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The Parabolic Curve:
Creating Operational Agility in the Third Offset Strategy

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About the Forum

The Mitchell Forum exists to give an open venue to authors with ideas and thoughts on national defense and aerospace power. The series features topics and issues of broad interest and significant impact on current and emerging policy debates. The views expressed in this series are those of the author, and not necessarily those of the Mitchell Institute.

Abstract

The "third offset strategy" is viewed as the third chapter of a long running United States defense policy, an evolution driven by a requirement to "offset" current and future threat capabilities in an increasingly complex and constrained environment. Unfortunately, the rhetoric of this strategy has seemingly outpaced content to support its goals. The US Air Force's Strategic Master Plan and Future Operating Concepts, for example, provide a broad vector and vision, but lack actionable substance.

In this paper, the author outlines what he coins "the parabolic curve," which seeks to reform the current construct of the US Air Force to regain the erosion of airpower's advantages. Based on a few key principles, this approach provides a course-correction strategy that transcends the current linear long-term acquisition and sustainment of equipment, while simultaneously growing a more agile US defense industrial base.

To maintain this enduring strategic agility in both equipping and operations, the author advocates the introduction of the business "S-curve model." Applied in both acquisition and tactical development, this curve construct encapsulates critical thinking that will maintain a smaller and shorter OODA-loop, which is required to sustain the third offset strategy into the future.

Finally, this paper argues that cognitive transformation is required to succeed in any of the proposed endeavors, by challenging the partition of functional command of cross-functional platforms and recommends adopting concurrent tactical and doctrinal development for the force to remain viable.

Introduction

"The dynamic, complex future is already beginning to challenge us. It is time for this generation of Airmen to develop a way to succeed."

Secretary of the Air Force Deborah James and Air Force Chief of Staff Gen Mark Welsh [1]

The so-called "third offset strategy" is viewed as the third chapter of a long running United States defense policy, driven by a requirement to "offset" current and future threat capabilities in an increasingly complex and constrained environment. With senior defense officials and leaders pushing conceptual terms on a seemingly everyday basis, why should this new evolution of the offset strategy be any different? Why is strategic change warranted today, and how should it be implemented? To answer these questions it is vital to first understand the conditions at the user end of the strategy—the US military service operators whom the nation commits to execute every strategy.

The historical context and circumstances of the three offset strategies, which have unfolded since the end of World War II, are summarized in Table A. The intent and timing of the current initiative is appropriate, but readers should notice the common thread among the strategies. Relating to USAF Col John Boyd's Observation-Orientation-Decision-Action (OODA) loop, the continual need to revisit the beginning of the loop ("observation") and make course corrections was lacking in some form at the strategic level of all three offsets. [2]

Notably, the appetite for new systems and capabilities in the second-offset era is also characterized by the increasingly lethargic fielding of capabilities. The insatiable pursuit of "game changers" and "force multipliers" has developed a routine that continually extends cost to the taxpayer and time to the service member end user, all while absorbing massive near-term risk. When viewed at the macro level, one could argue strategic (and thus operational) agility has historically remained elusive through the entirety of the second offset

Table A: US offset strategy summary

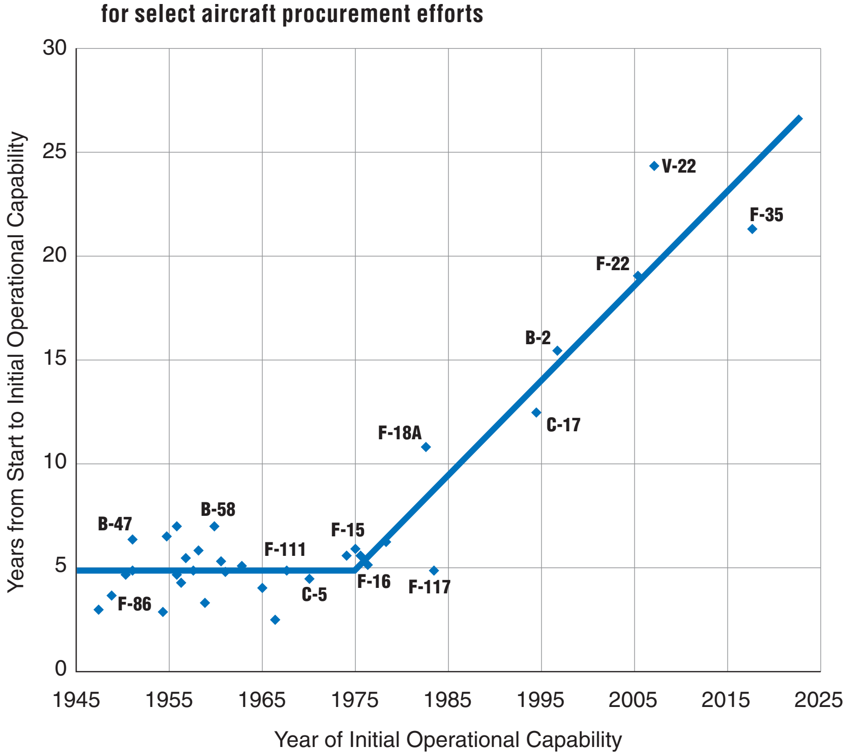
	PRESIDENT EISENHOWER'S "NEW LOOK" FIRST OFFSET (1950's)	SECRETARY OF DEFENSE HAROLD BROWN'S "OFFSET" SECOND OFFSET (1970's)	SECRETARY OF DEFENSE CHUCK HAGEL'S "THIRD OFFSET" THIRD OFFSET (2015)
STRATEGY	Nuclear dominance will offset large expenditures required to deter communist nations of the Warsaw Pact.	With a stalemate from nuclear deterrence, technological superiority will offset quantitative inferiority between outnumbered NATO forces and Warsaw Pact countries.	Technical and operational agility will provide mulitple solutions to operational and strategic problems that will reverse eroded advantages in a resource constrained environment in an unpredictable future.
ASSUMPTION	Soviet nuclear bombers would not have fighter escorts and needed to be intercepted at great distances from the United States.	Speed, stealth, standoff, and precision qualities can overcome Soviet quantities. High cost barriers to entry (i.e. stealth) will cement a long term strategic advantage.	Adversary pacing was underestimated and "diverse and worse" threat that may use hybrid, irregular, conventional, and/or nuclear warfare. Multi-optional, multi-domain solutions must be instantly available.
AIR FORCE HISTORICAL IMPACT	Beyond the large investment in strategic nuclear capability, the USAF invested heavily in high speed interceptors (F-102, F-104, and F-106) and tactical nuclear interdiction (F-100, F-101, and F-105).	Breakthroughs that modernized warfare were prevalent (e.g. AWACS, Link-16 data link, GPS, the internet, F-117, standoff radar mapping (JSTARS), and cruise missiles)	To be determined
THE NEED TO EVOLVE	No air superiority fighter or close air support aircraft would be designed for the next 20 years, causing an erosion of advantage. The deficiencies of this narrowly-focused offset directly led to the A-10 (1976), F-15 (1980), and F-16 (1981).	Massive acquisitions of leading edge monolithic systems slowed the pace of integration and usability of said platforms (B-2, AGM-158, F-22, F-35). The perceived pace of adversary capability tempered this "speed limit" of operational agility, while cost overruns and delays were common.	To be determined

era. Maintaining focus through a prism of diffuse uncertainty will continue to challenge unity of effort and the pursuit of the goal of lasting operational agility.

In 2015, the US Air Force (USAF) released its Strategic Master Plan (SMP) and Future Operating Concepts (FOC). Now, detailing how the service will turn science fiction-sounding concepts into actual science, strategy, and ultimately success is the next step. Instead of strategic vectors covered by the SMP or visions from the FOC, the following guiding principles should be used to keep this pursuit grounded in reality, by defining the limits of the discussion about what the USAF of 2035 will look like and how it will operate.

- Cost curves and cost exchanges will likely heavily shape the future force more than other factors.
- Platform agnosticism will distribute capability, cost, risk, and attrition.
- There will be no single game changers, only emerging enablers.
- Acquisition reform is required to make transformation a reality.
- The "parabolic curve" will regain eroded airpower advantages.
- Cognitive process reform is not just desired; it is required.

Figure 1: Time from program start to Initial Operational Capability (IOC) for select aircraft procurement efforts



Cost Curves and Operational Agility

The so-called "sequestration" cuts imposed by the 2011 Budget Control Act may one day be viewed as the primer for USAF transformation. The realization of this unsuspecting relationship is that cost management and operational agility are interrelated. As the elements of the first principle, a program's "cost curve" and "cost exchange" are the primary considerations for force projection, sustainment, and replenishment.

The timelines and cost curves of countless defense programs have notoriously slid to the right, causing political turmoil and delays to operational fielding. The repercussions of these overruns take three forms: continue, cancel, or change a program. This short term decision may be polarizing, but in the long term it is inconsequential—time is a commodity that simply cannot be bought back. Figure one depicts the historic aggregated time for aircraft programs to reach initial operational capability (IOC).

Remarkably, it has been nearly 40 years since a major USAF program was fielded in the time or with the capability that was initially specified. While some of these delays are attributable to the geopolitical environment, they are also due to officials shifting requirements after development activities were under way. During B-2 development in the 1980s, the design was modified to add a low-altitude profile capability.[3] The redesign delayed the B-2's first flight by two years, added almost a billion dollars to the program cost, with the end result being the late Cold War-era low-altitude capability requirement fell out of use before the B-2 was ever fielded.[4] More recently, the F-22 first flew in 1997, six years after the YF-22 won the Advanced Tactical Fighter fly-off competition and 16 years after the ATF requirements were drafted.[5] When IOC was declared in 2005, contract-to-combat-capable totaled almost 20 years.

Absolving politics from the B-2 and F-22 programs is difficult, but a look at the munitions portfolio reveals a similar result. The GBU-39 Small Diameter Bomb (fielded in 2006) is the last weapons program that used the established Joint Capabilities Integration and Development System (JCIDS) acquisition process. Since then, all other air weapons procured by the USAF have bypassed the normal procedure to seek program agility.[6]

A program's cost curve is a key leading metric to indicate a potential delay, which itself is the precursor for the "continue, cancel, or change" decision point. Operational agility, if achieved, means this decision point is never reached because organizational processes exist to permit people to continuously apply flexibility and adaptation to the program to remain on time. The US government owes it to the taxpayer and the service members who will use these weapons to never approach this decision point.

Platform Agnosticism: Capability, Cost, Risk, and Attrition

As the USAF attempts to modernize its force, it must also reevaluate the paradigm that currently defines how to apply this force. It seems obvious to state that it is a mistake to build a strategy around a single point of strength, because that often becomes a single point of vulnerability, or even worse, failure. However, due to previous limits of technology, this approach describes the present USAF force construct. Monolithic systems create a "center of gravity" for the adversary to target, whether it is a Combined Air and Space Operations Center (CAOC), the GPS constellation, the sole B-2 base in the world, or a base where limited fifth generation air-to-air fighters are forward deployed. The USAF force structure has found itself deep inside an efficiency paradox, where years of drawdowns seeking maximum efficiency actually reduces effectiveness in conflict, due to the variable of combat attrition.[7] This efficiency paradox is not limited to equipment, but airmen and personnel at the same time.

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By definition, any conflict with a near-peer adversary will involve a fight to gain air superiority. With a small number of expensive but capable systems, a basic description of the present state of the USAF's combat fleet, cost exchange with any attrition becomes unappetizing and therefore an un-executable plan. Also, this dynamic doesn't account for an industrial base that is no longer capable of supporting campaign attrition or quick post-conflict force replenishment, creating a "second order" vulnerability to attack by an adversary seeking to exploit this dynamic.

The introduction of "just-in-time" manufacturing in the 1980s has evolved the aerospace industry towards lean manufacturing practices, with the goal of maximizing efficiency and profit. This industry efficiency has also grown the supplier base of virtually every piece of equipment the military procures, which actually has the effect of reducing operational flexibility in the context above. Take the Joint Direct Attack Munition (JDAM) tail kit, for example. Although a relatively small, simple product when compared to other military acquisitions, the JDAM tail kit has over 75 suppliers that Boeing relies on to build its product.[8] Surging JDAM production requires orchestrating all 75 suppliers to also surge, making it exponentially more inflexible without a great deal of coordination.[9] This industry efficiency paradox is seen playing out in today's Operation Inherent Resolve (the coalition air campaign against Islamic State forces), where a JDAM dropped today will not be replaced in the inventory for up to two years.

Applying this industry relationship on a larger scale, newer aircraft are becoming more complex and take more specialized equipment to build and technicians to maintain. Concurrently, older aircraft in the inventory have production lines that are heading towards shutting down. To this point, in today's force structure each and every aircraft, regardless of how old they are, should be viewed as more vital than ever before. Attrition at any level would be a significant event that would lead to numerous second and third order effects, thereby forcing a re-evaluation of how the US fights wars. The third offset strategy stimulates this evaluation by developing a force structure that enables multiple courses of action for given scenarios.

Soviet leader Joseph Stalin famously said that "quantity has a quality all its own." Using a platform agnostic system multi-mission/multi-node (M2/MN) architecture would distribute capability, cost, risk, and attrition among smaller, cheaper unmanned platforms in even the most contested environments imaginable, for example. Additionally, the architecture could be built to encompass varying levels of manned or unmanned integration and size, permitting countless courses of action for force employment based on a commander's intent.

Distributing cost has an additional benefit of lowering the barrier of entry for coalition partners to augment the US in a high-end conflict, something that does not presently exist in a meaningful capacity. For the price of a single F-35, dozens of less expensive unmanned platforms could be procured and deployed to perform the mission with increased loiter time and capability while reducing comparable cost, in certain scenarios. Unmanned platforms need not be remote piloted aircraft (RPAs) though, and in most future cases they may not be. There are mature engineering concepts for highly maneuverable in-flight re-programmable drones capable of near-supersonic flight that can achieve over a thousand miles of range. Leveraging the range and payload of other platforms, these assets can be deployed from a C-17, C-130, or even B-52. Finally, because they use currently fielded technology (engine, flight control computer, navigation, and other elements) they cost less than $2 million a copy—and they are recoverable.[10]

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A distributed system would not only be sustainable in the attrition sense, but also self healing and rapidly replenishable, thus making the system reconstitutable. Moving attrition to unmanned platforms in more contested areas also reduces the risk of losing the aircrew, thus removing the third-order requirement to expose other airmen, such as a combat search and rescue (CSAR) task force, to a perilous mission environment.[11]

There Will Be No Game Changers, Only Emerging Enablers

The above proposition appears controversial, but it is not to say that investment in new technologies should not continue. Rather, there are some underlying associations that must be acknowledged.

First, technological maturity usually occurs a long time after the initial breakthrough, both in its comprehension and application. Second, breakthroughs themselves are seldom game changers, but more accurately described as emerging enablers. For instance, stealth is sometimes considered a game changer, but there were several underlying enablers for stealth that made this shift happen. The F-117, which first flew in 1981, was developed based on principles articulated by Russian scientist Pyotr Ufimtsev's paper "Method of Edge Waves in the Physical Theory of Diffraction."[12] The paper was published in 1962, translated in 1971, and used to design Lockheed's "Have Blue" proof of concept, which first flew in 1977.

Dependence on breakthroughs is a strategy founded in hope, especially in the information age. Today's global commerce and collaboration, modern information exchange, and system vulnerabilities all point to a basic truth: a breakthrough anywhere in the world (even within the US) can be assumed to be a breakthrough that could be used against the US. Organizations like the Defense Advanced Research Projects Agency (DARPA) and Strategic Capabilities Office exists to develop technology to avoid strategic surprise, but the US military must have the operational agility to win "after the surprise."[13]

Acquisition Reform and Transformation

The AGM-158 Joint Air-to-Surface Standoff Missile (JASSM), first declared operational in 2009, took 14 years to develop and tallied $7.2 billion in acquisition through 2015, (193 percent over the initial program cost).[14] Even more astonishing, JASSM is based on technology from the Tri-Service Standoff Attack Missile (TSSAM), a program begun in 1986—a full 30 years ago—which aimed to counter Soviet proliferation of SA-10 and SA-12 missile systems. The TSSAM program was cancelled in 1994 due to spiraling costs, but $13.7 billion had already been spent.[15] Twenty-one years and $21 billion after initial conception of the TSSAM the JASSM was finally fielded. But the missile is already in need of more money to modernize range, reliability, and survivability.

By its nature, acquisitions deal with large sums of funding, making them inherently political.

When a program experiences cost overruns and delay, it comes under the spotlight of Congress, and military leaders often take the "us versus them" approach to defending the program. This occurs even if it is the wrong pursuit, and conditions or the threat environment have changed. It can then become difficult to discern the facts, as the debate shifts from analytical to emotional. A trifecta of self-preservation via congressional interests, industrial lobbyists, and a given military leader's assigned program portfolio sets in. It is simply not possible to make the right professional decision for the nation and taxpayer, even though it could reflect negatively on an individual involved.

Sir Robert Alexander Watson-Watt, who developed radar in Britain to counter the rapid growth of the German Luftwaffe prior to World War II, advocated a "cult of the imperfect." He famously stated, "Give them the third best to go on with; the second best comes too late, the best never comes."[16] To remove platform or program bias and politics, this acquisition reform principle is very simple: every program of record (POR) should be categorized as "established," "incremental," "evolutionary," or "revolutionary." Annually, programs should be reassessed to see if they warrant re designation. This provides an unprecedented level of clarity into where a program fits into the national military strategy. Books could be written on the F-35's programmatics, but consider the following. In 2001, the Lockheed Martin X-35 was chosen as the winner of the Joint Strike Fighter fly-off competition. That same year, USB flash drives were invented (with 8 MB of memory), the first iPod was introduced, and there was still a distinction between computer ownership and internet access. The F-35 concept was bold and revolutionary.

...modularity and technology harvesting should be a key metric for all programs of record to create efficiency through risk reduction in acquisitions.

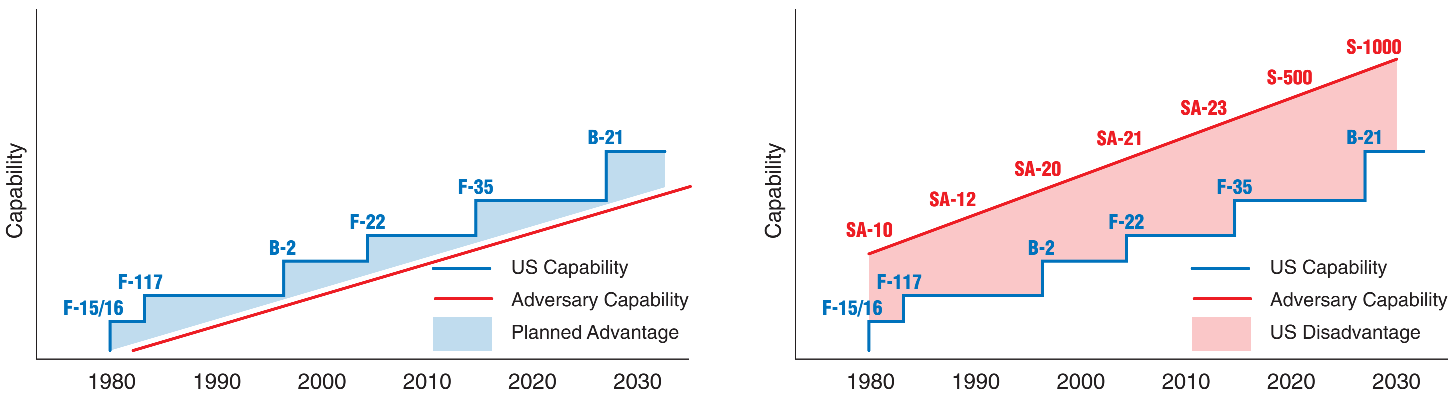
Today, flash drive capacity has increased 125,000 times in size, and the iPod has been replaced by the iPhone. By the time the F-35 reaches full operational capability in 2022, it will be more accurately described as evolutionary. The last F-35 delivered to USAF is slated to be in 2037, 36 years after it won the fly-off competition. While impossible to predict the future, forecasting reveals the F-35 will only be an incremental capability at best, from this viewpoint. To prove this, take any 36-year time period in the past century of military aviation. Some of these periods include the time from the first military airplane (1909) to the B-29 dropping the atomic bomb on Japan (1945); from the first P-51 Mustang (1940) to the first F-15 (1976); or the first USAF F-4 flight (1963) to the first F-22 flight (1997). There is not a lot of operational agility in any era, let alone the 21st century. Yet the trifecta of self-preservation described above about present day program management inhibits agile changes to programs.

Finally, modularity and technology harvesting should be a key metric for all programsof record to create efficiency through risk reduction in acquisitions. A great example of what not to do is seen in the "Century Series" aircraft of the 1960's. Together, these represented a mix of fighter-bombers (F-100, F-101A, F-105) and interceptors (F-101B, F-102, F-104, F-106) built by five manufacturers over an extremely small time period of around six years. While many visual similarities existed among the group, they used four different engines, three different electrical systems, and five of the models required extensive airframe modification to achieve satisfactory performance.[17] Undergoing a similar rapid fielding effort today would prove disastrous without modularity since there is no manpower to counter this lack of foresight. Today there are 60 percent fewer airmen than there were in 1960.[18]

"The Parabolic Curve"— Regaining Airpower's Advantage

Without appropriate and unified application of all of the above principles, operational agility will continue to be nothing but a bumper sticker that will fade and peel soon after the tenure of senior leaders end. In this regard, perhaps the US could adapt to a "fast follower" principle, similar to the ones that have served military rivals Russia and China very well. Both nations have achieved varying levels of operational agility through two different concepts: evolutionary modularity (Russia) and technical investment into rapid acquisitions (China).

Figure 2: Forecasted US military aircraft capabilities, alongside surface to air missile (SAM) threats



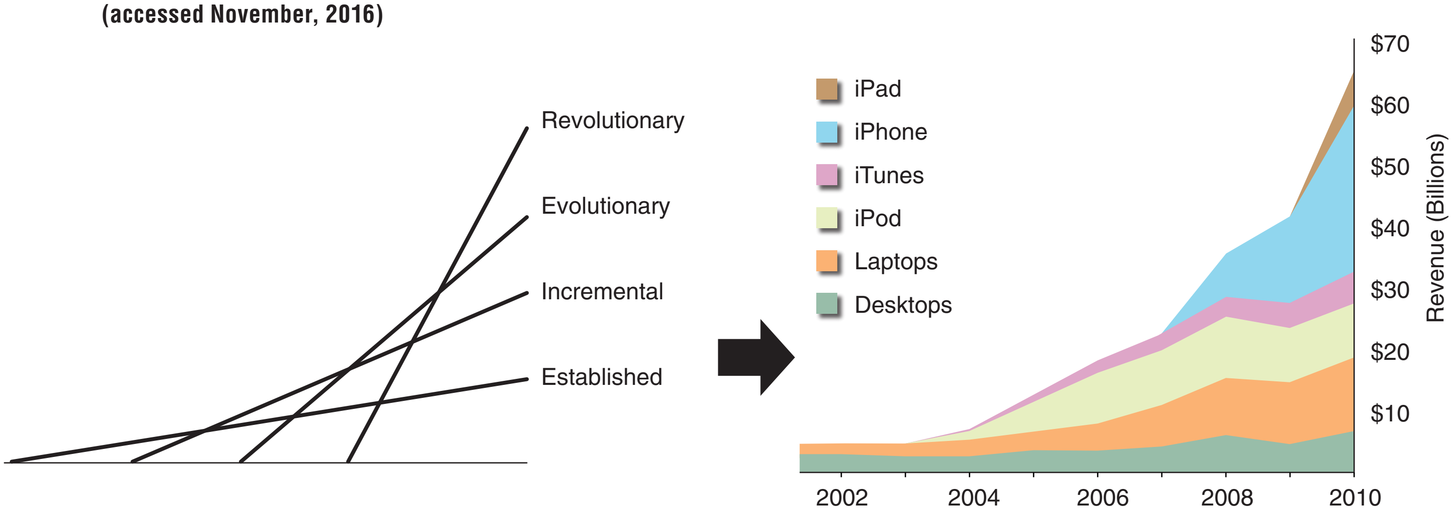
The Russian S-300 Surface-to-Air Missile System (SAM) family has enjoyed a 30-year streak as the most capable systems of their kind in the world, because evolutionary modularity has permitted multiple variants and upgrades to be fielded, each expanding the platform's capability more rapidly than the US could adapt to, as depicted in figure two.

However, by combining all of the above principles discussed, a foundation of operational agility begins to form a layered course-correction that resembles a parabolic curve. Taking an example from commercial industry, this parabolic curve is easily seen within Apple Inc.'s revenue growth when dissecting product innovation and development over time, as seen in figure three.

Just like in the Apple example, a program of record should represent a single line in the parabolic curve, complete with an "established, incremental, evolutionary, or revolutionary" association with the program. As a layered effort on the parabolic curve, program continuity, accountability, and agility could then be inherited. Under this construct, programs would not need to contend with changing requirements since those could easily be placed in follow-on or complementary systems. Furthermore, any notable delays would meet the "cancel" decision and the technological investment would be harvested by industry for the next line in the parabolic curve. This invigorated incentive is similar to the way that DARPA funds its industry collaborators for technological progress and innovation.

When a DARPA program ends, there is benefit in that the contracted performer is left

Figure 3: The operational agility "parabolic curve," next to Apple Incorporated's revenue stream.
Source: (right) Ron Newmann "Innovation and the S-Curve." Lecture. Lift Conference, March 19, 2013, http://www.slideshare.net/wright4/double-scurve-model-of-growth (accessed November, 2016)

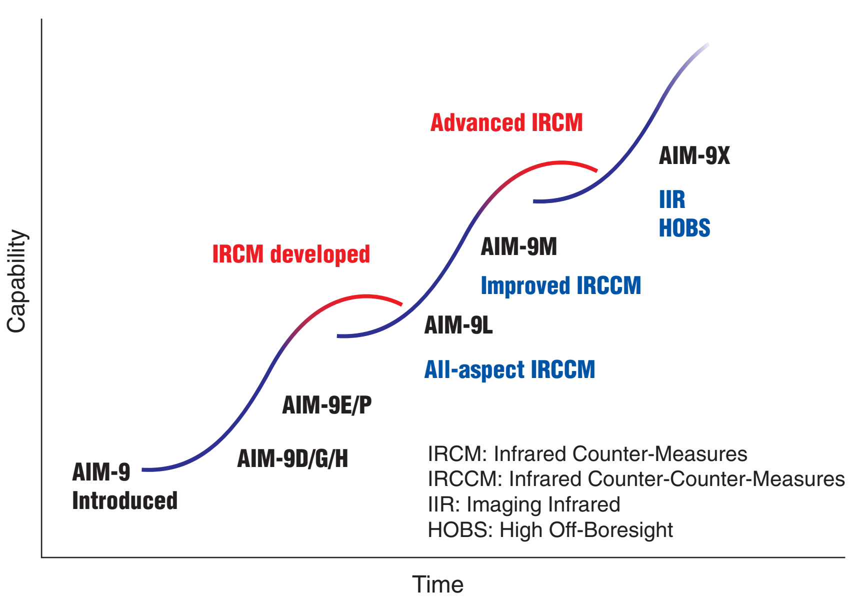


with a foundation for industry research and development (IRAD) that otherwise would not exist. Essentially, moving to a parabolic structure strategically distributes defense industry risk among several programs of smaller values. This "hard cancel and harvest" approach would keep industry energized in concurrent, competitive efforts, as companies know they could continually regroup and re compete for the next contract. This equally empowers the USAF to set the minimum speed limit for industry to stay on a timeline, more easily enforce accountability, and grow the supplier base.

While the parabolic curve can serve as the "up ramp" for the pace of innovation, when viewed on a larger scale, another commercial industry concept can be applied: the "S-curve." The S-curve simply shows the growth of a variable in terms of another variable.[19] In the case of military programs, the external variable is an adversarial evolution of countering-technology or minimizing a given technology's vulnerability to exploitation. The history of the AIM-9 infrared air-to-air missile in figure four provides a simple unclassified example of the S-curve.

Remaining aware of when the parabolic ramp up (the blue line) begins to stagnate due to a changing environment would create instant visibility to drive adaption in a more agile OODA loop than is comprehensible in the current system.

Figure 4: The technology "S-curve" life cycle of the AIM-9 missile



Cognitive Transformation and Operational Agility

Capability transformation through acquisition requires an equally weighted effort to modernize airpower application organization, processes, and doctrine. This requires cognitive transformation. Historically, core competencies lead to organizational structures but have traditionally prohibited cross functionality of platforms. While not so much of an issue in the past, cross-competency platform management warrants debate as emerging technologies will call into question 20th century constructs. Should a deployable unmanned system be organized by its deploying platform, the payload function it performs, or by who operates the system, whether a M2/MN platform or single entity.

The impact of a distributed M2/MN approach on the tactical level is not inconsequential either. Developing tactics at an unprecedented level and pace will inhibit effective application for years unless concurrent tactical development and training occurs. Curriculum and tactical methodology has gone mostly unchanged for decades due to the "second offset" concept of force packaging. Even at the pinnacle of tactical training, the focus remains predominantly looking backwards at refining and perfecting tactics that pre-date the internet.

While new platforms with new capabilities have been fielded, the premise of the mission package is generally unchanged from the Vietnam War. In Desert Storm, these packages were expanded to the limits of coordination well beyond the sizes forces trained to (and it some cases, exceeded levels of coordination and control).[20] An M2/MN architecture with numerous collaborative platforms will permit planning activities for larger forces with more capability and efficiency, and employ these forces with more precision than before. This has the potential to change the paradigm of today, where tactical and operational success is largely a victim of circumstance; dependent on having the right expertise together at the right location at the right time.[21]

The Air Force's Air University (AU) has generated some new transformation initiatives, starting with the publication of its own AU Strategic Master Plan, featuring a focus on regaining relevancy. While concurrency has garnered a negative connotation in acquisitions, the concept can be applied elsewhere with positive effect. To truly transform the way we fight, doctrine developmental concurrency will need to pull land warfare doctrine from the US Army and look for concepts of mass and maneuver that could be harvested, adapted, and then validated in the air domain. These efforts need to be fused with technological efforts across the rest of the USAF.

Seizing the initiative under the transformation of the third offset strategy will bring a unique combination of new technologies with legacy technologies, as well as new warfighting concepts with legacy concepts. Compounded with an increasingly complex and uncertain future, the USAF must embrace initiatives to evolve to not only remain relevant, but to ensure the service can remain a viable force multiplier for joint force operations.

Historically, operational agility has always been elusive, but it doesn't have to be. The Air Force, and the entire DOD, can do better. Our future depends on it. ✪

Footnotes

1 Department of the Air Force, Air Force Future Operating Concept, (September 2015) http://www.af.mil/Portals/1/images/airpower/AFFOC.pdf (accessed November, 2016), 2.

2 There are a handful of exceptions, namely the Army's Comanche and Crusader programs. USAF Col Michael Pietrucha's Air and Space Power Journal article, "The Comanche and the Albatross" explains the Comanche program cancellation. The XM2001 Crusader was slated to be the Army's next-generation self-propelled howitzer. After seven years, $11 billion spent, and only one prototype, it was cancelled when it was determined the system it was to replace, the M109A6 Paladin, was still a comparatively effective weapon. With ongoing upgrades, the Paladin remains in service today.

3 Brooks McKinney, "The B-2 Spirit Stealth Bomber Turns 25," Northrop Grumman, June 9, 2014, http://www.northropgrumman.com/Capabilities/B2SpiritBomber/Documents/pageDocuments/B-2_25th_Anniversary_Fact_Sheet.pdf (accessed November, 2016).

4 Ibid. Author's note: in the opening days of 1991's Operation Desert Storm, aircraft losses due to low-altitude profiles instituted a medium altitude operating floor. This restriction was also used in Operation Allied Force to mitigate operational risk.

5 *GlobalSecurity.org* "F-22 Raptor History," July 24, 2012, http://www.globalsecurity.org/military/systems/aircraft/f-22-history.htm (accessed November, 2016).

6 Col Michael W. Pietrucha, "Weapons Strategy 2.0," Headquarters Air Force Strategic Studies Group [Export Controlled], 2016.

7 Lt Col Geoffrey F. Weiss, "The Efficiency Paradox: How Hyperefficiency Can Become the Enemy of Victory in War," Air and Space Power Journal (Jan-Feb 2012): 2, http://www.au.af.mil/au/afri/aspj/digital/pdf/articles/Jan-Feb-2012/Feature-Weiss.pdf. (accessed November, 2016).

8 Ibid.

9 Ibid.

10 This describes Blue Force Technologies' "Grackle" penetrating vehicle, though the cost and range listed are understated due to the proprietary nature of the concept. A company white paper is available upon request describing the concept and its capabilities. Email scott.bledsoe@blueforcetech.com for inquiries.

11 One of the driving concepts behind Combat Search and Rescue (CSAR) is expeditious recovery (commonly referred to as the "golden hour"). The concept of attrition via the enemy, coupled with the golden hour, create extreme risk for CSAR personnel and platforms, creating even more potential personnel recovery events and even potentially halting combat operations to apportion additional forces.

12 Pyotr Ufimtsev, "Method of Edge Waves in the Physical Theory of Diffraction," Foreign Technology Division, (Air Force Foreign Technology Division, 1962), www.dtic.mil/cgi-bin/GetTRDoc?AD=AD0733203 (accessed November, 2016).

13 "After the surprise" and its context adapted from Newt Gingrich and Navy Capt Ronald E.Weisbrook, "Adapt or Die: The US Military's Responsibility to Protect America by Leading the Transformations in Science and Technology," Strategic Studies Quarterly (Winter 2007): 33, http://www.au.af.mil/au/ssq/2007/Winter/gingrich.pdf (accessed November, 2016).

14 Government Accountability Office, Assessments of Selected Weapon Programs, GAO-15-342SP, March 2015, 167. http://www.gao.gov/assets/670/668986.pdf (accessed November, 2016).

15 General Accounting Office, Missile Development: Status and Issues at the Time of the TSSAM Termination Decision, GAO/NSIAD-95-46, (Washington, DC: General Accounting Office, 1995) http://www.gao.gov/assets/230/220787.pdf (accessed November, 2016), 3.

16 Encyclopaedia Britannica Online, Sir Robert Alexander Watson-Watt, 11 June 2015, http://www.britannica.com/biography/Robert-Alexander-Watson-Watt.

17 Barry Leonard, ed., Military Planning in the Twentieth Century: Proceedings of the Eleventh Military History Symposium: 10-12 October 1984 (Darby, PA: Diane Publishing, 1986), 212-213.

18 Comptroller of the Air Force, United States Air Force Statistical Digest: Fiscal Year 2012, (Washington, DC: Deputy Assistant Secretary (Cost and Economics), 2013, 36, http://www.afhso.af.mil/shared/media/document/AFD-140613-009.pdf.

19 Andrew Latham, "What Is the S Curve in Business?" The Houston Chronicle Small Business Supplement, http://smallbusiness.chron.com/s-curve-business-23032.html (accessed November, 2016).

20 Author's note: "package q" was the largest strike package flown in Desert Storm and proved disastrous due to numerous small, inconsequential issues, ultimately leading to the loss of two F-16s (generating two POWs). Launched on day 3 of the war to hit targets in Bagdad, the massive package had almost 100 fighters, including 72 F-16s striking targets in the same target area. An armada of tankers and other support was also required.

21 Author's note: this is a widely held view among combat air force (CAF) tacticians and a view shared by the author based on crisis action planning in 2013, 2014, and 2015 at two different CAOCs.

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