THE P-51 MUSTANG: A CASE STUDY IN DEFENSE ACQUISITION

Alan Haggerty and Roy Wood

In the rapidly changing global situation, defense acquisition needs to be equally agile and innovative. We must look to every source—government, industry, and academia—for ideas to make warfighter systems more capable and affordable. This article presents a historical case study of the World War II *P-51 Mustang* fighter plane development that illustrates ways the aircraft designers embraced the challenge to build a world-class fighter aircraft in the face of a challenging enemy, entrenched bureaucracy, and immature industrial capability. Enduring lessons are presented for today's acquisition professional.

Keywords: *P-51 Mustang, P-40 Warhawk, North American Aviation, Curtiss-Wright Corporation, Risk, Aircraft Manufacturers*

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INNOVATIVE ··· FLEXIBLE ··· INTERDISCIPLINARY

The world is an unpredictable and dangerous place. In 1919, a group of men gathered to sign an armistice to close the "war to end all wars." A short two decades later, the world was fighting an even broader and bloodier war. In the mid-1970s, Iran, a staunch U.S. ally, was the strongest regional power in the Gulf. Five years later, the Shah had been deposed, Iran was in the midst of an anti-western revolution, and U.S. citizens were being held hostage. In 1989, the Berlin Wall separated East from West, and at Dick Cheney's confirmation as Secretary of Defense, no one even mentioned Iraq ("Background Briefing," 2001). One year later, the Berlin Wall was down and American forces were toe-to-toe with an 800,000-man Iraqi army. On September 10, 2001, the greatest national concern was the health of the stock market and which dot.com company would be the next to go under. On September 11, everything changed. Global instability, nuclear proliferation, and ongoing armed conflicts around the world threaten U.S. security. More ominously, such instability and global warfare appear to be growing at an alarming pace.

Defense Acquisition and the Changing Environment

Yet, defense acquisition appears to be ill prepared to respond to many of the rapidly emerging challenges. As a poignant example, improvised explosive devices were killing soldiers and Marines in Iraq, but the solution—a heavily armored Mine Resistant Ambush Protected vehicle—remained bogged down in a peacetime acquisition system until heroic, high-level efforts broke through the bureaucratic obstacles (DeCamp, 2007; Feickert, 2008). On April 6, 2009, Secretary of Defense Robert Gates refused to buy additional lots of F-22 fighter jets, designed for the Cold War and stuck in a 20-year development-to-delivery cycle (Gates, 2009). At some point, the question arises as to whether our defense acquisition process can ever be as responsive as necessary to rapidly changing global threats, or whether, after all is said and done, its application to today's acquisition environment is largely irrelevant and perhaps itself a danger.

Has defense acquisition always been this problematic, or are we in a particularly difficult transition period? Certainly, defense acquisition has always been hard. The first ship procurements for the U.S. Navy in the 1790s experienced cost and schedule overruns, congressional lobbying, and technology overreach (Toll, 2006). But, the nation rebounded to produce resounding achievements such as the nuclear powered submarine, the intercontinental ballistic missile, and, of course, the Manhattan Project. These programs all were begun

in response to significant global changes and dangerous emerging threats. Defense acquisition has shown tremendous responsiveness, when the need arises, to provide game-changing innovations that transform the trajectory of warfare.

The Case Study Approach

What enduring lessons, then, can we learn from events in history that required the system to respond quickly and effectively to deliver these transformational systems? This article develops one case study to explore the acquisition challenges brought about by severe environmental changes and synthesizes lessons from the case that could have applicability to our current acquisition system. This is but one case, albeit an interesting one, and *risk* is always inherent in generalizing findings (Yin, 2003). Nevertheless, in the acquisition business scholar-practitioners can gain valuable and perhaps far-reaching insights through studying successful developments and attempting to draw lessons from them; comparing and contrasting best practices; and discovering better ways of plying the trade today.

Case of the P-51 Mustang

The P-51 Mustang remains a highly recognizable, legendary World War II fighter aircraft that was the pride of both the United Kingdom and the United States. Development of this innovative aircraft was fraught with challenges—technical, political, and programmatic. The development story takes place in a world on the brink of a second global war, where allied forces were largely unprepared to face an enemy with better technology, war tactics, and wartime organization. In the United States, neither the military, having retreated to a peacetime pace after World War I, nor industry, recovering from the Great Depression, was prepared for another butter-to-guns transformation (Baumol, Nelson, & Wolff, 1994).

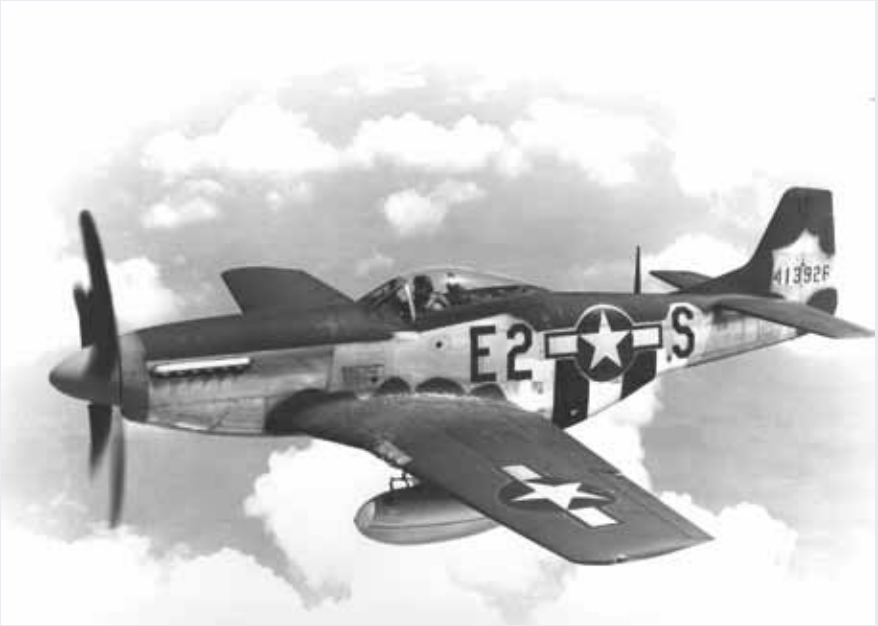
The year was 1940. World War II was raging, and Europe was in a desperate situation. In the United States, memories of the horrors of World War I were still fresh, and public sentiment had turned decidedly isolationist. Despite early warnings from many experts, the United States and its military were not well prepared for another global conflagration.

With the blitzkrieg, Germany had quickly rolled up much of continental Europe under the Nazi flag. The Battle of Britain was at hand, and the Royal Air Force (RAF) was critically short of fighter aircraft to respond to the coming German onslaught. British industry was clearly unable to meet the RAF's production needs, so a Purchasing Commission was sent to the United States in the hope of finding long-range fighter aircraft suppliers for its bomber escort missions.

The RAF agents initially approached the dominant U.S. aircraft supplier, the *Curtiss-Wright Corporation*, with a request to place an order for more than 300 of their best fighters—the *P-40 Warhawk*—which was also the main fighter in U.S. Army Air Corps service. Curtiss-Wright turned the order down due to lack of factory capacity.

The desperate British then turned to a small California company, *North American Aviation*, which specialized in building training aircraft. The British asked North American to consider a licensed production deal with Curtiss to build the Warhawk in their factory. The company's president, "Dutch" Kindelberger, asked for time to consider the offer. He knew that the P-40 Warhawk was a relatively old design that was tough and heavily armed, but slow and lacking the maneuverability and combat performance to go against the German Luftwaffe in air-to-air combat.

After some discussion, the young company president and his small design staff made an astonishing counter-proposal to the British. They offered to design and deliver a new airplane, using the latest in aviation technology. In doing so, they promised the British a



P-51 Mustang courtesy of the U.S. Air Force

fighter of far greater capability, while at the same time leapfrogging Curtiss-Wright and establishing their tiny company at the forefront of the international aviation industry.

The desperate British were taken aback. North American had never designed a combat aircraft before. They would have to build an entirely new factory and invent new processes to manufacture the airplane. And to fulfill the contract, they would have to produce a world-class fighter that could outperform the German Air Force. Their company's future, not to mention the survival of the United Kingdom and possibly that of the entire free world, was riding on their abilities.

Amazingly, the British agreed, with two provisos. First, North American should use the same engine as the P-40—the American Allison V-12. This engine had a simple, one-stage supercharger rated for low-altitude flight, since American doctrine at the time called for fighters to operate in direct support of ground troops at low level. Second, they had to design and produce the first prototype in less than 120 days! The company agreed to the British conditions and went to work on what would become the NA-73 Mustang.

North American's goal was to build the fastest aircraft they could make given the limits of the Allison engine. Their designers decided to use two cutting-edge technologies that had never been included in a production fighter aircraft before.

The first was the *laminar-flow wing*. The laminar-flow airfoil was the product of massive investments in the 1920s and 1930s by the U.S. government, specifically the National Advisory Committee on Aeronautics (NACA), the forerunner of the National Aeronautics and Space Administration. This design "smoothed" the otherwise turbulent airflow across the wing surfaces, reduced drag, and increased aircraft speed and efficiency ("Laminer Flow Airfoil," 2010).

The second was an untried cooling radiator design called the *Meredith effect duct*. The Meredith duct was essentially a divergent-convergent duct with a radiator at its widest part. The theory was that the engine's waste heat would accelerate the flow of air through the duct, producing a ramjet effect to reduce engine cooling drag at high speeds. The design had never been used before, and, in fact, had only been proposed as a theoretical possibility in an academic paper in Britain between the World Wars (Meredith, 1936).

Exactly 117 days later, on borrowed wheels, the prototype Mustang rolled out of the North American factory (Bowman & Laurier, 2007, p. 7). The British immediately placed a large production order, and the RAF Mustang was soon in front-line service as a low-altitude attack and close-support fighter.

A few months later, the United States entered the war. The U.S. Army Air Corps had several new fighters coming online, but they

lacked a first-rate ground attack and tactical reconnaissance plane; therefore, the Corps ordered the Mustang under the U.S. designation A-36 Apache. The British Mustang and U.S. A-36 Apache served in several theaters with great success, and if the story had ended there it would have been a superb historic case study of the technology and defense industry communities working together in a time of great need.

But, of course, the story didn't end there. The American tactic of low-altitude fighter combat proved to be flawed—aerial dogfights were high-altitude affairs in the European theater. The Allison engine was not up to the task because its supercharger lost power at high altitude. The British, however, had developed the Rolls Royce Merlin, with a superlative high-altitude supercharger. This innovative two-speed, two-stage supercharger had been designed by a young Cambridge University mathematician, Stanley Hooker, and it allowed the Merlin to operate at high power to altitudes above 40,000 feet (Hooker, 1984).

The new P-51 Mustang, with the improved Merlin engine and larger fuel tanks, went on to dominate the air war over Europe, and later the Pacific. The German Air Force commander said after the war that he knew the war was lost when he looked up and saw Mustangs in the skies over Berlin (Rickard, 2007). In the opinion of many historians, the P-51 turned the tide of the war in Western Europe and was crucial in gaining the final victory there.

Case Analysis

The P-51 Mustang may have been one of the greatest success stories in the history of defense acquisition and a triumph of innovative technology insertion. Note that the Mustang did not spring wholly formed from a highly structured requirements generation process or from the pages of some early edition of DoD Instruction 5000.02 (DoD, 2008). The Mustang succeeded because its makers were driven by a combination of urgent warfighting need, intense industry competition, and the freedom to draw on the intellectual forces of government, industry, and academia to help them succeed.

This story may hold additional critical lessons. First, consider the source of the technologies used to give the Mustang its superb performance.

LAMINAR FLOW WING

The laminar flow wing came from a government research and development agency, funded by the U.S. Congress. Experiments and trials were conducted in massive wind tunnels at NACA labs in Lang-

ley, Virginia, and at Moffett Field in California. NACA was solving an interesting physics problem, but the solution had not made its way into any application toward the war effort until the North American team took the concept and applied it to the Mustang. Similarly, the Meredith Effect radiator duct was the product of basic academic research published in a scholarly journal.

Lessons. The U.S. government continues to spend substantial sums on basic and applied research at laboratories and universities across the country and with our allies. Harvesting that technology has been, and continues to be, devilishly difficult and unpredictable. Historically, that seems to be the nature of innovation. When the right programs in need of technology solutions bump into the right technologists who have been working on similar problems, magic happens. Rather than a stepwise, rational process to solve difficult problems, this is a perfect illustration of the classic "garbage can" model of organizational problem solving (Cohen, March, & Olsen, 1972). Here, a seeker with a problem is rummaging around and happens to find another with a potential solution, but who is unaware that the problem exists.

To facilitate this form of "accidental" problem solving, there needs to be very proactive networking between programs-of-record actively seeking solutions, with the technology community who may have solutions to problems of which they are unaware. The aim must be to more intentionally force these innovation "collisions" to happen more frequently. All too often, promising solutions lie dormant waiting on someone to pick them up, dust them off, and look at using them in new and fresh ways.

SUPERCHARGER CONCEPT

Stanley Hooker's supercharger concept enabled the Mustang to outperform the German Luftwaffe in high-altitude dogfights. The technology was not originally envisioned, however, as a military improvement. Rather, it was developed, tested, and matured in the highly competitive environment of civil aircraft racing competitions.

Lessons. Today's downsized defense industry, similar to that of the United States and United Kingdom between World Wars I and II, lacks robust competition. Indeed, without a daunting enemy threat, not even a clear vision or pressing need exists for innovation in defense systems. However, a vigorous commercial sector working in an unforgiving global competitive environment continues to develop new and innovative products, many with defense-application potential. These need to be identified and encouraged. Too often, when a po-

tential military or dual-use item emerges from a commercial source, it becomes subject to oppressive import and export restrictions. This practice has a chilling effect on commercial innovation, makes U.S. industry less competitive globally, and needs to be changed. The Defense Department also needs to help foster greater competition among second- and third-tier defense and commercial subcontractors, as well as buy and use as much unaltered off-the-shelf technology as possible from non-defense businesses. To facilitate transitioning commercial technology to defense use, there must be a healthy market scanning ability within the DoD to identify those promising products and vendors that add competitive value to our programs. As seen in Iraq and Afghanistan, innovative insurgents and terrorists will require U.S. defense, in order to succeed, to also exercise the cutthroat entrepreneurialism for which Americans have become famous.

SUCCESS OF THE UNDERDOG

Finally, "Dutch" Kindelberger, the legendary head of North American Aviation, had the technical savvy, gambler's instinct, and almost insane confidence in his company to go head-to-head with the best *aircraft manufacturers* in the world—and win.

Lessons. The aviation industry of the 1930s was in its heyday, similar to this era's dot.com and information technology industries, with allure that attracted smart, aggressive entrepreneurs. Aviation pioneers of the 1930s hired bright young designers and engineers, and gained confidence by cutting their professional teeth in the great commercial air races of the 1930s. Today, we need to attract and reward similar entrepreneurial risk taking in defense and defense-related commercial industry. Thousands of Kindelbergers are out there anxious to change the world. The challenge is to find and enlist them in the effort to maintain the strongest military on the globe.

The Secret Sauce

None of these insights are original, and many might argue that these lessons are already being incorporated into the policies and processes of defense acquisition. If the recipe is so simple, then why are current defense projects so fraught with challenges? Why can't defense acquisition seem to tackle a modern-day project like the Mustang and be just as successful?

The authors believe we can, but, over the past 40 years, we have allowed ourselves to grow accustomed to 10-year missile developments and 20-year fighter aircraft acquisitions. We've built a

risk-averse bureaucracy that favors innovation-stifling oversight and rigid, failure-intolerant policies to responsible program risk taking and a sense of urgency in fielding weapons systems. The current acquisition system has become so unwieldy that any sense of urgency or spark of innovation is often lost or frustrated.

Recommendations

The way ahead will be challenging. We have to move from a system that imposes sweeping requirements to one where simpler is better, and good enough is, well, good enough. The first Mustang wasn't a war-winning pony, but had sufficient design margin to be adapted to evolving threats and changing operational assumptions. Today's systems should be designed and managed this way too.

We cannot allow our acquisition system to continue to be so rigid and risk-averse that we lose the opportunity to adopt new technologies when they come along. The magic can happen if we allow it, but we must be aware that technologies can emerge from unexpected places. These are often the real game-changers. History is replete with examples—the Internet (originally a nuclear attack-resistant government network), stealth (first proposed in a Russian academic paper), and unmanned aerial vehicles (emerging from radio-controlled scale models for hobby enthusiasts). We should embrace the garbage can model and begin actively networking challenged programs with technologists who might have solutions.

Finally, we need to reenergize the sense of urgency that we should be feeling as our troops fight in a prolonged counterinsurgency war in southwest Asia. While our national survival is not yet imminently at stake as Britain's was in 1940, we must work to streamline our processes to deliver needed battlefield equipment much sooner. We cannot be satisfied with the current system, and we can never become complacent or resigned to the status quo.

We should study and learn from the lessons of history, like the Mustang story. From it, we can remind ourselves that Americans are, by nature, innovative and entrepreneurial. We must restore our self-confidence in our ability to do remarkable things, remain steadfast in our resolve to improve our system, become intolerant of bureaucratic obstacles to innovation, and rededicate ourselves to the task of making our nation safer for ourselves and our children. The next acquisition success story is out there if we can muster the courage to succeed.

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