and appreciate new opportunities. Ensure that the Individual Development Plans for these employees include post-assignment positions utilizing this experience.
Recommendation #2D – Unifying Culture (Networking and Broadening) CG AFC establish **external** developmental assignments in other organizations such as other Army, DoD, US Government, FFRDCs, SETAs, academia, industry non-profits, and, if possible, for-profit industry. Ensure that the Individual Development Plans for these employees include post-assignment positions utilizing this experience. • Use of the Intergovernmental Personnel Act (IPA) is a potential vehicle • The Army Research Laboratory (ARL) open campus currently has 700 researchers from academia and industry – Cooperative R&D Agreement (CRADA) is most common vehicle but IPA also possible

[16] Ed Worley, "Developmental assignments help grow workforce skills," Aug 2016, https://www.army.mil/article/172832/developmental_assignments_help_grow_workforce_skills

4. CORE COMPETENCIES

The core competencies methodology was pioneered by Prahalad and Hamel in their seminal paper published in the Harvard Business Review[17] and subsequently expanded and updated in several books. Several American corporations have employed the methodology, and the FY 13 ASB Study "Army S&T Core Competencies" applied the model to the Army. The FY 13 study team recognized that modifications would need to be made to fit an Army application, so to maintain fidelity with the original research, the team consulted with Professor Hamel about those modifications. Out of that, the team developed a working definition of core competency:

> An Army S&T core competence is an integrated set of skills, processes and capabilities (e.g., facilities, tools) for which Army S&T is uniquely qualified, and that is essential for identifying, developing and transitioning key technologies into end products for the operational Army, such that the products:
> - Satisfy important current and future operational needs (Customer Value),
> - Are superior to adversary capabilities (Competitor Differentiation), and
> - Provide the basis for leap-ahead capabilities (Extendibility)

4.1 IDENTIFYING CORE COMPETENCIES

The FY 19 study team received a briefing from CCDC leadership and discussed their implementation of the core competencies model. The CCDC team briefed all their personnel and funding were allocated to core competencies. However, they didn't provide the definition used to determine whether and how an effort was a core competency. The list of core competencies more resembled a work break down structure. Along with the 6+2 Army Modernization Objectives, core competencies should serve as the basis to determine future funding, talent management, and infrastructure priorities.

As defined by Prahalad and Hamel, "…a strategic architecture is a roadmap of the future that identifies which core competencies to build and their constituent technologies." It's inherently cross-cutting, as it represents the competencies of the entire corporation (or in this case, the entire command) and not any individual organizational line (such as CCDC). It's important that strategic architecture development be driven visibly from the top to underscore ownership. Organizational lines must be held accountable for not only helping to develop the architecture, but for their stewardship of the core competencies and constituent technologies identified therein.

The study team believes that a strategic architecture would establish objectives for AFC to better define and build its competencies. Resources must be identified and allocated in a manner transparent to the entire organization. This helps to ensure a consistent, principle-based approach for moving the organization forward while mitigating any lingering ambiguity

[17] C. K. Prahalad and Gary Hamel, "The Core Competence of the Corporation," Harvard Business Review, May-June 1990, http://hbr.org/1990/05/the-core-competence-of-the-corporation/ar/1

over corporate goals. It also serves to inform industry, Army senior leadership, and the Planning, Programming, Budgeting, and Execution System (PPBES) as to what S&T investments should be prioritized. S&T investments in core competency areas should not be limited to only near- and midterm programs.

Thus, when the Program Objective memorandum (POM) is built for 6.1-6.3 funding, the investment strategy will address more than funding the current highest priority 6+2 Army Modernization Objectives captured by the CFTs. There needs to be funding for core competencies to capture cutting edge innovation and disruptive technologies for an enduring superiority over future threats. Total S&T funding should include funding critical to the CFTs, but also core competencies, Special Interest Items (Army, OSD, White House and Congressional), responsible stewardship of the Center and Laboratory system (i.e., ensuring the Army acts as a smart buyer), international cooperation, university research, etc. The rest of the S&T total obligation authority (TOA) are other priorities to be addressed after the other categories are satisfied.

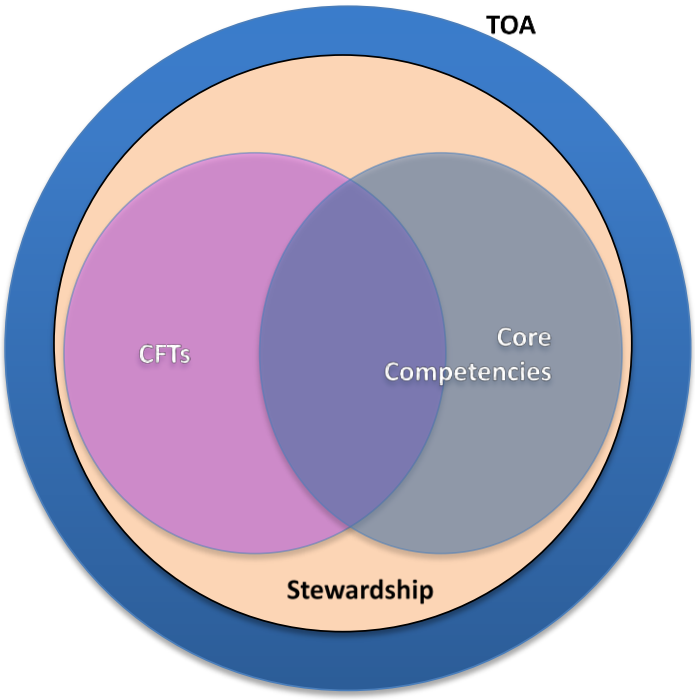


Figure 4.1 Core Competencies' Role in Portfolio

A technology personnel gap analysis as described in the FY 13 ASB study would ensure that the Army retains and grows the personnel necessary to support the chosen technical core competencies.

To address the need for focus on core competencies, the study team made the following finding and recommendation:

Finding #3A – Identifying Core Competencies The identification of core competencies in industry must be a top-down process requiring approval by the CEO.
Recommendation #3A – Identifying Core Competencies CG AFC establish the core competencies within AFC in a top-down process with a feedback loop and approved by CG.

4.2 SYSTEMS ENGINEER CORE COMPETENCIES

Systems Engineers develop, analyze and manage systems/sub-systems, concepts, architectures, interfaces and top-level designs as well as the overall requirements. This is a critical job for both present Army platforms and future systems the Army will need to develop for MDO. The Systems Engineering team will need to manage complexity and risks to ensure that the MDO systems will perform as intended in the operational environment.

Systems Engineering has become a specialized discipline supported by university-level courses and degrees as well as by professional associations such as the International Council on Systems Engineering (INCOSE). The organizations support training, symposia on new tools/ techniques, and networking for Systems Engineers in the international community.

AFC recruits and hires civilian employees and tracks civilian positions by Office of Personnel Management (OPM) General Schedule and Position Classification Standards.[18] The governing statute establishes the principle of providing equal pay for substantially equal work and states that standards issued by OPM shall define the various classes of positions in terms of duties, responsibilities, and qualification requirements. These General Schedule Position Classification Standards are commonly referred to as occupational series.

The term Systems Engineer is not recognized by OPM even though they currently list 29 distinct series code/position titles under the 0800 Engineering and Architecture Group.[19] One reason for this discrepancy could be that there is no single definition for systems engineering, although the Defense Acquisition Guidebook[20] offers the following:

> Systems engineering (SE) is a methodical and disciplined approach for the specification, design, development, realization, technical management, operations and retirement of a system. A system is an aggregation of system elements and

[18] As established by the Classification Act of 1949, which has been codified in chapter 51 of title 5, United States Code (USC). See Office of Personnel Management, "Introduction to the Position Classification Standard," August 2009, https://www.opm.gov/policy-data-oversight/classification-qualifications/classifying-general-schedule-positions/positionclassificationintro.pdf .

[19] Office of Personnel Management, "Handbook of Occupational Groups and Families," December 2018, https://www.opm.gov/policy-data-oversight/classification-qualifications/classifying-general-schedule-positions/occupationalhandbook.pdf

[20] Defense Acquisition University, *Defense Acquisition Guidebook, Chapter 3 Systems Engineering*, September 2017, https://www.dau.edu/tools/dag

> enabling system elements to achieve a given purpose or provide a needed capability. The enabling system elements provide the means for delivering a capability into service, keeping it in service or ending its service, and may include those processes or products necessary for developing, producing, testing, deploying and sustaining the system.

Using this definition, the Defense Acquisition Guidebook further defines a Systems Engineer as:

> [T]he Program Lead Systems Engineer, the Chief Engineer or Lead Engineer with SE responsibility and the SE staff responsible for SE processes and who plan, conduct and/or manage SE activities in the program.

Without an OPM recognized systems engineering standard and occupational series, AFC may not be able to recruit, hire, and maintain the systems engineering talent necessary to meet its objectives.

The number of Systems Engineers in CCDC seems small compared to the Army's needs. The study team noted that CCDC currently lists only 80 Systems Engineers within the Command, 70 of whom are in the CCDC Armaments Center. The tea, surmises that this discrepancy is due to variances in reporting of workforce talent demographics due to a lack of an OPM standard for systems engineering, which makes aggregate analysis and reporting difficult and less informative.

Government SEs have been listed as a crucial resource to develop and manage capabilities from requirements to development, and more are needed.

Finding #3B – Systems Engineering Core Competencies The number of Systems Engineers (SE) in CCDC seems small compared to the Army's needs. We note that CCDC currently lists only 80 SE within the Command, 70 of whom are in the CCDC Armaments Center. Government SE have been listed as a crucial resource to develop and manage capabilities from requirements to development, and more are needed than what has been listed above. • Office of Personnel Management (OPM) does not have a "Systems Engineer" occupational series
Recommendations #3B – Systems Engineering Core Competencies • SA request OPM recognize Systems Engineers. • CG AFC verify that Systems Engineers are being coded and counted properly. • CG AFC direct hiring more system engineers to fulfill development needs.

4.3 ADDITIVE MANUFACTURING CORE COMPETENCIES

The development by Bell Laboratories of the transistor to replace the vacuum tube was enabled by being able to grow materials that performed the function of the vacuum tube at scales 1000 times smaller. This in turn greatly reduced the size of the circuit switching facilities. The

transistors were connected to other circuit elements such as capacitors and inductors using a circuit board that contained the necessary wiring. The reduction in size allowed processing capability in new environments such as strategic missiles where the new capability increased accuracy.

But the launch vibrations of the missiles were so great that the interconnections of the transistors and other circuit elements on the circuit board would break thereby making the missile incapable of performing its assigned mission. The solution to this problem was the Integrated Circuit where all the components on the printed circuit board were imbedded in a single solid structure and were connected by metal internal lines. This was the beginning of additive manufacturing (AM) and it created the semiconductor industry we have today with capabilities that would not exist otherwise. Over time, the ability to create a substrate atom by atom has led to using metal that can be embedded in structures to remove heat at efficiency levels not available otherwise.

The AM printer traces back to 1986 when Chuck Hull was awarded a patent and the first real physical part was printed from a computer-generated file. The first AM printer using powders appeared in 1992 using a laser to break down the powder. In the 2000s, biological structures were produced using AM printing and a human bladder was created at the Wake Forest Institute for Regenerative Medicine.[21]

Today, AM printing is becoming commonplace. The cost of printers has decreased while their accuracy has improved. Machines are user friendly, making it easier to design 3D models. This has allowed physical structures for boosters, missiles, and fuel air mixing to be created.

In reviewing the Core Competencies' of CCDC, the study team found that while ARL had listed AM as a foundational effort in materials, there was no indication that AM was being investigated as a method to develop new capabilities elsewhere in CCDC. This may be due, in part, to the expense of required AM equipment. However, the potential impact of AM on Army capability is so large that investments in creating the capability need to be explored. The following finding and recommendation address AM as an Army core competency:

Finding #3C – Additive Manufacturing Core Competencies While additive manufacturing is listed as a foundational research competency area at ARL, this technique does not appear to be used as a tool in other areas of CCDC. It seems to us that additive manufacturing should be an overall core competency since it can be used to develop capabilities that cannot be created any other way. For example, propulsion system designs can be envisioned that cannot be realized without additive manufacturing.
Recommendation #3C – Additive Manufacturing Core Competencies CG AFC make additive manufacturing a CCDC core competency.

[21] Joseph Flynt, "A Detailed History of 3D Printing," 3D Insider, https://3dinsider.com/3d-printing-history/ accessed Aug 2019.

5. THE ACQUISITION PROCESS

The Army Acquisition Executive (AAE) is the single official within the Army responsible for all acquisition functions within the Army. As designated by the Secretary of the Army, ASA(ALT) currently serves as the AAE.[22] For each Army-managed acquisition program, the AAE designates a Milestone Decision Authority (MDA), usually him/herself for major programs (see Appendix E for a detailed description of the Army acquisition process).

It's important to note the acquisition process does not follow a rigid, one-size-fits-all methodology. Acquisition programs and procedures are tailored to the characteristics of the product being acquired and to the totality of circumstances associated with the program, including operational urgency and risk factors.

5.1 PRIOR TO MATERIAL DEVELOPMENT DECISION (MDD)

Acquisition begins with a requirement for an item or capability the warfighter needs, such as a weapon or other piece of equipment.

Army planners assess current and future threats and operating environments (OE) as well as strategic documents such as the National Security Strategy, the National Defense Strategy, and the Army Vision to forecast capabilities the Army will require and to determine if capability gaps exist.

When a capability gap is identified, the Army analyzes whether it can be addressed by Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities, or Policy (DOTMLPF-P) changes. If possible, the capability shortfall is resolved via what is known as a "non-materiel solution," such as revisions to doctrine or policy updates.

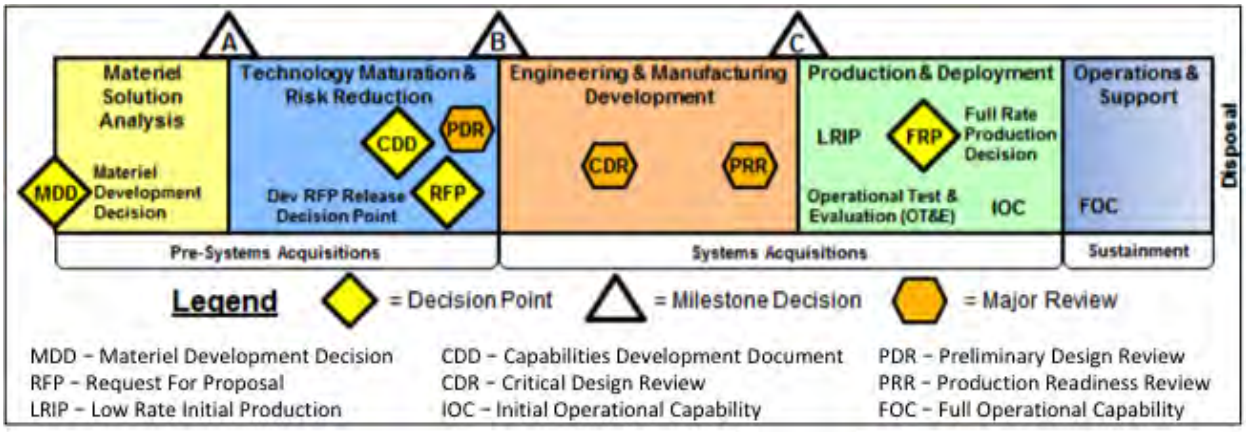
If Army planners determine that a materiel development item is required, a Materiel Development Decision (MDD) is made by the MDA and the Army begins the acquisition process to procure the item or system. This may involve purchasing off-the-shelf goods or the development of something new.

An Initial Capabilities Document (ICD) is created by developers to help support the MDA's MDD decision. The ICD provides justification for the requirement by stating the specific capability gaps that exist and recommending potential materiel solutions to resolve them. The ICD serves as the basis for the Materiel Solution Analysis (MSA) Phase that follows the MDD.

5.2 MDD THROUGH MS B

The next phases of the acquisition process contain several milestones (Fig. 5.1).

[22] Headquarters Department of the Army, Army Regulation 70-1 – Army Acquisition Policy, 16 June 2017, http://www.dami.army.pentagon.mil/site/ARTPC/docs/ar70_1.pdf



Source: acqnotes.com

Figure 5.1 The Acquisition Process

Key documents and reviews are required to pass from one benchmark to the next. The major decision points and phases from MDD to MS B include:

- Materiel Development Decision (MDD) is a point in time when analysis has identified a capability gap/need and the MDD Review has determined that a materiel solution is needed. The Analysis of Alternatives (AoA) that follows MDD is expected to identify a preferred materiel solution.

- Materiel Solution Analysis (MSA) Phase between MDD and MS A assesses potential solutions for a needed capability. The main task is to conduct an AoA to evaluate the mission effectiveness, operational suitability, and estimated Life-Cycle Cost of alternative solutions. The AoA identifies a preferred material solution which may have several technology alternatives to be assessed if it's not clear which is best.

- MS A is an MDA-led review at the end of the MSA Phase, when the AoA has been completed. The MDA approves a materiel solution and recommends or seeks approval to enter the Technology Maturation & Risk Reduction (TMRR) Phase.

- The TMRR Phase between MS A and B develops and demonstrates prototype designs to reduce technical risk, validate designs, validate cost estimates, evaluate manufacturing processes, and refine requirements. Critical technologies are demonstrated in competitive prototyping activities.

- MS B is an MDA-led review at the end of the TMRR Phase. Its purpose is to make a recommendation or seek approval to enter the Engineering when the AoA has been completed and Manufacturing Development (EMD) Phase.

A project exits the TMRR Phase only when the technology has been demonstrated in a relevant environment and manufacturing risks have been identified. Current DoD policy requires a

system to achieve a minimum of Technological Readiness Level 6 (TRL 6) in the TMRR Phase, which means a system/subsystem model or prototype demonstration in a relevant environment has occurred, such as a high-fidelity laboratory environment or in a simulated operational environment. There are several points of alignment between acquisition phases and milestones, TRLs, and Budget Activities (BA) (Fig. 5.2; see Appendix F for TRL and BA).

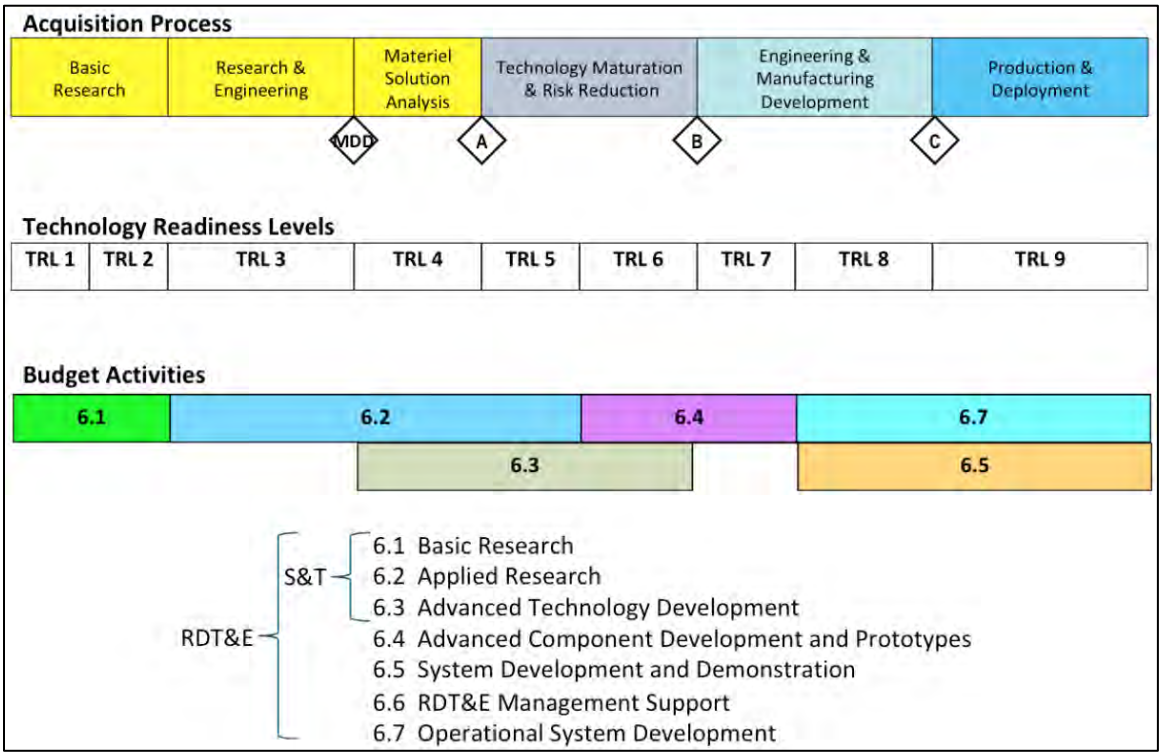


Figure 5.2 Milestones (Current DoD Policy)

The MDA will authorize the release of the Draft RFP following the Preliminary Design Review. This is considered the most critical decision point in the acquisition process because it allows for the release of RFPs to industry to begin development or start Low-Rate Initial Production (LRIP).

Only then can a program pass MS B and enter the Engineering and Manufacturing Development (EMD) Phase, which is where the product is built. Prior to or at MS B, a PM will also be assigned to carry the project forward.

5.3 FOLLOWING MS B

The purpose of the EMD Phase is to verify that all operational and derived performance requirements have been met and to complete the development of a system or increment of capability, complete full system integration, develop affordable and executable manufacturing processes, complete system fabrication, and test and evaluate the system.

The EMD Phase consists of multiple design iterations and reviews to converge on a final design for production. This process culminates in a Critical Design Review (CDR) which provides an opportunity for assessment of design maturity based on program-related measures, such as adequate developmental testing, various logistic analyses, and establishment of system reliability based on demonstrated reliability rates, to name just a few. During this phase the PM will also finalize designs of the product support elements.

The EMD Phase ends when the following conditions have been met:

1) The design is stable and is no longer being modified

2) The system meets validated capability requirements demonstrated by developmental and initial operational testing

3) Manufacturing processes have been effectively demonstrated and are under control

4) Industrial production capabilities are reasonably available

5) System has met or exceeded all directed EMD Phase Exit criteria and MS C Entrance Criteria.

MS C is the decision point where a program is reviewed to determine if it can exit the EMD Phase and commence the Production and Deployment (PD) Phase.

The PD Phase permits full rate production, though Low Rate Initial Production (LRIP) may be required by the MDA. MS C also allows for limited deployment of Major Automated Information Systems (MAIS) or software intensive systems with no production components.

The purpose of the PD phase is to produce and deliver products that are requirement-compliant and will fill the identified capability gap. During this phase, the product is fielded and used by operational units and all system sustainment and support activities are initiated if they haven’t already commenced.

During the PD Phase, the product must reach Initial Operational Capacity (IOC). IOC is considered the first attainment by a unit of the capability the item is supposed to provide. It requires that the unit and support personnel have been trained to operate and maintain the item or system in an operational environment, and certification that the unit can be supported in an operational environment, as needed. The designation usually occurs after full-rate production and implies the unit is combat ready.

Once FRP has commenced and an IOC has been achieved, a program moves into the Operations and Support (O&S) Phase. This phase has two major efforts: life cycle sustainment and disposal.

During O&S the PM must measure, assess, and report on system readiness using sustainment metrics, and implement corrective actions for trends diverging from required performance outcomes.

At some point during the O&S phase, Full Operational Capability (FOC) must be reached. This is defined as when all units and/or organizations in the force structure scheduled to receive a system have received it and can employ and maintain it.

Once the capability is no longer needed or a system has reached the end of its useful life, the Disposal phase begins, governed by legal and regulatory requirements regarding security, safety, and the environment. The Army acquisition process officially ends upon proper disposal of the item.

6. ACQUISITION PROCESS RECOMMENDATIONS

The following set of recommendations addresses process changes after MDD that will improve the probability of success for AFC development programs by minimizing schedule slippage, cost overruns, and performance shortfalls.

6.1 CONTINUITY OF LEADERSHIP THROUGHOUT ACQUISITION PROCESS BEFORE MDD THROUGH MS B

During the visits, interviews and document reviews conducted by the ASB Study Team, there was no indication of sufficient process change or continuity of leadership across the acquisition process to solve the historical causes of acquisition cost growths, schedule slippages, and performance shortfalls. It was also not clear who would formulate and champion innovative and disruptive technology-based systems concepts and lead that project effort to the point where it is transitioned to a board-selected PM by MS B.

It remains unclear who is responsible/accountable, with the requisite authorities, for leading the development of the multitude of synchronized critical work products required between MDD and MS B. These work products include the AoA, acquisition program baseline, acquisition strategy, competition, technology development plan, core logistics/repair analysis, system threat analysis, manpower/personnel, independent cost analysis, data management strategy, test & evaluation master plan, etc.

In short, the Army lacks continuity of leadership from MDD to MS B.

This study team recommends the Army follow industry best practices that keep the product team together throughout the development process for important programs. For AFC, continuity of leadership throughout development will lead to better understanding of program capabilities in late phases and increased attention to user needs in early phases because personnel from all phases would be involved throughout the process. Therefore, once the decision (MDD) is made to begin the Materiel Solutions and Analysis Phase, the IPT should persist and the lead should transfer from the FCC to the system concept manager residing in CCDC. When a board-certified PM is appointed prior to MS B, the PM assumes leadership of the IPT.

Alignment of incentives and organizations, unity of effort and internal/external strategic communications will suffer if this lack of continuity of leadership between MDD and MS B remains unresolved by the Army leadership.

Finding #4A – Continuity of Leadership Industry best practice for developing a new product is to establish a persistent team that involves personnel from all steps in the process with appropriate team members taking the lead as progress is made.

Recommendation #4A – Continuity of Leadership

SA establish a process in which:

- An Integrated Product Team (IPT), led by Futures and Concepts Center (FCC) through Materiel Development Decision (MDD), will be formed after high priority opportunities/challenges/issues are identified. IPT membership shall include experts in analysis of operational and system requirements, technology readiness, costing, acquisition, and budget and personnel availability, who have the authority to commit their organizations for this purpose and to communicate freely with all IPT members.
- At MDD, a Combat Capabilities Development Command (CCDC) system concept manager will be assigned by CG AFC to lead the IPT for each prioritized challenge/opportunity/issue that requires a materiel solution. This person must be a systems engineer who is acquisition certified.
- After a Board-selected Program/Project/Product Manager (PM) is appointed by MS B by the Army Acquisition Executive, program lead will transition from AFC to Army Acquisition. The current system concept manager could become the PM if he/she becomes Board-selected.
  - To avoid conflicts of interest, care should be taken to avoid having the same PM currently managing other ongoing similar systems.

6.2 HQDA SPECIAL TASK FORCE

In the past, major high priority programs included a Headquarters Department of the Army (HQDA) Special Task Force (STF).[23] It was found that establishing an STF:

- Collapses the time and expense to concurrently develop all the required analyses and consistent/coherent documents required for MS B (including EMD RFP preparation),
- Fosters warfighter buy-in for the program, and
- Sets the conditions for minimal schedule and cost overruns.

Examples of successful major acquisition programs that had an STF include the Second Generation FLIR Horizontal Technology Integration Program[24] and Army Digitization.[25] Given

[23] TRADOC Regulation 381-1, Threat Management, 19 April 1993, https://adminpubs.tradoc.army.mil/regulations/TR381-1.doc , para 4-2.b, and Army Regulation 381-11, Intelligence Support to Capability Development, 30 Jan 2019, https://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/ARN11575_AR_381-11_FINAL.pdf , para 2-1.a.

[24] Karl Scott Flynn, "Analysis of the Army's Horizontal Technology Integration Policy: A Case Study of the Second Generation Forward-Looking Infrared Program," March 1995, Naval Postgraduate School thesis, DTIC ADA294620, and Jerry A. White and George T. Singley III, "Horizontal Technology Integration: A New Way of Doing Business," Army Magazine, August 1994, pages 29-30.

[25] Susan J. Wright, "History of the Army Digitization Office," IDA Paper P-3521, July 2000, https://apps.dtic.mil/dtic/tr/fulltext/u2/a384101.pdf

the proven effectiveness and efficiencies of an STF, the Army should require an STF for new ACAT I and ACAT II programs (see Appendix F).

Finding #4B – DA Special Task Force • Industry best practice for ensuring a key very important project is brought to completion is to establish a special team to oversee the process and develop plans for successful development. • SA has authority to establish a Special Task Force to do the same.[26] • DoD examples of successful special task forces include Second Generation FLIR Horizontal Technology Integration and Army Digitization.
Recommendation #4B – DA Special Task Force SA/CSA establish, for ACAT I and II, Special Task Forces to produce required Milestone B decision documents (e.g.): • Modernization plan (resource constrained) • Test and Evaluation Master Plan • Integrated Logistics Support Plan • Requirements documents • Baseline cost estimate • Draft acquisition strategy and acquisition plan • Draft Request for Proposals

6.3 TECHNOLOGY MATURATION

The TMRR phase is a key element of the acquisition process, as it is meant to reduce technology risks associated with the integrated system under development. Currently, TMRR aligns with achieving TRL 5 and TRL 6 (Fig. 6.1) between MS A and B.

TRL	Definition	Description
5	Component and/or breadboard validation in a relevant environment.	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so they can be tested in a simulated environment. Examples include “high-fidelity” laboratory integration of components.
6	System/subsystem model or prototype demonstration in a relevant environment.	Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in a technology’s demonstrated readiness. Examples include testing a prototype in a high-fidelity laboratory environment or in a simulated operational environment.
7	System prototype demonstration in an operational environment.	Prototype near or at planned operational system. Represents a major step up from TRL 6 by requiring demonstration of an actual system prototype in an operational environment (e.g., in an aircraft, in a vehicle, or in space).

Figure 6.1 Definitions of TRLs 5, 6, and 7

[26] TRADOC Regulation 381-1, op. cit.

6.3.1 TRL 7 BEFORE MS B

Two key studies have analyzed data from DoD Programs related to the TRL levels achieved between MS A and MS B. The 1999 GAO study[27] and the 2015 MIT Sloan study[28] both found that achieving TRL 7 before MS B vice after greatly enhanced program success. For example, the authors of the Sloan report stated a study of 62 U.S. DoD programs found that those programs reaching TRL 7 or higher by the start of system development finished practically on time and on budget, whereas those programs with technologies below a TRL 7 showed, on average, development cost growth of 32%, acquisition unit cost increase of 30%, and schedule delay of 20 months.

The critical difference achieved at TRL 7 is that the system prototype, including system and subsystem interfaces, is integrated and demonstrated in a realistic operational environment.

The 1999 GAO report described conditions conducive to achieving technical maturity:

> The experiences of DOD and commercial technology development cases GAO reviewed indicate that demonstrating a high level of maturity before new technologies are incorporated into product development programs puts those programs in a better position to succeed… Two conditions were critical to closing the maturity gap. First, the right environment for maturing technologies existed. Key to this environment was making a science and technology organization, rather than the program or product development manager, responsible for maturing technologies to a high TRL. When a maturity gap persisted, managers were given the flexibility to take the time to mature the technology or decrease product requirements so that they could use another, already mature technology. Second, both technology and product managers were supported with the disciplined processes, readily available information, readiness standards, and authority to ensure technology was ready for products. This support enabled these managers to safeguard product development from undue technology risks. On the other hand, immature technologies were sometimes incorporated into products for reasons such as inflexible performance requirements, increasing the likelihood of cost overruns and delays in product development. Product managers had little choice but to accept the technologies and hope that they would mature successfully. However, the pressures of product development made for an environment less conducive to maturing technology.
>
> For several reasons, DOD is likely to move technologies to product development programs before they are mature. Science and technology organizations, which traditionally operate within fixed budget levels, do not necessarily have the funds to

[27] GAO, "Best Practices – Better Management of Technology Development Can Improve Weapon System Outcomes," GAO/NSIAD-99-162, July 1999.
[28] Alison Olechowski, Steven D. Eppinger, and Nitin Joglekar, "Technology Readiness Levels at 40: A Study of State-of-the-Art Use, Challenges and Opportunities," MIT Sloan School, 2015 Proceedings of PICMET'15, April 2015, https://web.mit.edu/eppinger/www/pdf/Eppinger_PICMET2015.pdf

mature technology to the higher TRLs. Programs are more able to command the large budgets necessary for reaching these levels. The pressures exerted on new programs to offer unique performance at low cost encourage acceptance of unproven technologies.

The study team found the results of these earlier studies remained valid, leading to the following finding and recommendation:

Finding #5A - TRL 7 before Milestone B Many studies found that having Technology Readiness Level (TRL) 7 at Milestone B (MS B), rather than Milestone C (MS C), greatly enhanced the probability of program success. • In 1999, Government Accountability Office (GAO) recommended that the SECDEF require that technologies needed to meet a weapon's requirements reach a high readiness level (analogous to TRL 7) before making the commitment to the development and production of a weapon system. • In 2015, MIT Sloan noted that a GAO study of 62 DoD programs found that those programs that reached TRL 7 or higher by the start of system development finished practically on time and on budget; whereas those programs with technologies below TRL 7 showed, on average, development cost growth of 32%, acquisition unit cost increase of 30%, and schedule delay of 20 months.
Recommendation #5A - TRL 7 before Milestone B SA change the process to require that programs achieve Technology Readiness Level (TRL) 7 before MS B, as opposed to before MS C, unless a waiver is obtained from SA. • TRL 7 requires a system prototype demonstration in an operational environment; TRL 6, which requires demonstration in a relevant environment, is the current requirement before MS B.

There's a significant advance in the product under development between TRL 6 and TRL 7 (Fig. 6.2). For example, under TRL 6, a cannon and its projectile are tested to demonstrate that it will fire and impact a target area with an acceptable circular error probability. In TRL 7, the cannon is tested in an integrated, albeit simplified system in an operational environment. The integrated system tests the full operational loop that includes targeting, command and control, target update in flight, and battle damage assessment (BDA). Thus, at TRL 7, information such as the impact of rate of fire will be better understood. Changing the rate of fire can make a significant difference in which cannon reload options are acceptable. In addition, if the cannon is to be used against a target that can change location during the time of flight of the projectile (estimated to be approximately 15 minutes), the projectile must be able to receive a target update and to change course as needed. If that requirement is not established prior to MS B, it will lead to costly schedule delays and cost overruns.

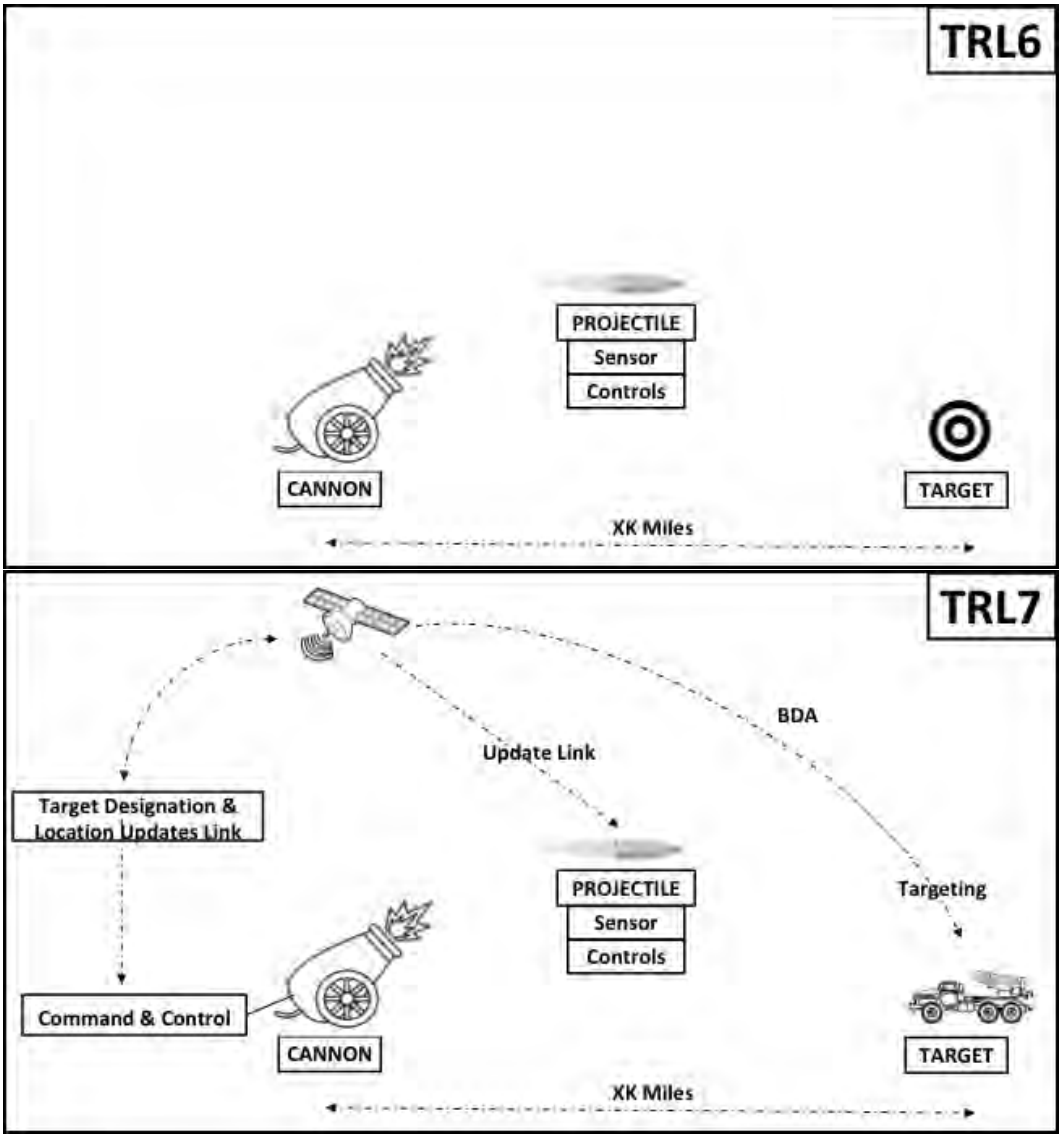


Figure 6.2 Example: Strategic Long-Range Cannon (SLRC)

The recommended achievement of TRL 7 prior to MS B is consistent with the definition of BA 4 from the 2017 DoD Comptroller's Financial Management Regulation,[29] which indicates that BA 4 efforts occur prior to MS B and that TRL 6 and 7 should be achieved:

> Budget Activity 4, Advanced Component Development and Prototypes (ACD&P). Efforts necessary to evaluate integrated technologies, representative modes, or prototype systems in a high fidelity and realistic operating environment are funded in this budget activity. The ACD&P phase includes system specific efforts that help expedite technology transition from the laboratory to operational use. Emphasis is on proving component and subsystem maturity prior to integration in major and

[29] DoD Comptroller, *DoD 7000.14-R, Financial Management Regulation*, Volume 2B, Chapter 5, November 2017, https://comptroller.defense.gov/Portals/45/documents/fmr/current/02b/02b_05.pdf

complex systems and may involve risk reduction initiatives. Program elements in this category involve efforts ***prior to MS B*** and are referred to as advanced component development activities and include technology demonstrations. Completion of ***Technology Readiness Levels 6 and 7*** should be achieved for major programs. Program control is exercised at the program and project level. A logical progression of program phases and development and/or production funding must be evident in the FYDP. (Emphasis added)

When the Army implements this recommendation, the current acquisition process/TRL/BA alignment (Fig. 5.2) will shift to ensure the programs are in a better position to succeed (Fig. 6.3).

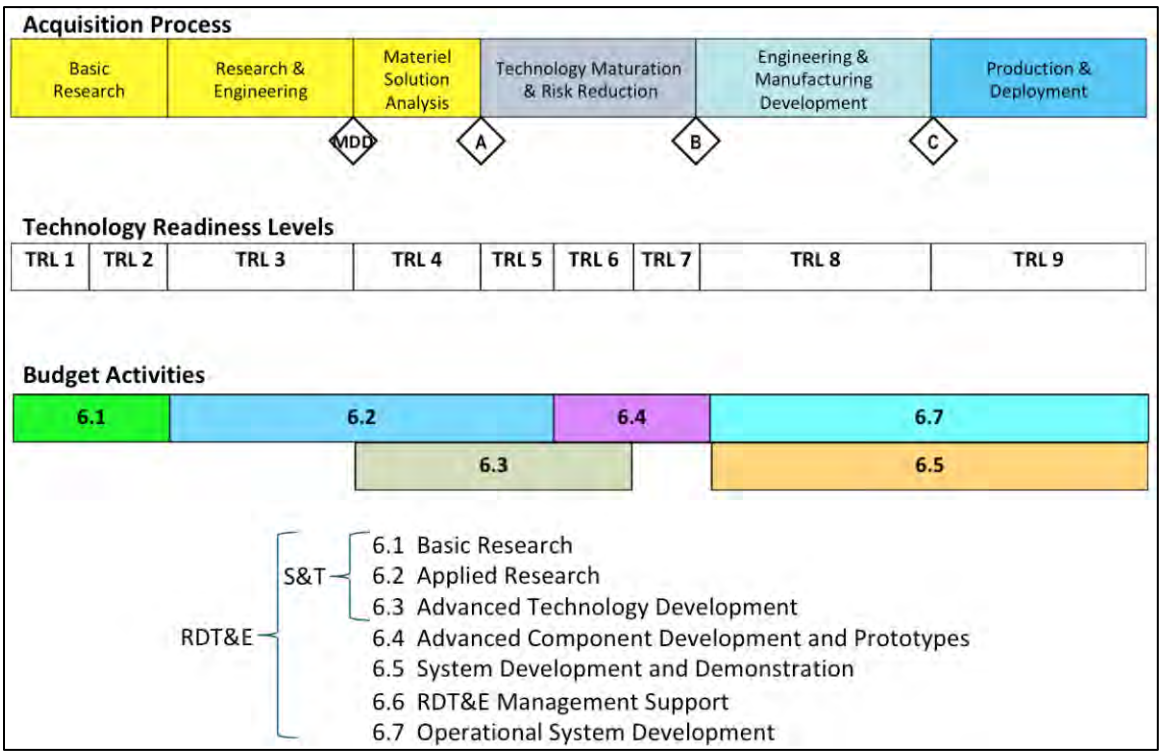


Figure 6.3 Revised Milestones

6.3.2 MULTIPLE PROTOTYPES

The design and testing of multiple prototypes early in the concept and technology development phases before MS B will benefit the solution or set of solutions for new concepts. By using structured testing and experimentation, the Army can improve its understanding of different approaches to the requirements and gaps in capability. This process will enable innovations for disruptive technologies. By opening the window of possible solutions, innovators and developers from a broader community will have an opportunity to participate, which could stimulate new breakthroughs and/or alternative thinking on operational procedures and utility.

Broad Agency Announcements (BAAs) and Other Transactional Authorities (OTAs) have been successfully used in the past to bring new ideas to the problem set with reduced administrative burdens on the innovators and developers. New collaborations across performer teams are also possible.

The intent of this multiple prototyping approach is to develop a high level of confidence that the best alternative is selected prior to reaching MS B. As such, this could serve as a pathway to the DoD Prototyping Strategy for Major Defense Acquisition Programs (MDAP) per the GA0-17-309 report.[30] The benefits of this approach led the study team to develop the following finding and recommendation:

Finding #5B – Multiple Prototypes GAO found that using multiple system prototyping approaches was worth the investment. • The desired outcome is known but the approach to achieve that outcome is unknown. Broad Agency Announcements and Other Transactional Authorities (BAAs/OTAs) for developing multiple prototypes are a well-known accepted approach.
Recommendation #5B – Multiple Prototypes SA change the process to require that multiple prototypes are developed between Milestones A and B in order to provide confidence that the right alternative is chosen, unless a waiver is obtained from SA.

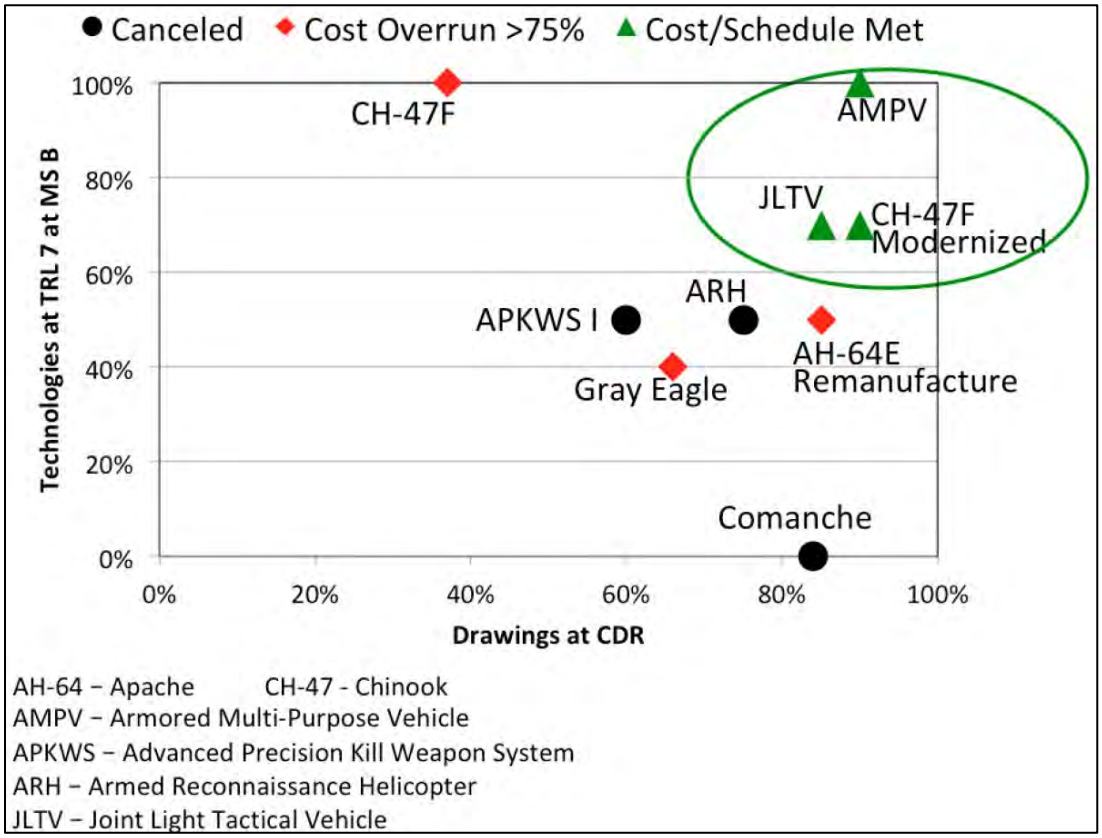
6.3.3 90% DRAWING RELEASE

The 90% Drawing Release refers to drawings that have been reviewed and approved by the Program Team. There have been several studies that have analyzed source data from DoD Programs related to the percentage of drawings releasable at CDR during EMD. These studies indicate that programs with a high percentage of drawings releasable at CDR have a higher probability of avoiding schedule slippage, cost overruns, and performance shortfalls. The study team's review of the 2002 GAO Report[31] and the 2015 study by Katz, et al[32] led to the following finding and recommendation:

[30] GAO, "Weapon Systems – Prototyping Has Benefited Acquisition Programs, but More Can Be Done to Support Innovation Initiatives," GAO-17-309, June 2017.
[31] GAO, "Best Practices – Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes," GAO-02-701, July 2002.
[32] Katz et al, "The Relationship of Technology and Design Maturity to DoD Weapon System Cost Change and Schedule Change During Engineering and Manufacturing Development," Systems Engineering Vol 18, No 1, 2015. https://onlinelibrary.wiley.com/doi/abs/10.1111/sys.21281

Finding #5C – 90% Drawing Release • In 2002, GAO found DoD programs that completed 90% of drawings by Critical Design Review (CDR) had more successful outcomes. • For example, the AIM-9X and the F/A-18E/F limited cost increases to 4 percent or less and schedule growth to 3 months or less. The AIM-9X had 95 percent of its drawings completed at its critical design review. The F/A-18E/F had over 90 percent of its higher level interface drawings completed. • In 2015, Katz et al found that if at least 90% of design drawings were releasable at the CDR (between MS B and MS C), cost growth and schedule slippage were less likely during the Engineering and Manufacturing Development (EMD) Phase.
Recommendation #5C – 90% Drawing Release SA change the process to require that at least 90% of the design drawings are released before CDR, unless a waiver is obtained from SA

To capture the impact of technology maturation in the acquisition process, the study team analyzed Army programs that demonstrated TRL 7 technology maturity at MS B and 90% drawing release that met cost and schedule goals, compared with those that did not and were either cancelled or had significant cost overruns (Fig. 6.4; see Appendix G for a more detailed discussion of the data).



Data Taken from GAO Annual Weapon System Assessments

Figure 6.4 Army Program Analysis

7. DECKER-WAGNER REVIEW

The Final Report of the 2010 Army Acquisition Review, "Army Strong: Equipped, Trained and Ready," referred to colloquially after its two co-chairs, The Decker-Wagner Report, was published in January 2011. In addition to providing a deep dive into the Army acquisition process and problems it found therein, the report contained recommended reforms that the Army, DoD, and Congress could enact to improve what the authors described as the Army's "track record of too many cancellations, schedule slippages, cost over-runs and failures to deliver timely solutions to the warfighters' requirements."

In collecting its data, a panel of senior military and civilian leaders interviewed over 100 individuals with experience in Army acquisition, to include industry stakeholders, and reviewed numerous prior acquisition studies, relevant laws, policies, and regulations. A key discovery was nearly everyone interviewed agreed major reforms were needed to improve the effectiveness of the Army acquisition system. These individuals also believed the problems could be solved by Army leadership.

The Decker-Wagner Report identified four major challenges preventing the Army from optimizing its acquisition program, which had a direct, negative impact on fielding the equipment it needed to fight and decisively win on current and future battlefields:

1. **The erosion of Army requirements and acquisition core competencies**. All of acquisition begins with requirements, but the reviewers found that in 2010, a deliberate yet tailorable process involving collaboration among the requirements/operational, cost/benefits analysis, technology, systems engineering, testing, project management, sustainment, and contracting communities did not exist and had too often been attempted in an uncoordinated, serial approach.

2. **The reduction of the number of qualified people essential to acquiring modern equipment.** The panel found that while oversight staff responsible for process was rising in the years prior to 2010, during the same period, the number of qualified, accountable professionals charged to develop and produce products was dwindling. Specifically mentioned was a need for more systems engineers, operations and cost analysts, and contracting officers. The report stated the problem "lies not in a shortage of money for the existing workforce, but in how it is allocated."

3. **The acquisition process in 2010 was NOT collaborative**, **but sequential with multiple opportunities for oversight staffs to question and challenge requirements.** Mean time to approve system requirements was excessively long, and once approved, the associated acquisition milestones were not synchronized with the POM or budget cycles, resulting in program starts occurring 2-3 years after the operational need was identified. Once a program started, according to the report, additional delays were

likely, which increased cost and extended the time needed to field the requirement. There existed too many opportunities for someone to say no and to delay or stop the acquisition process.

4. **The acquisition system was ineffective and inefficient.** As evidence, the reviewers noted the termination of 22 Major Defense Acquisition Programs (MDAPs) of record before completion between the years 1990-2010. This meant the sunk cost of terminations amounted to 25% of available Development Test and Evaluation Funding. The panel found that every year between 1996 and 2010 the Army spent more than $1 billion annually on canceled programs.

After reviewing the challenges besetting Army acquisition, Decker-Wagner authors listed four categories under which the Army needed to take corrective action. Within these categories were 76 recommendations for implementation, including the specific offices that should take responsibility for the implementation of each recommendation. The four overarching categories were:

1. Making the requirements process collaborative and timely

2. Emphasizing informed management of risk, rather than an aversion to risk in which initiative is stifled

3. Refocusing on core competencies, aligning acquisition organizations and enforce accountability by all stakeholders in acquisition

4. Providing adequate resources to restore core competencies in requirements development and acquisition workforces

On July 15, 2011, SECARMY issued a directive that the Deputy Under Secretary of the Army (DUSA), with assistance from the ASA(ALT), would lead the Army in implementation of the Decker-Wagner recommendations. The Army conducted what they later referred to as a "careful review" of the recommendations and began to take steps to implement those found appropriate. The Army identified 63 of Decker-Wagner's 76 recommendations for implementation; 57 of which could be implemented by the Army alone, with the remaining six requiring action outside the Army. The 13 recommendations not selected for implementation were deemed inconsistent with DoD and Army acquisition policy, or otherwise overlapped with concurrent institutional reform efforts.

By March 2013 the Army had completed instituting 53 of the 63 recommendations, with the remaining 10 pending completion. In most cases, the Army issued policy memoranda and/or directives to implement Decker-Wagner recommendations. Otherwise, it changed regulations, instituted new processes, or proposed changes to organizations outside the Army and whose approval were necessary to implement the reform. The Army provided a report to Congress

describing the steps that had been taken and other contextual information for each of the recommendations it chose to implement.[33]

7.1 REVIEW SELECTED DECKER-WAGNER RECOMMENDATIONS

After reviewing Army implementation of the Decker-Wagner report, the study team found the 13 recommendations that had been dismissed should be revisited, given the changes which have taken place since the report was published.

Finding #6 – Decker-Wagner Recommendations
In March 2013, the Army deemed 13 recommendations from this study to be inconsistent with Departmental and Army acquisition policy or otherwise overlapped with concurrent institutional reform efforts, and therefore chose not to implement them.

The 13 Decker-Wagner recommendations that weren't implemented by the Army:

1. **SECARMY and CSA:** For key ACAT I programs, establish a Special Task Force (STF), chartered by either the CSA or SecArmy, that is: 1) Co-chaired by a TRADOC MG and an acquisition GO/SES technically qualified for the system pursued; 2) Conducted off-site, outside the Washington, DC area, for a finite period of performance; 3) Convened as necessary to prepare for the MS A and B decisions; 4) Organized and populated with experienced, qualified talent, from the Army Secretariat, ARSTAFF, TRADOC, AMC, ATEC and other Army Commands with the authority to commit their organizations; 5) Invites members of the JCS, DOT&E and OUSD(AT&L) as appropriate; 6) Tasked to collaboratively develop and provide to AAE, AMC and TRADOC a comprehensive, consistent set of requirements, acquisition milestone decision products and source selection documents; 7) Used to draft the RFP and assess comments received; 8) Prepared to provide some STF members to serve on the SSEB or SSAC.

2. **SECARMY**: VCSA should co-chair the ASARC with the ASA(ALT); ASARC to make appropriate recommendations to the AAE.

3. **SECARMY and CSA:** Focus development and production on what the operational force needs fielded in the next 7 years.

4. **USA, ASA(ALT), ASA(FM&C), OSD, Congress**: Request rapid acquisition discretionary funding for ONS to support COCOMs during such periods.

5. **AAE and DDR&E**: Properly define and promulgate Integration Readiness Level (IRL) and Manufacturing Readiness Level (MRL) criteria for use in determining readiness to enter EMD and production.

[33] Secretary of the Army, "Report to Congress: Implementing Acquisition Reform: Decker-Wagner Army Acquisition Review," March 2013, https://www.army.mil/e2/c/downloads/213466.pdf.

6. **AAE and VCSA**: Make PMs lead/accountable for acquisition logistics during development through successful IOC fielding and LCMCs lead/accountable for post-fielding operational logistics.

7. **AAE**: Promulgate acquisition strategy templates for the 6 types of acquisition programs[34] to manage by risk as well as scope.

8. **AAE (with DAE)**: Require the PM to identify to the ASARC which type of program acquisition strategy is proposed and justify any deviation from the attributes for that type.

9. **AAE (with DAE)**: Restrict Type 5 acquisitions to only 'game changing' military capabilities.

10. **AAE**: Emphasize more Type 1, 2 & 3 acquisition for shorter cycles, more stability, rapid tech insertion and reduced 'requirements/technology creep'

11. **AAE**: Re-designate PEO Soldier to be PEO Soldier and Small Unit.

12. **CG AMC; (add ASA(ALT) for 4)**: Disestablish RDECOM and return the RDECs to the LCMC Commanders: 1) Establish a MG or SES 5 Executive Director for RDA reporting directly to the CG AMC; 2) Annually review Labs and RDECs to eliminate low value added, duplicate efforts; 3) Use the 332 RDECOM positions saved to resource the additional TRADOC and AMSAA ORSA positions, the Directorate for Advanced Systems at AMRDEC, TARDEC, CERDEC, NSRDEC and ARL, and military DASCs; and 4) Disposition of ARL and ARO should be determined by the on-going ASA(ALT) study.

13. **CG AMC**: AMC establish a cadre of best practitioners experienced in establishing and conducting SSEBs. This cadre should be a cell in AMC HQ that deploys to form and serve as the leadership for ACAT I SSEBs and is responsible for the lessons learned during SSEBs.

Recommendation #6 – Decker-Wagner Recommendations

SA request a second review of the 13 Decker-Wagner recommendations that the Army chose not to implement.

- In the ensuing 6 years many changes have modified Departmental and Army acquisition policies and institutional reforms (e.g., establishing AFC).

[34] Type 1: Non-developmental item, Type 2: Existing system with block improvement, Type 3: New system providing improved existing capability, Type 4: New system providing new capability with proven technologies, Type 5: New system for early adoption of advanced technologies, RA: Rapid acquisition.

8. MEASURES OF EFFECTIVENESS

The overall goal of the recommendations described above is to avoid schedule slippage, cost overruns, and performance shortfalls while encouraging cooperation and unity among AFC organizations. Implementing these recommendations will help AFC accomplish improved acquisition results and avoid the pitfalls leading to program cancellations.

In response to SECARMY's task in the TOR to provide a method of gauging AFC's implementation, the study team developed three measures of effectiveness:

1. After 6 months, has SECARMY and CG AFC directed implementation of the recommendations provided in this report?

2. At the end of Year 1, have all best practices assigned to CG AFC been implemented (#2 Unifying Culture and #3 Core Competencies)? Have all projects followed the recommendations implemented by SECARMY or obtained a waiver (#4 Continuity of Leadership and #5A, #5B, #5C Technology Maturity)?

3. At the end of Year 2 and annually thereafter, ensure all programs continue to follow recommendations.

ASB believes that these timeframes are achievable and must be met to maintain momentum and meet leadership expectations. Time is of the essence.

9. FINDINGS AND RECOMMENDATIONS

The following summarizes the study team's findings and recommendations regarding the future operation of AFC.

1. Board(s) of Advisors

Finding #1 – Board of Advisors

Industry best practices include establishing a Board of Advisors to help the CEO on strategic matters beyond routine governance.

Recommendation #1 – Board of Advisors

SA establish a Future Force Modernization Enterprise Board of Advisors chaired by CG AFC that includes at a minimum:

- COCOMs
- ASA(ALT)
- TRADOC
- AMC
- FORSCOM
- External (to Army)

Purpose is to conduct strategic discussions on future needs and operational requirements.

2. Unifying Culture

Finding #2 – Unifying Culture

- Geography challenges inhibit making AFC a single unified organization.
  - AFC dispersed over 40 locations
  - Messages from headquarters are not reaching lower level staff in a timely manner
- What AFC is trying to accomplish organizationally is done by private industry on a regular basis.
- Industry best practices include:
  - Establish a culture where employees feel empowered and involved in the transformation
  - Foster relationships across sub-organizations to promote an inclusive culture

Recommendation #2A – Unifying Culture (Empowering Employees)

CG AFC establish a communication strategy to create shared expectations and report related progress. Communications from CG AFC to staff should reach everyone, including lower level staff, the same day.

- Ensure consistency of message
- Encourage two-way communication
- Provide information to meet specific needs of employees

Recommendation #2B – Unifying Culture (Empowering Employees)

CG AFC establish a process to involve all employees to obtain their ideas and gain their ownership for the transformation. Establish an email suggestion box where anyone who has an idea to make the Army better can send it directly to CG AFC special email.

- Involve employees in planning and sharing performance information
- Incorporate employee feedback into new policies and procedures

Recommendation #2C – Unifying Culture (Networking and Broadening)

CG AFC establish developmental assignments in which technical people who are interested in learning about other technologies can be integrated at another organization **inside AFC** for long enough (9 months?) to establish social and technical networks and better understand and appreciate new opportunities. Ensure that the Individual Development Plans for these employees include post-assignment positions utilizing this experience.

Recommendation #2D – Unifying Culture (Networking and Broadening)

CG AFC establish **external** developmental assignments in other organizations such as other Army, DoD, US Government, FFRDCs, SETAs, academia, industry non-profits, and, if possible, for-profit industry. Ensure that the Individual Development Plans for these employees include post-assignment positions utilizing this experience.

- Use of the Intergovernmental Personnel Act (IPA) is a potential vehicle
- The Army Research Laboratory (ARL) open campus currently has 700 researchers from academia and industry – Cooperative R&D Agreement (CRADA) is most common vehicle but IPA also possible

3. Core Competencies

Finding #3A – Identifying Core Competencies

The identification of core competencies in industry must be a top-down process requiring approval by the CEO.

Recommendation #3A – Identifying Core Competencies

CG AFC establish the core competencies within AFC in a top-down process with a feedback loop and approved by CG.

Finding #3B – Systems Engineering Core Competencies

The number of Systems Engineers (SE) in CCDC seems small compared to the Army's needs. We note that CCDC currently lists only 80 SE within the Command, 70 of whom are in the CCDC Armaments Center. Government SE have been listed as a crucial resource to develop and manage capabilities from requirements to development, and more are needed than what has been listed above.

- Office of Personnel Management (OPM) does not have a "Systems Engineer" occupational series

Recommendations #3B – Systems Engineering Core Competencies

- SA request OPM recognize Systems Engineers.
- CG AFC verify that Systems Engineers are being coded and counted properly.
- CG AFC direct hiring more system engineers to fulfill development needs.

Finding #3C – Additive Manufacturing Core Competencies
While additive manufacturing is listed as a foundational research competency area at ARL, this technique does not appear to be used as a tool in other areas of CCDC. It seems to us that additive manufacturing should be an overall core competency since it can be used to develop capabilities that cannot be created any other way. For example, propulsion system designs can be envisioned that cannot be realized without additive manufacturing.
Recommendation #3C – Additive Manufacturing Core Competencies
CG AFC make additive manufacturing a CCDC core competency.

4. Continuity of Leadership

Finding #4A – Continuity of Leadership
Industry best practice for developing a new product is to establish a persistent team that involves personnel from all steps in the process with appropriate team members taking the lead as progress is made.
Recommendation #4A – Continuity of Leadership
SA establish a process in which:

- An Integrated Product Team (IPT), led by Futures and Concepts Center (FCC) through Materiel Development Decision (MDD), will be formed after high priority opportunities/challenges/issues are identified. IPT membership shall include experts in analysis of operational and system requirements, technology readiness, costing, acquisition, and budget and personnel availability, who have the authority to commit their organizations for this purpose and to communicate freely with all IPT members.
- At MDD, a Combat Capabilities Development Command (CCDC) system concept manager will be assigned by CG AFC to lead the IPT for each prioritized challenge/opportunity/issue that requires a materiel solution. This person must be a systems engineer who is acquisition certified.
- After a Board-selected Program/Project/Product Manager (PM) is appointed by Milestone B by the Army Acquisition Executive, program lead will transition from AFC to Army Acquisition. The current system concept manager could become the PM if he/she becomes Board-selected.
    - To avoid conflicts of interest, care should be taken to avoid having the same PM currently managing other ongoing similar systems.

Finding #4B – DA Special Task Force

- Industry best practice for ensuring a key very important project is brought to completion is to establish a special team to oversee the process and develop plans for successful development.
- SA has authority to establish a Special Task Force to do the same.
- DoD examples of successful special task forces include Second Generation FLIR Horizontal Technology Integration and Army Digitization.

Recommendation #4B – DA Special Task Force

SA/CSA establish, for ACAT I and II, Special Task Forces to produce required Milestone B decision documents (e.g.):

- Modernization plan (resource constrained)
- Test and Evaluation Master Plan
- Integrated Logistics Support Plan
- Requirements documents
- Baseline cost estimate
- Draft acquisition strategy and acquisition plan
- Draft Request for Proposals

5. Technology Maturity

Finding #5A – Multiple Prototypes

GAO found that using multiple system prototyping approaches was worth the investment.

- The desired outcome is known but the approach to achieve that outcome is unknown. Broad Agency Announcements and Other Transactional Authorities (BAAs/OTAs) for developing multiple prototypes are a well known accepted approach.

Recommendation #5A – Multiple Prototypes

SA change the process to require that multiple prototypes are developed between Milestones A and B in order to provide confidence that the right alternative is chosen, unless a waiver is obtained from SA.

Finding #5B - TRL 7 before Milestone B

Many studies found that having Technology Readiness Level (TRL) 7 at Milestone B (MS B), rather than Milestone C (MS C), greatly enhanced the probability of program success.

- In 1999, Government Accountability Office (GAO) recommended that the SECDEF require that technologies needed to meet a weapon's requirements reach a high readiness level (analogous to TRL 7) before making the commitment to the development and production of a weapon system.
- In 2015, MIT Sloan noted that a GAO study of 62 DoD programs found that those programs that reached TRL 7 or higher by the start of system development finished practically on time and on budget; whereas those programs with technologies below TRL 7 showed, on average, development cost growth of 32%, acquisition unit cost increase of 30%, and schedule delay of 20 months.

Recommendation #5B - TRL 7 before Milestone B

SA change the process to require that programs achieve Technology Readiness Level (TRL) 7 before MS B, as opposed to before MS C, unless a waiver is obtained from SA.

- TRL 7 requires a system prototype demonstration in an operational environment; TRL 6, which requires demonstration in a relevant environment, is the current requirement before MS B.

Finding #5C – 90% Drawing Release

- In 2002, GAO found DoD programs that completed 90% of drawings by Critical Design Review (CDR) had more successful outcomes.
- For example, the AIM-9X and the F/A-18E/F limited cost increases to 4 percent or less and schedule growth to 3 months or less. The AIM-9X had 95 percent of its drawings completed at its critical design review. The F/A-18E/F had over 90 percent of its higher level interface drawings completed.
- In 2015, Katz et al found that if at least 90% of design drawings were releasable at the CDR (between MS B and MS C), cost growth and schedule slippage were less likely during the Engineering and Manufacturing Development (EMD) Phase.

Recommendation #5C – 90% Drawing Release

SA change the process to require that at least 90% of the design drawings are released before CDR, unless a waiver is obtained from SA

6. Decker Wagner Recommendations Not Implemented

Finding #6 – Decker-Wagner Recommendations

In March 2013, the Army deemed 13 recommendations from this study to be inconsistent with Departmental and Army acquisition policy or otherwise overlapped with concurrent institutional reform efforts, and therefore chose not to implement them.

Recommendation #6 – Decker-Wagner Recommendations

SA request a second review of the 13 Decker-Wagner recommendations that the Army chose not to implement.

- In the ensuing 6 years many changes have modified Departmental and Army acquisition policies and institutional reforms (e.g., establishing AFC).

APPENDICES

APPENDIX A: TERMS OF REFERENCE

SECRETARY OF THE ARMY
WASHINGTON

04 JAN 2019

MEMORANDUM FOR

Deputy Under Secretary of the Army, 110 Army Pentagon, Room 3E650, Washington, DC 20310-0110
Chairman, Army Science Board, 2530 Crystal Drive, Room 7098, Arlington, Virginia 22201

SUBJECT: Request for an Army Science Board Study titled "Army Futures Command"

1. I request that the Army Science Board (ASB) conduct a study titled, "Army Futures Command." The purpose of the study is to develop recommendations for internal processes for the U.S. Army Futures Command (AFC) on how AFC should operate, once fully established, to achieve the outcomes described in the Department of the Army General Order 2018-10 (Establishment of United States Army Futures Command):

> "AFC leads the Army's future force modernization enterprise. AFC assesses and integrates the future operational environment, emerging threats, and technologies to develop and deliver concepts, requirements, future force designs, and supports the delivery of modernization solutions."

Specifically, the study will focus on establishing best practices within the command to ensure that AFC matures advanced systems concepts, technology, and materiel solutions into deployed systems based on the future threat and operational environment and then, through research and development, turns the materiel solutions into deployed warfighting systems.

2. The Army established AFC on 1 July 2018 to lead its modernization enterprise for future forces. In its initial operating capability (IOC), AFC will have the following organizations assigned to it:

a. Army Capabilities Integration Center (ARCIC)

b. Capability Development and Integration Directorates (CDIDs)

c. U.S. Army Training and Doctrine Command (TRADOC) Analysis Center (TRAC)

d. Research, Development, and Engineering Command (RDECOM)

e. Army Materiel Systems Analysis Activity (AMSAA)

SUBJECT: Army Science Board Study "Army Futures Command (AFC)"

f. Cross functional teams

If established properly from the outset, unity of command across these multiple elements of the Army's Modernization Enterprise will facilitate the rapid fielding of innovative capabilities that perpetuate the Army's technical overmatch of peer and near-peer competitors.

3. To assist the Army with the stand-up and design of AFC, the ASB study team's tasks will include, but will not be limited to, the following:

a. Recommend process and procedure changes deemed necessary to achieve AFC objectives. These changes may range from making semantical shifts, such as adopting business terms in favor of Government acquisition terms to adopting commercial organizational structures that ensure integration across the command, to reinterpreting the Federal Acquisition Regulation more in line with other Services and Department of Defense agencies.

b. Recommend the incorporation of selected best practices from large commercial, public service, and other Government organizations that have demonstrated success either driving or surviving continuous, disruptive change.

c. Assess the current implementation of recommendations from the following Army-commissioned reports:

(1) 2010 Army Acquisition Review, "Army Strong, Equipped, Trained and Ready" (Decker-Wagner Report)

(2) ASB fiscal year 2013 study titled "Army Science and Technology Essential Core Competencies"

d. Examine the relationships required with industry to ensure that the Army focuses on core competencies and leverages the best available outside talent to create a fast moving, innovative, and future-thinking organization.

e. Recommend measures of effectiveness (MOE) that will clearly identify success and help to articulate that success in strategic communication. Metrics must be value based, output oriented, and geared toward describing what AFC, as an organization, does differently.

4. The Secretary of the Army is the sponsor of this study. The Commanding General, AFC will assist the study team with accessing information necessary to conduct this study.

5. Provide a briefing with findings and recommendations by 30 September 2019 to the Chief of Staff, Army and me. The study will operate in accordance with the Federal

SUBJECT: Army Science Board Study "Army Futures Command (AFC)"

Advisory Committee Act and Department of Defense Directive 5105.4, "Department of Defense Federal Advisory Committee Management Program." It is not anticipated that this study will need to go into any particular matters regarding the meaning of United States Code, nor will it cause any member of the study team to be placed in the position of acting as a procurement official that may constitute a conflict of interest.

Mark T. Esper

CF:
Chief of Staff, Army
Under Secretary of the Army
Vice Chief of Staff, Army
Commander,
U.S. Army Training and Doctrine Command
U.S. Army Futures Command

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APPENDIX B: STUDY TEAM MEMBERS

Tony Tether, PhD – Chair

Nancy Chesser, PhD – Vice-Chair

Members

LtGen (Ret) Emerson Gardner

Bill Guyton

COL (Ret) Susan Myers, PhD

Government Advisor

Rob Swope, ASA(ALT)

Senior Mentor:

George Singley III

Study Manager:

Mary Arthur, CCDC Army Research Laboratory

Tech Writer/Editor:

Mark Swiatek

APPENDIX C: SITE VISITS AND INTERVIEW LINES OF INQUIRY

The team visited numerous organizations within AFC as well as other Army, DoD, and FFRDC organizations.

- AFC
  - Headquarters
    - Army Applications Lab (AAL)
    - Army Test & Evaluation Command (ATEC) – direct support to AFC
    - Directorate of Systems Integration (DSI)
  - Futures and Concepts Center (FCC)
  - Combat Capabilities Development Command (CCDC)
    - C5ISR Center
    - Data & Analysis Center
    - Chem-Bio Center
    - Army Research Laboratory (ARL)
  - Combat Systems Directorate
- Other Army
  - PEO Intelligence, Electronic Warfare & Sensors (IEW&S)
  - PEO Command, Control, Communications – Tactical (C3T)
  - Rapid Capabilities & Critical Technologies Office (RCCTO)
- Other DoD
  - USMC, Capabilities Development Directorate
- Federally Funded R&D Centers (FFRDCs)
  - MIT Lincoln Lab
  - Aerospace Corp

The following documents were provided to organizations prior to visits with the study team:

- SA Memo: Secretary of the Army Memorandum for Deputy Under Secretary of the Army and Chairman, Army Science Board, Subject: Request for an Army Science Study titled "Army Futures Command ," 4 January 2019 (see Appendix B – Terms of Reference)

- Biographies of AFC Study team members

Lines of inquiry for most organizations followed the Tasks listed in the TOR. These are provided chronologically by organization below.

Aerospace Corporation; National Capital Region (13 March 2019)

- Documents provided: SA Memo and Bios.
- Lines of Inquiry: Tasks from the TOR.

AFC Study team members engaged with Jamie Morin, VP & Executive Director, Center for Space Policy & Strategy. Additionally, participants discussed how to incentivize and shape Army innovation, the role that FFRDCs currently serve towards this end, and how they might better serve this role. Study team members received an overview on the Aerospace Corporation, and a white paper on FFRDC Staff Years of Technical Effort (STE) Ceiling Relief.

MIT Lincoln Laboratory; National Capital Region (13 March 2019)

- Documents provided: SA Memo and Bios.
- Lines of Inquiry: Tasks from the TOR.

AFC Study team members engaged with Jaymie Durnan, Deputy Assistant to the Director for Strategic Initiatives. Additionally, participants discussed how to incentivize and shape Army innovation, the role that FFRDCs currently serve towards this end, and how they might better serve this role.

Aberdeen Proving Ground, MD (8-11 April 2019):

Army Test & Evaluation Command (ATEC)
AFC Combat Capabilities Development Command (CCDC)
CCDC Armaments Center (AC)
CCDC Army Research Laboratory (ARL)
CCDC Aviation & Missile Center (AvM)
CCDC C5ISR Center
CCDC Chemical Biological Center (CBC)
CCDC Data & Analysis Center (DAC)
CCDC Soldier Center (SC)
PEO C3T
PEO IEW&S

- Documents provided: SA Memo and Bios.
- Lines of Inquiry: Tasks from the TOR plus the additional questions listed below.

The following questions were provided to AFC and its sub organizations:

1. Questions about AFC in general
    a. Does the AFC organization satisfy the dictates of Unity of Command?
    b. Does the AFC organization satisfy the dictates of Unity of Direction?
    c. What are potential MOEs to measure AFC success in 2 years?
2. Questions about AFC HQ:
    a. What processes have been streamlined and improved?
    b. What is fate of current CFTs going forward? Are future CFTs replaced by IPTs?
    c. Who has the responsibility for searching for innovation and disruptive technologies/ solutions/ products?
    d. Who has the responsibility for developing, formulating, analyzing and advocating systems concepts?
3. Questions about Futures and Concepts Directorate:

   a. Where in the Futures and Concepts organization are future Competition (as opposed to Conflict) operations and concepts considered and developed?
   b. What would be a representative existing program that we could track through the Top-Down Process starting with Futures and Concepts?
   c. What is required from other organizations for Futures and Concepts to perform its part of the Top-Down Development Process?
   d. What criteria are used to choose IPT leads?
   e. Who is responsible for Technology Net Assessments listed in Top Down Process?
4. Questions about Combat Capabilities Development Command:
   a. What are core competencies for the Centers and ARL and how are they selected?
   b. What are the criteria for determining whether the core competencies are to be maintained in-house vs outsourced?
   c. What is the role for CCDC In the emerging Top-Down Process?
   d. What is the most recent official CCDC (or RDECOM) RDT&E strategy and resource-constrained RDT&E Plan.
   e. What is the process for maintaining the dictates of Unity of Command and Direction within AFC CCDC since a significant funding percentage for them comes from PEO/PMs and LCMC whose Direction/Purpose can have different Goals from AFC as well as the PEO/PM's acting as Bosses for the efforts conflicting with AFC CCDC Boss system?
5. Questions about Combat Systems:
   a. What is the relationship between Combat Systems and ASA(ALT) with respect to the roles of the PMs?

The following questions were provided to PEO C3T and PEO IEW&S:

1. How are the PEOs addressing the following?
   a. Lack of transition of successfully "completed" S&T projects to EMD ("Valley of Death")
   b. Funding legacy systems versus new starts incorporating innovative and/or disruptive technologies/capabilities
   c. Use of acquisition strategies encouraged by numerous DoD acquisition reforms and allowed by DODI 5000 but which run into artificial Army barriers to using such strategies
   d. Management of risk not embraced because too many are empowered to say no
2. What PEO or AFC organization advocates for advanced systems concepts and advances them to a Materiel Development Decision?
3. What are the PEO/PM processes to manage the movement of prototyping/experiments direct to production? ACTD/JCTDs? Rapid Prototyping?
4. What is the relationship between AFC CCDC, AFC Combat Systems, and the AAE/ASAALT with respect to the roles of the PMs?

5. Are CCDC/PM technology transition agreements enforced? Any successes?
6. What actions can AFC take to enhance PM's ability to deliver programs on cost and schedule and meet performance requirements?
7. What actions can PEOs take to ensure CFT priorities are integrated into final acquisition outputs?
8. What actions have the PEOs taken to eliminate or at least mitigate the enduring problems identified in the 2010 Army Acquisition Review (Decker-Wagner Report) that have caused many program cancellations? Example problems include:
    a. Overly optimistic forecast of funding available for Army modernization.
    b. Weak baseline, modeling, trade studies or analysis of alternatives.
    c. Unconstrained weapon system requirements.
    d. Underestimation of risk, particularly technology readiness levels.
    e. Failure to eliminate technological risk prior to MS B (MS B) approval.
    f. Program skipped or under-resourced pre-MS B prototyping.
    g. Too many programs started only to prove unaffordable in the budget and Future Years Defense Program (FYDP).
    h. Affordability reprioritization.
    i. Schedule slip.
    j. Requirements and technology creep.
    k. Cost overruns.
    l. Program restructured, quantities cut, unit costs skyrocketed and program support lost.

Individuals with whom the ASB study team engaged included:

Organization	Individual(s)
Army Test & Evaluation Command (ATEC)	MG Joel Tyler (CG), Mr. Robert Miele (Executive Tech Dir), Mrs. Sandi Weaver (Chief of Staff), and others in ATEC
AFC Combat Capabilities Development Command (CCDC)	MG Cedric Wins (CG), CSM Jon Stanley (CSM), Mr. John Willison (DtCG), and others in CCDC HQ
CCDC Armaments Center (AC)	Mr. John Hedderich (Director) via VTC
CCDC Army Research Laboratory (ARL)	Dr. Scott Schoenfeld
CCDC Aviation & Missile Center (AvM)	Dr. Juanita Christen (Director) via VTC
CCDC C5ISR Center	Mr. Patrick O'Neil (Director)
CCDC Chemical Biological Center (CBC)	Dr. Eric Moore (Director) and Dr. Way Fountain

CCDC Data & Analysis Center (DAC)	Mr. James Amato (Director), Dr. Patrick Baker, and Mr. Christopher Barrett
CCDC Soldier Center (SC)	Mr. Doug Tamilio (Director) via VTC
PEO C3T	MG David Bassett
PEO IEW&S	MG Kirk Vollmecke

Participants discussed the Army Modernization Priorities, the AFC structure and mission, the Army acquisition process and reform, CCDC's 2019+ Campaign Plan, core competencies, integrated technology development and modernization, continued Army operationalization, and multi-domain operations. Study team members received briefs on the priorities, activities, and operations of ATEC, CCDC, C5ISR, CBC, DAC, and PEO IEW&S; toured ATEC and DAC facilities; received a demonstration of DAC research capabilities; and witnessed two scheduled tests at ATEC.

AFC Future Concepts Center (FCC); Ft. Eustis, VA (15 April 2019)

- Documents provided: SA Memo and Bios.
- Lines of Inquiry: Tasks from the TOR plus the additional questions listed below.

1. Questions about AFC in general
    a. Does the AFC organization satisfy the dictates of Unity of Command?
    b. Does the AFC organization satisfy the dictates of Unity of Direction?
    c. What are potential MOEs to measure AFC success in 2 years?
2. Questions about AFC HQ:
    a. What processes have been streamlined and improved?
    b. What is fate of current CFTs going forward? Are future CFTs replaced by IPTs?
    c. Who has the responsibility for searching for innovation and disruptive technologies/ solutions/ products?
    d. Who has the responsibility for developing, formulating, analyzing and advocating systems concepts?
3. Questions about Futures and Concepts Directorate:
    a. Where in the Futures and Concepts organization are future Competition (as opposed to Conflict) operations and concepts considered and developed?
    b. What would be a representative existing program that we could track through the Top-Down Process starting with Futures and Concepts?
    c. What is required from other organizations for Futures and Concepts to perform its part of the Top-Down Development Process?
    d. What criteria are used to choose IPT leads?
    e. Who is responsible for Technology Net Assessments listed in Top Down Process?
4. Questions about Combat Capabilities Development Command:
    a. What are core competencies for the Centers and ARL and how are they selected?
    b. What are the criteria for determining whether the core competencies are to be maintained in-house vs outsourced?

   c. What is the role for CCDC In the emerging Top-Down Process?
   d. What is the most recent official CCDC (or RDECOM) RDT&E strategy and resource-constrained RDT&E Plan.
   e. What is the process for maintaining the dictates of Unity of Command and Direction within AFC CCDC since a significant funding percentage for them comes from PEO/PMs and LCMC whose Direction/Purpose can have different Goals from AFC as well as the PEO/PM's acting as Bosses for the efforts conflicting with AFC CCDC Boss system?
5. Questions about Combat Systems:
   a. What is the relationship between Combat Systems and ASA(ALT) with respect to the roles of the PMs?
6. What is role of FCC in AFC?
   a. What is role of each FCC component?
   b. What is expected input & output for each interface
   c. Interfaces within AFC
   d. Interfaces beyond AFC
7. Per OPORD, FCC is responsible for the tasks below. What is current status for each?
   a. Develop Future OE
   b. ICW CCDC and CSD develop, refine and analyze requirements. Ensure requirements and technologies mature in concert
   c. Provide analytic underpinnings for concepts and requirements
   d. Plan and execute annual large-scale experiment
   e. Assume lead for developing MDO 2.0
   f. ICW CCDC design mechanisms by which knowledge generated by CCDC and other Army S&T/research and development activities informs assessment of the FOE and revision of Army warfighting concepts
8. What best practices have you identified to achieve FCC goals?
9. What are links with CFTs?
10. Is FCC participating in planning for Strategic Long Range Cannon?
11. Please address the questions about FCC in the list of general questions for AFC.
12. Can you provide insight into questions about other organizations?
13. Show how Strategic Long Range Cannon (or another CFT project) would move through the development process. We have read the document describing the process.

AFC Study team members engaged with: LTG Eric Wesley (FCC DCG), MG John George (FCC Deputy Director/Chief of Staff), Dr. Richard Parker (FCC Assistant to the Deputy Director), BG James Bienlien (Director, FCC Requirements Integration Directorate), Mr. Bradley Pippin (Acting Director, FCC Futures Integration Directorate, and Director of TRADOC Analysis Center (TRAC), Ft. Leavenworth), CSM Paul Biggs (FCC CSM), Mr. Henry Franke (Deputy Director, FCC Directorate of Concepts), and additional subject matter experts at TRAC White Sands Missile Range (WSMR), NM, via video teleconference. Additionally, participants discussed the Army Modernization Framework, the Future OE, Multi-Domain Operations, Army Modernization Strategy and Annual Mission Guidance, AFC and FCC structure and mission, the FCC Top-Down Futures Development Process, the Army acquisition process and reform, and core

competencies. Study team members received an FCC overview brief, briefings on Multi-Domain Operations and the Future Force Modernization Enterprise (FFME), and copies of TRADOC Pamphlet 525-3-1 on Multi-Domain Operations in 2028 (December 2018) and The Operational Environment and the Changing Character of Future Warfare (23 October 2018).

Army Rapid Capabilities and Critical Technologies Office (RCCTO) and CCDC Army Research Laboratory (ARL); National Capital Region (17 April 2019)

- Documents provided: SA Memo and Bios.
- Lines of Inquiry: Tasks from the TOR plus the additional questions listed below.

1. Questions about AFC in general
    a. Does the AFC organization satisfy the dictates of Unity of Command?
    b. Does the AFC organization satisfy the dictates of Unity of Direction?
    c. What are potential MOEs to measure AFC success in 2 years?
2. Questions about AFC HQ:
    a. What processes have been streamlined and improved?
    b. What is fate of current CFTs going forward? Are future CFTs replaced by IPTs?
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    d. Who has the responsibility for developing, formulating, analyzing and advocating systems concepts?
3. Questions about Futures and Concepts Directorate:
    a. Where in the Futures and Concepts organization are future Competition (as opposed to Conflict) operations and concepts considered and developed?
    b. What would be a representative existing program that we could track through the Top-Down Process starting with Futures and Concepts?
    c. What is required from other organizations for Futures and Concepts to perform its part of the Top-Down Development Process?
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    a. What are core competencies for the Centers and ARL and how are they selected?
    b. What are the criteria for determining whether the core competencies are to be maintained in-house vs outsourced?
    c. What is the role for CCDC In the emerging Top-Down Process?
    d. What is the most recent official CCDC (or RDECOM) RDT&E strategy and resource-constrained RDT&E Plan.
    e. What is the process for maintaining the dictates of Unity of Command and Direction within AFC CCDC since a significant funding percentage for them comes from PEO/PMs and LCMC whose Direction/Purpose can have different Goals

from AFC as well as the PEO/PM's acting as Bosses for the efforts conflicting with AFC CCDC Boss system?

5. Questions about Combat Systems:
    a. What is the relationship between Combat Systems and ASA(ALT) with respect to the roles of the PMs?

AFC Study team members engaged with Mr. Bienvenido (Ben) Intoy (RCCTO Director of Operations) and Dr. Philip Perconti (ARL Director). Additionally, participants discussed the Army Modernization Priorities, the AFC structure and mission, the Army acquisition process and reform, CCDC's 2019+ Campaign Plan, core competencies, integrated technology development and modernization, continued Army operationalization, and multi-domain operations. Study team members received briefs on the priorities, activities, and operations of RCCTO and ARL; and on ARL Open Campus.

AFC HQ, AFC Army Applications Laboratory (AAL), AFC Combat System Directorate (CS), and AFC Directorate of Systems Integration (DSI); Austin, TX (19-20 June 2019)

- Documents provided: SA Memo and Bios.
- Lines of Inquiry: Tasks from the TOR plus the additional questions listed below.

1. Questions about AFC in general
    a. Does the AFC organization satisfy the dictates of Unity of Command?
    b. Does the AFC organization satisfy the dictates of Unity of Direction?
    c. What are potential MOEs to measure AFC success in 2 years?
2. Questions about AFC HQ:
    a. What processes have been streamlined and improved?
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    c. Who has the responsibility for searching for innovation and disruptive technologies/ solutions/ products?
    d. Who has the responsibility for developing, formulating, analyzing and advocating systems concepts?
3. Questions about Futures and Concepts Directorate:
    a. Where in the Futures and Concepts organization are future Competition (as opposed to Conflict) operations and concepts considered and developed?
    b. What would be a representative existing program that we could track through the Top-Down Process starting with Futures and Concepts?
    c. What is required from other organizations for Futures and Concepts to perform its part of the Top-Down Development Process?
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    a. What are core competencies for the Centers and ARL and how are they selected?

   b. What are the criteria for determining whether the core competencies are to be maintained in-house vs outsourced?
   c. What is the role for CCDC In the emerging Top-Down Process?
   d. What is the most recent official CCDC (or RDECOM) RDT&E strategy and resource-constrained RDT&E Plan.
   e. What is the process for maintaining the dictates of Unity of Command and Direction within AFC CCDC since a significant funding percentage for them comes from PEO/PMs and LCMC whose Direction/Purpose can have different Goals from AFC as well as the PEO/PM's acting as Bosses for the efforts conflicting with AFC CCDC Boss system?
5. Questions about Combat Systems:
   a. What is the relationship between Combat Systems and ASA(ALT) with respect to the roles of the PMs?

The following additional lines of inquiry were provided to DCG ARL:

1. There is no question in our minds that you are working hard to create processes which integrate FCC, CCDC and ASA(ALT) together so the flow of an idea to MDD to MS A and MS B has minimal turbulence. As you know our ASB effort is putting together concepts to overcome the rocky parts that existed in the past. But we would like to hear what you think is an approach to overcome the past problems.
2. We are also interested in your opinion on how the 31 lines of effort in the CFTs are progressing. Are they getting the attention needed for success?
3. In addition to the above issue, a question we have considered is how do you integrate an organization consisting of organizations which in the past were independent of each other to become cohesive and play ball on the same side? This is especially challenging when the organizations are geographically separated. Again as you know, we have come up with some ideas that we believe will help but we would like to get your ideas. We believe we have avoided the technique of "beatings will continue until morale improves." But that technique is easy to fall back on.
4. World class research does require the best scientists and engineers. This is really hard for AFC to acquire since the best scientists and engineers are sought after by many other organizations especially industry. One idea is to advertise the Army, and AFC in particular, as a place for a new engineer or scientist to come to work first hand on important problems and gain a skill and knowledge, and by doing so be sought by industry. This is really using the old recruiting technique to join the Army/AFC and "BE ALL YOU CAN BE" learning about solving problems and managing people to get the most out of them. The hope is that he/she will love it so much that industry will have a hard time getting them to leave and even if they do leave, you now have a person in industry who really understands the Army.
5. One last topic is that of Core Competencies. Of course having a good definition of Core Competencies is critical. In some cases it seems to be a list of all competencies within

the organization. In other cases it is a list of the topics in which the organization is a world leader. Other lists fall somewhere in between. There are also various views on how core competencies should impact funding. One view is that funding of core competencies can be used to justify funding activities in which the organization is the best, or only, source of needed expertise, even if those areas do not support current priorities. Another view is that the Army (CCDC) should only fund the internal development of Core Competencies and buy the rest from industry. On the other hand there are those that agree that Core Competencies need to be funded internally but see no reason not to fund internal effort on other competencies if for nothing more than to be able to evaluate what industry is selling (be a "smart buyer"). Within the ASB there is not consensus on this issue. But what do you think?

The following lines of inquiry were provided to the Director, AFC Combat Systems:

1. One of the issues is the process of how does a program, funding, leadership and accountability transfer at MDD, Milestone A, Milestone B, Milestone C, and even from PM to AMC? From AFC to TRADOC?
2. We are developing a transition process which we believe will be acceptable to FCC, CCDC and ASA(ALT). This approach requires multiple prototypes to be developed because, while we know where we want to end up, we usually do NOT know which approach is the right one. Developing several prototypes with different approaches allows us to more likely pick the right one. In addition we are considering moving TRL 7 to occur as a necessary condition to pass Milestone B. GAO and other researchers show that the best predictor of program success is TRL 7 (not TRL 6) by Milestone B with 90% drawing release by EMD Critical Design Review. But we are not visiting to talk about our ideas. We want to hear what you think.

The following line of inquiry was provided to the Director, AFC AAL:

It seems to us that the Army Applications Lab is an experiment to see if a more industry-like organization can improve the identification, capture, and transition of innovative and disruptive technologies to acquisition from places like DARPA or Industry. While probably too early to really tell, how is it going? Have you discovered any internal Army or DOD restrictions which, while not deliberately created to impede your success, are getting in the way?

The following line of inquiry were provided to the Director, Systems Integration:

The DSI appears to be the equivalent of AFC's G-8 and focused on PPBES activities. The G-8 concept is viewed very favorably and in fact DARPA looked upon the G-8 as DARPA's transition point. Is this analogy true and if not how do you see the organization?

AFC Study team members engaged with LTG James Richardson (AFC DCG); MG Patrick Burden (AFC Director for Combat Systems); MAJ Jeremy Prince and Mr. John Thane (AAL); Dr. Kimberly Sablon (AFC Director for Science and Technology); Ms. Celeste Kennamer (DSI Deputy Director); and COL Karl Nell (DSI) via teleconference. Additionally, participants discussed organizing to function as opposed to functioning based on legacy organization, systems engineering and systems-of-systems engineering, Army acquisition process and reform, prototyping, Army S&T prioritization, and core competencies.

USMC Combat Development Command, Combat Development and Integration (CD&I) Capability Development Directorate; Quantico, VA (8 July 2019)

- Documents provided: SA Memo and Bios.
- Lines of Inquiry: Tasks from the TOR.

AFC Study team members engaged with BGen James Adams (Director, Capability Development Directorate), MAJ Ryan Collins (Liaison Officer from AFC FCC), and other members of the Capability Development Directorate. Additionally, participants discussed similarities and differences between priorities, activities, and operations of AFC and USMC; discussed which USMC practices might be relevant and applicable to AFC; and multi-domain operations. Study team members received copies of the USMC Force Development System User Guide (April 2018) and the Modern Louisiana Maneuvers (June 1999).

APPENDIX D: THE ACQUISITION PROCESS

Acquisition is the process the Army uses to acquire products necessary to accomplish its mission to deploy, fight, and win decisively against any adversary, anytime, and anywhere.

The Army Acquisition Executive (AAE) is the single official within the Army responsible for all acquisition functions within the Army. As designated by SECARMY, ASA(ALT) currently serves as the AAE.[35] For each Army-managed acquisition program, the AAE designates an MDA (usually him/herself for major programs).

It's important to note the acquisition process does not follow a rigid, one-size-fits-all methodology. Acquisition programs and procedures should be tailored to the characteristics of the product being acquired and to the totality of circumstances associated with the program, including operational urgency and risk factors.

All of acquisition begins with a requirement for an item or capability the warfighter needs, such as a weapon or other piece of equipment. Army planners assess current and future threats and OE as well as strategic documents such as the National Security Strategy, the National Defense Strategy, and the Army Vision, to forecast capabilities that the Army will require and to determine if capability gaps exist.

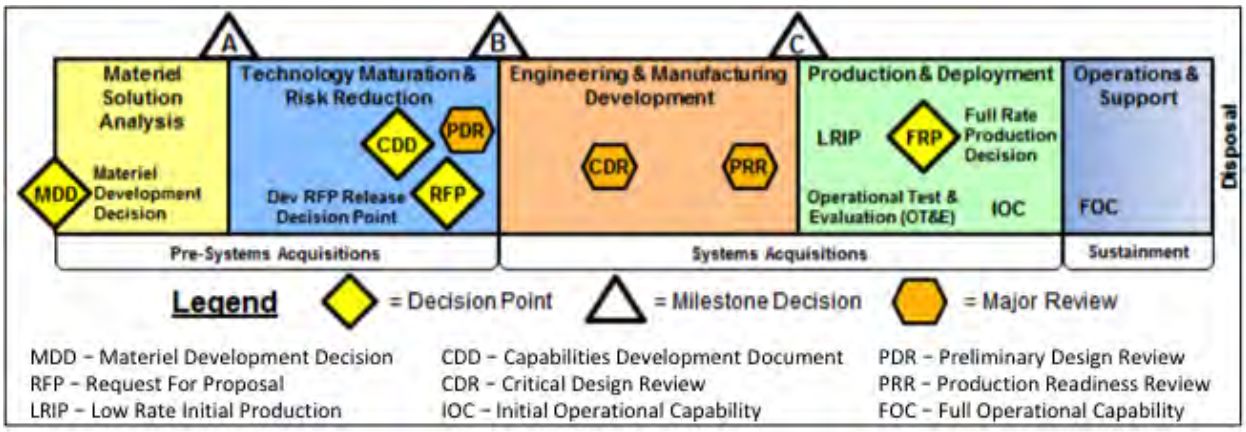
When a capability gap is identified, the Army analyzes whether it can be addressed by Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities, or Policy (DOTMLPF-P) changes. If yes, the capability shortfall is resolved via what is known as a non-materiel solution, such as a revision to doctrine or policy updates.

If Army planners determine that a materiel development item is required, a Materiel Development Decision (MDD) is made by the Milestone Decision Authority (MDA) and the Army begins the acquisition process to procure the item or system. This may involve purchasing off-the-shelf goods or the development of something new.

An Initial Capabilities Document (ICD) is created by developers to help support the MDA's MDD decision. The ICD provides justification for the requirement by stating the specific capability gaps that exist and recommending potential materiel solutions to resolve them. The ICD serves as the basis for the Materiel Solution Analysis (MSA) Phase that follows the MDD.

There are several Phases and milestone points for the Army acquisition process, along with key documents and reviews required to pass from one benchmark to the next (Fig. D.1).

[35] Headquarters Department of the Army, Army Regulation 70-1 – Army Acquisition Policy, 16 June 2017, http://www.dami.army.pentagon.mil/site/ARTPC/docs/ar70_1.pdf



Source: acqnotes.com

Figure D.1 The Acquisition Process

The major decision points and phases from MDD to MS B include:

- Materiel Development Decision (MDD) is a point in time when analysis has identified a capability gap/need and the MDD Review has determined that a materiel solution is needed. The Analysis of Alternatives (AoA) that follows MDD is expected to identify a preferred materiel solution.

- Materiel Solution Analysis (MSA) Phase between MDD and MS A assesses potential solutions for a needed capability. The main task is to conduct an AoA to evaluate the mission effectiveness, operational suitability, and estimated Life-Cycle Cost of alternative solutions.

- Milestone A is an MDA-led review at the end of the MSA Phase. Its purpose is to make a recommendation or seek approval to enter the Technology Maturation & Risk Reduction (TMRR) Phase.

- The TMRR Phase between MS A and B develops and demonstrates prototype designs to reduce technical risk, validate designs, validate cost estimates, evaluate manufacturing processes, and refine requirements.

- Milestone B is an MDA-led review at the end of the TMRR Phase. Its purpose is to make a recommendation or seek approval to enter the Engineering and Manufacturing Development (EMD) Phase.

During the MSA Phase, an Analysis of Alternatives (AoA) is performed to identify a preferred materiel solution, which may have several technology alternatives to be assessed if it is not clear which is best. An AoA is a study that assesses technology options associated with the potential materiel solutions and provides information on each solution's mission effectiveness, operational suitability and estimated life cycle costs. The AoA is used by the MDA to select and approve a materiel solution at MS A and inform the development of the Acquisition Strategy

(AS), which is a comprehensive, written plan that identifies and describes the approach that will be used to acquire the materiel solution necessary to address the requirement.

A draft Capabilities Development Document (CDD) will also be produced during the MSA phase specifying operational requirements for the system that will deliver the capability that meets operational performance criteria specified in the ICD. The CDD will include Key Performance Parameters (KPPs), Key System Attributes (KSAs), Additional Performance Attributes (APAs), and other related information necessary to develop one or more increments of the materiel capability solution.

The MSA phase ends only when the AoA has been completed and the MDA approves a materiel solution, the Acquisition Strategy, the Systems Engineering Plan (SEP), the Test and Evaluation Master Plan (TEMP), and the Life Cycle Sustainment Plan (LCSP) at MS A (MS A). The program then transitions into the Technology Maturation & Risk Reduction (TMRR) Phase.

The purpose of the TMRR Phase is to reduce technical risk by demonstrating critical technologies in competitive prototyping activities. During this Phase, acquisition personnel will determine and mature the appropriate set of technologies to be integrated into a full system; reduce all sources of risk; further develop and then approve a final CDD at the CDD Validation (CDD-V) review; conduct a preliminary design review (PDR) of the proposed system; and release the Development Request for Proposal (DRFP) at the Development RFP Decision (DRFPD).

A project exits the TMRR Phase only when the technology has been demonstrated in a relevant environment and manufacturing risks have been identified. Current DoD policy requires a system achieve a minimum of Technological Readiness Level 6 (TRL 6) in the TMRR Phase, which means a system/subsystem model or prototype demonstration in a relevant environment has occurred, such as a high-fidelity laboratory environment or in a simulated operational environment (Fig. D.2).

In addition to prototyping, the CDD must be validated. The decision point occurs where major cost and performance trades have been completed and enough risk reduction has been completed to support a decision to commit to a set of requirements that will be used for Preliminary Design Review (PDR) and item development and production.

The PDR is a technical assessment to ensure a system is operationally effective. It is conducted before the start of detailed design work and is the first opportunity for the Government to closely evaluate designs created internally and/or by contractors. The PDR establishes the allocated baseline (hardware, software, human/support systems) and underlying architectures to ensure that the system under review has a reasonable expectation of satisfying the requirements within the currently allocated budget and schedule.

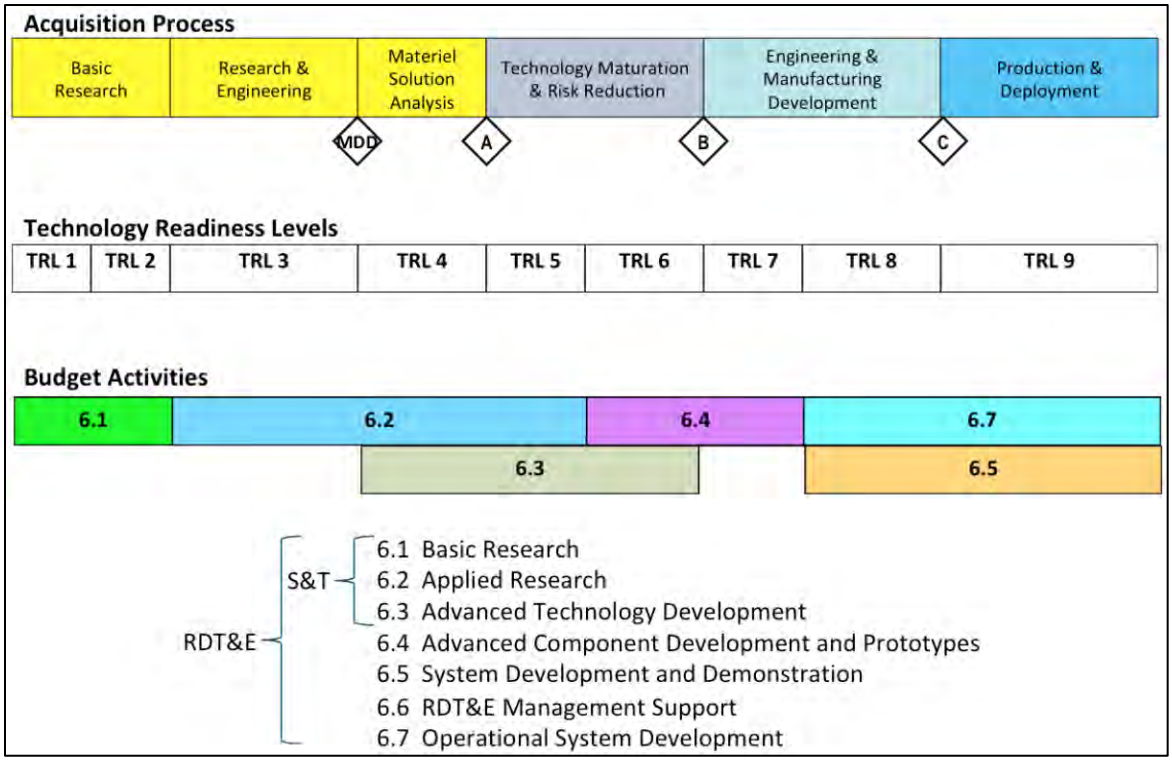


Figure D.2 Milestones (Current DoD Policy)

The MDA will authorize the release of the DRFP following the CDD validation and the PDR. This is considered the most critical decision point in the acquisition process because it allows for the release of RFPs to industry to begin development or start Low-Rate Initial Production (LRIP). Prior to the DRFPD the MDA must ensure all risks are understood and under control, that the program plan is sound, and that the program will be affordable and executable. Only then can a program pass MS B and enter the Engineering and Manufacturing Development (EMD) Phase, which is where the product is built. Prior to or at MS B a PM will also be assigned to carry the project forward.

At MS B the MDA will approve an updated Acquisition Strategy (AS), the Acquisition Program Baseline (APB), LRIP quantities, the exit criteria for the EMD Phase, and the type of contract that will be issued. The MDA will also issue a MS B Certification and Determination Document and an Acquisition Decision Memorandum (ADM), in addition to deciding to accept or reject any PM's information waiver requests for the next decision event.

Finally, before a new DoD acquisition program can be initiated at MS B, the following three questions must be answered affirmatively by the MDA:

1) Does the acquisition support core/priority mission functions that need to be performed by the Federal government?

2) Does the acquisition need to be undertaken by the DoD Component because no alternative private sector or government source can better support the function?

3) Does the acquisition support work processes that reduce costs, improve effectiveness, and make maximum use of commercial off-the-shelf technology?

The purpose of the EMD Phase is to verify that all operational and derived performance requirements have been met and to complete the development of a system or increment of capability, complete full system integration, develop affordable and executable manufacturing processes, complete system fabrication, and test and evaluate the system before proceeding into the Production and Deployment (PD) Phase. In addition, during EMD, all hardware and software design is completed; open risks are systematically retired; prototypes or first articles are built and tested to ensure they comply with capability requirements; and steps are taken to prepare for production or deployment, to include the establishment of an initial product baseline for all configuration items.

The EMD Phase consists of multiple design iterations and reviews to converge on a final design for production. The CDD, AS, SEP, LCSP, and TEMP guide this effort. This process culminates in a Critical Design Review (CDR) which provides an opportunity for assessment of design maturity based on program-related measures, such as adequate developmental testing, various logistic analyses, and establishment of system reliability based on demonstrated reliability rates. During this phase the PM will also finalize designs of the product support elements.

A Production Readiness Review (PRR) will also occur during EMD. In addition to determining if the design is ready for production, the PRR assesses whether prime contractor and major subcontractors have accomplished adequate production planning without incurring unacceptable risks that will breach thresholds of schedule, performance, cost, or other established criteria. PRRs are normally performed toward the end of EMD and should be performed during the System Capability and Manufacturing Process Demonstration to identify and mitigate risks as the design progresses.

The EMD Phase ends when the following conditions have been met:

1) The design is stable and is no longer being modified

2) The system meets validated capability requirements demonstrated by developmental and initial operational testing as required in the TEMP

3) Manufacturing processes have been effectively demonstrated and are under control

4) Industrial production capabilities are reasonably available

5) System has met or exceeded all directed EMD Phase Exit criteria and MS C Entrance Criteria

MS C occurs where a program is reviewed to determine if it can exit the EMD Phase and commence the PD Phase. When entry has been authorized by the MDA it means LRIP may begin for Major Defense Acquisition Programs (MDAPs).

A subsequent review within this phase may allow for full rate production of the system, though only after Operational Test and Evaluation (OT&E), and only once the system meets performance standards and is reliable, the contractor has demonstrated control of the manufacturing process, and adequate support and sustainment systems have been established. Entry into the PD Phase permits full rate production although Low Rate Initial Production (LRIP) may be required by the MDA. MS C also allows for limited deployment for Major Automated Information Systems (MAIS) or software intensive systems with no production components.

The purpose of the PD phase is to produce and deliver products that are requirement-compliant and will fill the capability gap identified at the beginning of the acquisition process. It is during this phase that the product is fielded and used by operational units and all system sustainment and support activities are initiated if they haven't already commenced. During the PD Phase, OT&E will occur in which the system is field tested under realistic combat conditions to ensure the product is operationally effective and suitable, bringing the system to TRL 9. When applicable, Live Fire Test and Evaluation (LFT&E) will be conducted to examine the vulnerability and lethality of a system. LFT&E will provide information to decision-makers on potential user casualties, vulnerabilities, and lethality, taking into equal consideration susceptibility to attack and combat performance of the system. It will also ensure that knowledge of user casualties and system vulnerabilities or lethality is based on testing of the system under realistic combat conditions; will allow any design deficiency identified by the testing and evaluation to be corrected in design or employment before proceeding beyond LRIP; and will assess recoverability from battle damage and battle damage repair capabilities and issues.

Once sufficient OT&E and LFT&E have been completed, evaluation reports will be issued which will aid in the MDA's decision on whether or not to authorize Full Rate Production (FRP) for MDAPs or require further changes to the product.

During the PD Phase, Initial Operational Capacity (IOC) is attained. IOC criteria are defined in a program's CDD. IOC is considered the first attainment by a unit of the capability the item is supposed to provide. It requires that the unit and support personnel have been trained to operate and maintain the item or system in an operational environment, and certification that the unit can be supported in an operational environment as needed. The designation usually occurs after full-rate production and implies the unit is combat ready.

Once FRP has commenced and an IOC has occurred, a program moves into the Operations and Support (O&S) Phase of an acquisition program's life cycle. This phase has two major efforts: life cycle sustainment and disposal. During this phase the PM will deploy the Product Support Strategy and monitor its performance according to the LCSP.

For the O&S phase to be successful, a program must maintain performance and sustainment requirements, remain affordable, and achieve cost reductions to the greatest extent possible. This will require close coordination between the user, resource sponsors, manufacturers, and other stakeholders, along with effective management of support arrangements and contracts.

During O&S the PM must also measure, assess, and report on system readiness using sustainment metrics, and implement corrective actions for trends diverging from required performance outcomes defined in the Acquisition Program Baseline and LCSP.

At some point during the O&S phase, Full Operational Capability (FOC) will be reached. This is defined as when all units and/or organizations in the force structure scheduled to receive a system have received it and can employ and maintain it. In other words, the capability gap originally identified at the beginning of the acquisition process as an Army requirement that is necessary to accomplish the mission has been met.

Once the capability is no longer needed or a system has reached the end of its useful life, the final, disposal phase of the Army acquisition process and the product life cycle commences. The purpose is to demilitarize and dispose of an item, which must be done in such a way as to comply with legal and regulatory requirements related to security, safety, and the environment. This can be accomplished by recycling or reusing the system components and materials; reprocessing system components and materials into a useful format; sale or donation to the private sector or other governments, or via waste disposal. Once proper disposal of an item has been achieved, the Army acquisition process ends.

APPENDIX E: ACQUISITION SYSTEM DEFINITIONS

E.1 ACQUISITION CATEGORY DEFINITIONS[36]

Acquisition Category	Reason for ACAT Designation (all funding in FY 2014 constant dollars)	Decision Authority*
ACAT I	Major Defense Acquisition Program (MDAP) Estimated to require an eventual total expenditure: • for RDT&E of more than **$480 million** or, • for procurement, of more than **$2.79 billion**	ACAT I: DAE or as delegated
ACAT IA	Major Automated Information System (MAIS) Estimated to exceed: • **$40 million** for all expenditures, for all increments, regardless of the appropriation or fund source, directly related to the AIS definition, design, development, and deployment, and incurred in any single fiscal year; or • **$165 million** incurred from the beginning of the Materiel Solution Analysis Phase through deployment at all sites; or • **$520 million** incurred from the beginning of the Materiel Solution Analysis Phase through sustainment for the estimated useful life of the system.	ACAT IA: DAE or as delegated
ACAT II	Does not meet criteria for ACAT I or IA Major system. Estimated to require an eventual total expenditure • for RDT&E of more than $185 million, or • for procurement of more than $835 million	CAE or the individual designated by the CAE
ACAT III	Those acquisition programs that do not meet ACAT I or II criteria.	

* DAE – Defense Acquisition Executive, CAE – Component Acquisition Executive (Secretary of a Military Department or Head of Defense Agency)

E.2 BUDGET ACTIVITY DEFINITIONS[37]

6.1 Budget Activity 1, Basic Research. Basic research is systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications towards processes or products in mind. It

[36] Source: http://acqnotes.com/acqnote/acquisitions/acquisition-category

[37] Source: DoD Comptroller, *DoD 7000.14-R, Financial Management Regulation*, Volume 2B, Chapter 5, November 2017, https://comptroller.defense.gov/Portals/45/documents/fmr/current/02b/02b_05.pdf

includes all scientific study and experimentation directed toward increasing fundamental knowledge and understanding in those fields of the physical, engineering, environmental, and life sciences related to long-term national security needs. It is farsighted high payoff research that provides the basis for technological progress. Basic research may lead to: (a) subsequent applied research and advanced technology developments in Defense-related technologies, and (b) new and improved military functional capabilities in areas such as communications, detection, tracking, surveillance, propulsion, mobility, guidance and control, navigation, energy conversion, materials and structures, and personnel support. Program elements in this category involve pre-MS A efforts.

6.2 Budget Activity 2, Applied Research. Applied research is systematic study to understand the means to meet a recognized and specific need. It is a systematic expansion and application of knowledge to develop useful materials, devices, and systems or methods. It may be oriented, ultimately, toward the design, development, and improvement of prototypes and new processes to meet general mission area requirements. Applied research may translate promising basic research into solutions for broadly defined military needs, short of system development. This type of effort may vary from systematic mission-directed research beyond that in Budget Activity 1 to sophisticated breadboard hardware, study, programming and planning efforts that establish the initial feasibility and practicality of proposed solutions to technological challenges. It includes studies, investigations, and non-system specific technology efforts. The dominant characteristic is that applied research is directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters. Applied Research precedes system specific technology investigations or development. Program control of the Applied Research program element is normally exercised by general level of effort. Program elements in this category involve pre-MS B efforts, also known as Concept and Technology Development phase tasks, such as concept exploration efforts and paper studies of alternative concepts for meeting a mission need.

6.3 Budget Activity 3, Advanced Technology Development (ATD). This budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment. Budget Activity 3 includes concept and technology demonstrations of components and subsystems or system models. The models may be form, fit, and function prototypes or scaled models that serve the same demonstration purpose. The results of this type of effort are proof of technological feasibility and assessment of subsystem and component operability and producibility rather than the development of hardware for service use. Projects in this category have a direct relevance to identified military needs. Advanced Technology Development demonstrates the general military utility or cost reduction potential of technology when applied to different types of military equipment or techniques. Program elements in this category involve pre-MS B efforts, such as system concept demonstration, joint and Service-specific experiments or Technology Demonstrations and generally have Technology Readiness Levels of 4, 5, or 6. (For further discussion on Technology Readiness Levels, see the Assistant Secretary of Defense for Research and Engineering's Technology Readiness

Assessment (TRA) Guidance.) Projects in this category do not necessarily lead to subsequent development or procurement phases, but should have the goal of moving out of Science and Technology (S&T) and into the acquisition process within the Future Years Defense Program (FYDP). Upon successful completion of projects that have military utility, the technology should be available for transition.

6.4 Budget Activity 4, Advanced Component Development and Prototypes (ACD&P). Efforts necessary to evaluate integrated technologies, representative modes, or prototype systems in a high fidelity and realistic OE are funded in this budget activity. The ACD&P phase includes system specific efforts that help expedite technology transition from the laboratory to operational use. Emphasis is on proving component and subsystem maturity prior to integration in major and complex systems and may involve risk reduction initiatives. Program elements in this category involve efforts prior to MS B and are referred to as advanced component development activities and include technology demonstrations. Completion of Technology Readiness Levels 6 and 7 should be achieved for major programs. Program control is exercised at the program and project level. A logical progression of program phases and development and/or production funding must be evident in the FYDP.

6.5 Budget Activity 5, System Development and Demonstration (SDD). System Development and Demonstration (SDD) programs have passed MS B approval and are conducting engineering and manufacturing development tasks aimed at meeting validated requirements prior to full-rate production. This budget activity is characterized by major line item projects, and program control is exercised by review of individual programs and projects. Prototype performance is near or at planned operational system levels. Characteristics of this budget activity involve mature system development, integration, demonstration to support MS C decisions, conducting live fire test and evaluation, and initial operational test and evaluation of production representative articles. A logical progression of program phases and development and production funding must be evident in the FYDP consistent with the Department's full funding policy.

6.6 Budget Activity 6, RDT&E Management Support. This budget activity includes management support for research, development, test, and evaluation efforts and funds to sustain and/or modernize the installations or operations required for general research, development, test, and evaluation. Test ranges, military construction, maintenance support of laboratories, operation and maintenance of test aircraft and ships, and studies and analyses in support of the RDT&E program are funded in this budget activity. Costs of laboratory personnel, either in-house or contractor operated, would be assigned to appropriate projects or as a line item in the Basic Research, Applied Research, or ATD program areas, as appropriate. Military construction costs directly related to major development programs are included in this budget activity.

6.7 Budget Activity 7, Operational System Development. This budget activity includes development efforts to upgrade systems that have been fielded or have received approval for full rate production and anticipate production funding in the current or subsequent fiscal year. All items are major line item projects that appear as RDT&E Costs of Weapon System Elements

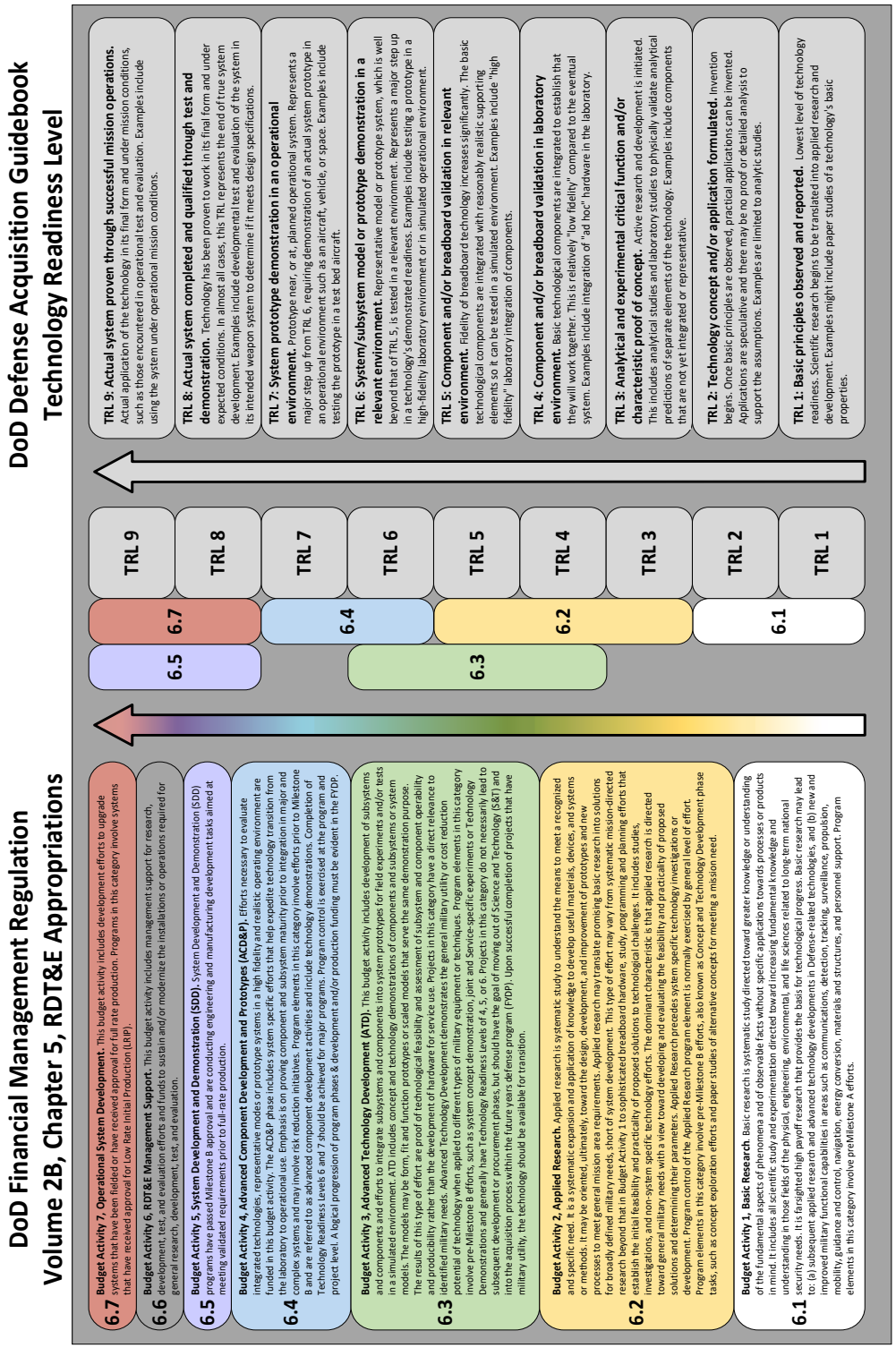
in other programs. Program control is exercised by review of individual projects. Programs in this category involve systems that have received approval for Low Rate Initial Production (LRIP). A logical progression of program phases and development and production funding must be evident in the FYDP, consistent with the Department's full funding policy.

E.3 TECHNOLOGY READINESS LEVEL (TRL) DEFINITIONS AND DESCRIPTIONS[38]

TRL	Definition	Description
1	Basic principles observed and reported.	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development (R&D). Examples might include paper studies of a technology's basic properties.
2	Technology concept and/or application formulated.	Invention begins. Once basic principles are observed, practical applications can be invented. Applications are speculative, and there may be no proof or detailed analysis to support the assumptions. Examples are limited to analytic studies.
3	Analytical and experimental critical function and/or characteristic proof of concept.	Active R&D is initiated. This includes analytical studies and laboratory studies to physically validate the analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.
4	Component and/or breadboard validation in a laboratory environment.	Basic technological components are integrated to establish that they will work together. This is relatively "low fidelity" compared with the eventual system. Examples include integration of "ad hoc" hardware in the laboratory.
5	Component and/or breadboard validation in a relevant environment.	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so they can be tested in a simulated environment. Examples include "high-fidelity" laboratory integration of components.
6	System/subsystem model or prototype demonstration in a relevant environment.	Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high-fidelity laboratory environment or in a simulated operational environment.
7	System prototype demonstration in an operational environment.	Prototype near or at planned operational system. Represents a major step up from TRL 6 by requiring demonstration of an actual system prototype in an operational environment (e.g., in an aircraft, in a vehicle, or in space).
8	Actual system completed and qualified through test and demonstration.	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation (DT&E) of the system in its intended weapon system to determine if it meets design specifications.
9	Actual system proven through successful mission operations.	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation (OT&E). Examples include using the system under operational mission conditions.

[38] Source: Assistant Secretary of Defense for Research and Engineering, Department of Defense Technology Readiness Assessment (TRA) Guidance, Apr 2011, https://www.acq.osd.mil/ecp/DOCS/DoDGuidance/TRA2011.pdf

E.4 BUDGET ACTIVITIES AND TRLS[39]



[39] Source: https://www.dau.edu/cop/stm/DAU%20Sponsored%20Documents/FMR-TRL%20map.pdf#search=TRL%20Budget%20activities

APPENDIX F: ANALYSIS OF SELECTED ARMY PROGRAMS

Beginning in 2003, the General Accountability Office (GAO) has prepared an annual Report to Congressional Committees that assesses Weapon Programs.[40] These reports provide historical data that permit analyzing selected Army program outcomes. Data were also taken from two other GAO reports included in the list of references.

The 2003 annual report explains the GAO approach:

> GAO's assessments are anchored in a knowledge-based approach to product development that reflects best practices of successful programs. This approach centers on attaining high levels of knowledge in three elements of a new product or weapon—technology, design, and production. If a program is not attaining this level of knowledge, it incurs increased risk of technical problems, accompanied by cost and schedule growth. If a program is falling short in one element, like technology maturity, it is harder to attain knowledge in succeeding elements.

These knowledge points and associated indicators are defined as follows.

1. Knowledge point 1: Resources and needs are matched. … A best practice is to achieve a high level of technology maturity at the start of product development. This means that the technologies needed to meet essential product requirements have been demonstrated to work in their intended environment.

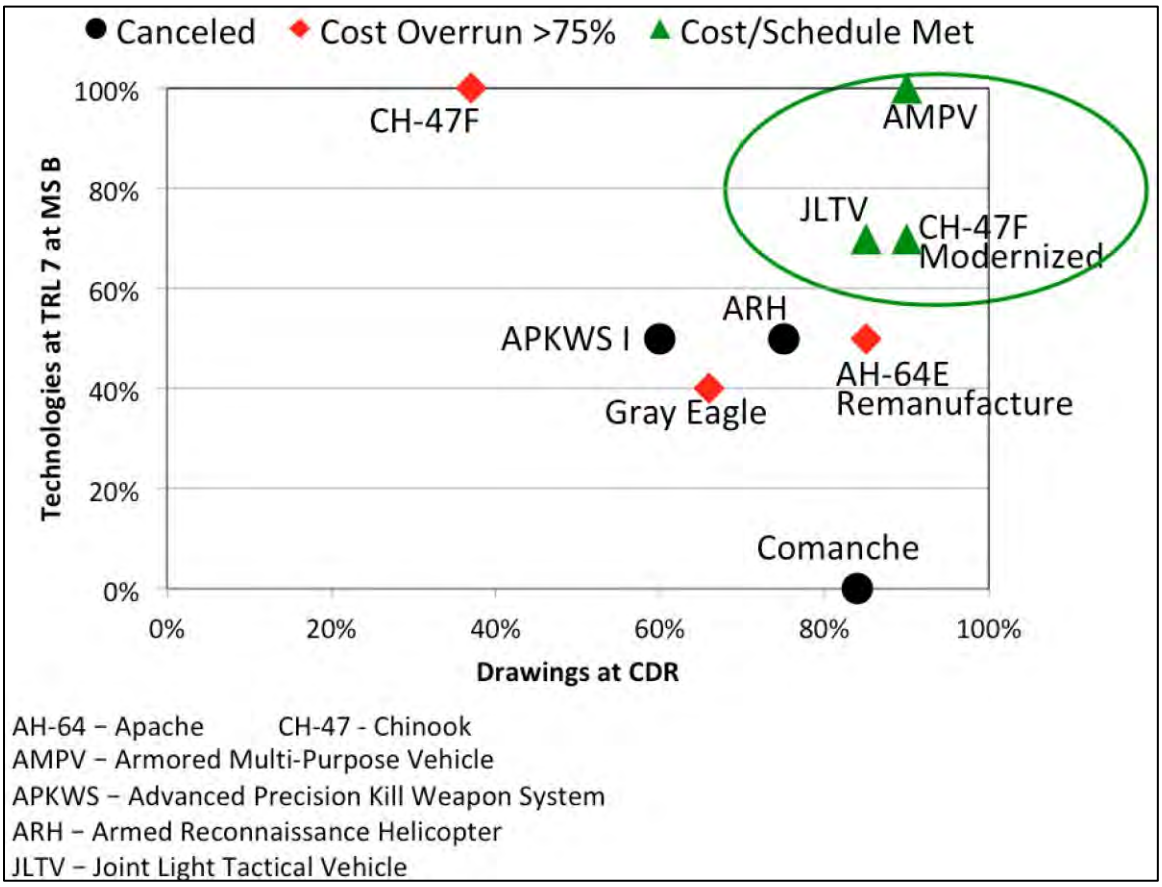
2. Knowledge point 2: The product design is stable. … A best practice is to achieve design stability at the system-level critical design review, usually held midway through development. Completion of engineering drawings at the system design review provides tangible evidence that the design is stable.

3. Knowledge point 3: Production processes are mature. … A best practice is to achieve production maturity at the start of production. This means that all key manufacturing processes produce output within statistically acceptable limits for quality.

This analysis focuses on the first two knowledge points. The plot below indicates for nine Army programs the technology maturity achieved by MS B and the percentage of drawings released by critical design review. The color and shape of each data point indicate whether the program was canceled (black circle), had cost overruns greater than 75% (red diamond), or met schedule and cost goals (green triangle). Note that the successful programs are clustered in the upper right corner indicating high technology maturity and a high percentage of drawing release.

[40] GAO Annual weapons assessments from 2003-2019 were used to develop this analysis are available at https://www.gao.gov/reports-testimonies/

The remainder of this Appendix summarizes the data available for each program and the rationale for the location of each data point.



F.1 Army Program Analysis

F.1 CANCELED PROGRAMS

Advanced Precision Kill Weapon System (APKWS)	

- 2005: Development start 12/02, APKWS entered system development and held its design review before demonstrating that its critical laser guidance technology was fully mature. GAO considered technology maturity to be ~50% While the system's design was

otherwise stable at the March 2004 design review, initial system-level testing identified problems with the design. Program officials released 100 percent of the drawings but testing uncovered the need for design changes.

- 2006: Integration of the laser on the fins rather than the head of the missile proved to be more problematic then originally estimated. The integration issue contributed to the cost overrun and protracted schedule, which led to program curtailment by the MDA, PEO Missiles & Space, January 2005. A restructured APKWS II is expected to begin mid-2006.

- Data Point: 50% TRL 7 by MS B, 100% Drawing release by CDR but reduced to 60% since design had to be changed, Program canceled due to configuration issues that could not be overcome.

Armed Reconnaissance Helicopter	

- 2007: Development start 7/05, GAO assessed technology maturity at ~50%

- 2008: Sensor will not demonstrate maturity until 6/08. Navy was to lead sensor development effort, but delays meant that ARH would bear the burden of development. Stop-work order issued 3/07. GAO assessed ~75% design release.

- 2009: Program ended 10/08 following a critical Nunn-McCurdy unit cost breach.

- Data Point: 50% TRL 7 by MS B, 75% design release, Program canceled after critical Nunn-McCurdy cost breach

Comanche Reconnaissance Attack Helicopter RAH-66	

- 2001: Meeting the size and weight requirements depended on new technologies such as advanced forward-looking infrared and integrated avionics. The Army decided to launch the program despite the significant lack of knowledge about the needed technologies, leaving a mismatch between requirements and available resources, and chose to develop the new technologies during the product development program.

- 2003: Schedule – Development Start 4/00, Full-rate decision 11/09
  Design maturity – the program has released 73% of drawings and rescheduled the design review by 9 months later.

- 2004: 84% of design drawings were released by design review. The Army has terminated the Comanche program to reallocate resources.

- 2016a: Comanche experienced 101% cost growth and 120% schedule delay. There were many reasons, of which technology immaturity is only one. Other factors, such as changing the scope, funding, and pace of the program for affordability reasons, have also contributed.

- Data Point: 0% TRL 7 by MS B, 84% Drawing release by CDR, Program canceled due to technology immaturity, cost increases, schedule delays, performance shortfalls, and reallocation of resources due to changing priorities in the Army.

F.2 PROGRAMS WITH LARGE COST OVERRUNS

Apache AH-64E Remanufacture	

- 2010: Upgrading AH-64D in three sets of upgrades; first of which requires AH-64Ds being sent to factory, second and third are field upgrades. Apache Block III (AB3) entered system development in July 2006 with its one critical technology—an improved drive system—nearing maturity. GAO assessed maturity at ~50%.
  85% design release for first upgrade at design review.

- 2011: The AB3 program experienced a Nunn-McCurdy unit cost breach of the critical threshold in June 2010, due to the addition of 56 new-build helicopters to the upgrade program (new-build helicopters cost 3x remanufactured ones). The program was split to separate new build from remanufacture.

- 2012: Apache Block III Remanufacture program (not including new builds) R&D cost increases above 8/06 baseline: R&D 42%, procurement 49%

- 2013: First set of upgrades is underway (28 AH-64Es delivered). Due to government-wide affordability concerns annual production rate reduced from 60 to 48. Total program cost increase 58%, unit cost increase 49%

- 2019: Increase in total acquisition cost 79%

- Data Point: 50% TRL 7 by MS B, 85% design release, Cost increase 79%

CH-47F Improved Cargo Helicopter	

- 2003: Schedule – Development Start 12/97, Full-rate decision 11/04
  37% of drawings released at design review
  Nunn-McCurdy breach December 2001 due to increased labor and material costs, added requirements, recapitalization of SOF aircraft, and initial underestimate of costs.
  Program re-baseline.

- 2004: All critical technologies are mature and were demonstrated prior to integration into the CH-47F development program

- 2005: Unit cost doubled over 1998 estimate, Total program cost increased by 131%

- 2006: Total quantities increased to include 55 new-build helicopters. Total program cost increased by 279% over 1998 estimate

- 2019: Total program cost increased by 355%

- Data Point: 100% TRL 7 by MS B, 37% design release, Cost increase by 355%

Gray Eagle Unmanned Aircraft System MQ-1C (formerly Extended Range/Multi-Purpose Unmanned Aircraft and Sky Warrior UAS)	

- 2006: Two of four critical technologies were mature at development start (50%)

- 2007: 92% drawing release at CDR

- 2008: In Sept 2007 DoD directed that Predator and Sky Warrior be combined.
- 2009: Due to requirements changes, redesign, and technology improvement the number of drawings has increased by 39%, reducing the design release at CDR to 66%
- 2010: AF has decided not to acquire MQ-1C Predator so program merger moot.
- 2011: Program entered production Feb 2010. Five critical technologies – heavy fuel engine and deicing are mature, automatic takeoff and landing, tactical common data link, and manned-unmanned teaming are nearing maturity so 40% technology maturity
- 2012: A Mar 2011 aircraft accident resulted in hardware and software changes and testing delays.
- 2013: All five technologies are now mature. There was also a 67% increase in drawings due to new ground control system.
- 2014: May be more design changes if tail retrofit accepted.
- 2019: Total acquisition cost increase 457%
- Data Point: 40% TRL 7 by MS B, 66% Drawing release by CDR, Cost increase 457%

F.3 PROGRAMS ON COST AND SCHEDULE

Armored Multi-Purpose Vehicle (AMPV)	

- 2013: MDD March 2012
- 2014: Acquisition strategy is based on modifying an existing platform and bypasses the technology development phase to begin in system development
- 2015: Entered system development in December 2014 with critical technologies fully mature

- 2016: Critical design review 6/16, IOC 6/22
- 2017: 90% drawing release by CDR
- 2018: Following CDR the number of drawings grew by 19% so that the number released at CDR was reduced to 76%
- 2019: Following testing the number of drawings was reduced by 19% so 90% were released prior to CDR. Projected IOC 3/22, Unit cost increase 1.8%
- Data Point: 100% TRL 7 by MS B, 90% Drawing release by CDR, On cost and schedule.

CH-47F Modernized Cargo Helicopter (CH-47F Block II)	

- 2019: Development start 7/17, Design review 12/17, low-rate production 8/21. The program office has identified two critical technologies—Ferrium C61 steel and the advanced Chinook rotor blade (ACRB)—that it assesses as approaching maturity. TRL 6 rather than TRL 7 at program start – partial credit – 70%. Released 90% of design drawings by CDR. Prior to CDR, however, the program did not elect to developmentally test a fully configured, production representative prototype in its intended environment. Until the program completes this testing, it cannot know whether its design is stable. Program is ahead of schedule and within expected cost.
- Data Point: 70% TRL 7 by MS B, 90% design release, On cost and schedule

Joint Light Tactical Vehicle (JLTV)	

- 2012: In October 2008 the Army awarded three technology development contracts. The contractors delivered prototypes in May 2010 and testing was completed in June 2011. Based on test results the Army and Marine Corps made changes to requirements to improve likelihood of meeting requirements and reducing cost.

- 2013: Two critical technologies nearing maturity at system development start August 2012. Army issued three EMD contracts

- 2014: In lieu of a critical design review, the program held a design understanding review in January 2013, and according to program documents, confirmed that all three contractors had more than 90 percent of design files under configuration control.

- 2017: GAO indicates Technology maturity at development start was demonstrated at TRL 6 (in a relevant environment) but not TRL 7 (in a realistic environment) – partial credit 70%.

- 2019: During 2018 the program's total number of drawings increased to accommodate needed retrofits, capability changes, and delayed release of vehicle parts. These drawing increases caused the program to fall just short of 90% design drawings released at CDR. Acquisition cost 4.7% below original estimates.

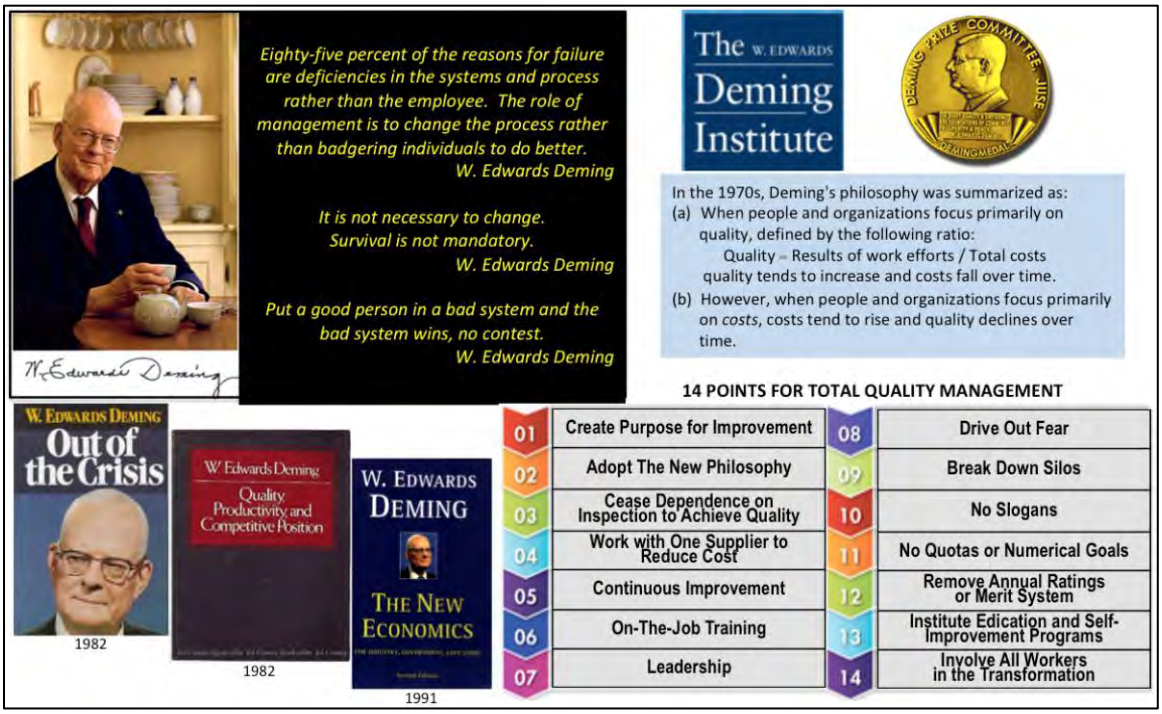
- Data Point: 70% TRL 7 by MS B, 85% design release, On cost and schedule

APPENDIX G: DEMING'S TOTAL QUALITY MANAGEMENT (TQM)

W. Edwards Deming was a leader in developing TQM in the U.S. during the 1980s. The Deming technique used by Ford Motor Company transformed the company into using cutting edge technical solutions to build cars with high quality compared to other manufacturers at a competitive price. As a result, Ford became competitive with the Japanese.

Deming is best known for his 14 Points for TQM (Fig. G.1), first presented in 1982 book Out of The Crisis.[41] Other famous quotations include:

- Eighty-five percent of the reasons for failure are deficiencies in the systems and process rather than the employee. The role of management is to change the process rather than badgering individuals to do better.
- It is not necessary to change. Survival is not mandatory.
- Put a good person in a bad system and the bad system wins, no contest.



G.1 W. Edwards Deming (1900-1993)

[41] W. Edwards Deming, *Out of the Crisis,* MIT Press, 1982.

APPENDIX H: ASB APPROVED BRIEFING WITH FINDINGS & RECOMMENDATIONS

The following briefing was presented to ASB members in plenary session on 18 July 2019. The study team's findings and recommendations were adopted unanimously by the ASB membership.

Background

"The competitive advantage the Army has long enjoyed has eroded."
The Honorable Ryan D. McCarthy, Undersecretary of the Army, Oct 2017

- Effective 1 July 2018, AFC was established with a goal of unity of command with regard to the development of future capabilities. AFC opened its doors in Austin in January 2019.
- **Mission:** "Develop the required Army of the future through increased lethality and capability overmatch against potential peer adversaries."
- **Vision:** "AFC will drive an agile process to more quickly produce better solutions with greater value; unify the modernization enterprise and enable it to speak with one, four-star voice; and build trust by creating transparency across the future force modernization enterprise."
- **Structure**: "AFC consists of a headquarters and three major subordinate organizations: the Futures and Concepts Center (FCC), Combat Capabilities Development Command (CCDC), and Combat Systems Directorate."

Source: The Army's Plan for the Establishment of U.S. Army Futures Command, Report to Congressional Committees by Secretary Esper, 1 Jan 2019

BLUF - AFC Organization & Army Acquisition Process

Two Important Outputs

- AFC organizational changes to enhance probability of success
  - Boards of Advisors
  - Unifying Horizontal and Vertical Culture
  - Core Competencies: Add Systems Engineering and Additive Manufacturing
- Army Acquisition System Changes independent of AFC to dramatically change output performance
  - Assure continuity of leadership
    - Establish Special Task Force to produce Milestone B decision documents
  - Move TRL 7 to be before Milestone B
    - Encourage multiple prototyping
  - Enforce 90% Drawing Release to be before CDR

Outline

- Study Introduction
  - Terms of Reference
  - Team Members
  - Visits
  - Key Reports
- Army Futures Command Organization
- The Acquisition Process
- Measures of Effectiveness

Terms of Reference (TOR) Tasks

A. Recommend process and procedure changes deemed necessary to achieve AFC objectives. These changes may range from making semantical shifts, such as adopting business terms in favor of Government acquisition terms to adopting commercial organizational structures that ensure integration across the command, to reinterpreting the Federal Acquisition Regulation more in line with other Services and Department of Defense agencies.

B. Recommend best practices from large commercial, public services, and other Government organizations that have demonstrated success either driving or surviving continuous, disruptive change.

C. Assess current implementation of recommendations from:
   - 2010 Army Acquisition Review, "Army Strong, Equipped, Trained and Ready" (Decker-Wagner Report)
   - 2013 ASB study "Army S&T Essential Core Competencies"

D. Examine relationship required with industry to ensure Army focuses on core competencies and leverages the best available outside talent to create a fast moving, innovative, and future-thinking organization.

E. Recommend Measures of Effectiveness (MOEs) that will identify success and help articulate that success.

ASB AFC Team

Members

- Tony Tether, PhD - chair
- Nancy Chesser, PhD - vice chair
- LtGen (Ret) Emo Gardner, USMC
- Bill Guyton
- COL (Ret) Sue Myers, PhD

Government Advisor

- Rob Swope, ASA(ALT)

Senior Mentor

- George Singley III

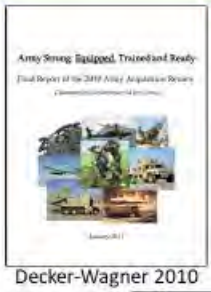
Study Manager

- Mary Arthur, CCDC Army Research Laboratory

Team Visits

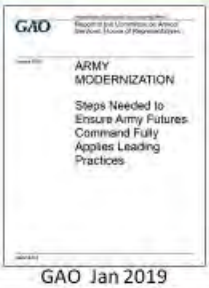
- AFC
  - Headquarters
    - Army Applications Lab (AAL)
    - Army Test & Evaluation Command (ATEC) – direct support to AFC
    - Directorate of Systems Integration (DSI)
  - Futures and Concepts Center (FCC)
  - Combat Capabilities Development Command (CCDC)
    - CSISR Center
    - Data & Analysis Center
    - Chem-Bio Center
    - Army Research Laboratory (ARL)
  - Combat Systems Directorate
- Other Army
  - PEO Intelligence, Electronic Warfare & Sensors (IEW&S)
  - PEO Command, Control, Communications – Tactical (C3T)
  - Rapid Capabilities & Critical Technologies Office (RCCTO)
- Other DoD
  - USMC, Capabilities Development Directorate
- Federally Funded R&D Centers (FFRDCs)
  - MIT Lincoln Lab
  - Aerospace Corp

Key Reports

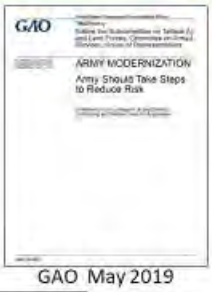


Decker-Wagner 2010

GWU Maturity 2013



GAO Jan 2019



GAO May 2019

Core Competencies 2013

MIT Sloan TRLs at 40 2015

GAO May 2019

GAO – Government Accountabilty Office GWU – George Washington University

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Secretary of the Army Responsibility Definitions

- "The **Commanding General, AFC**, leads and is responsible for the Army's future force modernization enterprise. As the Army's Chief Futures Modernization Investment Officer, the Commanding General, **in consultation** with the Assistant Secretary of the Army (Acquisition, Logistics and Technology) (ASA (ALT)), will prioritize, direct, integrate, and synchronize **science and technology*** efforts, operations, and organizations across the Army's modernization enterprise."
- "The **ASA (ALT)** is responsible for overseeing the acquisition, logistics, and technology matters of the Department of the Army. The ASA (ALT) is also the Army's chief scientist. As the Army Acquisition Executive, the ASA (ALT) is responsible for the management and control of the Army **acquisition system**."**

* Budget Activities 6.1-6.3 ** 6.1-6.3 plus 6.4-6.7

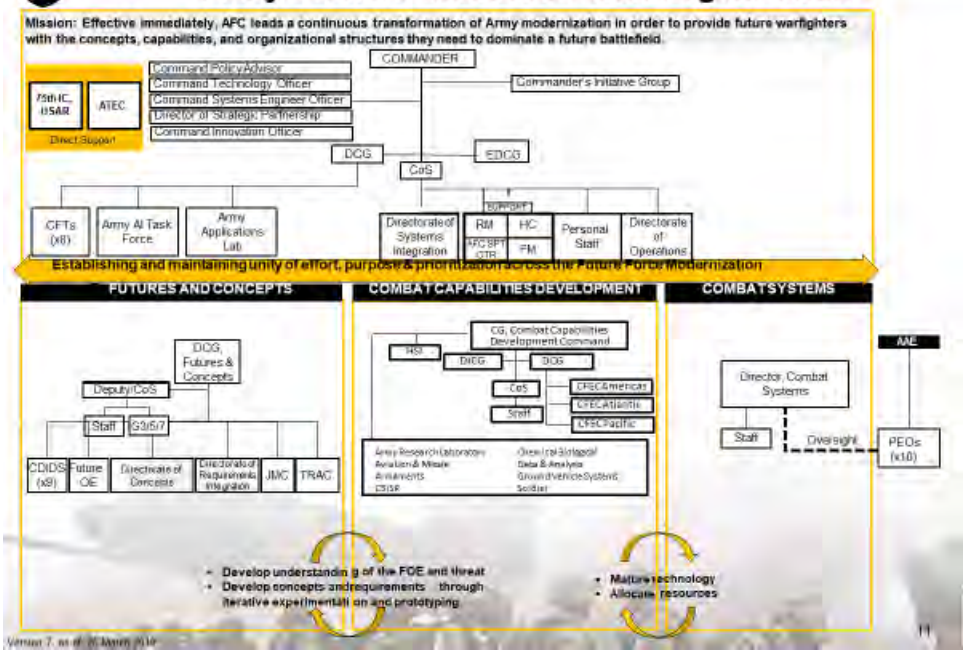
Source: The Army's Plan for the Establishment of U.S. Army Futures Command, Report to Congressional Committees by Secretary Esper, 1 Jan 2019

ASB – ARMY FUTURES COMMAND UNCLASSIFIED 10

25 MAR 2019 VERSION

ARMY FUTURES COMMAND

Army Futures Command Task Organization



Finding & Recommendation #1 – Boards of Advisors

Finding:

- Industry best practices include establishing a Board of Advisors to help the Chief Executive Office (CEO) on strategic matters beyond routine governance.

Recommendation:

- SA establish a Future Force Modernization Enterprise Board of Advisors chaired by CG AFC that includes at a minimum:
  - COCOMs
  - ASA(ALT)
  - TRADOC
  - AMC
  - FORSCOM
  - External (to Army)

  Purpose is to conduct strategic discussions on future needs and operational requirements.

Finding #2 – Unifying Culture

- Geography challenges inhibit making AFC a single unified organization.
  - AFC dispersed over 40 locations
  - Messages from headquarters are not reaching lower level staff in a timely manner

- What AFC is trying to accomplish organizationally is done by private industry on a regular basis.
- Industry best practices include:
  - Establish a culture where employees feel empowered and involved in the transformation
  - Foster relationships across sub-organizations to promote an inclusive culture

Recommendation #2 – Unifying Culture (Empowering Employees – Vertical Integration)

A. CG AFC establish a communication strategy to create shared expectations and report related progress. Communications from CG AFC to staff should reach everyone, including lower level staff, the same day.
   - Ensure consistency of message
   - Encourage two-way communication
   - Provide information to meet specific needs of employees

B. CG AFC establish a process to involve all employees to obtain their ideas and gain their ownership for the transformation. Establish an email suggestion box where anyone who has an idea to make the Army better can send it directly to CG AFC special email.
   - Involve employees in planning and sharing performance information
   - Incorporate employee feedback into new policies and procedures

Recommendation #2 – Unifying Culture (Networking and Broadening – Horizontal Integration)

C. CG AFC establish developmental assignments in which technical people who are interested in learning about other technologies can be integrated at another organization **inside AFC** for long enough (9 months?) to establish social and technical networks and better understand and appreciate new opportunities. Ensure that the Individual Development Plans for these employees include post-assignment positions utilizing this experience.

D. CG AFC establish **external** developmental assignments in other organizations such as other Army, DoD, US Government, FFRDCs, SETAs, academia, industry non-profits, and, if possible, for-profit industry. Ensure that the Individual Development Plans for these employees include post-assignment positions utilizing this experience.
   - Use of the Intergovernmental Personnel Act (IPA) is a potential vehicle
   - The Army Research Laboratory (ARL) open campus currently has 700 researchers from academia and industry – Cooperative R&D Agreement (CRADA) is most common vehicle but IPA also possible

Finding and Recommendation #3A – Identifying Core Competencies

Definition: The 2013 ASB study defined an Army S&T core competency as an integrated set of skills, processes and capabilities (e.g., facilities, tools) for which Army S&T is uniquely qualified, and that is essential for identifying, developing and transitioning key technologies into end products for the operational Army, such that the products:

- Satisfy important current and future operational needs (Customer Value),
- Are superior to adversary capabilities (Competitor Differentiation), and
- Provide the basis for leap-ahead capabilities (Extendibility).

Finding:

- The identification of core competencies in industry must be a top-down process requiring approval by the Chief Executive Officer (CEO).

Recommendation:

- CG AFC establish the core competencies within AFC in a top-down process with a feedback loop and approved by CG.

Finding and Recommendation #3B – Systems Engineer Core Competencies

Finding:

- The number of Systems Engineers (SE) in CCDC seems small compared to the Army's needs. We note that CCDC currently lists only 80 SE within the Command, 70 of whom are in the CCDC Armaments Center. Government SE have been listed as a crucial resource to develop and manage capabilities from requirements to development, and more are needed than what has been listed above.
  - Office of Personnel Management (OPM) does not have a "Systems Engineer" occupational series

Recommendations:

- SA request OPM recognize Systems Engineers.
- CG AFC verify that Systems Engineers are being coded and counted properly.
- CG AFC direct hiring more system engineers to fulfill development needs.

Finding and Recommendation #3C – Additive Manufacturing Core Competencies

Finding:

- While additive manufacturing is listed as a foundational research competency area at ARL, this technique does not appear to be used as a tool in other areas of CCDC. It seems to us that additive manufacturing should be an overall core competency since it can be used to develop capabilities that cannot be created any other way. For example, propulsion system designs can be envisioned that cannot be realized without additive manufacturing.

Recommendation:

- CG AFC make additive manufacturing a CCDC core competency.

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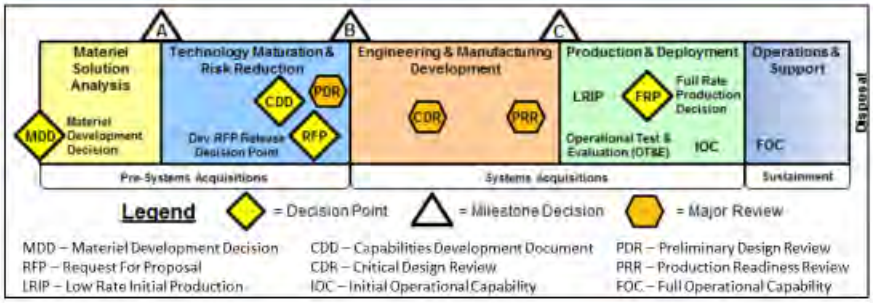
Overview of DoD Acquisition Process



Each acquisition program falls into an acquisition category (ACAT) dependent on overall funding level and importance. The category dictates the level of oversight a program will require. Oversight is provided by the Milestone Decision Authority (MDA) appointed by DoD senior leadership. Unless delegated, the USD(A&S) is MDA for ACAT I, the Component Acquisition Executive is the MDA for ACAT II or III.

- ACAT I: R&D of more than $480M & total procurement $2.79B
- ACAT II: R&D of more than $185M & total procurement $835M
- ACAT III: Less than ACAT II

Source:acqnotes.com

Major Decision Points and Phases

- Materiel Development Decision (MDD) is a point in time when analysis has identified a capability gap/need and the MDD Review has determined that a materiel solution is needed. The Analysis of Alternatives (AoA) that follows MDD is expected to identify a preferred materiel solution.
  - Materiel Solution Analysis (MSA) **Phase** between MDD and Milestone A assesses potential solutions for a needed capability. The main task is to conduct an AoA to evaluate the mission effectiveness, operational suitability, and estimated Life-Cycle Cost of alternative solutions.
- Milestone A is an MDA-led review at the end of the MSA Phase. Its purpose is to make a recommendation or seek approval to enter the Technology Maturation & Risk Reduction (TMRR) Phase.
  - The TMRR **Phase** between Milestones A and B develops and demonstrates prototype designs to reduce technical risk, validate designs, validate cost estimates, evaluate manufacturing processes, and refine requirements.
- Milestone B is an MDA-led review at the end of the TMRR Phase. Its purpose is to make a recommendation or seek approval to enter the Engineering and Manufacturing Development (EMD) Phase.

Finding #4A – Continuity of Leadership

- Industry best practice for developing a new product is to establish a persistent team that involves personnel from all steps in the process with appropriate team members taking the lead as progress is made.

Recommendation #4A – Assured Continuity of Leadership

SA establish a process in which:

- An Integrated Product Team (IPT), led by Futures and Concepts Center (FCC) through Materiel Development Decision (MDD), will be formed after high priority opportunities/challenges/issues are identified. IPT membership shall include experts in analysis of operational and system requirements, technology readiness, costing, acquisition, and budget and personnel availability, who have the authority to commit their organizations for this purpose and to communicate freely with all IPT members.
- At MDD, a Combat Capabilities Development Command (CCDC) system concept manager will be assigned by CG AFC to lead the IPT for each prioritized challenge/opportunity/issue that requires a materiel solution. This person must be a systems engineer who is acquisition certified.
- After a Board-selected Program/Project/Product Manager (PM) is appointed by Milestone B by the Army Acquisition Executive, program lead will transition from AFC to Army Acquisition. The current system concept manager could become the PM if he/she becomes Board-selected.
  - To avoid conflicts of interest, care should be taken to avoid having the same PM currently managing other ongoing similar systems.

Finding and Recommendation #4B – Department of the Army Special Task Force

Finding:

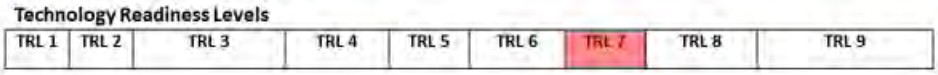
- Industry best practice for ensuring a key very important project is brought to completion is to establish a special team to oversee the process and develop plans for successful development.
- SA has authority to establish a Special Task Force to do the same.*
- DoD examples of successful special task forces include Second Generation FLIR Horizontal Technology Integration and Army Digitization.

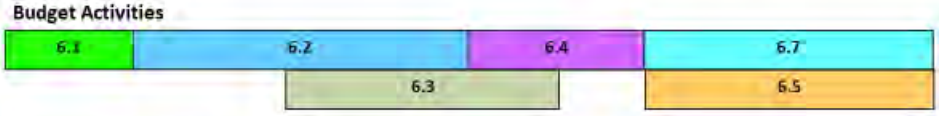
Recommendation:

- SA/CSA establish, for ACAT I and II, Special Task Forces to produce required Milestone B decision documents (e.g.):
  - Modernization plan (resource constrained)
  - Test and Evaluation Master Plan
  - Integrated Logistics Support Plan
  - Requirements documents
  - Baseline cost estimate
  - Draft acquisition strategy and acquisition plan
  - Draft Request for Proposals

* TRADOC TR 381-1, 19 Apr 1993

Milestones (Current DoD Policy)





S&T
- 6.1 Basic Research
- 6.2 Applied Research
- 6.3 Advanced Technology Development

RDT&E
- 6.4 Advanced Component Development and Prototypes
- 6.5 System Development and Demonstration
- 6.6 RDT&E Management Support
- 6.7 Operational System Development

Finding #5A – Technology Maturation (TRL 7)

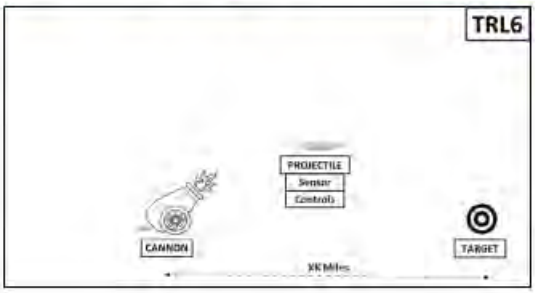
- Many studies found that having Technology Readiness Level (TRL) 7 at Milestone B (MS B), rather than Milestone C (MS C), greatly enhanced the probability of program success.
  - In 1999, Government Accountability Office (GAO) recommended that the SECDEF require that technologies needed to meet a weapon's requirements reach a high readiness level (analogous to TRL 7) before making the commitment to the development and production of a weapon system.
  - In 2015, MIT Sloan noted that a GAO study of 62 DoD programs found that those programs that reached TRL 7 or higher by the start of system development finished practically on time and on budget; whereas those programs with technologies below TRL 7 showed, on average, development cost growth of 32%, acquisition unit cost increase of 30%, and schedule delay of 20 months.

TRL Definitions

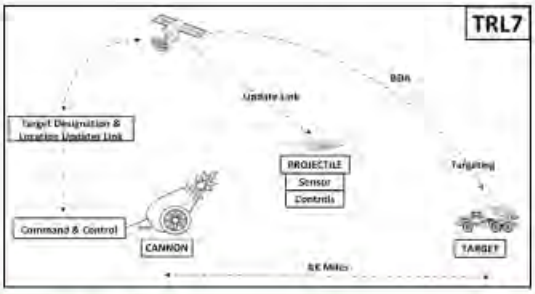
TRL	Definition	DoD Defense Acquisition Guidebook Description
1	Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Examples might include paper studies of a technology's basic properties.
2	Technology concept and/or application formulated.	Invention begins. Once basic principles are observed, practical applications can be invented. Applications are speculative and there may be no proof or detailed analysis to support the assumptions. Examples are limited to analytic studies.
3	Analytical and experimental critical function and/or characteristic proof of concept	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.
4	Component and/or breadboard validation in laboratory environment.	Basic technological components are integrated to establish that they will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of "ad hoc" hardware in the laboratory.
5	Component and/or breadboard validation in relevant environment.	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so it can be tested in a simulated environment.
6	**System/subsystem model or prototype demonstration in a relevant environment.**	**Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness.**
7	**System prototype demonstration in an operational environment.**	**Prototype near, or at, planned operational system. Represents a major step up from TRL 6, requiring demonstration of an actual system prototype in an operational environment such as an aircraft, vehicle, or space.**
8	Actual system completed and qualified through test and demonstration	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.
9	Actual system proven through successful mission operations	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. Examples include using the system under operational mission conditions.

Example: Strategic Long Range Cannon

- TRL 6: Cannon shoots a projectile safely and rest of system is demonstrated in component tests and live/virtual/ constructive simulations.



- TRL 7: Cannon system targets, fires, tracks projectile, updates target location to projectile, projectile maneuvers, battle damage assessment in an operational environment.



Recommendation #5A – Technology Maturation (TRL 7)

- SA change the process to require that programs achieve Technology Readiness Level (TRL) 7 before MS B, as opposed to before MS C, unless a waiver is obtained from SA.
  - TRL 7 requires a system prototype demonstration in an operational environment; TRL 6, which requires demonstration in a relevant environment, is the current requirement before MS B.

Finding & Recommendation #5B – Technology Maturation (Prototyping)

Finding:

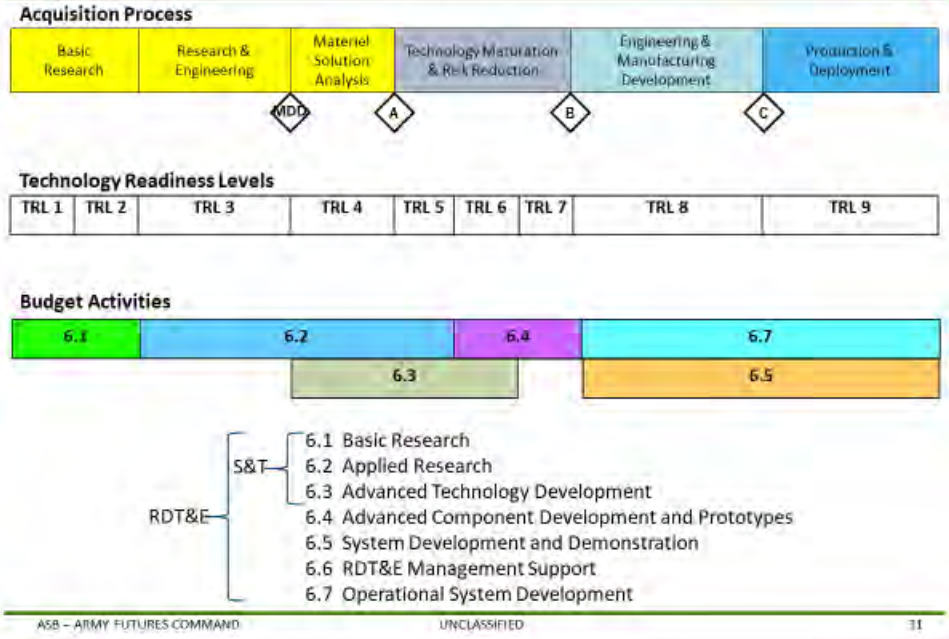
- GAO found that using multiple system prototyping approaches was worth the investment.*
  - The desired outcome is known but the approach to achieve that outcome is unknown. Broad Agency Announcements and Other Transactional Authorities (BAAs/OTAs) for developing multiple prototypes are a well known accepted approach.

Recommendation:

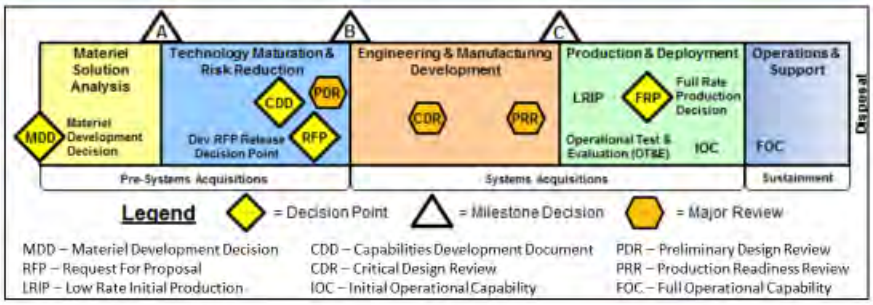
- SA change the process to require that multiple prototypes are developed between Milestones A and B in order to provide confidence that the right alternative is chosen, unless a waiver is obtained from SA.

* GAO, "Weapon Systems – Prototyping Has Benefited Acquisition Programs, but More Can Be Done to Support Innovation Initiatives," GAO-17-309, June 2017.

Milestones (Recommended)



Overview of DoD Acquisition Process - CDR



The EMD Phase consists of multiple design iterations and reviews to converge on a final design for production. This process culminates in a Critical Design Review (CDR) which provides an opportunity for assessment of design maturity.

Source:acqnotes.com

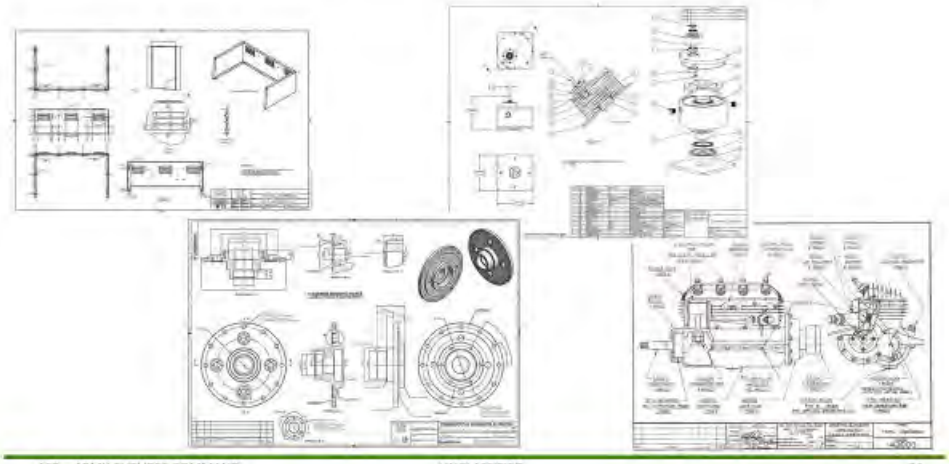
Finding #5C – Technology Maturation (Drawings)

- In 2002, GAO* found DoD programs that completed 90% of drawings by Critical Design Review (CDR) had more successful outcomes.
- For example, the AIM-9X and the F/A-18E/F limited cost increases to 4 percent or less and schedule growth to 3 months or less. The AIM-9X had 95 percent of its drawings completed at its critical design review. The F/A-18E/F had over 90 percent of its higher level interface drawings completed.
- In 2015, Katz et al** found that if at least 90% of design drawings were releasable at the CDR (between MS B and MS C), cost growth and schedule slippage were less likely during the Engineering and Manufacturing Development (EMD) Phase.

* GAO, "Best Practices – Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes," GAO-02-701, July 2002.
** Katz et al, "The Relationship of Technology and Design Maturity to DoD Weapon System Cost Change and Schedule Change During Engineering and Manufacturing Development," Systems Engineering Vol 18, No 1, 2015.

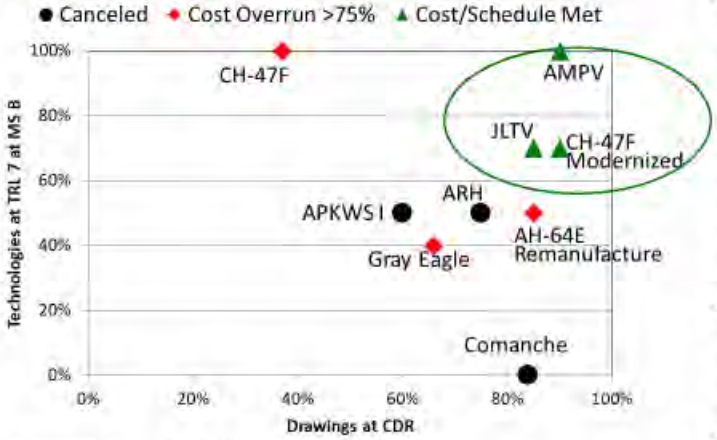
Recommendation #5C – Technology Maturation (Drawings)

- SA change the process to require that at least 90% of the design drawings are released before CDR, unless a waiver is obtained from SA.



Army Program Examples

Data taken from GAO Annual Weapon System Assessments



AH-64 – Apache CH-47 - Chinook
AMPV – Armored Multi-Purpose Vehicle
APKWS – Advanced Precision Kill Weapon System
ARH – Armed Reconnaissance Helicopter
JLTV – Joint Light Tactical Vehicle

Notes:

- Comanche was canceled after 100% cost growth and 120% schedule slippage due to technology immaturity, changing scope and other factors. The decision was made due to changing priorities in the Army.
- APKWS I was canceled due to configuration issues that could not be overcome.
- ARH was canceled after critical Nunn-McCurdy cost breach.

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Measures of Effectiveness

6 months:

- Has CG AFC directed implementation of suggested recommendations?
- Has SA directed implementation of suggested recommendations?

Year 1:

- Have all best practices assigned to CG AFC been implemented?
- Have all projects followed the recommendations implemented by SA or obtained a waiver.

Year 2 and annually thereafter, ensure all programs continue to follow recommendations.

These timeframes are achievable and must be met to maintain momentum and meet leadership expectations. Time is of the essence.

Recommendation Summary (1 of 2)

1. SA establish a Future Force Modernization Enterprise Board of Advisors chaired by CG AFC that includes, at a minimum, COCOMs, ASA(ALT), TRADOC, AMC, FORSCOM, and External (to Army). Purpose is to conduct strategic discussions on future needs and operational requirements.
2. Unifying Culture
   - 2A - CG AFC establish a communication strategy to create shared expectations and report related progress. Communications from CG AFC to staff should reach everyone, including lower level staff, the same day.
   - 2B - CG AFC establish a process to involve all employees to obtain their ideas and gain their ownership for the transformation. Establish an email suggestion box where anyone who has an idea to make the Army better can send it directly to CG AFC special email.
   - 2C - CG AFC establish developmental assignments in which technical people who are interested in learning about other technologies can be integrated at another organization inside AFC for long enough (9 months?) to establish social and technical networks and better understand and appreciate new opportunities.
   - 2D - CG AFC establish external developmental assignments in other organizations such as other Army, DoD, US Government, FFRDCs, SETAs, academia, industry non-profits, and, if possible, for-profit industry.
3. Core Competencies
   - 3A - CG AFC establish the core competencies within AFC in a top-down process with a feedback loop and approved by CG.
   - 3B - System Engineer Core Competency
     - SA request OPM recognize Systems Engineers.
     - CG AFC verify that Systems Engineers are being coded and counted properly.
     - CG AFC direct hiring more system engineers to fulfill development needs.
   - 3C - CG AFC make additive manufacturing a CCDC core competency.

Recommendation Summary (2 of 2)

4. Leadership
   - 4A - Assured Continuity of Leadership – SA establish a process in which:
     - An Integrated Product Team (IPT), led by Futures and Concepts Center (FCC) through Materiel Development Decision (MDD), will be formed after high priority opportunities/challenges/issues are identified.
     - At MDD, a Combat Capabilities Development Command (CCDC) system concept manager will be assigned by CG AFC to lead the IPT for each prioritized challenge/opportunity/issue that requires a materiel solution. This person must be a systems engineer who is acquisition certified.
     - After a Board-selected PM is appointed between Milestone A and Milestone B by the Army Acquisition Executive, program lead will transition from AFC to Army Acquisition. The current system concept manager could become the PM if he/she becomes Board-selected.
   - 4B - SA/CSA establish, for ACAT I and II, Special Task Forces to produce required Milestone B decision documents.
5. Technology Maturation
   - 5A - SA change the process to require that multiple prototypes are developed between Milestones A and B in order to provide confidence that the right alternative is chosen, unless a waiver is obtained from SA.
   - 5B - SA change the process to require that programs achieve Technology Readiness Level (TRL) 7 before MS B, as opposed to before MS C, unless a waiver is obtained from SA.
   - 5C - SA change the process to require that at least 90% of the design drawings are released before CDR, unless a waiver is obtained from SA
6. SA request a second review of the 13 Decker-Wagner recommendations that the Army chose not to implement.

Summary

We believe that if the recommendations provided earlier in this brief are implemented, AFC mission success will be greatly increased and future system development will be improved.

APPENDIX J: GLOSSARY OF TERMS, ABBREVIATIONS AND ACRONYMS

3D	Three Dimensional
AAE	Army Acquisition Executive
AAL	Army Applications Lab – in AFC HQ
ACAT	Acquisition Category (see Appendix F.1)
ACD&P	Advanced Component Development and Prototypes (Budget Activity 4)
ADM	Acquisition Decision Memorandum
AFC	Army Futures Command
AI	Artificial Intelligence
AM	Additive Manufacturing
AMC	Army Materiel Command
AMRDEC	Aviation and Missile RDEC (see table below)
AMSAA	Army Materiel Systems Analysis Activity – now in CCDC Data and Analysis Center
AoA	Analysis of Alternatives
APA	Additional Performance Attribute
APB	Acquisition Program Baseline
ARCIC	Army Capabilities Integration Center (part of TRADOC, moved to FCC)
ARDEC	Armament RDEC (see table below)
ARL	Army Research Laboratory – part of CCDC
ARSTAFF	Army Staff
AS	Acquisition Strategy
ASA(ALT)	Assistant Secretary of the Army (Acquisition, Logistics and Technology)
ASARC	Army Systems Acquisition Review Council
ATD	Advanced Technology Development (Budget Activity 3)
ATEC	Army Test & Evaluation Command – direct support to AFC
BA	Budget Activity – see Appendix F.2
BAA	Broad Agency Announcement
BDA	Battle Damage Assessment
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
C5ISR	Command, Control, Communications, Computers, Cyber, Intelligence, Surveillance, and Reconnaissance
CCDC	Combat Capabilities Development Command (formerly RDECOM, part of AFC)
CDD	Capabilities Development Document
CDD-V	Capabilities Development Document – Validation
CDID	Capability Development & Integration Directorate – formerly TRADOC, now FCC
CDR	Critical Design Review
CEO	Chief Executive Officer
CERDEC	Communications-Electronics RDEC (see table below)
CFT	Cross Functional Team
CG	Commanding General
COCOM	Combatant Command
CRADA	Cooperative R&D Agreement

CSA	Chief of Staff of the Army
CSD	Combat Systems Directorate
DA	Department of the Army
DAE	Defense Acquisition Executive
DCR	DOTMLPF-P Change Request
DoD	Department of Defense
DOT&E	Director, Operational Test and Evaluation
DOTMLPF-P	Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities - Policy
DRFP	Development Request for Proposals
DRFPD	Development Request for Proposals Decision
DSI	Directorate of Systems Integration (in AFC HQ)
DUSA	Deputy Undersecretary of the Army
ECBC	Edgewood Chemical Biological Center (see table below)
EMD	Engineering and Manufacturing Development (Acquisition Phase)
FCC	Futures and Concepts Center – part of AFC
FFME	Future Force Modernization Enterprise
FFRDC	Federally Funded Research and Development Center
FLIR	Forward-Looking Infrared
FOC	Full Operational Capability
FORSCOM	Forces Command (Army)
FRP	Full Rate Production
FYDP	Future Year Development Program
GAO	Government Accountability Office
GO	General Officer
GO	General Order
HQ	headquarters
HQDA	Headquarters Department of the Army
ICD	Initial Capabilities Document
INCOSE	International Council on Systems Engineering
IOC	Initial Operational Capability
IPA	Intergovernmental Personnel Act
IPT	Integrated Product Team
IRL	Integration Readiness Level
JCS	Joint Chiefs of Staff
KPP	Key Performance Parameters
KSA	Key System Attributes
LCMC	Life Cycle Management Command
LCSP	Life Cycle Sustainment Plan
LFT&E	Live Fire Test and Evaluation
LRIP	Low Rate Initial Production
MAIS	Major Automated Information System
MDA	Milestone Decision Authority
MDAP	Major Defense Acquisition Program

MDD	Materiel Development Decision
MDO	Multi-Domain Operations
MG	Major General
MIT	Massachusetts Institute of Technology
MOE	Measure of Effectiveness
MRL	Manufacturing Readiness Level
MS A	Milestone A
MS B	Milestone B
MS C	Milestone C
MSA	Materiel Solution Analysis (Acquisition Phase)
NSRDEC	Natick Soldier RDEC (see table below)
O&S	Operations and Support (Acquisition Phase)
ONS	Operational Needs Statement
OPLAN	Operational Plan
OPM	Office of Personnel Management
OPORD	Operations Order
ORSA	Operations Research/Systems Analysts
OSD	Office of Secretary of Defense
OT&E	Operational Test and Evaluation
OTA	Other Transactional Authority
OUSD(AT&L)	Office of the Under Secretary of Defense for Acquisition, Technology and Logistics
PD	Production and Deployment (Acquisition Phase)
PDR	Preliminary Design Review
PEO	Program Executive Office
PM	Program/Project/Product Manager
POM	Program Objective Memorandum
PPBES	Planning, Programming, Budgeting, and Execution System
PRR	Production Readiness Review
R&D	Research and Development
RCCTO	Rapid Capabilities and Critical Technologies Office
RDEC	Research, Development, and Engineering Center (AMRDEC, ARDEC, CERDEC, NSRDEC, or TARDEC) – see table below
RDECOM	Research, Development, and Engineering Command – now CCDC
RDT&E	Research, Development, Test and Evaluation (6.1 through 6.7 funding)
RFP	Request for Proposal
ROC	Rehearsal of Concept
S&T	Science and Technology (6.1 through 6.3 funding)
SA	Secretary of the Army
SDD	System Development and Demonstration (Budget Activity 5)
SE	Systems Engineers
SECDEF	Secretary of Defense
SEP	Systems Engineering Plan
SES	Senior Executive Service

SETA	Scientific, Engineering, and Technical Assistance
SLAD	Survivability Lethality Analysis Directorate in ARL – see table below
SSAC	Source Selection Advisory Committee
SSEB	Selection Evaluation Board
STE	Staff Years of Technical Effort
STF	Special Task Force
TARDEC	Tank & Automotive RDEC (see table below)
TEMP	Test and Evaluation Master Plan
TMRR	Technology Maturation and Risk Reduction (Acquisition Phase)
TOA	Total Obligation Authority
TOR	Terms of Reference
TRA	Technology Readiness Assessment
TRAC	TRADOC Analysis Center
TRADOC	Training and Doctrine Command
TRL	Technology Readiness Level (see Appendix F.3)
USC	United States Code
VCSA	Vice Chief of Staff

Linkage between previous organizations and AFC organizations

Prior Organization	Current Organization in AFC
Army Capabilities Integration Center (ARCIC) in TRADOC	Futures and Concepts Center (FCC)
Capability Development and Integration Directorates (CDIDs) and associated Battle Labs in TRADOC	Part of FCC
TRADOC Analysis Center (TRAC) in TRADOC	Part of FCC
Research, Development, and Engineering Command (RDECOM) in AMC	Combat Capabilities Development Command (CCDC)
Army Materiel Systems Analysis Activity (AMSAA) in RDECOM	CCDC Data & Analysis Center
Survivability Lethality Analysis Directorate (SLAD) in ARL	Part of CCDC Data & Analysis Center
Armament RDEC (ARDEC) in RDECOM	CCDC Armaments Center
Aviation and Missile RDEC (AMRDEC) in RDECOM	CCDC Aviation & Missile Center
Communications-Electronics RDEC (CERDEC) in RDECOM	CCDC C5ISR (Command, Control, Computers, Communications, Cyber, ISR) Center
Edgewood Chemical Biological Center (ECBC) in RDECOM	CCDC Chemical Biological Center
Natick Soldier RDEC (NSRDEC) in RDECOM	CCDC Soldier Center
Tank & Automotive RDEC (TARDEC) in RDECOM	CCDC Ground Vehicle Systems Center
Army Research Laboratory (ARL) in RDECOM	Army Research Laboratory in CCDC

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