Technomics
Better Decisions Faster

From "Plan and Pray" to "Sense and Respond"

Wargaming Defense Acquisition

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Abstract

“The most dangerous phrase in the language is, ‘We've always done it this way.’” - *Rear Admiral Grace Hopper, Ph.D.*

The need for flexible and rapid solutions in the face of emerging threats warrants a radical reset in defense acquisition. NATO’s canonical post-World War II plan-acquire-pray acquisition processes lack the agility to meet a generational change in what military historian John Keegan calls the face of battle.

A new paradigm is urgently needed to meet the exigencies of modern warfare with the adaptability of the best business firms: innovating and reacting at the speed of competition. This paper provides an innovative risk-driven framework for an Acquisition War Game that laser-focuses on key metrics such as scalability, logistical footprint, time-to-contract, and fungibility – to support today’s battles and near-peer competition with our enemies.

This new Acquisition War Game strategy ***senses and responds*** rather than ***plans and prays***, meeting reality head-on in an ever-changing battlespace.

Keywords: Cost/Benefit Analysis, Data-Driven, Decision Analysis, DOD/MOD, Methods, Modeling, Analysis of Alternatives, Wargaming

Biographies

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Dr. Brian Flynn supports national security efforts at Technomics' Arlington, Virginia, headquarters. He has a deep understanding of and strong working relationships with many of the cost and operations research organizations in the US DoD and the NATO Alliance. His areas of expertise include capability portfolio analysis and AoAs, weapon system and software cost estimating – including the cloud, EVM, econometric modeling, and corporate financial health. Dr. Flynn has undying pride in his service as a Marine.

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A Framework for Wargaming Defense Acquisition

Alex Wekluk, Ben Bergen, and Brian Flynn

Technomics

"Humans are allergic to change. They love to say, 'We've always done it this way.' I try to fight that. That's why I have a clock on my wall that runs counterclockwise."

Grace Hopper, Ph.D. Mathematician, RADM US Navy, and American Hero

Preamble

Naval drones attacking enemy ships. Aerial drones targeting enemy troops. Ukraine today. And tomorrow? Imagine swarms of drones, numbering in the thousands, *each one* cheap to manufacture, hard to detect, armed with high explosives, riding the ocean waves from every point of the compass. And with *adaptive AI* orchestrating the attack at the speed of quantum computing. Faster and better than any human mind. The objective? Sink to the bottom of the sea a $13B Ford-Class aircraft carrier, its 75 aircraft (worth billions), and its crew of 2,600 commissioned officers and sailors.

The need for *flexible and rapid solutions* in the face of such emerging threats warrants a *radical reset* in defense acquisition. NATO's[1] canonical post-World War II planning and acquisition processes, still in vogue today throughout the alliance, including the US, lacks the agility to meet what could be a generational change in the *face of battle*, using John Keegan's classic phase. We're at the cusp of a frightening future, with the fight in Ukraine providing merely a glimpse.

[1] North Atlantic Treaty Organization

NATO's *plan-acquire-pray* paradigm worked under conditions of relative certainty and incremental change. The maintained hypotheses and Bayesian probabilities of traditional warfare rang true for decades. But the deep uncertainty and rapid technological innovation of today have broken the norms.

A new acquisition paradigm is needed – urgently. To meet the exigencies of tomorrow, let alone those of today's fight.[2] Perhaps akin to practices in the business world – where the best firms constantly re-think strategy, innovate, and react to the competition with counter moves – in an endless cycle of *adaptability*.

If the old model of acquisition is too old, too rigid, too inflexible, then what is better? This paper rises to the challenge with an *Acquisition War Game* strategy that *senses* and *responds* rather than *plans* and *prays*. It meets *reality* head on, or, in Lincoln's words, "Runs the machine as we find it." Not as we wished it were.

[2] In August 2023, a pair of Ukrainian sea-based drones damaged a Russian warship and tanker in the Black Sea near Crimea. The drones are small vessels piloted by remote control that ram into targets and explode. Ukraine again in November 2023 launched a naval drone attack against Russian vessels, damaging two assault boats near Chernomorske, Crimea. These strikes have forced the Russian Navy to move its warships and supply vessels farther east, to the naval base in Novorossiysk, a port city on the Russian mainland. The effect is to push the Russian fleet farther and farther into the eastern recesses of the Black Sea – making logistical operations more difficult.

1 Introduction

The Department's requirements, resourcing, and acquisition processes favor control, compliance, and predictability over rapid innovation and adaptability. They reinforce supremacy of the bureaucracy over the battlefield, despite a *highly* dedicated workforce. Frustrated and enraged with late delivery of Mine-Resistant Ambush-Protected vehicles (MRAPs) to protect US ground forces from roadside bombs in Iraq, then-Secretary of Defense Robert Gates famously remarked,

"The troops are at war, but the building isn't." [3]

Secretary Gates' immediate predecessor, Donald Rumsfeld, offered a similar perspective just one day prior to 9/11 in comments to his staff. He reflected that DoD's "Big A" processes[4] are

"… a relic of the Cold War, a holdover from the days when it was possible to forecast threats for the next several years because we knew who would be threatening us for the next several decades. [The systems are] … one of the last vestiges of central planning on Earth."[5]

The traditional paradigm of ***Plan and Pray*** made perfect sense in an environment of stable threats, measured growth in technology, established platform designs and production lines, and an acquisition and contracting oversight approach that focused on compliance, using cost-based accounting principles.[6] Acquisition programs with little or no cost and schedule growth from their original baseline were deemed successful. The paradigm sought to eliminate waste and to increase efficiency. Noble objectives – but only when viewed through a narrow lens.

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[3] As quoted by Dr. Kathleen Hicks, Deputy Secretary of Defense, Arlington, VA., September 2023.
[4] "Big A" refers to a confluence of DoD's JCIDS, Acquisition, and PPBE processes.
[5] (Rumsfeld)
[6] (Greenwalt and Patt); page 10.

The long-standing business processes and thousands of pages of regulations were seemingly engineered to limit mistakes. By so doing, they unfortunately discouraged risk in delivering breakthrough technology to the warfighter *when needed* rather than *when available*. Indeed, complicated, duplicative, and convoluted processes, when divorced from a sense of urgency, can *undermine* the Department's ability to innovate and deliver capability *fast* and *at scale*.

Senior defense officials are sounding the alarm – a clarion call for change in the acquisition paradigm in the face of threats from Russia, China, North Korea, and Iran *simultaneously*. "What the United States needs to compete isn't an update of our already best-in-class weapons systems: an F-35 with longer range and more payload, or a faster, lighter M2 Bradley."[7] Such changes are incremental. They don't meet current let alone future needs. Ukraine, for example, operates Bradley Fighting Vehicles today. But they're kept off the front lines because of Russian ISR[8] drones which find them and artillery which destroys them. The US needs to develop and field breakthrough technology fast, such as robotics and AI[9] – but ripe enough to scale in time to matter for the warfighter – across all domains.

Why the urgency?

As Deputy Secretary of Defense Dr. Kathleen Hicks warns:

> ***"Our main strategic competitor today, the PRC[10], has spent the last 20 years building a modern military carefully crafted to blunt the operational advantages we've enjoyed for decades."*** [11]

In launching the Replicator initiative in September 2023 to deliver All-Domain Attributable Autonomous Systems (ADA2), Dr. Hicks emphasized the need for an

[7] Ibid.
[8] Intelligence, Surveillance and Reconnaissance
[9] Artificial Intelligence
[10] Peoples' Republic of China
[11] (Hicks)

"innovation playbook" of *how to change* – a prescription of the methods that will allow the Department to "scale what's relevant in the future *again* and *again* and *again*."

This paper rises to the challenge. It fills the Deputy Secretary's need. It provides an innovation playbook in the form of a Departmental acquisition engine that can force our enemy's hand through adaptability, agility, and fungibility.

Our ground-breaking playbook, based on a ***Sense and Respond*** and *Acquisition Wargaming* perspective, fills the gap between theory and practice. It provides an analytical paradigm and a set of *measurable* innovation metrics, all new to the DoD, that emphasize the Department's need to launch and terminate new development efforts more quickly, to change tack on current investments based on exigencies of the battlefield, to get new technologies into production at scale, to leverage the strength of the commercial sector including firms that typically don't do business with DoD, and to budget agilely. It is the right innovation at the right time.

2 The System of Yesterday: *React*

2.1 Forged by Strife

The United States of America was created in conflict between great powers, forged in struggle for survival, and sharpened with ever-present threats to democracy. The whetstone to the nation's military might has historically been near-peer conflicts posing existential threats to the nascent democratic ideal. Near-peer conflicts are those fought against a state or collection of challengers with the power and motivation to confront the US on a global scale where the outcome is in doubt[12]. These struggles – from the Revolutionary War to the Cold War all the way to the Global War on Terror – could be characterized as the US military ***reacting*** to adversaries. In colonial times, the United States faced global powers like Great Britain, Spain and France with their empires' might. The industrial revolution brought new foes such as Germany, Austria-Hungary and Japan in World Wars I and II. The modern nuclear age brought stalemate and Mutually Assured Destruction (MAD) with the USSR and China through proxy wars in Korea, Vietnam and Afghanistan.

2.2 Historical Near-Peer Conflicts

Some background in the form of a refresher on the US ***react*** strategy for global conflicts is prudent and follows. The US has tended towards isolationism when confronted with global conflicts. This isolationism has often made the military flat-footed when war is declared, forcing an enormous whole-of-country approach to industrial ramp-up. President Woodrow Wilson famously declared in 1914 after the outbreak of World War I, "The United States must be neutral in fact as well as in name during these days that are to try men's souls."[13] President Franklin Delano Roosevelt echoed similar sentiments in 1939: "The nation will remain a neutral nation, as long as it remains within

[12] (Szayna)
[13] (Wilson)

my power to prevent, there will be no blackout of peace in the United States."[14] Despite their best intentions, the US did obviously become embroiled in the 'European Wars'. In fact, in 1939, the US military ranked 39th in the world, holding on to vestiges of bygone force structures, including over 50,000 horses to pull artillery.[15]

Ultimately, American industrial might prevailed in both conflicts. World War I (WWI) saw rapid change from horse cavalry at the outset of the war to the invention of tanks, observation and fighting planes, radio, chemical weapons, motorized transport vehicles and ambulances.[16] American factories and farms responded to the national call for armaments and materiel.

During World War II (WWII), automotive factories were retooled to produce tanks and planes, and massive shipyards were constructed or expanded. Over 5,500 Liberty and Victory-class ships were produced for the US Merchant Marine alone.[17] Figure 1 shows the number of major naval vessels produced by the US during WWII; the other major country combatants produced a third of the ships *combined*. A critically important detail that is often neglected: American factories were nearly impervious to attack – nestled in industrial zones, such as Los Angeles and Detroit, thousands of miles away from war zones.

[14] (Roosevelt)
[15] (PBS)
[16] (National Air and Space Museum)
[17] (National Park Service)

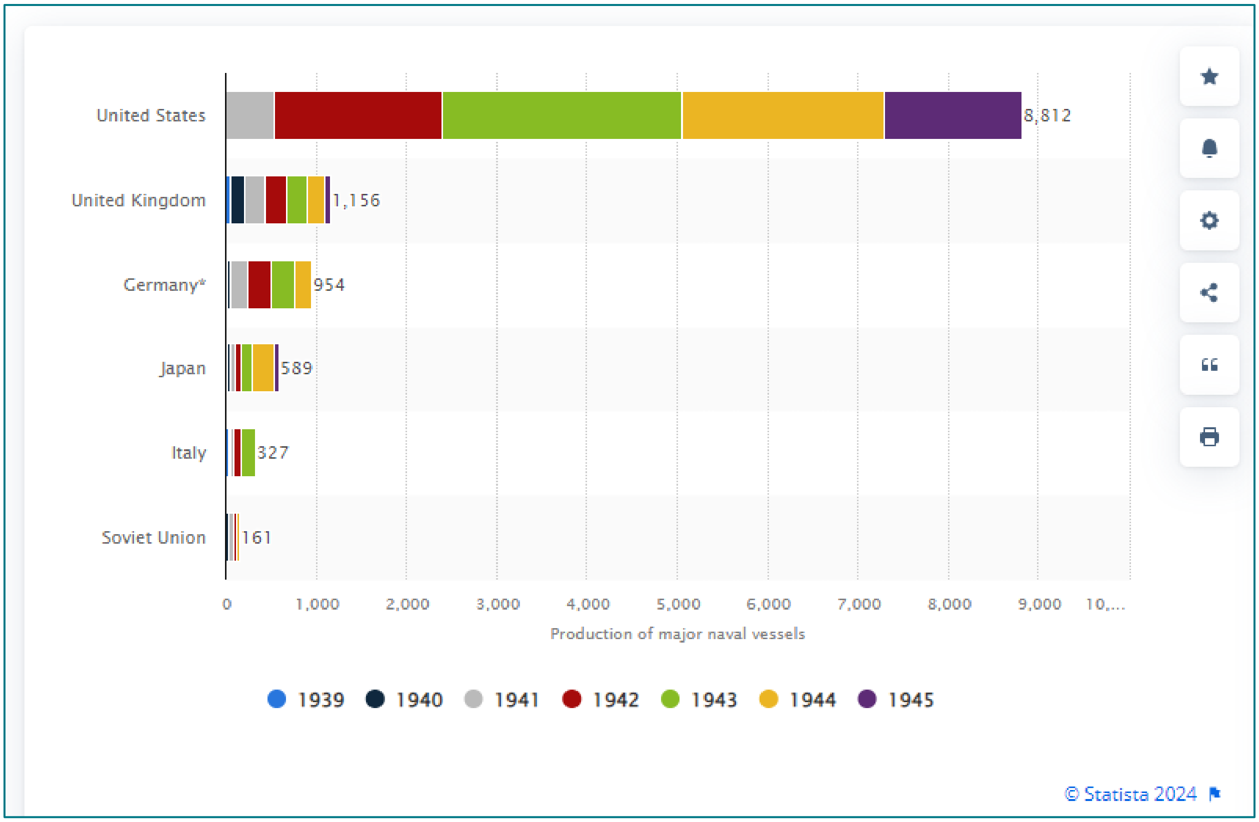

Figure 1. Annual number of major naval vessels produced by the major powers during WWII from 1939 to 1945.[18]

While the ***pace*** of WWII production was staggering, the improving ***weapons of war*** were even more impressive. Nearly every major weapon or weapon platform evolved drastically or was completely invented during the four years of involvement. One of the only weapons that stayed consistent from the start of the conflict to the finish was also one of the simplest: the M1 Garand semiautomatic rifle, designed in 1936.[19] At the outset of the war, a few modern air forces still had biplanes. By the end of the conflict, Germany had ushered in the jet age and the rocket age. The US built the Pentagon in only 16 months by 3 shifts of construction workers going 24/7 due to a critical shortage

[18] (Statista Research)
[19] (National Museum of American History)

of office space for the burgeoning warfighting effort.[20] One of the most successful fighter planes of the war, the P51 Mustang, was designed and prototyped with the first flying unit within only 117 days after the order was placed due to a critical need to protect long-range bombers.[21] WWII innovations included the Manhattan Project, building the world's first atomic weapons, in addition to radar, the first modern computers, advanced tanks, jet engines, and unmanned rockets leading the way to the post-war space program.[22]

It is a firmly established fact that in the near-peer conflicts of WWI and WWII, innovations made during the war were the only way the U.S. could compete with and ultimately defeat its adversaries. But what happens when Cold War systems face current threats? Modern platforms such as hypersonics and carrier-killer missiles could render carriers obsolete. Hackers could disrupt logistics and supply chains. Drones could exploit vulnerabilities in tanks, artillery and fighting vehicles. Anti-satellite weaponry could blind and deafen American eyes and ears in space.

Is it such a stretch of the imagination, therefore, to think that the current systems fielded to defeat the enemies of the next big war are … ***wrong***?

2.3 Military Spending

There is nothing wrong with US defense spending, and nothing close to resembling the lack of US preparedness for WWI and WWII. Quite the contrary. Figure 2 shows a healthy US DoD budget for 'O&S[23], Acquisition and Infrastructure' gradually increasing in real dollar terms.[24] Figure 3 shows US military spending dwarfing that of all other countries; in fact, thirteen of the fifteen countries on the list are directly allied or partner

[20] (Lange)
[21] (Hickman)
[22] (Burton)
[23] Operations and Sustainment
[24] The dotted lines departing from the Base Budget represent Overseas Contingency Operations (OCO), a euphemism for the two-decade-long war in Afghanistan (and, initially, Iraq).

nations. Only two nations on the top fifteen spenders list, albeit the (distant) second and third, can be considered adversaries, near-peer or otherwise.

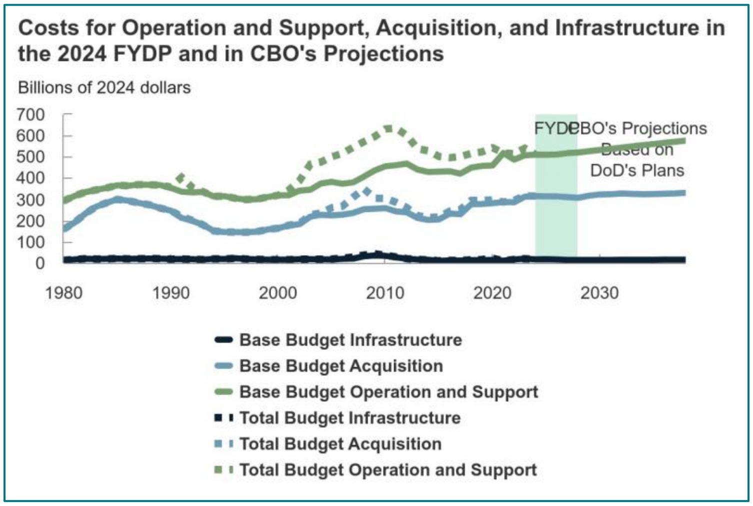

Figure 2. US DoD Budget Since 1980.[25]

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[25] (Congressional Budget Office)

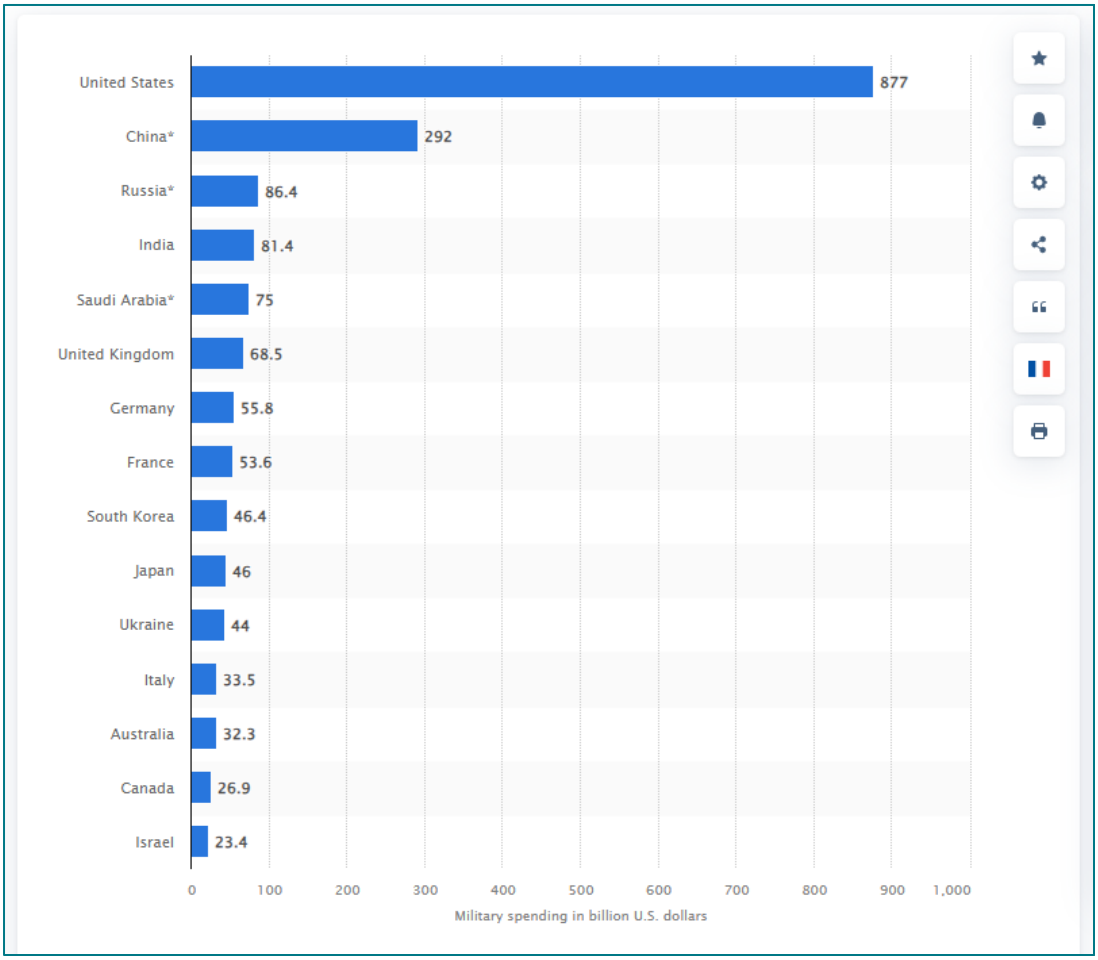

Figure 3. Countries with the highest military spending worldwide in 2022.[26]

Conversely, Army strength in *people*, a symbol of US ability to project power and win land conflicts, is shown to be at post-WWII lows in Figure 4. All that money spent on acquisitions does not translate to a greater number of capable soldiers in the ranks. There is a risk in investing in warfighting systems predominantly, especially if those systems prove inadequate in a great power conflict, at the expense of well-trained and battle-ready soldiers.

[26] (Statista)

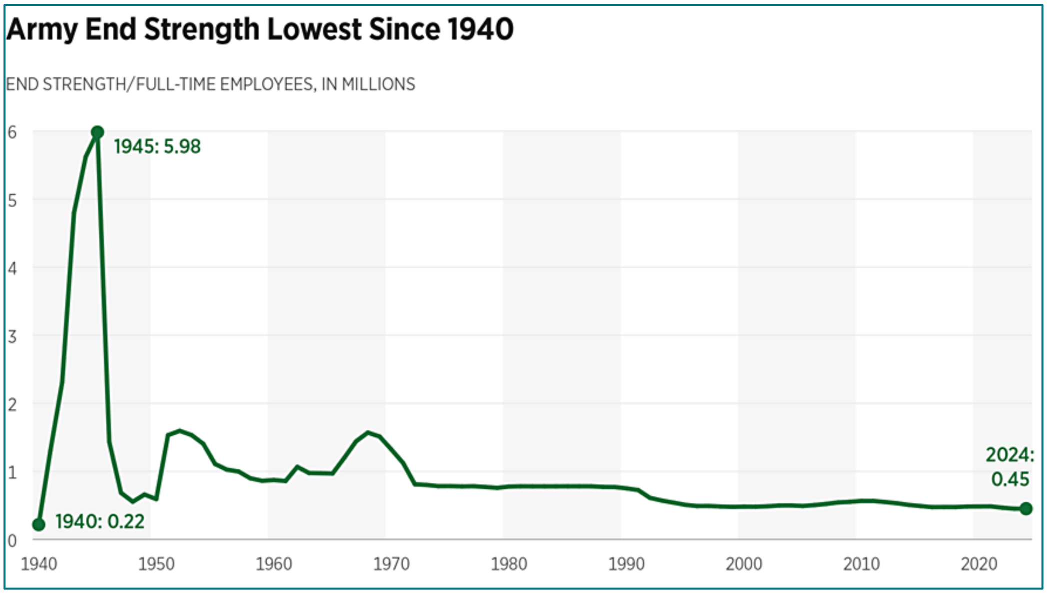

Figure 4. Army Strength in full-time professional soldiers.[27]

The issue this paper raises is not with the budget, or even the *pre-war* makeup of the armament of the armed services. The deep concern of the authors is the inflexibility of the current acquisition structure to handle rapidly evolving threats. Furthermore, the mechanisms in place to improve the process only serve to reinforce contract biases and entrench the post-WWII military industrial complex.

3 The System of Today: *Plan and Pray*

3.1 Backdrop

The ***Plan and Pray*** paradigm of Figure 5 adopts the principles of Capability-Based Planning (CBP).[28] "The idea is simple enough - start with what you want to achieve and work back to what you need."[29]

[27] (Spoehr)
[28] (The Technical Cooperation Program (TTCP)). The TTCP was created in 1957 between the United States and the United Kingdom to exchange ideas on best practices in defense planning, research, and development. Canada, Australia, and New Zealand later joined the group.
[29] (Taylor)

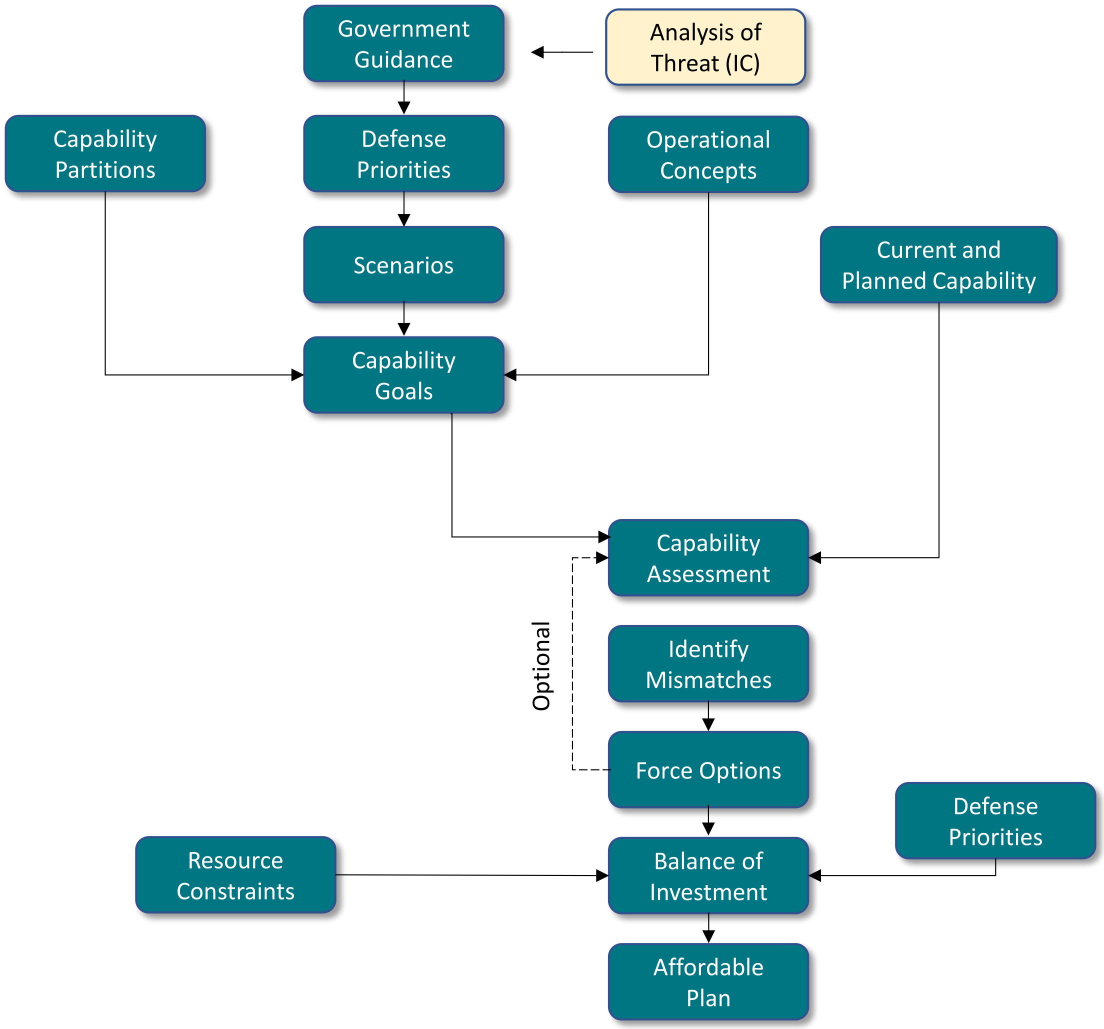

*Figure 5. The **Plan and Pray** Paradigm.*

In theory, here's how the process works. Threats are identified. Then requirements are defined in system-agnostic terms based on warfighting scenarios. For instance, instead of asking how many new large-deck amphibious vessels are needed to replace an older class, and with what new technologies (e.g., radar, communications, engines), the more fundamental issue is addressed: *how best* to get the US Marines and their equipment to the fight. This deeper dive into the true essence of the issue widens the aperture of decision space to include options such as military airlift, expeditionary forward deployments, and pre-positioned equipment in US territories (such as Guam) and allied nations (such as Germany and South Korea).

The CBP framework is institutionalized in departments and ministries of defense throughout the NATO Alliance and other allied countries such as Australia. It's the *de facto* gold standard.[30] Voluminous directives, instructions, and manuals support planning, budgeting, force development, and acquisitions of materiel solutions – with capabilities the common lexicon.

In the US, for example, the Intelligence Community (IC)[31] informs the President's *National Security Strategy* (NSS), which defines the country's approach to addressing global threats to ourselves and our allies. The Secretary of Defense (SECDEF) and Chairman of the Joint Chiefs of Staff (CJCS), based on the broad guidance of the NSS, set priorities in their *National Defense Strategy* and *National Military Strategy* directives, respectively. The Joint Staff and the Services postulate scenarios, analyze capabilities to meet requirements, set priorities, and build and deploy the force, under budget constraints from Congress. The *lingua franca* of defense planning, of course, is *money*.

The end goal? Delivery of the *right* cost-effective and affordable *capability* to the warfare *when needed* – that is, at the *right* time. As opposed to the *wrong* capability or the right capability only when *available*.

The central tenet of the capability-based planning framework, then, is an emphasis on *long-term* prediction of *future needs* and an attempt to optimize the acquisition of high-performance weapon systems against *projected* requirements. As NATO Assistant Secretary General for Defense Investment, former Canadian Ambassador Wendy Gilmore, cogently summarizes, "We plan, and hope we get it right."[32]

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[30] (Stephan De Spiegeleire)
[31] The U.S. Intelligence Community (IC) comprises 18 organizations including the Office of the Director of National Intelligence (ODNI), the Central Intelligence Agency (CIA), and DoD components such as Defense Intelligence Agency (DIA), the National Security Agency (NSA), the National Reconnaissance Office (NRO), and the National Geospatial- Intelligence Agency (NGA).
[32] (Defence and Security Economics Workshop)

3.2 Pain Points

During long stretches of relative stability in the threat environment, such as the Cold War years of the 1950's and 1960's, the paradigm of ***Plan and Pray*** worked well, producing the greatest military force in the world, albeit with notable acquisition failures.

But theory breaks down in the face of messy, unforeseen reality, as currently witnessed in Ukraine due to factors such as technological innovations and shifting adversaries. Issues arise which clog the arteries of the ***Plan and Pray*** framework leading to rigidity, inertia, and slow response times to an ever-evolving geopolitical landscape, not only in Eastern Europe but in the Indo-Pacific theatre and once again in the Middle East.

Indeed, technological competition with our adversaries has exposed the weaknesses of the *linear*, *hierarchical* paradigm of ***Plan and Pray*** in meeting military needs. Russia and the People's Republic of China (PRC) lead the US in fielding hypersonic projectiles. The PRC has a larger navy than the US and is growing its nuclear triad. It leads the world in the number of AI patents. And it's developed and fielded twenty-five new unmanned aircraft systems from 2010 to 2020, including stealthy carrier-based assets.[33]

Senior Pentagon officials are sounding the alarm. As the Chairman of the Joint Staffs of Staff recently warned "US/China competition is an "… infinite game in a constantly changing environment. Accelerate change or lose."[34] The Chairman's Deputy further offered that the US "… excels in Force-generation and Force-employment but is *weaker* in Future-Force-design."

Shortcomings of the ***Plan and Pray*** paradigm, in view of today's clarion call for increased agility and initiative, include:

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[33] (Greenwalt and Patt)
[34] (General C.Q. Brown)

- **Reliance on Prescience.** Threats evolve, the security environment changes rapidly, and scenarios postulated by defense planners prove too narrow in scope. As former Secretary of Defense Robert Gates famously quipped:

> ***"And here's the history. In the 40 years since Vietnam, we have a perfect record in predicting where we will use military force next: We've never once gotten it right.***[35]

- **Slow Adoption of New Technologies**. Technologies such as robotics and AI are central to future conflict and are largely commercial and globalized. Legacy defense acquisition processes and today's consolidated defense industrial base struggle to accommodate *timely adoption* of these technologies, as evidenced by recent lengthy time cycles (more than ten years) for development and fielding of major new-start weapon systems.[36] The Army, for example, is on its **fourth** try to replace the Bradly Fighting Vehicle, with LRIP[37] not scheduled to begin until late this decade.

- **Inflexibility of the PPBE Process**. While acquisition reform has been the norm since at least the time of the Goldwater-Nichols Act,[38] the Department's Planning, Programming, Budgeting, and Execution (PPBE) system, with a focus on appropriations and the "color of money," has been more stable since its origin in the 1960's under Secretary of Defense Robert McNamara.[39] PPBE encodes divisions between research, production, and operations activities that stymy

[35] Former SECDEF Robert Gates, 2014, in response to a question by journalist Mike Allen at a Politico conference. Secretary Gates continued "If you think about it from Grenada to Haiti to Somalia to Panama to Iraq twice to Afghanistan to Libya twice, the Balkans and so on — in not one of those cases did we have any hint six months ahead of the start of hostilities that we were going to have military forces in those places"
[36] (Greenwalt and Patt)
[37] Low-Rate Initial Production
[38] The Goldwater–Nichols Department of Defense Reorganization Act of October 4, 1986, was an attempt to fix problems caused by inter-Service rivalry, which had emerged during the Vietnam War, and which had contributed to the catastrophic failure of the Iranian hostage rescue mission in 1980, under President Carter.
[39] Mr. McNamara established the Planning, Programming, and Budgeting System (PPBS).

iterative or feedback-based development. New programs with emergent technology must typically wait more than two years to be included in the budget.

- **Long Cycle Times**. As Dr. Bill LaPlante advises, “Production is deterrence.”[40] But cycle times or time-to-market for DoD material solutions are increasing over time, as Figure 6 shows, with cycle time defined as the time elapsed between program initiation (usually at Milestone B) and Initial Operational Capability (IOC). Cycle time, then, represents the speed at which DoD fields new capabilities. By the time material solutions reach the warfighter, they’re sometimes approaching obsolescence, or suffering significant reliability and availability issues. A classical example is Littoral Combat Ship (LCS), both the Freedom Class and Independence Class, with LCS’s capability for self-defense in the littoral found lacking shortly after IOC.

[40] Undersecretary of Defense (Acquisition and Sustainment).

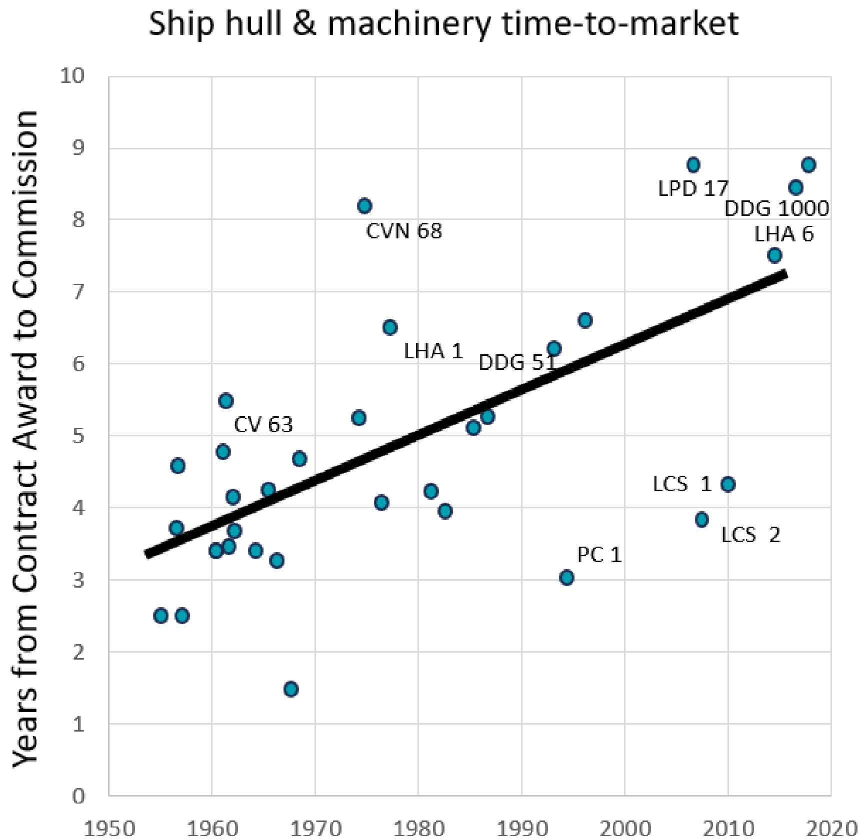

Figure 6. Secular Uptrend in Cyle Time for Navy Ships.

- **<u>Myopic View of Affordability Analysis</u>.** The money lies in sustainment. Historically, however, defense leadership has focused primarily on development and procurement costs.

- **<u>Difficulty in Making Tradeoffs Between Capability Partitions</u>.** Due to ongoing global power shifts, future military operations will likely take place in a drastically changed geopolitical environment. But DoD's record is poor in responding to change, and particularly in making tradeoffs between capability and capacity within and between portfolios (e.g., ballistic missile defense versus tactical air versus strategic sealift) across the Services and combatant commands.

- **<u>Rigid Institutionalization</u>.** The individual armed Services (Army, Navy, Marine Corps, Air Force, Space) are understandably resistant to initiatives to transfer money to joint missions, given that they have more confidence in their own methods to address risk in their battlespace. Consequently, there's an abiding tension as capabilities are envisaged to be executed in a joint environment, but budgets are allocated to Services.

4 The System of Tomorrow: *Sense and Respond*

4.1 Mandate

Faced with renewed near-peer competition with Russia and China, and in view of current military operations in Ukraine and the Middle East, western defense organizations are gaining awareness of how Emergent and Disruptive Technologies (EDT) have ushered in a new way of warfighting. Indeed, the emergence of *digital* and *cognitive* dimensions of Multi-Domain Operations (MDO) requires a transformation of ends, ways and means.[41] The battlespace of today demands enhanced use of Command, Control, Communications, Computers, Intelligence, Surveillance, Reconnaissance (C4ISR) along with orchestrated fires across different domains (land, sea, air, space, ground, network), and lightning maneuver.[42]

Easier said than done. Quick, decisive, "master strokes" that deliver victory in a matter of days or even months are exceedingly rare. The history of conflict presents endless counterexamples – bloody attritional campaigns that draw in vastly greater resources than originally anticipated – personnel, money, and materiel.[43] Yes, the bombing of

[41] The focus of military strategy on MDO dominates defense planning throughout the NATO Alliance and amongst allied nations such as Australia, South Korea, and Japan. MDO, in essence, is the combination and coordination of effects across military and sometimes non-military domains.
[42] As witnessed in Ukraine today, drones capture geospatial information on enemy forces, including at the individual soldier level. The information is then transmitted to howitzers, Bradleys, tanks, and mortar platoons for action.
[43] Examples include the Vietnam war and Operation Iraqi Freedom (OIF), with the latter's mantra of "Shock and Awe," a concept expounded in the 1996 publication "Shock & Awe: Achieving Rapid Dominance," National Defense University, Harlan K. Ullman and James P. Wade Jr.

Hiroshima and Nagasaki ended the war quickly in the Pacific in 1945. But the atomic bomb took years to develop.

Hubristic assessments about the ability to achieve victory quickly and cheaply can make matters worse, leading to organizational ignorance, often profound and sometimes egregious, of the *ways* and *means* to achieve *perceived* ends. Think the trench warfare of World War I, the two wars in Iraq, and Afghanistan. Optimism bias too often prevails.

With this stark reality in mind, the ***Sense and Respond*** paradigm of Figure 7 seeks *not* to completely eschew the old framework of planning, programming, and acquisition but to use the best of it *while* simultaneously adopting new methods to address the fast and ever-changing face of battle.

> ***"US/China competition is an infinite game, in a constantly changing environment. Accelerate change or lose." – General CQ Brown*** [44]

[44] (General C.Q. Brown)

4.2 Conceptual Framework

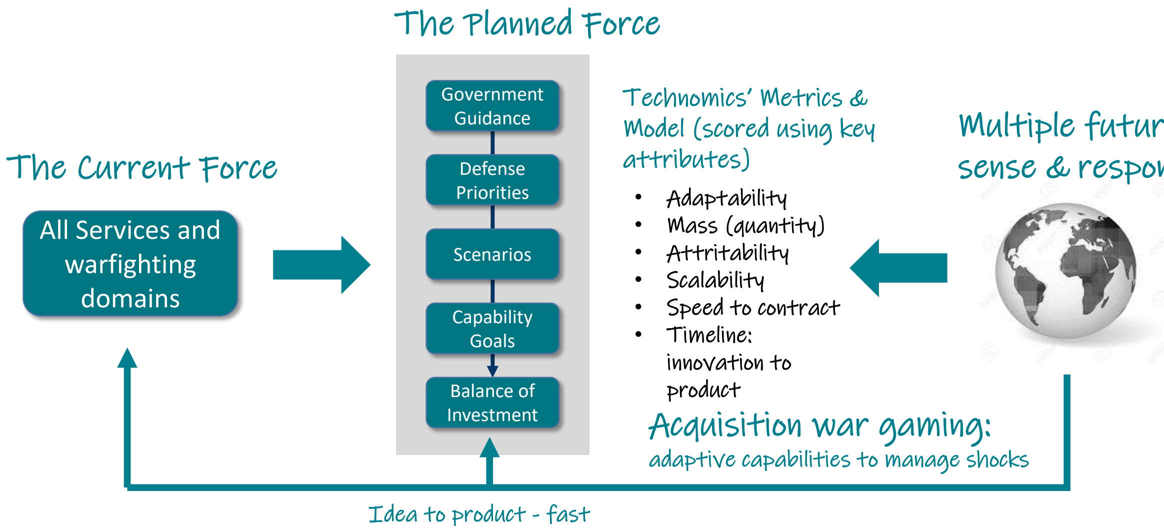

*Figure 7. **Sense and Respond** Framework.*

The ***Sense and Respond*** framework leverages complimentary perspectives to assess the ways and means of meeting requirements in the Chairman's "… *constantly changing environment*," depicted in the figure as traditional planning (left to right) and robust innovation (right to left). The framework synthesizes the insights from these perspectives to arrive at conclusions and recommendations for shaping the force.

Traditional Planning

Moving from left to right in the figure, traditional planning begins with the current force as a baseline upon which to identify *incrementally* revised capabilities across the entire Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities, and Policy (DOTmLPF-P) spectrum. The current force morphs into the planned force, or the target of the investment pipeline – with a focus on the Future Years Defense Program (FYDP) and the President's Budget (PB) but with investments often spanning decades.

The planned force, then, is an aspirational dot on the horizon – a derivate of the ***Plan and Pray*** paradigm with its positives and pain points alike. It incorporates the incrementally improved set of capabilities – at least in theory. But as Dr. Mark Husband of DAU[45] posits[46]

> ***"… the DoD has rightly been criticized for spending as much as 40 percent of its acquisition funding on programs that were terminated before delivering capability."***

A good example of aspirational planning is the US Army's ***fourth*** attempt to replace the aging M2 Bradley fighting vehicle. The XM-30 replacement, now in prototype design by competing Original Equipment Manufacturers (OEMs), will include significant innovations such as incorporation of a 50mm cannon, development of new types of ammunition, and creation of a virtual crew member. Impressive. But the XM-30 vehicle itself will nevertheless remain roughly 80% common with its predecessor – a Rough Order of Magnitude (ROM) metric common across major weapon systems in the DoD.

Robust Innovation

Moving from right to left in the figure, robust innovation begins with a more forward-looking approach to identify novel capability options that are different from the current and planned force but that respond *faster* and *more efficiently* and *effectively* to multiple possible futures as they unfold and become reality.

Leveraging lessons from the on-going fights in Ukraine and the Middle East, technological developments in the private sector, and current initiatives from NATO (e.g., an analysis of the future of "fire and maneuver") Figure 8 depicts examples of current trends that can help shape the composition of the future forces in the ***Sense and Respond*** paradigm, across all phases of conflict.

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[45] Defense Acquisition University
[46] (Husband and Kaspersen), page 10.

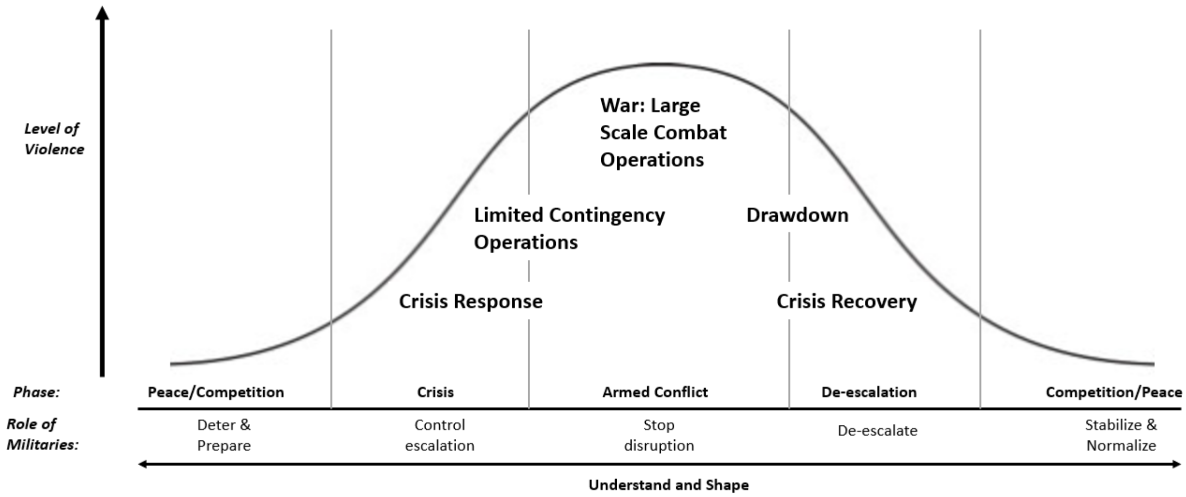

Figure 8. Multiple Phases of Conflict.[47]

- **Technology**. Military organizations within the NATO alliance have a poor track record in developing and fielding Emergent and Disruptive Technologies. The Mid-Tier Acquisition (MTA) pathway in the DoD has helped – but not nearly enough. The speed of private-sector innovation continues to far outpace defense planning and procurement timelines. Perhaps a "good enough" approach might be useful to at least keep minimally abreast of new technologies as they unfold – rather than investing in exquisite capabilities that might take a decade or longer to reach the battlefield.

- **Government Timelines**. These are too long and too complex for rapid execution. They likely need overhauling to create capability opportunities more frequently; to support flexibility in both program portfolios and "colors of money"[48]; and to create incentives that encourage disruptive practices, including working with startups and venture capitalists. Unfortunately, despite laudable efforts such

[47] Adapted and altered from source (de Wijk, Bekkers and Sweijs)
[48] Budget appropriations within the Department are often restrictive as to what they can be spent on (e.g., R&D vs. Production) and difficult to reprogram, and recent attempts have been made to introduce greater flexibility, such as BA-08 funding for Software Acquisition Pathway programs, which doesn't distinguish between Development and Maintenance, thus better fitting the DevSecOps paradigm.

as the creation of the Army's Future Command and Secretary's Austin's Defense Innovation Unit (DIU), the infamous "valley of death" prevails – the inordinate time required to get technology into the production phase of acquisition.

- **Artificial Intelligence**. Emergent AI-based capabilities can support force planning and application; battlespace awareness and understanding; fast, precise, and resilient kill chains; and resilient sustainment.[49] AI developments in communications systems, autonomous and unmanned systems, synthetic and extended reality are unfolding. AI may soon allow campaigns to be executed autonomously at a distance without physical command nodes. These developments challenge the prevailing paradigm of national security, defense, and warfighting.[50] The pace and the extent to which AI will replace humans to execute missions is uncertain; but, it undoubtably will influence the future of warfare.

- **Supply**. Even with perfect awareness and understanding, even with ideal force-protection and force-application assets, egregious problems on the battlespace will ensue if the force lacks supply. As Dutch Admiral Rob Bauer, the Chair of NATO's Military Committee, recently reflected based on experience in Ukraine, "… every war after say four-five-six days becomes about logistics."[51]

- **Data, Data, Data**. Urgently needed is the capability to synthesize the ever-growing reams of information obtained from a wealth of sources such as space-based ISR, unmanned systems across domains, and conventional assets. To overcome the *fog-of-more*, there's an urgent need for improved data processing and machine-learning algorithms, backbone communications networks, and personnel to support the analysis and dissemination of intelligence.[52] Finally,

[49] (Deputy Secretary of Defense), page 5.
[50] (de Wijk, Bekkers and Sweijs).
[51] (Defense News)
[52] Ibid.

data, analytics, and AI capability will require tremendous *computing power*. Demand will grow exponentially as adoption scales.

- **Integration**. Countering the hybrid threats of today requires complex and creative solutions. Militaries can and do carry out kinetic and cyber-attacks behind enemy lines, making use of robotic systems as intelligence collectors and force providers. This requires truly *integrated* forces with seamless transitions between intelligence gathering, offensive cyber operations, influencing campaigns, and conventional battles.[53] Integration will be critical to achieve optimal tradeoffs between commonality and complexity, as Figure 9 shows, given that the Department is an "enterprise of enterprises.[54]

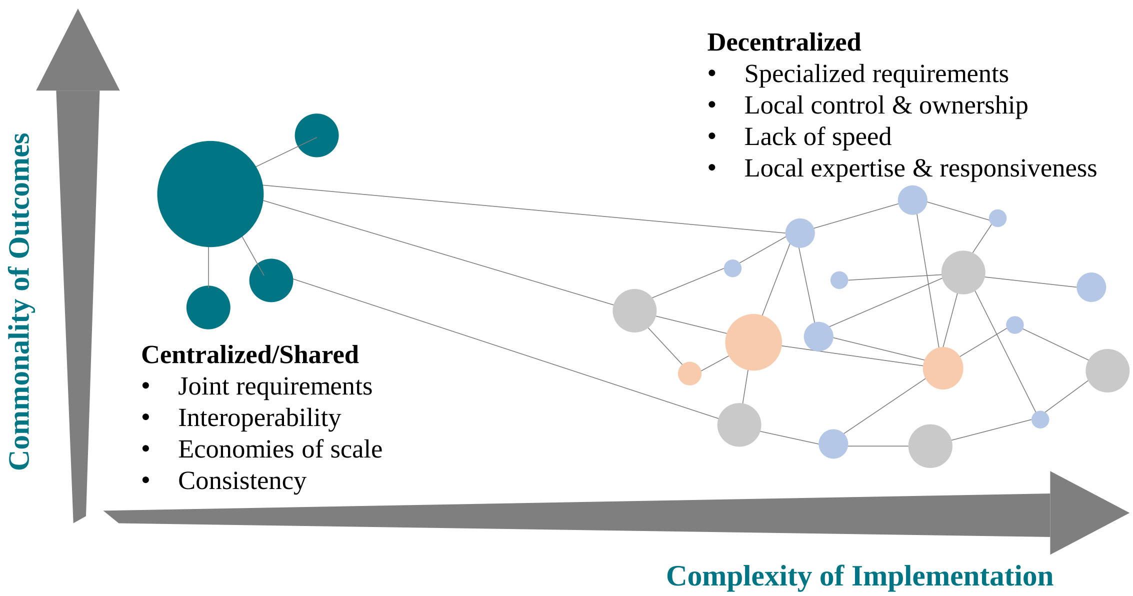

Figure 9. Commonality versus Complexity.

[53] "The Future of NLD SOF: Towards an All-Domain Force."
[54] (DoD's Software Modernization Strategy)

4.3 Measures of Contract Adaptability (MOCA)

The transition from a ***Plan and Pray*** framework to a ***Sense and Respond*** approach for decision-makers can be abetted by comparing potential solutions across identified success measures we have termed Measures of Contract Adaptability (MOCA). These measures span a comprehensive set of key drivers identified as crucial for achieving a higher probability of success and appropriateness as a solution. The seven groups of MOCA offer stakeholders a ***measurable*** means to assess the effectiveness of a solution for the warfighter, minimizing the risk of realizing it's the wrong solution after substantial investment. Ideally with these MOCA in mind, the US would pursue fewer of the endless franchise systems such as the F-35 or the Abrams tank, in favor of quicker-to-field, quicker-to-replace systems that will not outstay their welcome in the military of tomorrow.

MOCA comprise ***time to contract***, ***scalability***, ***time to production***, ***logistics footprint***, ***adaptability*** of the defense industrial base, ***response*** to today's fight, and ***fungibility***. Each measure, shown in Figure 10 and described in Table 1, serves as a key determinant of a program's success, requiring measurement, monitoring, and understanding by all key decision-makers. This evaluation approach ensures a more informed decision-making process, reducing the likelihood of costly missteps in program development and procurement. These measures could be tailored and applied at the contract, program, portfolio, or enterprise level.

Figure 10. Measures of Contract Adaptability (MOCA)

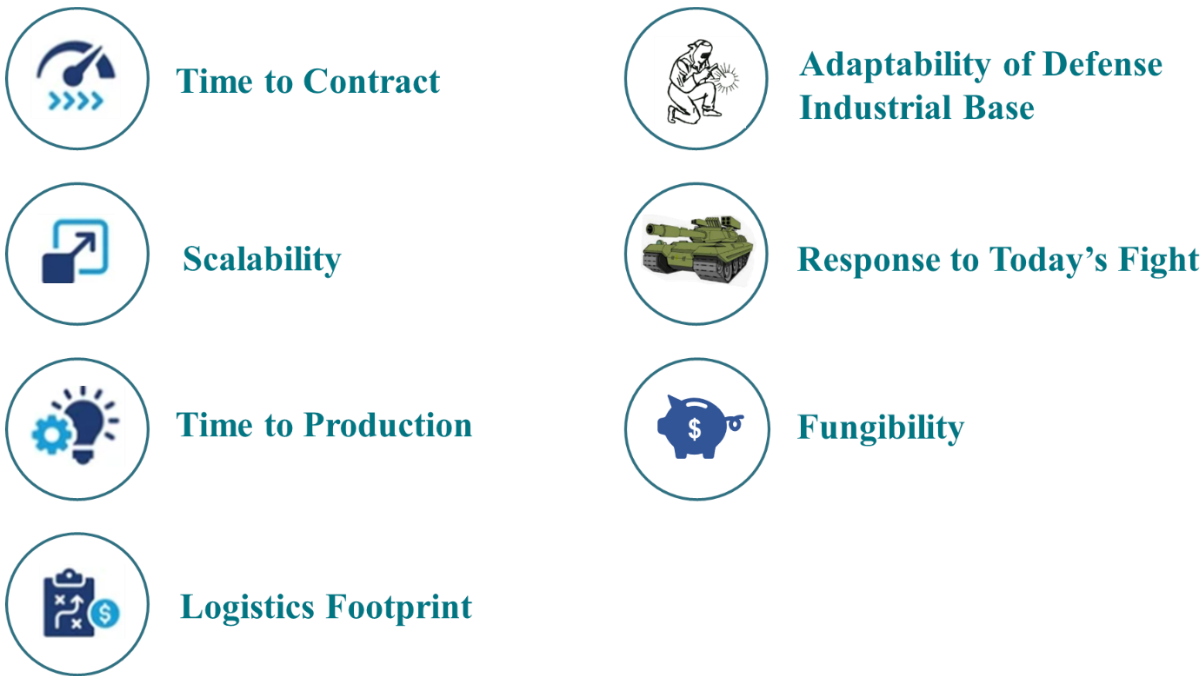

Table 1. Measures of Contract Adaptability

Attribute to Support the *Sense and Respond* Framework	Top-Level Explanation and Assessment
Time to Contract: Duration from the initial identification of a requirement until the finalization of a contract to fulfill that requirement	• Does the length of the contracting process hinder the ability to respond to urgent operational needs? • Are there measures in place to expedite contracts for critical capabilities in crisis?
Scalability: Ability to efficiently expand or reduce military operations, capabilities, and systems to meet changing mission requirements and operational demands	• Does the current infrastructure support scalable solutions for unforeseen military needs or conflicts?
Time to Production: The period it takes for a new technology to transition from initial research and development stages to full-scale manufacturing and deployment	• Are partnerships with industry and academia optimized to reduce the time from innovation to implementation? • Is there an efficient pathway from research and development to full-scale production that supports rapid fielding of critical technologies?
Logistics Footprint: Size, scale, and complexity of the logistical operations and resources required to support military forces	• Extent of personnel involvement, the geographical spread, the number of companies, components, and materials involved
Adaptability of Defense Industrial Base: Ability to efficiently modify and adjust operations and outputs in response to evolving military needs, technological changes, and other external factors	• Can the industry pivot to new technologies in response to emerging threats? • Can the industry support rapid integration of innovative solutions to maintain technological superiority?
Response to Today's Fight: The speed with which OEMs and their vendors respond to the exigencies of the battlefield, such as the need for drones and the 155mm ammunition	• Does the current defense procurement and manufacturing ecosystem support swift shifts in priorities to address emergent threats and operational demands effectively? • Key questions include readiness, ease of transport into the battlefield, mission success rate, versatility against a range of threats, and adaptability to environments
Fungibility: Degree to which the material solution is affordable, attritable, and cost effective	• Is the system cheap enough to lose? • If lost, will the technology be compromised? • Does the expense make sense? (e.g., firing an $800K/unit round to defeat an enemy target when a $1K drone might suffice)

Our hypothesis proposes that these seven measures are pivotal in predicting the success of a Major Defense Acquisition (MDA) program and its ability to promptly adapt to field changes. These measures serve as a scorecard, enabling the assessment and prediction of the effectiveness of resulting contracts. Programs excelling in these categories stand the best chance of avoiding obsolescence as the battlespace evolves. Presently, acquisition programs are not assessed against these criteria as they are awarded; rather, the focus remains on meeting a backlog of additional requirements inherited from the previous generation's solution. To counter this oversight, we propose the continuous evaluation of these seven measures within the Analysis of Alternatives (AoA) process. This approach will increase the likelihood of selecting the most appropriate and effective solution.

The ***time to contract*** measure is critical for swiftly developing, producing, and delivering systems to the warfighter. According to a 2018 GAO study, the average time to award a contract is 387 days for competitive bids and 278 days for sole-source contracts.[55] These contracts navigate numerous milestones before the eventual winner can commence work. The acquisition plan must be written and approved, undergo readiness reviews across various stakeholders, issue the Request for Proposal (RFP), allow time for proposal submissions, compare Independent Government Cost Estimates (IGCEs) to proposals, engage in negotiations, gain final approval. Then, at long last, the contract can be awarded. Such prolonged procedures significantly delay program kickoff, jeopardize warfighter delivery, and increase the risk of technological obsolescence. Swift contract awards allow contractors to advance system development in a timely manner. In the dynamic battlespace, exemplified in Ukraine, delays may render initial solutions ineffective or impractical, prompting stakeholders to abandon programs or redesign requirements.

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[55] (GAO)

It is crucial that contracts and systems are ***adaptable***, possessing the capability to rapidly **scale** production up or down in response to the changing battlespace, as previously discussed. Taking the example of Ukraine with the procurement of 155mm shells, it becomes evident that scaling is imperative. Before the war, the US Army produced 14,000 shells per month. However, after a year of war, this figure doubled to 28,000, and there are plans to further increase production to 60,000 by summer 2024 and 100,000 by the end of 2025—a sevenfold production increase in four years[56]. Achieving such a substantial increase necessitates major investment in modernizing the US industrial base and opening additional production lines. Despite the increased production, the US has struggled to meet battle demand due to the 155mm program's inability to scale rapidly enough, a limitation rooted in previous production capacity. Currently, the US Army is requesting $3.1 billion to purchase additional rounds, with half of the funding allocated for increasing industrial capacity[57]. While this investment aims to enhance future scalability, recognizing and addressing scalability shortfalls earlier would have enabled the Army to meet requirements more readily, underscoring the importance of proactive measures and scoring current capabilities.

Another key measure is the **time to production** at scale (time to market). According to the Center for Strategic and International Studies (CSIS), the DoD takes an average of 6.9 years to reach Initial Operational Capability (IOC) from Milestone B[58]. This lengthy process requires program planners to plan years in advance to ensure the system reaches the field when needed. It is vital for decision-makers to understand the development timeline when comparing systems with similar capabilities, specifically the rate at which programs progress through Technology Readiness Levels (TRL). The time required for a system to evolve from a TRL 5 (technology validated in a relevant environment) to TRL 9 (actual system proven through successful mission operations) will vary across systems. Understanding the progression duration for each system is

[56] (Skove)
[57] (Stone)
[58] (Blivas, Tidwell and Dwyer)

essential as this factor plays a decisive role in determining when the system will be ready for field deployment.

The **logistics footprint** and the **adaptability of the US industrial base** are also critical measures in major defense acquisition programs. These categories involve constant interactions between numerous stakeholders across multiple organizations, including program managers, engineers, and manufacturers, all working towards the goal of bringing the system to the warfighter. Key considerations and questions must be addressed to determine the complexity and adaptability of the operations. This includes the extent of personnel involvement, the geographical spread, the number of companies, components, and materials involved. This leads to further questions about supplier diversity: Does the program rely on a sole supplier, or can multiple vendors provide the necessary components? Are the components highly specialized and technical, or are they primarily Commercial Off the Shelf (COTS) items? The more complex the supply chain and logistics footprint, particularly with single sources, the higher the risk of disruption. The program's resilience in the face of supply chain disruptions and its ability to quickly adapt to alternative suppliers are vital in times of conflict.

Additionally, the ability to **respond effectively to today's fight** will be essential. With the rapid evolution of threats and the dynamic nature of the modern battlespace, systems must succeed in various mission spaces and adapt alongside the enemy. Key questions include readiness, ease of transport into the battlefield, mission success rate, versatility against a range of threats, and adaptability to environments. The use of surveillance drones has made the battlefield more transparent, making it harder to move large amounts of vehicles and troops without the other side knowing[59]. This has made the use of large, armored vehicles less effective against agile, lower-cost alternatives. As a result, both sides have relied on alternative solutions.

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[59] (Gady)

Finally, the measure of ***fungibility*** is crucial. This involves assessing the affordability and replaceability of systems. Key considerations include the cost of system loss, the sustainability of using expensive assets against lower-cost threats (e.g., using multimillion-dollar missiles against inexpensive drones), and the reusability of systems. Questions about resupply times, the impact of system loss on personnel, and the replaceability of autonomous systems are vital. These factors are essential when evaluating systems for acquisition, ensuring that resources are used effectively and sustainably in various conflict scenarios.

4.4 Measurable MOCA Success Metrics

For each Measure of Contract Adaptability, we have identified key drivers that can be scored to aid stakeholders in anticipating what constitutes "success." While there are many factors that go into predicting success, this framework can serve as a starting point to help compare various programs on the same playing field. A comprehensive catalogue of these drivers is available in Section 8.2 Complete List of Acquisition Wargaming MOCA.

Time to Contract:

This measure, while having fewer drivers compared to others, values the importance of efficiency in the contracting process. Time to contract includes the ability for rapid contract adaptation by incorporating changes, modifications, and updates enables swift action in response to evolving mission conditions. Mission conditions may require the ability to exercise options, issue delivery orders, implement contract modifications, and seamlessly transition to new contracts if needed. The agility with which contracts are awarded and executed can significantly influence a program's timeline and its ability to meet the warfighter's needs promptly.

Scalability:

The scalability of an acquisition program is influenced by several key drivers, among which lead time and unit cost are particularly critical. Lead time refers to the time between the placement of an order and the delivery of the product. Shorter lead times enable more efficient and effective product delivery, granting stakeholders enhanced decision-making flexibility. Conversely, extended lead times constrain flexibility, potentially hampering the program's ability to adapt to changing needs or environments.

Similarly, unit cost has a significant influence on a program's scalability. High unit costs limit the extent to which a system can be scaled, as financial constraints become more pronounced with larger quantities. Systems that achieve similar capabilities at lower costs offer a more sustainable path to scalability, enabling higher quantities. Recognizing and managing these drivers—lead time and unit cost—is essential for ensuring a program can scale effectively and meet its objectives within constraints.

Time to Production:

The timeframe for transitioning from Development to Production can significantly differ across programs, presenting a notable challenge in forecasting due to the potential for unexpected delays and schedule overruns. However, a critical factor in understanding the timeframe is knowing the system's TRL progression. The TRL serves as a valuable indicator of a system's maturity and reliability, informing decision-makers about the feasibility and risk associated with its development and deployment.

Systems with lower TRLs are inherently associated with greater uncertainty and risk. This heightened uncertainty not only increases the likelihood of schedule overruns but also impacts the program's ability to meet its deployment and operational goals within the planned timeline. Conversely, systems demonstrating higher TRLs indicate a level of maturity and development that suggests a lower risk of unexpected challenges disrupting the transition to production at scale. Understanding and evaluating the TRL during the decision-making process is essential for mitigating risks and ensuring a smoother progression from development to operational readiness.

Logistics Footprint

The logistics footprint of a program includes several critical factors, including the quantity of at-risk materials and resiliency to supply chain disruptions. Many complex programs deal with a vast range of materials and components, the availability of which can be severely impacted during conflicts. These disruptions can result in delays, shortages, or complete cancellations.

In scenarios where a critical part cannot be procured, the system is at risk of not being fielded. The necessity of having contingency plans, such as backup components, additive manufacturing capabilities, or alternative suppliers, becomes crucial. This is particularly true in times of conflict, where supply chain dynamics are likely to undergo significant shifts, potentially impacting the availability of essential materials and parts.

Adaptability of Industrial Base

The adaptability of the US Industrial Base is another crucial measure. It is quantifiable through various drivers, among which the diversification of the Industrial Base stands out. The potential halt in production due to inability to procure an at-risk material or part, as highlighted in the logistics footprint section, underscores the importance of diversification. By broadening the base of part suppliers and minimizing reliance on single sources, production stoppages can be significantly mitigated. Qualifying a broader array of companies to supply components not only reduces this risk but also enhances the government's flexibility in design adjustments, increases the chances of selecting the most qualified vendors, and increases the likelihood of cost savings due to competition. Additionally, encouraging suppliers to apply their expertise in existing domains to new areas can further increase the Industrial Base’s adaptability and flexibility. The expansion in supplier capabilities will allow suppliers to build and support a broader range of systems.

Response to Today’s Fight

In the context of today's rapidly evolving battlefield, the capacity for systems to feature a modular mission profile and rapid deployment emerges as critical. Systems confined to narrow operational scenarios lack versatility, diminishing their value across the broader spectrum of potential engagements. Modern systems must be adaptable, capable of addressing diverse requirements to remain relevant. Equally crucial is the speed of deployment; systems must reach the battlefield promptly, minimizing staging time.

Delays in deployment increase the risk of missing critical operational windows, thereby compromising effectiveness.

Fungibility:

Fungibility, the final measure in our framework, focuses on the degree to which the materiel solution is affordable, attritable, and cost effective. An important driver is the cost per use which evaluates both the unit cost and the frequency of use, offering a comprehensive view of a system's economic efficiency. For instance, comparing a high-cost round to a low-cost drone, both designed for a single use, highlights the importance of considering both cost and operational utility. A $1K drone, assuming comparable effectiveness against a common target, represents a much more fungible option than an $800K round. This perspective on fungibility underscores the preference for solutions offering repeated utility, facilitating a more nuanced comparison of system efficacy and value.

5 Acquisition War Games: The Analytical Engine

5.1 Wargaming Acquisition

The MOCA framework presents a rich evaluation construct by which to gauge contracts, programs, and portfolios of programs. MOCA could be tailored and applied to evaluating current or future contracts and acquisition approaches. US military doctrine draws a lot from *war games*, which attempt to measure the efficacy of systems hypothetically squaring off against a range of simulated enemy systems. Scenarios, starting from vignettes of real-world plausible events such as a Chinese incursion over the Taiwan Strait, are run ad infinitum to account for every possible perturbation and risk. For cost modelers and acquisition experts, this is akin to running Monte Carlo (MC) analysis on risk profiles. Instead of *cost uncertainty*, the war game plays in *technical efficacy uncertainty*. Military wargaming is thoroughly researched but is not without its flaws, however. A recent 2023 GAO report to the Committee on Armed Services, House of Representatives, raised concerns with information sharing and misalignment of resources, stakeholders, and standards of educating war gamers.[60] War games are often too stove-piped and narrowly focused.

War games can be played out at the policy, strategic, operational, or tactical level. They help to examine concepts, educate commanders, and ensure system viability. They also inform decision-makers where to deploy assets and where to expect adversary assets and countermeasures. The modern concept of a war game goes back to the 19th century in Prussia, and gained a widespread acceptance when Prussia defeated France in the Franco-Prussian War.[61]

In the intervening years to today, wargaming has seen popular acceptance in video games and board games for casual use, military simulations for professionals, and even business wargaming. Business wargaming aims to help a company succeed in a competitive marketplace with role-playing simulating moves and counter-moves of rival businesses.[62] Business war games draw additionally from Nobel Prize laureate John Nash's Game Theory, with mathematical approaches to moves, counter-moves and strategies. He posited many strategies involving payoff to actions, and what happens when a competitor is aware of your plans and factors your objectives into their strategy. One such solution to a game is the Nash Equilibrium, in which each player tries to maximize expected payoff, and they have sufficient intelligence (seeing through the aforementioned fog of war to deduce the "correct" solution to the game).

A big takeaway of the Nash Equilibrium is that no success is possible unless the other participants' strategies are considered and that the only real solution may be a game state where none of the participants achieve their goal.[63] A ready example of the Nash Equilibrium is trench warfare of WWI, and the reluctance of any warring parties to change strategy for mutual benefit. If this sounds familiar to a non-economist, you might have seen it in the movie *A Beautiful Mind,* in which Russell Crowe plays Nash. The

[60] (US Government Accountability Office)
[61] ("Foreign War Games")
[62] (Singh)
[63] (Nash)

movie cleverly portrays a group of male college students in a night on the town. The group sees a group of female students, and Nash lays out scenarios where all participants approach the same female, and then ones where all participants approach different females. Nash uses the opportunity to find a weakness in Adam Smith's "survival of the fittest"; instead, the group of competitor suitors would benefit most not by operating in their own interest, with their own strategy, but alongside the strategy of the other participants in collective self-interest. (Who knew Nash invented the wingman?!)

Thus, there is a great deal of research available for military wargaming. If an observer is lax with the exact definition, a great deal of business and game theory wargaming add to the body of knowledge to leverage. So where could a new breed of game find a niche?

We are proposing a new type of wargaming, involving the ***efficacy*** of *acquisition systems* to position the US for fighting the next big war. Of course, the US Department of Defense *and* the Intelligence Community should collaborate to reduce the GAO-identified stovepipes around wargaming. By using the MOCA identified above, an ***Acquisition War Game (AWG)*** could then test contract structures and adaptability to respond to a new adversary system or countermeasure. Historically, when bombs start to drop signaling the start of a near-peer conflict, our existing warfighting systems have proven inadequate for the duration of the conflict. Section 2 of this paper highlighted some stark examples of the rapid pace of technological change: from horse cavalry to tanks in WWI, and from biplanes to jets in WWII! If that can be expected in the next conflict (and it should **definitely** be expected), then we should also expect a complete realignment of acquisitions when that happens.

Acquisition Wargaming would involve the same vignettes as traditional military wargaming, such as a Chinese Taiwan Strait incursion. Next, those vignettes would be put through their paces with simulations resembling a 10,000-run MC analysis. Each simulation would answer the question of different systems and combinations of systems being inadequate. Imagine if our tanks and fighting vehicles were able to be targeted by drones with a high degree of effectiveness, as we are actually seeing in Ukraine right now. That would increase the standoff distance between the front lines and those assets. The same could be true in Taiwan if China's DF-21D "carrier killer" missile is proven effective: their range of nearly 1,000 miles ***already*** forces our carriers, the centerpiece of our naval strategic battlegroups, to stay well away from the Chinese mainland.[64] The iterations would change the threats, and the responses; current and future potential threats. An ***AWG*** would ask this question over and over again: If some or all systems are vulnerable or obsolete, what would change?

5.2 Renewed Focus on Acquisition *Strategy*

An ideal ***AWG*** would focus on acquisition strategy, and its objectives would be to leverage scoring criteria to evaluate program contract fungibility. Our MOCA construct provides an innovative new approach, because these are not typically leveraged metrics when determining the next major acquisitions. We are all familiar with the requirements generation process today: build the same system as before, with *more stringent requirements*.

A jet should carry a bit more payload and have longer range; an electro-optical telescope satellite should have a slightly better Ground Resolution Distance (the size of an individual pixel when translated to the earth). These requirements are suited to similar systems as before: if a carrier previously housed around 64 (but up to 130) aircraft, the next big system should improve upon that slightly, and have a higher speed and more electronic countermeasures. That means that the replacement system will likely be an even bigger carrier. If ***AWGs*** run many scenarios where carriers are ineffective, they should run alternatives where their replacements are disaggregated and non-monolithic. Perhaps the "escort carrier" role of WWII would be a preferable option. These carriers were half the length of the typical fleet carriers of the time and helped to offload lesser strategic priorities from the fleet carriers. They could also be built in a fraction of the time at a fraction of the cost. A smaller ship in a disaggregated architecture would be able to onramp new technologies and counter-countermeasures

[64] (CSIS)

in a critical fraction of the time of our current *Nimitz*-Class carriers and their eventual *Ford*-Class replacements. Currently, those replacements take eight to ten years from laying a keel to commissioning, at a hefty price tag of nearly $13B ***each*** in base year 2018.

Run properly with all the relevant stakeholders, Acquisition Wargaming might help to break up longstanding shortcomings in our acquisition system. It is a well-established fact that contractors spread construction of their systems across as many states as possible to demonstrate the job-creating benefits of their system. Lockheed's F-35 website has an infographic with each state selectable to show the allocation of the ***$72B annually*** that is spent on the program.[65] The graphic is shown in Figure 11 with Oregon and the nearly half a billion dollars per year of investment in that state alone.

The objective of these systems is to ensure programs have a lot of political support, even if the program is not what the Department of Defense needs or wants. By scoring programs with MOCA in an ***AWG***, planners could have an objective approach by which to disaggregate our huge monolithic warfighting systems into smaller and more fungible contracts with improved warfighting adaptability. Geographically-distributed funding does not necessarily cause an issue for smaller and less-entrenched programs, but certainly should not be an objective that currently helps to "bulletproof" a program. In a case such as shipbuilding, geographic distribution is much more challenging due to the specific nature of shipyards. Today, large ship programs receive support from powerful Senators such as John Warner (R-VA) for Newport News Shipbuilding (NNS), support that make those programs a top priority in the inevitable logrolling trades of the budget process.

[65] (Lockheed Martin)

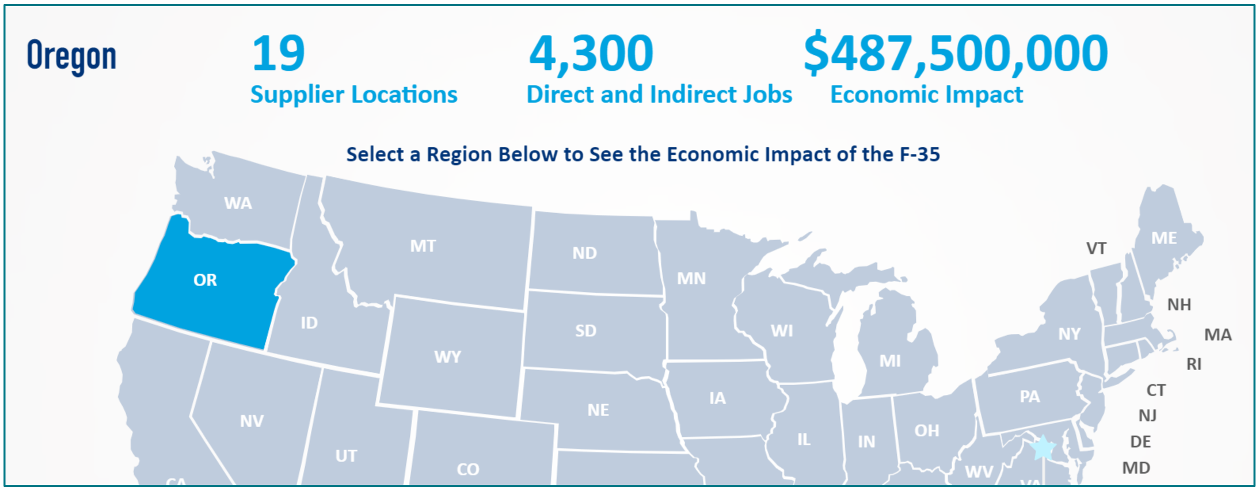

Figure 11. LM graphic showing economic impact of F-35, selecting Oregon.

5.3 Utility of MOCA in Acquisition Wargaming

The MOCA we developed are *measurable* metrics that either directly represent a key aspect of adaptability or indirectly measure a proxy. As an example, the previous section discussed the negative impact of politics in the current acquisition system. ‘Political influence’ is impossible to measure directly; however, MOCA give a framework for indirect measurements such as ‘number of states involved in production’ or ‘percentage of program by state’ that *could* measure such an impact. The MOCA in our paper are suggestions but can be tailored, adapted, and improved depending on the objective of the ***AWG*** being run.

5.3.1 MOCA Scoring – Dynamic Range and Reweighting

Our team developed a test model to examine the effectiveness of programs against the MOCA criteria. We scored programs and developed a reweighting schema to account for the dynamic range of some of the variables. For example, ‘lead time’, one of the ***Scalability*** key drivers, has a vastly different range of potential outcomes in days or months than another ***Scalability*** measure, ‘available square footage’ (of factory space) in thousands or millions of square feet. Additionally, some MOCA such as lead time are better to be lower, while others such as factory space is better higher. Our team chose to account for the dynamic range by comparing to the *median* value with percentage, and an inverse percentage for MOCA drivers that are better if they are lower. An alternative option could be minimum/maximum weighting. The model was designed to measure the impact of each MOCA, based on *all* the scored programs being assessed. Median weighting is less susceptible to outliers, which is especially important when considering some of the measures could overwhelm other measures. One example is floor space, wherein one industrial partner could have a million available square feet (sqft) of space, while another has tens of thousands. While advantageous, a million sqft may not be needed for any given new system, so the second vendor should not be penalized too much. For now, each key driver of the MOCA is weighted equally in a process similar to *weighted least squares*. If there are enough stakeholders in the ***AWG***, a Borda Count or Delphi Technique may be a preferable way to prioritize certain MOCA or key drivers, especially for given system types. These techniques are well-characterized in the Cost Estimating Body of Knowledge and are provided here primarily for context.

5.3.2 Tabulated Scoring

AWG involves focusing on a vignette such as a Taiwan Strait incursion by China. In one scenario of that vignette, we might need more conventional fleet carriers and that system would score highly militarily. In others, we would find the time to field the system too long, and another system might be preferable. MOCA for those opposing scenarios would rank based on conflict scenarios; if carriers are desperately needed, 'Response to Today's Fight' would contribute most. If conflict timelines are too short to field a carrier, 'Time to Contract' or 'Fungibility' would contribute most. Alternative drone concepts could also be scored to determine which procurement strategy to take: in many conflict vignettes and scenarios, a disaggregated architecture of responsively-designed drones would likely score better than a single monolithic drone system such as Global Hawk.

The final step of the scoring process is to aggregate the cumulative score of the program. For the sample model, the team calculated the average of all the MOCA, building a single unitless composite score that could be compared to scores of other contracts or systems. When aggregating with MC analysis, we could have a sense of how adaptable that platform would be across many scenarios.

Not all MOCA key drivers identified by our team are applicable to all situations. Factory floor space has nothing to do with the immense shipyards needed for a fleet carrier keel. An agile software program, when compared against a carrier or a satellite, would have incredibly high scoring; however, many of the measures do not make sense for other warfighting platforms. The sample model our team constructed ignored null responses that were not relevant to the system being measured, reweighting the remaining measures and key drivers proportionally.

5.3.3 AWG Simulations

After determining a weighting scheme, we developed two alternative approaches to the ***AWG***. The first is a ***Monte Carlo simulation***. In our model, each key driver has a distribution formed by the example programs. Those programs could be past, present, or planned. The distributions for each driver are all *correlated* to one another; higher correlations for in-family MOCA drivers, and lower for other MOCA drivers. For the MC simulation, each run represents a randomly chosen 'way of the world' in which different parameters might be an optimal approach to the conflict vignette and scenario. The MC run would yield a distribution around each MOCA that could help to score each system.

The second ***AWG*** approach is a ***Manual Branching*** exercise, wherein a traditional war game would determine the efficacy of systems against enemy systems through repeated trials. The ***AWG*** would make simulated adjustments each time to the acquisition pipeline accordingly, with the full participation of procurement executives in the agencies involved.

5.3.4 Wargaming Objectives

Agency leads could benefit from running the AWG, armed with this new technique by which to prioritize ***change*** over traditional monolithic procurement options. Dr. Troy Meink, PDD/NRO (Principal Deputy Director of the National Reconnaissance Office), listed rate of change as the critical discriminator against our adversaries. His point extended from procurement and fielding of systems all the way to economic dominance. MOCA measures could help provide a data-driven means to objectively grade programs and portfolios, leading to a prioritization of agile, responsive systems.

Ultimately, a well-run ***AWG*** would identify the 'grizzly bears' of the US military industrial complex. Grizzly bears can survive in feast or famine – equally comfortable scrounging for food in tundra or fishing a stocked salmon stream. Grizzlies can hibernate if needed; additionally, they can spend more or less time in dens as needed. They have been known to gain 50% of their bodyweight before hibernation, consuming both plants and animals as available.

The US needs more military grizzly systems: platforms that can be scaled up or down, respond to changing conditions, onramp new technologies and weaponry, and operate in sparse or rich budget environments without fear of massive contract change or cancellation costs. The ***AWG*** construct helps to prioritize those programs and find them among the aging systems that are trapped in ever-increasing requirement and cost increase spirals.

6 Conclusions and Recommendations

Time and again, history demonstrated the incredible pace of technological change during great power conflicts. Time and again, the US has failed to predict the next big war or has the materiel already in place that would be required to win. The ***React*** strategy was devastating for the Lusitania, the sinking of which precipitated US involvement in WWI. The US was caught so severely off-guard in WWI that it bought nearly all its fighter planes from France and England due to the absence of required infrastructure.[66] The ***React*** strategy was devastating for Pearl Harbor, with the surprise attack that ushered the US into WWII. The ***React*** and the ***Plan and Pray*** strategies failed to account for the unexpected incursions into Korea and Vietnam, jungle warfare or the Chinese decision to join the wars. Following the ***Plan and Pray*** strategy may well

[66] (National Museum of the United States Air Force)

prove devastating too in the future – specifically in the likely event that we fail to identify the “correct” threats and corresponding requirements to build systems needed for victory. Up and down the leadership chain, everybody seems to lambaste the acquisition process and see the need for responsive acquisitions.

What, then, can leadership do about it?

Our team developed a new framework to help guide the US military and IC towards a responsive ***Sense and Respond*** strategy. Our seven MOCA provide guideposts for evaluation based on metrics that were previously unmeasurable – often with data we already collect for acquisition contracts. Using ranking schema identified in this paper, we provided a way to evaluate contracts or systems both in place today, **or** planned for tomorrow.

We recommend agencies and oversight organizations employ our framework to run Acquisition War Games immediately, ideally in conjunction with traditional games and without the usual stovepipes or turf wars. Agencies need to identify and prioritize those systems and contracts that are responsive, agile, and fungible to meet the enemies of tomorrow head-on.

Our future might just depend on it.

7 Other Applications of MOCA and AWG

AWG and MOCA can be extended to other areas of wargaming. For example, AWG could develop Order of Battle priorities for planners: what would acquisition groups do in a near-peer conflict by Day 1? Day 7? Day 90? A plan for what contracts would need to be rescoped, cancelled, or increased could be an important product from working through these vignettes and scenarios with objective MOCA metrics.

7.1 Order of Battle

AWGs would have substantial benefits in addition to MOCA and contract efficacy. The key to winning a great power struggle is responsiveness. A war game could give us a huge advantage in the immediate window after missiles start to fly. Envision what will likely happen once the war starts. In the ensuing days and months, acquisition organizations will:

- ***Cancel*** some contracts that take ***too long***
- ***Rescope*** some contracts that need ***more*** systems
- ***Rescope*** some contracts that need ***less*** systems
- ***Start new*** contracts
- ***Redesign*** components, sensors, or payloads to meet ***adapting*** needs
- ***Mothball*** systems in the field that are ineffective, saving resources previously spent for Operations and Sustainment

Looking back at recent experience in Iraq, Afghanistan, and Ukraine, battlefield priorities shifted from planes and tanks to force protection; for example: Mine-Resistant Ambush-Protected vehicles, or MRAPs, Improvised Explosive Device (IED) detection, drone warfare, and as mentioned previously, 155mm shells. The battlefield of the future will certainly involve space awareness and protection, drones, AI, and any number of new systems we have not imagined yet. Is this any different from the emergent battleground of ironclads in the US Civil War? Tank warfare in WWI? Carrier warfare and blitzkrieg in WWII? Drone warfare in Ukraine?

Operational planners should of course know where to move divisions and attack groups when war breaks out. But could acquisition and logistics planners anticipate what budgets will be cut and which ones will be increased? Can we assess programs now to better posture for the future? Can acquisition wargaming these scenarios improve US acquisition responsiveness overall? The answer to these questions is, without doubt, a resounding "***yes***."

7.2 Sensitivity Analysis

A robust ***AWG*** could answer the questions identified in this paper, helping to re-prioritize and re-gear the US military strategy away from ***Plan and Pray*** toward ***Sense and Respond***. AWGs could also help identify the sensitivity of our systems to new war stimuli. For example, if carrier killer missiles expand their range, how sensitive are our carriers and war doctrine to that evolving threat? Would we need to reorganize naval battle groups, and would that impact new acquisitions? How would contracts and new systems evolve to face that new threat?

Experienced wargamers play those scenarios out thousands of times in traditional wargames. With the techniques developed by the authors, new problems are identified and mitigated early. Our approach facilitates sensible, forward-looking prioritization of more responsive systems, contracts and acquisition processes. MOCA will inform sensitivity analyses by enabling creation of Pareto curves showing cost versus adaptiveness or expanded Monte-Carlo analysis with more robust probability distributions for expected efficacy of systems under a wider range of new conditions.

8 Appendix A: Resources

8.1 Acronyms, Initialisms & Abbreviations

Acronym	Definition
ADA2	All-Domain Attributable Autonomous Systems
AI	Artificial Intelligence
AWG	Acquisition War Game
Big A	DoD's JCIDS, Acquisition and PPBE processes
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CBP	Capability-Based Planning
CJCS	Chairman of the Joint Chiefs of Staff
COTS	Commercial Off the Shelf
CSIS	Center for Strategic & International Studies
DAU	Defense Acquisition University
DIU	Defense Innovation Unit
DoD	Department of Defense
DOTmLPF-P	Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities, and Policy
EDT	Emergent and Disruptive Technologies
FYDP	Future Years Defense Program
GAO	Government Accountability Office
IC	Intelligence Community
IED	Improvised Explosive Device
IGCE	Independent Government Cost Estimate
IOC	Initial Operational Capability
ISR	Intelligence, Surveillance and Reconnaissance
LRIP	Low-Rate Initial Production
MAD	Mutually-Assured Destruction
MC	Monte Carlo
MDO	Multi-Domain Operations
MOCA	Measures of Contract Adaptability
MRAP	Mine-Resistant Ambush-Protected
MTA	Mid-Tier Acquisition
NATO	North Atlantic Treaty Organization
NNS	Newport News Shipbuilding
NRO	National Reconnaissance Office
NSS	National Security Strategy
O&S	Operations and Sustainment
OEM	Original Equipment Manufacturer

PB	President's Budget
PDD	Principal Deputy Director
PPBE	Planning, Programming, Budgeting and Execution
PRC	People's Republic of China
RFP	Request for Proposal
ROM	Rough Order of Magnitude
SECDEF	Secretary of Defense
SOF	Special Operations Forces
sqft	Square Feet
TRL	Technology Readiness Level
USSR	Union of Soviet Socialist Republics
WW1	World War 1
WW2	World War 2

8.2 Complete List of Acquisition Wargaming MOCA

The following tables encapsulate our research findings and presents a complete list of key drivers of the Measures of Contract Adaptability. They are designed to facilitate the quantification and assessment of these measures, offering a structured approach to scoring. This framework enables stakeholder to make informed decisions.

Time to Contract Drivers

Contract Adaptability	Ability to exercise options, issue delivery orders, implement contract modifications, and seamlessly transition to new contracts if needed.
Award Time	Time taken to award contract

Scalability Drivers

Production Capacity	Number of units or products that can be manufactured within a given timeframe
Throughput	Rate at which products are produced, processed, or completed
Lead Time	Determine the time it takes to fulfill an order from the moment it is placed to the moment it is delivered to the customer. Shorter lead times indicate higher scalability.
Resource Utilization	Evaluate the utilization of manufacturing resources such as machines, labor, and materials.
Downtime	Amount of time manufacturing operations are halted due to maintenance, equipment failures, or other issues.
Production Cost	Analyze the cost per unit produced, including raw materials, labor, energy, and overhead costs.

Yield Rate	Percentage of products that pass quality control and meet the required standards.
Supplier Performance	Ability of your suppliers to provide materials and components on time and at the required quality.
Scrap and Rework Rates	Percentage of defective products that need to be discarded (scrap) or reworked.
Flexibility	How easily the manufacturing process can adapt to produce different products or handle changes in demand.
Lead Time Variability	Consistency of lead times.
Available Sq Footage	Unoccupied floor space within a manufacturing facility, essential for accommodating additional production capacity or new equipment
Space Utilization	Efficient organization and optimization of available space within a manufacturing facility to maximize productivity, minimize waste, and facilitate seamless scaling of operations.
Capital Expenditures	The financial investments necessary for acquiring, upgrading, or maintaining physical assets, including buildings and equipment, to support the scalability of manufacturing operations
Modularity of facility	The extent to which a manufacturing facility is designed in modular units, allowing easy reconfiguration and integration of new components or production lines to adapt to changing demands.

Time to Production Drivers

Transition Success Rate	Measures the percentage of projects that successfully transition from the development phase to production.
Technology Readiness Level (TRL) Progression	Track the progression of technologies through different TRL stages during the development-to-production transition.
Utilization of Dual-Use Technologies	Monitor the extent to which dual-use technologies (technologies with both military and civilian applications) are successfully integrated into military production.
Prototype Testing Duration	Track the time taken to test prototypes and gather feedback from testing phases.
Production Setup Time	Measure the time required to set up the production line, including configuring machinery, training staff, and preparing for mass production
Production Ramp-Up Time	Measure the time taken to increase production from initial low volumes to full-scale mass production.
Time to Market	Calculate the total time taken from the project's initiation to the moment the product is fielded.

Logistics Footprint

Number of suppliers	Total count of distinct companies or entities that provide materials, components, or services within a specified period

Number of parts	Total count of unique parts, components, or materials supplied by all the vendors or suppliers.
Location of suppliers	Geographical dispersion and distribution of suppliers providing goods or services
Transportation Cost per Mile or per Unit	Total transportation expenses divided by the distance traveled or the number of units transported
Mode of Transportation Utilization	Breakdown of transportation modes used (air, sea, land) and the percentage of each mode's utilization
Time in Transit	Average time taken for transportation of critical components or materials
Inventory Turnover Ratio	Measure of how quickly inventory is used or sold within a specific time period
Days of Inventory	Average number of days goods are held in inventory before being used in production.
Warehouse Capacity Utilization	Percentage of warehouse space being used compared to total available space.
Carbon Emissions	Measure of greenhouse gas emissions associated with transportation and logistics activities.
Waste	Waste in packaging, manufacturing, and logistics operations.

Adaptability of Industrial Base Drivers

Number of at-risk materials	Count of materials or components deemed critical or susceptible to supply chain disruptions, geopolitical risks, scarcity, or other factors that may impact production or delivery.
Resilience to Disruptions	Ability to recover quickly from supply chain disruptions, measured by downtime or recovery time after an event
Supply Chain Cycle Time	Time taken from order placement to final delivery, reflecting the efficiency of the entire supply chain process
Lead Time Variability	Measure of consistency in lead times for various components and materials.
Supplier On-Time Delivery Performance	Percentage of deliveries from suppliers made on time.
Supplier Corrective Action Requests	Number of requests made to suppliers for corrective actions due to quality issues.
On-Time Delivery Performance:	Percentage of deliveries from suppliers made on time as per the agreed-upon schedule.
Lead Time Adherence	Consistency in meeting agreed-upon lead times for supplying materials or components
Supplier Fill Rate	Percentage of orders filled by suppliers without shortages or delays
Inventory Age	Average age of inventory items in stock, indicating potential obsolescence or overstocking issues
Supply Chain Risk Index	Assessment of potential risks and vulnerabilities within the supply chain, considering factors like geopolitical, environmental, and operational risks

Response to Todays Fight

System Availability	Percentage of time system is available for operation
Interoperability	Evaluate the system's compatibility and interoperability with other defense systems and allied forces to ensure seamless collaboration
System Success Rate	Percentage of time system operates when relied upon
Deployment Speed	Measure the time it takes to deploy forces to a specific location in response to a crisis
Mission Success Rates	Evaluate the success rates of military missions conducted in response to contemporary threats
Sealift and Airlift Capacity	Evaluate the capability to rapidly transport military assets and personnel to different theaters of operation
Modularity Index	Number of different mission requirements the system can meet and respond to.
Integration of Artificial Intelligence	Evaluate the extent to which AI is integrated into systems for decision-making and operational efficiency
Supply Chain Response Time	Measure the time it takes to replenish critical supplies during a mission
Logistics Cost as a Percentage of Operations Budget	Assess the efficiency of the logistics system by evaluating its cost-effectiveness.
Communication and Command Control	Evaluate the reliability and redundancy of communication systems to maintain command and control capabilities even in challenging environments
Intelligence Integration	Assess how well the system integrates intelligence data to enhance decision-making and mission planning
Uptime	The percentage of time the system is operational
Latency	The time it takes for a system to respond to a request. It's crucial to monitor and ensure that response times are within acceptable limits
Mean Time Between Failures (MTBF)	The average time between system failures

Fungibility Drivers

Cost-Effectiveness	The ratio of cost to performance, where lower costs for equivalent or superior capabilities increase fungibility
Uses Per Dollar	A measure of how many times a system or component can be used relative to its cost, highlighting both economic efficiency and operational utility

Modularity	The degree to which a system can be modified or adapted for different roles or missions, enhancing its utility across various scenarios
Interoperability	The ability of different systems, units, or forces to work together seamlessly, which can significantly increase the fungibility of assets across different platforms or branches of the military.
Maintenance and Sustainment Costs	Lower long-term costs associated with maintaining, repairing, and sustaining systems contribute to their overall fungibility by making them more economically viable over their lifecycle
Reusability	The capacity for components or systems to be reused in different contexts or for different missions, enhancing their value and reducing waste
Unit Cost	The cost of a single unit

8.3 Bibliography

Defense News May 2023.

""Foreign War Games"." Heistand, Translated by H.O.S. *Selected Professional Papers Translated from European Military Publications*. Washington, D.C.: US Government Printing Office, 1898. 233-289. https://archive.org/details/selectedprofess00divigoog/page/n244.

Air Force Conference. *Air Force Conference*. Arlington, VA: Air and Space Forces Association, September 11-13, 2023.

Blivas, Alec C, Brenen Tidwell and Morgan Dwyer. "Cycle Times and Cycles of Acquisition Reform." 2020.

Burton, Kristen D. PhD. "The Scientific and Technological Advances of World War II." *The National WWII Museum* n.d. https://www.nationalww2museum.org/war/articles/scientific-and-technological-advances-world-war-ii.

Congressional Budget Office. "Long-Term Implications of the 2024 Future Years Defense Program." 2023. PDF.

CSIS. *Missile Threat CSIS Missile Defense Project*. 28 Mar 2022. https://missilethreat.csis.org/missile/df-21/#:~:text=The%20DF%2D21D%20is%20a,accuracy%20of%2020%20m%20CEP. 1 Feb 2024.

de Wijk, Rob, et al. "The Future of NLD SOF: Towards an All-Domain Force." July 2021.

Defence and Security Economics Workshop. Ottawa, Canada, 26 and 27 October 2023.

Deputy Secretary of Defense, Dr. Hicks. "Data, Analytics, and Artificial Intelligence Adoption Strategy." 2023.

"DoD's Software Modernization Strategy." n.d.

Gady, Franz-Stefan. *ForeignPolicy*. 6 December 2023.

GAO. "Defense Contracts DOD Should Develop a Strategy for Assessing Contract Award Time Frames." 2018. Document.

General C.Q. Brown, Chairman of the Joint Chiefs of Staff. *Air Force Conference*. Air and Space Forces Association, 11 to 13 September 2023.

Greenwalt, Dan and William Patt. "Competing in Time: Ensuring Capability Advantage and Mission Success through Adaptable Resource Allocation." February 2021.

Hickman, Kennedy. "World War II: North American P-51 Mustang." *Military History* (2014).

Hicks, Deputy Secretary of Defense Kathleen. "Remarks: "Unpacking the Replicator Initiative" (As Delivered)." *Defense News Conference*. Arlington, Virginia, Sept. 6, 2023.

Husband, Dr. Mark and Mr. Keith Kaspersen. "The AoA - An Early Filter to Create an Affordable Program." *Defense AT&L* (May–June 2012).

Lange, Katie. *https://www.defense.gov/News/Feature-Stories/Story/article/1867440/pentagon-history-7-big-things-to-know/*. 19 12 2019.

Lockheed Martin. *https://www.f35.com/f35/about/economic-impact.html*. n.d. 6 Feb 2024.

Meink, Dr. Troy. *Coffee and Conversation with Troy Meink, PhD* INSA President Suzanne Wilson Heckenberg. 4 Mar 2022. YouTube.

Nash, John F. "Equilibrium Points in n-Person Games." *Proceedings of the National Academy of Sciences* 1950: 48-49. Periodical.

National Air and Space Museum. *https://airandspace.si.edu/stories/editorial/technology-world-war-i*. 6 4 2017. 10 1 2024.

National Museum of American History. *https://americanhistory.si.edu/collections/nmah_418516*. n.d. 25 1 2024.

National Museum of the United States Air Force. *WWI Production*. 2024. https://www.nationalmuseum.af.mil/Visit/Museum-Exhibits/Fact-Sheets/Display/Article/197455/wwi-production/.

National Park Service. *https://www.nps.gov/articles/liberty-ships-and-victory-ships-america-s-lifeline-in-war-teaching-with-historic-places.htm*. n.d. 11 1 2024.

PBS. *https://www.pbs.org/kenburns/the-war/war-production*. n.d. 15 1 2024.

Roosevelt, Franklin Delano. "US Neutrality, Fireside Chat." 3 Sept 1939.

Rumsfeld, Secretary of Defense Donald H. "DOD Acquisition and Logistics Excellence Week Kickoff - Bureaucracy to Battlefield." *The Pentagon*. Monday, September 10, 2001.

Singh, Arjan. "Using War Games to Predict Competitors' Moves." 1 July 2019. *Life Science Leader.* Website. 1 Feb 2024.

Skove, Sam. *Defense One*. 27 November 2023.

Spoehr, Thomas W. *2024 Index of U.S. Military Strength*. 24 01 2024. https://www.heritage.org/military-strength/assessment-us-military-power/us-army.

Statista. *Countries with the highest military spending*. n.d. https://www.statista.com/statistics/262742/countries-with-the-highest-military-spending/.

Statista Research. *https://www.statista.com/statistics/1336932/wwii-major-naval-vessel-production-annual/*. 1 1 1998. 29 1 2024.

Stephan De Spiegeleire, Principal Scientist. n.d.

Stone, Mike. *Reuters*. 7 November 2023.

Szayna, et al (RAND). *The Emergence of Peer Competitors*. Santa Monica, CA: RAND, 2001.

Taylor, Dr. Ben. *TTCP*. Canada, 2013.

The Technical Cooperation Program (TTCP). "Guide to Capability-Based Planning." 2004.

US Government Accountability Office. "Additional Actions Could Enhance DoD's Wargaming Efforts." April 2023. https://www.gao.gov/assets/gao-23-105351.pdf.

Wilson, Woodrow. "Message on Neutrality." 19 Aug 1914.