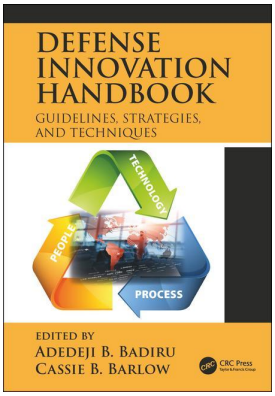

Defense Innovation Handbook
Guidelines, Strategies, and Techniques

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Commercial technologies in the Department of Defense

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chapter five

Commercial technologies in the Department of Defense

Technology evolution and implications for acquisition professionals

Sally J. F. Baron

Contents

Introduction

The Department of Defense (DOD) has long used commercial products and the cooperation between DOD and industry is nothing new. From weapons and materials in the Revolution, to trucks and tractors in the World War I era, to fabric for uniforms throughout its history, commercial products from industry have provided superior warfighting ability to the US.

The fact that the founding of an entire military service—the Air Force—was based on an invention made completely within the private sector—yes; the Wright Flyer—is often downplayed.

Throughout US history, the acquisition process has been both successful while also being plagued with inefficiency, complexity and occasionally malfeasance. Over the past several decades nothing has changed the acquisition world more than the onslaught of high-tech products in the commercial market. Technology, including computers, telephones, workstations, laptops, satellite imagery, antenna networks, medicine and much more have grown exponentially in both technological advancement and availability that most could not have predicted while Defense Department acquisition practices have not kept pace.

Acquisition procedures, outlined in the Federal Acquisition Regulations (FAR), control the purchase of products from industry for delivery to the battlefield, but these procedures have become cumbersome and outdated. The difficulty in this is that many companies with potentially superior technologies may not have the infrastructure, nor might they desire it, to compete for DOD contracts. The process typically requires staffs of lawyers and contract experts. Critics have asserted that the FAR does not offer a streamlined process and does more to harm than help acquisition.

The military acquisition force, both civilian and uniformed, will have to develop new procedures to keep top commercial technologies in the hands of the warfighter when they offer better solutions that can get to battle faster. This chapter reviews the history of industry and commercial products' role and importance in defense. It examines the early history of flight and how it changed defense acquisition in this country, as well as selected histories of computing and space. The chapter concludes by suggesting methodologies to keep the US DOD on the cutting edge in both high technology and efficiency.

Department of Defense acquisition background

The *Department of Defense* (DOD) has evolved since the Revolutionary War to the most powerful military on Earth. Much of that success is a result of the ingenuity of people when they are given the latitude and incentive to work and achieve in a free, capitalistic society, coupled with a people who are determined to protect their freedom. The United States has provided the most optimal environment for innovation and creativity ever in recorded history. Our industrial base is unparalleled as our founders and first citizens, most of whom escaped oppressive governments where even certain ideas were a punishable crime, recognized the need for a society where basic freedom and the pursuit of happiness were self-evident rights assured by the *Constitution.* Ideas and innovation have flourished. Predictably, in the early days, innovators from oppressed countries immigrated to the US free society by the millions. As a result, innovation and creativity abounded and in a very short time the US went from a poor, fledgling country to one where more inventions flourished and quality of life improved.

From the signing of the *Declaration of Independence* and the rights provided by the *Constitution,* we have long recognized the need to defend personal rights and freedoms. History has illustrated that our earliest wars were won with superior industry, as well as the tenacity of America to remain independent and free. In World War II, our industrial base out-produced our adversaries, manufacturing nearly 300,000 aircraft for the allied forces from Niagara, New York to Los Angeles, California. Automobile factories were converted to armored vehicle production facilities in months, and tens of thousands were produced. We were fast and furious.

Industry was part of warfare then and as warfare evolved, the very best innovations in the world continually came from US private industry. Though the DOD supported research and development, Silicon Valley entrepreneurs provided the country, and the world, with superior computing and related technologies such as communication and digital imagery. As the world embraced these new technologies, they became more available and less expensive due to economies of scale.

The Gulf War (Operation Desert Storm, 1991) was handily won in less than two months with our on-orbit assets and superior technologies guiding smart bombs to precision hits with little or no collateral damage. Space, computing and communication technologies combined to allow warfighters instantaneous information previously unavailable. Economics plays heavily into all warfare: *if we cannot afford it we cannot have it*. We must also recognize that if we cannot defend it, we cannot have it, and we must begin with the assumption that resources are *finite*. These are axioms of existence of a well-defended nation.

Today, the DOD is a highly developed, complicated organization with wide and varied tasks and comprises numerous sub-organizations. Its total 2016 fiscal year proposed budget was $585B, and active duty members totaled approximately 2,118,000 (World Almanac, 2017). How is all this effectively organized and managed? With a lot—arguably too much—bureaucracy. The FAR has grown since inception and continues to grow with each change or new law that affects acquisition. It is rarer, however, that antiquated policies are deleted. What are we left with? An enormous document that no one completely understands with policies and regulations that frequently contradict one another. What is an acquisition officer to do? Deal with it, change it, or work around it. Dealing with it is a short-term solution and changing it is the only long-term, albeit cumbersome, solution. A discussion of how to work around it will come later. The more technology changes, the harder the FAR will be to manage. Inevitably the FAR will become larger, longer, less relevant and more unmanageable as has been the trend. This simply needs to stop. The current administration (2017) has asked that adding a single new regulation will require that two old ones be deleted. This is the first tangible step to reducing the sheer mass of the FAR in recent history (Lam, 2017).

Meanwhile, to comprehend the technological evolution and the changes implied we shall take a brief look at defense acquisition history next.

Acquiring the best products for the warfighter: from the beginning

The early US military had its hands full. The Revolutionary War, a fight for our independence from England, was a fight against one of the then most advanced militaries on the planet. The US needed to equip its forces rapidly, and it did; but not without pain and problems. The government was young, small and inexperienced. Once independence was secured on July 4, 1776, the Congress realized that the nation would need to build a strong military both for defense and also for western exploration.

Over a century later, perhaps the greatest test of US sovereignty was the Civil War. The North clearly had an industrial advantage which would ultimately secure the United States. Pennsylvania's well-established iron mills out-produced those in the South by about 10:1 (Sorenson, 2009). One of the greatest technological advances of the Civil War was the

move from vulnerable wooden ships to iron and steel. Again, although the South had iron ships, this new shipbuilding technology put the industrial North at a great advantage as it had greater resources with which to build iron and steel products, including ships. Other weaponry such as canons, rifles and pistols were more advanced in the North. The North also took great advantage of its superior rail system.

Congress spent great monies to improve industry and keep the Union together, but where there is money, there typically is malfeasance. Sadly, this has been omnipresent throughout the history of government; it was as true then as it is now. As a result of fraudulence in the early Civil War, in 1861, the Congress developed the Committee on Government Contracts (1861) as the first of many Congressional oversight select committees to guard against loss in the government contracting business. Adding oversight has become a common practice for the US government in response to criminal activity and poor management and this has led to layer upon layer of bureaucracy and inefficiency.

Continuing with military acquisition cases, the nation's fortitude would once again be tested in the late nineteenth century in the Spanish-American War. The demise and sinking of the *USS Maine ACR-1*, as well as the deaths of 252 of her 350 crewmen, would preface the Spanish-American War by about six months. The ship's construction history provides insight into the acquisition process of the time. The *USS Maine* was commissioned in September 1895. Though it had a steam engine (rather than wind power) and iron cladding, it was considered out of date by the time it reached service (*USS Maine*, 1895). Considered an armored cruiser, her construction came at a time when naval technologies and needs were changing rapidly. The ship was designed by Theodore T. Wilson, who was likely preferred because he was American, and the ship was to be the largest US Naval vessel to date at 324′4″. Congress authorized funds for construction in 1886, and the keel was laid in the Brooklyn Navy Yard in 1888. The nine-year building time was considered slow, and though she was armored, by 1895, other naval ships were armored with lighter-weight, stronger steel. As such, the *Maine*'s role became ambiguous because she lacked both the firepower and armor to serve as a cruiser. Acquisition and procurement delays have a huge cost that is not always obvious.

As industry became stronger and more important to the United States during this time, in the late 1800s many inventors and aviation enthusiasts worldwide were pursuing heavier than air flight. The most successful team was, of course, the Wright brothers of Ohio. The following section offers a case study in their attempts to bring their invention to the US defense officials of the War Department.

Aircraft and Department of Defense

First flight: An examination of a new technology

Here we examine one of the greatest and most important inventions of all time and the War Department's response to this revolutionary technology. Orville and Wilbur Wright were brothers, inventors, and metallurgists. They had a bicycle shop in Dayton, Ohio, and from their work with bicycles they concluded that if a human could manage the balance of a bicycle, then, quite possibly, a human could control weight and balance of a flying machine. The brothers had been interested in the problem of human flight from boyhood, and their interest manifested itself in work beginning in about 1900, which was funded largely by family, friends and other interested parties. After reading *Progress in Flying*

Machines, by Octave Chaunte, the Wrights contacted the author, which began a long and important relationship.

After years of building, studying, and trial and error, the Wrights met with success on December 17, 1903, in Kitty Hawk, North Carolina. They continued to modify and perfect their flying machine and in 1904 made over one-hundred flights with improved controls and safe landings. By 1905 the Wright brothers were satisfied they had a practical, salable product, and having borrowed money during their five years of experimentation, they were anxious to pay debts. They approached the US War department through Representative Robert M. Nevin. Their exchanges are instructive and are included as follows:

> *Note*: All the Wrights' correspondence are represented here as they appear in *Miracle at Kitty Hawk*, edited by Fred C. Kelly (Kelly, 2002). They are unchanged from original form, with the exception of the **bold type** for emphasis as noted.
>
> ***January 18, 1905; Letter from Wilbur Wright to Congressman Robert M. Nevin***
>
> The series of aeronautical experiments upon which we have been engaged for the past five years has ended in the production of a flying-machine of a type fitted for **practical use.** It not only flies through the air at high speed, but it also lands without being wrecked. During the year 1904 one hundred and five flights were made at our experimenting station, on the Huffman prairie, east of the city; and though our experience in handling the machine has been too short to give any degree of skill, we nevertheless succeeded, toward the end of the season, in making two flights of five minutes each, in which we sailed round and round the field until a distance of about three miles had been covered, at a speed of thirty-five miles an hour. The first of these record flights was made November 9th, in celebration of the phenomenal political victory of the preceding day, and the second on December 1st, in honor of the one-hundredth flight of the season.
>
> The numerous flights in straight lines, in circles and over "S" shaped courses, in calms and in winds, have made it quite certain that flying has been brought to point where it can be made a great **practical use** in varying ways, one of which is that of **scouting and carrying messages** in time of war. If the latter features are of interest to our own government, we shall be pleased to take up the matter either on a basis of providing machines of agreed specification, at a contract price, or of furnishing all the scientific and practical information we have accumulated in these years of experimenting, together with a license to use our patents; thus putting the government in a position to operate its own account.
>
> If you can find it convenient to ascertain whether this is a subject of interest to our own government, it would oblige us greatly, as early information on this point will aid us in making our plans for the future.

Nevin had promised to take the letter to the Ordinance Board (Part of the War Department) and speak on behalf of the Wrights, but he was unable to deliver it personally due to illness. Nonetheless, he indeed got it into the right hands and received this reply shortly after:

> ***Reply to Congressman Nevin from the Board of Ordinance and Fortification, signed by Major General G. L. Gillespie [exact date not available]***
>
> I have the honor to inform you that, as many requests have been made for financial assistance in the development of designs for flying-machines, the Board has found it necessary to **decline to make allotments** for the experimental developments of devices for mechanical flight, and has determined that, before suggestions with that object in view will be considered, the device must have been brought to the stage of practical operation without expense to the United States.
>
> It appears from the letter of Messrs. Wilbur and Orville Wright that their machine has **not yet been brought to the stage of practical operation,** but as soon as it shall have been perfected, this Board would be pleased to receive further representations to them in regard to it.

What was going on here? From the most casual read, it looks like the Board did not carefully read the Wrights' proposal. The Wrights clearly state that they spent many years developing a product that is currently operational. The word *practical* appears three times in their proposal, and they even suggest a function: reconnaissance, yet the Board seems to ignore this. They offer two types of contracting and what they consider the product ready. Strangely, the Board responds by emphasizing that they will not offer financial assistance, something the Wrights never requested, and asks them to come back when they have a machine ready for practical use. This short, simple letter, signed by Major General G.L. Gillespie appears to be one of the biggest acquisition blunders in military history. The Wrights offered exclusive rights to their invention and the government all but ignored them.

The Wright brothers were more than disappointed but not defeated. Their next actions are a harbinger of many commercial companies to come: they sought customers overseas. Note: I have interviewed countless commercial companies that told me they seek overseas companies as a result of their frustration with the US acquisition procedures.

We shall follow their continued dialogue in the following.

> ***May 28, 1905; Letter from Wilbur Wright to Octave Chaunte (author, supporter, and friend)***
>
> We stand ready to furnish a practical machine for use in war at once, that is, a machine capable of carrying two men and fuel for a fifty-mile trip. We are only waiting to complete arrangements with some government. **The American government has apparently decided to permit foreign governments to take the lead in utilizing our invention for war purposes.** We greatly regret this attitude of our own country, but seeing no way to remedy it, **we have made a formal proposition to the British Government** and expect to have a conference with one of its representatives very soon.

May 30, 1905; Letter form Octave Chaunte to Wilbur Wright

As an American I greatly regret that our government has apparently decided to allow foreign governments to take the lead in utilizing your invention. Please advise me, 1st, Whether you have approached our war office? &c 2nd, Whether you would object to my putting a flea in its ear?

June 1, 1905; Letter from Wilbur Wright to Octave Chaunte

We would be ashamed of ourselves if we had offered our machine to a foreign government, without giving our own country a chance at it, but our consciences are clear. At the Christmas holidays we talked with Mr. Nevin, congressman from this district, and he proposed that we write him a letter containing a general statement of our business, and that he take it to Mr. Taft and secure an appointment for us to meet with the War Department officials, thus saving us delay when we should visit Washington. But owing on sickness, he was compelled to turn over our letter without personally seeing Mr. Taft and shortly afterward received a letter from the Ordinance Department which I enclose. As we had made no request for appropriation, but on the contrary had offered to furnish a machine of "agreed specifications at a contract price," (which offer was entirely ignored,) we were driven to the conclusion that the letter of the War Department was intended as a flat turn down. We still think so.

A note to Col. Clapper informing him that we were ready to talk business with the British government soon brought a response from the English war office requesting us to make a definite proposition. We submitted our proposition, and now have an answer stating that an officer will be sent to see us.

It is no pleasant thought to us that any foreign country should take from America any share of the glory of having conquered the flying problem, but we feel that we have done our full share toward making this an American invention, and if it is sent abroad for further development the responsibility does not rest upon us. We have taken pains to see that "Opportunity" gave a good clear knock on the War Department door. It has been for years been our business practice to sell to those who wished to buy, instead of trying to force goods upon people who did not want them. If the American government has decided to spend no more money on flying machines till their practical use has been demonstrated in actual service abroad, we are sorry, but we cannot reasonably object. They are the judges.

The correspondence clearly illustrates the shock and frustration of the Wrights and Mr. Chaunte. Wilbur emphasizes that they are not in the business of marketing products to organizations or people who do not want them, and is adamant about justifying that they did their due diligence by offering the invention to the US War Department first. In spite of this, for a second time, in October 1905, Wilbur wrote directly to the Board of Ordinance to ensure there was no misunderstanding that the Wright Flyers were indeed

ready for practical use. The US government responded with a nearly identical letter as the earlier 1905 correspondence. At this point the Wrights were convinced that they needed to move on; stating their practice of not being marketeers; but rather inventors. The "form letter" type of a response indicates that the War Department had not done their research. The Wrights heavier-than-air flyer is something that the War Department long sought. In fact, the department invested in such a concept to the tune of $50,000 then-year dollars given to Samuel Langley to come up with such a machine. Langley failed miserably and as a result, the War Department did not believe that it could be done. This may have tainted their view of the Wright Flyer.

Next, Chaunte expresses his disgust in the lack of interest on the War Department, and encourages the Wrights to pursue interests overseas.

> ***June 6, 1905; Octave Chaunte to Wilbur Wright***
>
> My feelings were of mortification and regret that the United States war department should have extended to you a "flat turn down" as you express it. Now that I have cooled down I see some advantages to your being forced to consider the overtures made by Col. Clapper for the British Government, because: First, your invention is worth far more to the British than the United States government. Second, the **British are less hampered than we are in appropriating secret service funds,** so that you can probably get a better price, and sooner. Third, your invention will make more for peace in the hands of the British than in our own for its existence will soon become known in a general way and the knowledge will deter embroilments.

One need only speculate why Chaunte believes the flyer would be worth more to the British government. First, Great Britain is a group of islands; not part of a larger landmass as the United States, and second, their proximity to early twentieth century Germany is perhaps a greater concern. Chaunte implies that Great Britain may have been more desperate. Perhaps most interestingly, Chaunte observes that Great Britain is "less hampered" than the US. Could it be that even in 1905 the US War Department had already become its worst enemy with an encumbered ability to acquire new technology? Next, Wilbur responds to his longtime friend, Octave, defending their position and illustrating the Wrights' intention to move on.

> ***June 18, 1905; Wilbur Wright to Octave Chaunte***
>
> We have no intention of forgetting that we are Americans, and do not expect to make arrangements which would probably result in harm to our native country. The exact date of meeting the British representative is not fixed but will probably be within a month. Meanwhile we have decided to complete the machine and **take the risk of making a few private trials of the improvements we have added to the machine**. The machine will probably be complete in a couple of days and we will be testing it the latter part of the week if the weather is suitable. Of course we would be glad to have you visit us and see it go, if it should suit your convenience and pleasure.
>
> The doubts of Capt. Ferber and other foreigners worry us not at all. In fact they are rather an advantage to us while we are wishing

> to secure privacy. We certainly shall not disarrange our own plans to satisfy either public or private curiosity at this time.
>
> We find that we underestimated the weight of our last year's machine. We carried a total weight of about 915 lbs. This includes about 70 lbs. of steel bars which we used as ballast. The new machine with water and fuel will weigh almost exactly 850 lbs., with one man.
>
> We quite approve your decision to make only brief reference to our power machine in the Standard Encyclopaedia article. Until we are really ready to make the machine public there are many reasons why it is not best to say too much for publication.

It is critical that the acquisition professional understand that with commercial products, the private company assumes all risk in research and development—a very good deal for the taxpayer. Mr. Wright mentions here that they are in a continual improvement phase with the *flyer*—something that he understands is an assumption of risk. As with most new technologies, risk is very high. As technologies mature, risk typically decreases. Professor James March explains this best in his theories of *exploration* and *exploitation*. He notes that *exploration* is a riskier venture, requiring ventures into unknown paradigms and characterized by experimentation with new alternatives. "its returns are uncertain, distant, and often negative." When technologies mature, he notes, they do so as a result of *exploitation,* characterized by refinement of a known technology (March, 1991). Aircraft are a classic example of this. Where the Wright brothers absorbed the risk with ventures into the unknown, for at the time no one knew if a heavier than air machine would actually be possible, others benefitted from refinement of their invention. Over the past century, Martin, Airbus, Boeing, Cessna, Cirrus and others have refined aircraft far beyond what many could have fathomed. Indeed, the Wrights went on to refine their own invention.

Over the next two years, the Wrights entertained interests from Great Britain, France, Austria, Germany, and a US marketer who wanted to be a third party selling the machine to Russia. The greatest trouble they had both abroad and at home was disbelief in their invention. All parties wanted demonstrations, and several parties believed that once they understood flight they could more easily re-create it, saving funding, rather than purchasing from the inventors. It was not until 1907—nearly four years after the first flight—that the War Department made a solid offer to the Wrights. Simultaneously, the Wrights set up a company in France. The Wrights' offer to the US War Department follows. Recall that their initial offer suggested that the machine be used for reconnaissance.

May 17, 1907; Wright brothers to the US War Department

> We have some flyers in course of construction and would be pleased to sell one or more of them to the War Department, if an agreement to terms can be reached.
>
> These machines will carry two men, an operator and observer, and a sufficient supply of fuel for a flight of two hundred kilometers. We are willing to make it a condition of a contract that the machine must make a trial trip of not less than fifty kilometers at a speed of not less than fifty kilometers an hour, before its acceptance by the Department, and before any part of the purchase price is paid to us.
>
> If the War Department is in a position to purchase at this time, we will be pleased to have a conference for the purpose of discussing

> the matter in detail, or we are willing to submit a formal proposition if that is preferred.
>
> ***June 15, 1907; Wright brothers (Orville) to the War Department***
>
> The price quoted in our letter of May 31 should be understood as the price of the first flyer delivered to the Government and the instruction necessary to enable a representative of the War Department to operate it. The price does not include any period of time during which the use of the invention would belong exclusively to the United States, since a recent contract precludes our offering such a right.

While great reverence has been given to the Wright brothers historically speaking, again, little attention has been paid to what was quite possibly the greatest military oversight of all time: rejecting an invention that was practical and ready for use which was long sought and would be critical to warfare forevermore. Perhaps most importantly, the US government missed its chance at exclusivity to the Flyer design. Mr. Wright specifically states a "recent contract" precludes it. With two world wars just around the corner, one can only speculate what might have happened is the US had exclusivity on the flyer. History will never know.

It is instructive for the acquisition professional to examine why this happened. The Board of Ordinance barely even read the Wrights' letter. They assumed it was a letter seeking financial compensation, not a legitimate offer of a functioning commercial product. Who was Major General G.L. Gillespie, the signor of the letter? Major General George Lewis Gillespie Junior was a Medal of Honor winner from his action in the Civil War, and his headquarters assignment, 1904–1905 was his last in the service. While his military service as an overseer of great harbor construction projects earned him a reputation as a competent engineer, could it be that his knowledge of new technologies was sparse? And what was his staff doing? A special projects staff—then as now—should have been on top of new technologies especially the widely publicized Wright brothers' endeavors. The question is still asked today: what is the government's incentive to be effective or efficient? Their salary and benefits would not change and it is a robust theory that bureaucracies are a good place for the mediocre to hide as the bureaucracy's size diffuses responsibility. These are important issues then as now (Figure 5.1).

Clearly the military was interested in a heavier than air machine as they were funding efforts to create one; with little success. In 1898 the US government had given Samuel Langley $50,000 (then year dollars) to construct a heavier than air machine. By mid-1903 Langley had not gotten his Aerodrome off the ground, but he continued and secured $10,000 from the Smithsonian (his employer) and $12,000 from the Hodgkins fund. By 1904 the Aerodrome had two stupendous public failures in which Charles Manly, Langley's assistant, nearly drowned in the Potomac River. It was a huge embarrassment to the War Department and others who supported it. These plunders may have been why the War Department was not anxious to become involved in heavier-than-air flight.

Meanwhile, The Wright brothers' success was well reported in numerous periodicals, including *The San Francisco Call,* San Francisco, California ("Airship Flight is a Success," December 18, 1903), *The Times Dispatch*, Richmond, Virginia ("A Machine That Flies," December 19, 2017), *The Washington Times,* Washington, DC ("High Gale No Bar to Flying Machine," December 19, 1903), *The Minneapolis Journal* ("Airship was a Great Success: The

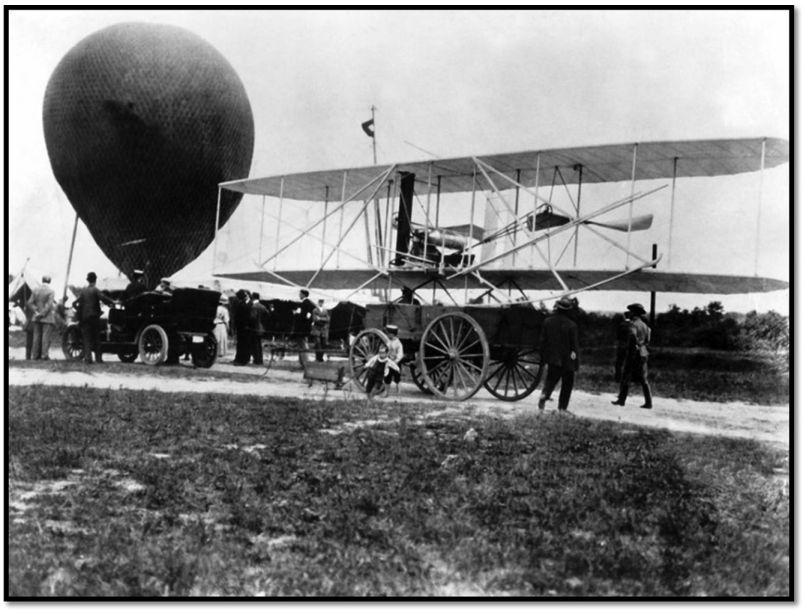

Figure 5.1 The Wright 1908 Model A Military Flyer was the first heavier-than-air military aircraft in history. It was purchased by the United States military from the Wright brothers in 1909. In this photo, it is arriving at Fort Myer, Virginia on a wagon. [No copyright on this photo as it is public domain; taken in 1909.]

Wright brothers Give Out a Statement Regarding Their Recent Experiments," January 6, 1904), and dozens more. How did Gillespie and his staff not notice the Wrights' success when it had appeared in so many newspapers?

The Wright brothers' successes did not escape the notice of a young Army Signal Corps Officer, William "Billy" Mitchell. He became passionate about flight and its applications in the military, and in 1920, when the Air Service was founded, he was promoted to brigadier general and was then their most senior ranking officer. He asserted his theory that properly armed aircraft could sink battleships and successfully demonstrated it in 1921. But his criticism of the Army and Navy earned him a court martial. He resigned from military service in 1926, and spent the rest of his life preaching air power (Howard, 1998). He died in 1936. Though Mitchell is widely known as the father of the United States Air Force, and was promoted to the rank of major general in 1942 (posthumously), it was not until after his death that the services appreciated his application of munitions to air power. In hindsight, his ideas changed the way war would be fought forever. Billy Mitchell had the foresight to see new applications for a commercial product. The military had finally recognized that products created in the private sector had military applications, but were not ready to listen to a change agent who had further applications for aircraft. There is an important lesson for the acquisition professional: open your mind to new ideas that may not seem completely logical at the time. Yet another management lesson from Major General Mitchell's life: new ideas are not always appreciated and are typically a risky business. As James March indicates, experiments into untested realms will often meet with resistance and possibly negative rewards.

One might ask: *What other technologies is the DOD missing today?* The lesson for the military professional is clear: superior products exist in the commercial market. What exists today? Are acquisition personnel duly diligent? Where would one find new technologies? Symposia, conferences, trade journals, and other publications are full of inventions. Their application to the military is up to the military's ability to understand new applications. Discussing ideas with colleagues and other professionals in industry is a good place to start.

History has shown that the eventual adoption of flight as a military tool has been a crucial advantage. It bears repeating that an entire new service—the Air Force—was created to support a commercial product from the very early twentieth century; yet the government itself out and out missed its first creation. Ideas for flight application were forthcoming, but the government did not always embrace them.

Other innovations would come in the twentieth century—innovation that hardy anyone predicted. The next case study examines computing and its role in defense.

Computing and defense

Computing was recognized very early on as important to a strong defense and the DOD had early and critical roles in computer advancement. In the 1960s computing moved from semi-conductors to the integrated circuit and the now famous "Moore's Law" (Intel CEO Gordon Moore predicted that chip density would double every 18 months) has held in principle (Ceruzzi, 2000). Today, laptops and hand-held computers have replaced the large, cumbersome, expensive, and sometimes classified computers of the past. Some of the first computers occupied large rooms in covert facilities. Now, complex problems can be solved by simple spreadsheets and problems that were at one time unsolvable, requiring millions of iterations, are now easily solved with simple programs. For example, optimization problems, formerly done by hand, may have required thousands if not millions of iterations and could not have been done by humans. Today, they are commonplace and have made manufacturing and production enormously efficient, saving consumers and taxpayers billions.

Both private and public sectors pushed and pulled computing technology and during the 1950s (post WWII) the government and especially the DOD invested huge monies in their development. Private companies saw applications and invested heavily in research and development. [See Figure 5.2 for a schematic on how the computing and space industries worked symbiotically over the past half-century.] Personal computing began to evolve in the 1980s. Desktop workstations first came into being by Hewlett-Packard, Apple, and later IBM and others. While few in the traditional, older computer companies had little hope for home computers, other entrepreneurs and hobbyists in Silicon Valley were determined to get them to market. Now workstations and laptops are not only a part of our daily lives at work, but home as well. The marriage of the Internet, a child of Defense Advanced Research Projects Agency (DARPA), along with home computing gave rise to millions of applications for home and business. New applications pop up by the millions—nearly all from innovators in the private sector. As Figure 5.2 illustrates, this huge demand for computing technology over the past 50 years caused a tremendous pull for both hardware and software. With great competition comes great efficiencies, and computing technology has gotten remarkably inexpensive.

Without computing, space, aircraft, and other important technologies would not be nearly where they are today. For example, satellite control, booster trajectories, and digital imaging were all the result of awesome computing power. These technologies continue to advance to this day, and many which were exclusively part of defense have crossed into

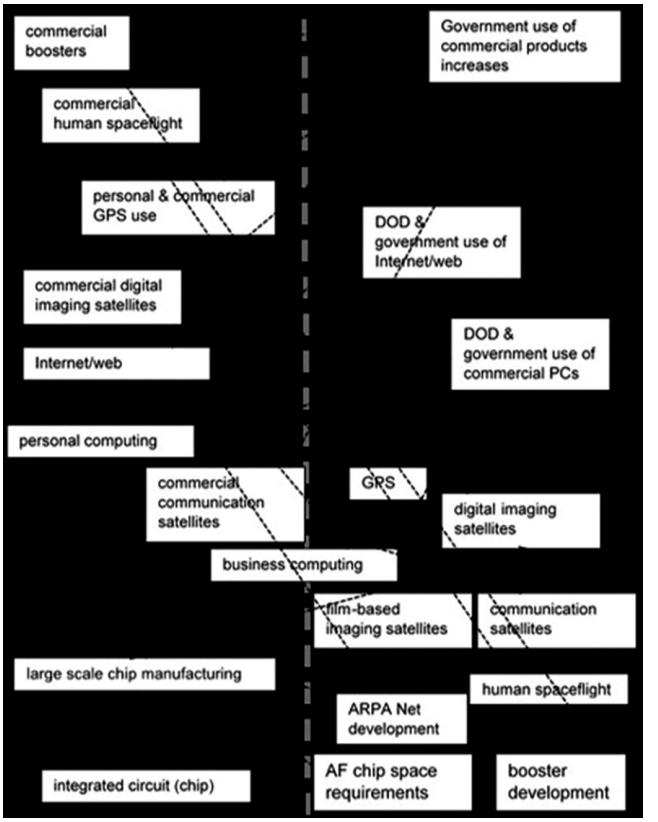

Figure 5.2 Symbiotic Relationship between Computing and Space in Public and Private Sectors.

the private sector as common, commercial technologies. In turn, efficiencies from competition have made them more affordable for the government, though the government is not always properly motivated to see these new efficiencies.

One of the most famous examples of military computing advances became evident to the public during the first Gulf War, Operation Desert Storm, 1991. Advances from the previous decade were incorporated into "smart" weaponry. The term "smart" is commonly used for weaponry that is able to direct itself even after released from the operator. For example, a "smart" bomb may be *heat seeking* and able to re-direct itself towards a target that emits heat. Other technologies allow guided weapons to avoid obstacles by pre-programming ground ephemera. Videos of guided weapons grabbed the attention of the world as they took out enemy targets with the precision of a surgeon's scalpel. This not only resulted in funding efficiency, but by targeting only military threats, collateral damage was reduced and innocent civilian lives saved. All this was the result of advanced computing and space technologies working together. The war was handily won in two months. This remarkable revolution in precision technology—combined with the fact that much of it could be seen by millions worldwide—did not go unnoticed by our adversaries.

When acquisition professionals consider computing, we must consider both hardware *and* software. Hundreds of COTS software companies have developed products that outpace what traditional defense contractors have produced; yet they still only fill the cracks of what is required in DOD. Under traditional FAR acquisition procedures COTS software

could not be effectively provided to the government. The following quote is from an interview with the CEO of a COTS software company developing products for defense.

> "… There is no way that the use of COTS can exist under a rigid system. Part of the advantage to using COTS is the ability to refresh technology when new improvements come along. This requires constant contact with our government partner as we think it's more efficient to refresh the technology ourselves. This is complicated stuff—really rocket science. For us to build code and then have someone else patch it—I mean they have to go through the entire learning cycle of learning the code. Further, the government system of a maximum of 15% profit will also never work with COTS. Commercial products are already developed. With software products especially, the incremental cost of producing and selling one more copy is almost negligible. Depending on how much integration we need to do, our profit can be 90%–99%. We have absorbed all the development costs ourselves" (CEO Alpha software Vendor). Note: Based on Interview with software company CEO who preferred to be anonymous.

In the *design-and-build* acquisition philosophy, maximum profit is 15%. As the CEO points out, this would not work at all in the software industry. Most of what software companies are selling is *intellectual property*. Typically software programs evolve during years of development with new upgrades released periodically. The commercial software company absorbs all research and development costs. This is indeed not a small expense considering the hefty labor hours required for programming.

Yet, in the past, government agencies have not been anxious to embrace commercial software. In the 1990s a large civilian government agency was seeking new software for a major program upgrade. The software company mentioned earlier (Alpha) offered up a fully running commercial product for $5M. A traditional defense company (Beta) bid for the program on a design-and-build contract for $100M to be ready in five years. The government awarded the contract to Beta. Beta broke baseline and was approved for more funding and more time. In the end, they did not deliver, and the government returned to Alpha who sold them a functioning program. No one from the agency was punished for poor decision-making, and the loss was entirely the taxpayers. As with the Wright brothers, the government, with its layers of bureaucracy, was not held accountable, and the bad news is buried in history.

During a recent conversation with the Alpha CEO he remarked that he is taking his product overseas, and for the first time in Alpha's history, they are in litigation with the government. As with the Wright brothers, Alpha has done their due diligence in trying to sell to the US. Part of the problem with software is that it is not tangible; and for some, understanding its value is difficult. As with the Wright Flyer, people at the highest levels of government could not understand a heavier-than-air machine and were perhaps unable to envision applications. Today, aircraft are common. But perhaps defense professionals who did not grow up with computers have difficulty understanding all their potential and unique applications of hardware and software.

In modern military there are few who did not grow up with space. Though much of early space in the mid-twentieth century was classified, much has been de-classified and is available in the commercial world. This is discussed next.

Space and defense

Present day satellites and ground systems could not exist without remarkable computing technologies discussed earlier, and global communications could not exist without satellites. Space technology was once owned exclusively by the government. In the 1950s, 60s and 70s, the Air Force and other government agencies, such as the National Reconnaissance Office (NRO), and National Aeronautics and Space Administration (NASA) were among the first to work with government industrial partners in what were then feasibility studies. Today, launch technologies, space digital imaging, and human spaceflight are available commercially. With aerospace in its infancy, only the government could afford to play in such a risky venture, and all of the first space efforts in the mid-twentieth century were only in the public sector—the government and its industrial partners. Contracts were written so that companies would not go out of business if these high-risk, high-tech efforts failed. No one knew whether or not a human being could survive in a microgravity environment or the radiation astronauts would experience outside the Earth's protective atmosphere. No one knew if rocket boosters would actually get a satellite to orbit, and there was plenty of reason to believe that launch failure would be the rule and not the exception.

Space is a critical part of defense, and the first entrees to space were motivated by defense. The world's first steps into space came in the mid-twentieth century: boosters, satellites, robotic and human spaceflight. Getting a satellite into orbit is difficult to say the least. Boosters are the traditional method, and are large, expensive and risky. From the beginning and throughout their history, the trip has been highly risky. Next, we examine a brief history of one of the world's newest space companies: *SpaceX.*

Case study: Commercial boosters and innovation

It was 2002 and Silicon Valley entrepreneur Elon Musk took a trip to Russia to purchase rockets and returned empty handed. He had just failed to purchase two Russian boosters to refurbish them for his stated goal of making humankind a multi-planetary species—beginning with a Mars colony. The Russians offered $8M for one booster and Musk countered with a buy-one-get-one-free deal: $8M for two. The Russians rejected him outright, apparently not taking him seriously (Vance, 2015). Shortly after his disappointment, Musk, a talented engineer and known risk-taker, assembled a business plan for a rocket company which, in June 2002, became Space Exploration Technologies: *SpaceX.*

Up until then, the history of entrepreneurs succeeding in space booster companies was sparse. The enormous cost of one or more launch failures typically has put them out of business. In the early days of space (1950s–1960s), the government was able to absorb such losses, but with commercial rocketry, such failures typically cause investors to give up and the companies to completely fail. *SpaceX* did not want to be beholden to government restrictions so it began and remains a 100% commercial company. Many pundits were sure they would fail like the rest.

Within three short years from inception, in November 2005, *SpaceX* was ready to launch its first rocket, the Falcon 1, from Kwajalein, in the Republic of the Marshall Islands. The first attempt was a no-go, but at the second attempt, in March 2006, the rocket launched. However, about 30 seconds after lift-off, the rocket spun out of control. Its payload, the Air Force Academy cadet-built FalconSAT-2 was ejected and remarkably fell back to Earth, crashing through the storage shed and landing near its delivery crate. "I guess it just wanted to come home," jested Col. Martin France, head of the Academy's Astronautics department. He continued, "We are not sorry for taking a risk on *SpaceX.*

Space would not happen without new technologies and people willing to take risks. Our FalconSAT-6 is now waiting for a ride on the *SpaceX* Falcon 9. Falcon 9 has become a well-established launch vehicle in a short amount of time because people have been willing to take a chance on it. Because of new companies like *SpaceX*, the Air Force can leverage the commercial market and optimize budgets." The FalconSAT-2 flight model—that launched and returned to the Pacific, can be seen at the Air Force Academy's Space System Research Center (SSRC) Museum (Based on Interviews with Colonel Martin France, US Air Force, Permanent Professor and Department Head, Astronautical Engineering Department, United States Air Force Academy, July 13, 2017) (France, 2017).

After the first launch failure, Musk told his discouraged employees, "*SpaceX* is in this for the long haul, and come hell or high water we are going to make this work" (Vance, 2015). Others from the space community reminded Musk of the failures of every booster known to humankind. Their first successful launch came in September 2008; only six years from the company's founding. To date, the tenacity of *SpaceX* has paid off. It has a respectable success rate and has added the *Dragon Capsule* to its inventory. As of this writing, the Dragon Capsule has resupplied the International Space Station (ISS) nine times. This is a feat that many experts said could not be done by any commercial company. The *Dragon V2* was introduced in 2014 and will carry up to seven astronauts and its engines are made entirely from additive manufactured components (3D printed), another huge advance in technology.

The company has accomplished remarkable feats that the government has never even attempted. In December 2015, *SpaceX* became the first organization to successfully land a rocket stage after launch. In March 2017, it became the first to land a re-furbished booster. In each case the booster landed on a *SpaceX*-owned sea-faring barge named *Of Course I Still Love You.* In June 2017, the company successfully refurbished a *Dragon Capsule* to supply the ISS. Companies putting their payloads on refurbished boosters will receive a discount; bringing the cost of a Falcon 9 booster launch from about $62M to perhaps as low as $40M. This is lower than current defense contractor offerings and highly competitive with overseas launches. *SpaceX* proudly makes their boosters in California with nearly all parts made in the United States meeting environmental guidelines not found overseas and personnel who are working there by choice. It is truly an American company.

How can they compete? Follow the money. *SpaceX* has always been dollar-conscious. Rocket companies have already existed for over a half-century; booster companies can provide boosters for hundreds of millions of dollars, but there is an axiom the government sometimes forgets: *if we cannot afford it we cannot have it.* Commercial companies can never forget this. In its very early history *SpaceX* came very close to being unable to financially cover its payroll and another launch failure may have put them over this cliff. No taxpayer backed bailouts—it could have been the end. Now, the commercial space company is robust with an impressive launch manifest. They are low cost and reliable. *SpaceX* has been called "disruptive" (Fernholz, 2014) to the status quo. Thank goodness for disruption: this is why the US is the economically strongest country in the world: we innovate. This is why Elon Musk immigrated here: to pursue his innovation dreams. Twenty years ago he was homeless, now *SpaceX* has already outperformed its government predecessors and current competitors (Figure 5.3). What next? Mr. Musk says the next goal is turning around a booster in 24 hours, and in a more recent statement, announced that *SpaceX* will provide the technology for humans to settle Mars (Pasztor, 2017).

Meanwhile, Musk has become a viable and highly competitive government supplier, but with new so-called *disruptive* organizations comes skeptics, and companies with Pentagon ties that are decades-old tend to be favored. In March 2014, the Air Force awarded some

Figure 5.3 Falcon 9 first stage landing on drone ship *Of Course I Still Love You*. This historic landing was the first of a refurbished booster, bringing access to space to a new level of efficiency. March 30, 2017. (Courtesy of *SpaceX*.)

$11Billion in contracts to ULA on a sole source basis. The cost was considerably higher than *SpaceX* offered on an unsolicited basis. In April 2014, *SpaceX* filed a lawsuit against the Air Force. Elon Must explained: "This is not *SpaceX* protesting and saying these launches should be awarded to us. We're just protesting and saying that these launches should be competed." The government argued that they could not allow *SpaceX* to compete until they had passed Air Force certifications, but Musk retorted that officials intentionally procrastinated certification in hopes of later securing post-government employment at ULA's parent companies. Military and civilian government defense employees frequently seek post-government retirement employment by defense contractors. On January 2015, *SpaceX* announced they would drop their lawsuit and that an agreement had been reached with the Air Force to certify them by mid-2015. *SpaceX*'s Falcon 9 rocket passed certification "ending a monopoly held by ULA, a joint venture of Lockheed Martin Corp. and Boeing Co., since its creation in 2006" (Shalal, 2015). Air Force Secretary Deborah James applauded this effort noting that it should drive down launch costs.

For the acquisition professional, there are many lessons. Once again, we have seen a superior technology originate in the private sector. Though critics have argued that *SpaceX* has had its share of launch failures, the early history of other booster companies is similar. Moreover, *SpaceX* has not only attempted re-use, but has succeeded; something traditional booster companies have not. In the early days of rocketry, booster companies were also given government funding on what were then feasibility studies: no one knew whether or not they would actually work. The government did not want to see high-tech companies dissolve—adversely affecting the US capabilities in space. These types of contracts were sensible at the time, but over the decades have caused defense industrial partners to become non-competitive. Meanwhile, commercial companies such as *SpaceX* and *Blue Origin* have taken these opportunities to innovate.

Department of defense contracting

> "Never tell people how to do things. Tell them what to do and they will surprise you with their ingenuity."
>
> **George S. Patton Jr.**

What is the point of describing the evolution of cutting-edge technologies? To clarify that they have advanced, and to emphasize that government acquisition policies typically do not advance with them; surely not nearly as fast. The larger and more hierarchical an organization, the slower it changes (Brown, 1998). We've come a long way technologically, but the DOD has had trouble keeping up. *Military specifications* (*milspecs*) are a method by which the DOD can get precisely what it wants, at least in theory. But *milspecs* have a well-earned reputation for getting in the way of progress. A commercial product is simply not created to adhere to *milspecs*. *Milspecs* exist based on the incorrect assumption that the best ideas come from the government. History has shown that the very best innovation comes from the private sector.

United States polices have fallen behind the commercial market. Visionary and statesman The Honorable William Perry has pushed DOD policy in an effort to match the pace of the technologies themselves, but adaptation has been lagging. Dr. Perry, once the Undersecretary of Defense for Research and Engineering (1977–1981) and later Secretary of Defense (1993–1997) was passionate about the need for change in the DOD. Having had a long and successful career as a businessperson and engineer, Dr. Perry noted that there was no chance that the government could possibly keep pace with the free market and its incentives for leading-edge, affordable technologies, and enacted policy that called for DOD to use commercial products when available (The Perry Memo, 1994) (Carter & Perry, 1999). His efforts to streamline acquisition processes are some of many. Each one has had its share of successes, but it is difficult to change a system in which the rewards for spending are plentiful. Some of those barriers were identified: *misaligned reward systems, entrenched networks* and *historical precedent* (Baron, 2004). The article's findings include Air Force personnel lacking knowledge of the commercial market as well. This must change.

Implications for the Department of Defense acquisition professional

In this chapter, we have established the superior efficiencies of the free market for defense innovation and production. We have also established the existence of entrenched systems that prevent the DOD from changing rapidly. The acquisition professional—indeed all those in DOD—should consider accordingly. How can our team get the best products and services to the warfighter and the best value to the taxpayer?

Clearly not all defense products are available in the commercial market. For example: stealth fighter aircraft. Though someday they may be purchased off-the-shelf; not today. From an optimization viewpoint, the most efficient way the services can perform acquisition is to leverage the commercial market for the items available there. The DOD does this to a considerable extent already. For example, there was a time when computing was not available off the shelf and the DOD was building workstations. The government now purchases workstations off-the-shelf from companies like Dell and Hewlett-Packard. Similarly, software to operate such workstations is also purchased off-the-shelf. It would be mind-boggling to think of the government trying to compete with these commercial products. By extension, the acquisition professional should consider other software available off-the-shelf and there is plenty. Many companies build off-the-shelf software and often a market

search is not that difficult. For example, countless private companies build and operate satellites. They have the same issues with privacy and hackers that the government has, and have excellent products. Try a Google search of satellite software and see what you find. The acquisition professional should purchase these items on a firm-fixed basis and "fly-before-buy;" that is; ensure the product is functioning prior to purchase. To be an excellent steward of the taxpayers' money, the acquisition professional should get the very best product for the very best price.

Commercial-off-the-shelf & market search

Let's say you are asked to purchase a refrigerator for the Air Force. How would you go about it? Would you give specifications to a company and have them build it to your exacting needs? Of course not! You would probably go down to Home Depot or Sam's Club and see what they have. Better yet, you may be more likely to hop online and see what is available that most closely meets the Air Force needs for the best price. This is the essence of a market search. The internet is quite possibly the best tool the acquisition professional has ever had, and it doesn't just work for refrigerators. Try Googling *COTS satellite ground control.* What did you find? Once you slug through all the government sites or people selling books, and maybe even a bedding company selling camping cots, you will likely find a several companies that perhaps you've never heard of who make products for use with actual satellites. Dig deeper and you will see animations and find people who you can actually talk with and will be more than delighted to show you their product. Be careful and thorough. You will also find what one of my interviewees called "Trojan Horse COTS." Large prime contractors who do not actually build commercial products are wise to the government's interest in becoming more efficient with the use of commercial products. As well, they are wise to the government mandates that require the use of commercial products when available and they want government business. You must do your research diligently and thoroughly to be a good steward for the taxpayer as well as get the best product to the warfighter.

Other transaction authority (OTA)

Though a child of the 1950s; when the US faced Soviet threats, the OTA has morphed over the past 60 years and DOD professionals are bringing it into its own. With the realization that commercial products need to be part of the warfighters' tools, the OTA is an excellent tool for bringing them from the private sector to the government. In essence the OTA is a superb way to speed up procurement by working outside the FAR. The OT or OTA is discussed in Chapter 4.

Summary

The Air Force came into being as a separate service based on the development of a commercial product: the aircraft. And we almost missed it. So what does the future hold? It is impossible to predict what technologies will be critical, but what is for sure is that as long as there is freedom of thought and a capitalistic market, innovators are motivated to invent as they always have, and top products will come from the commercial market.

At the time of the development of a heavier-than-air machine, it is not likely that anyone predicted the countless applications for which it would be the basis, nor the many other new technologies that could be combined in different ways to aid in the defense of

this young country. Once human flight was established, the next logical step was spaceflight which was undertaken by the Air Force and other government agencies working together with industrial partners; motivated by the threat of communism.

The Air Force is a remarkable service that has largely utilized cutting-edge technologies, but not always as efficiently or effectively as possible. The future acquisition professional needs to embrace such technologies and should consider the following.

1. *Research what is out there*. The commercial world has always been a source of innovation from the Wright brothers, to the Silicon Valley entrepreneurs, to *SpaceX*, and many, many more. This is truly the most important job an acquisition officer needs to do well, constantly and with a vengeance. The commercial market is constantly changing—not just year-to-year, but day-to-day. Companies that have had past failures, such as the three mentioned earlier, ultimately had huge successes. The acquisition professional must bring the best technologies to defense, or we will fall behind. Technologies exist in the open market that meet and *exceed* what the government owns. You just have to find them. Gadgets and gizmos with countless military applications are available to all: our friends and enemies. Stay on top of trade journals and other periodicals.
2. *Ignore sunk cost*. The sunk cost effect is a major human shortcoming. We tend to consider sunk cost when considering future investment in technologies. "But we've already put so much into this, we cannot change now!" Any economist will know that an expenditure already spent is gone and should not be considered in future investments. If the Air Force or any other organization has invested heavily in a technology development or a company that is not producing as promised with little hope of future success, it is essential to re-examine those technologies and consider other providers or a different path.
3. *Attend trade shows and symposia*. These are not a waste of time as some may think. The diligent professional will use these to leverage the best of breed technologies from the market and educate oneself with face-to-face learning often from actual inventors and developers. Ask questions, attend meetings and study literature. These can be extremely valuable.
4. *Watch what other countries are doing*. Private industry has no obligation to the DOD. Other countries without the enormous infrastructure of the United States' tremendous universities and grant procedures look toward commercial products where no development investment is required. Recall that the Wright brothers' first customer was not the US War Department as they had hoped and envisioned.
5. *Beware entrenchment*. Don't just think outside the box, live outside the box. We are creatures of habit and not all our habits are good. Examine the way "we've always done things" and think of how we could do them better. Beware of becoming entrenched in the old ways. If you are a supervisor, try to *reverse socialize.* That is, rather than teaching new people *the way we do things here,* try to learn from them and ask how they would do it. The youth of our country is the future.

Closing thoughts

As The Honorable Roberts Gates (Secretary of Defense; 2006–2011) told the Air Force Academy cadets in a lecture in 2010, as an officer you need to have the courage to tell blunt truths; though it will not likely be popular (Gates, 2010). History has shown that people often shy away from new ideas, and military history has its share of people willing to

stick their necks out to share new ideas that were not always popular. Air Force legends Billy Mitchell and Hap Arnold were both criticized for pressing forth their idea of putting armament on aircraft in order to sink enemy ships. Bernard Schriever is known as the father of the ICBM, but he had to fight many in the Pentagon who believed that any nuclear weapon should be flown by a human pilot.

What are we missing today? What commercial innovations will you speak up for use in the battlefield?

List of acronyms for Chapter 5

DOD	Department of Defense
COTS	Commercial-off-the-shelf
FAR	Federal Acquisition Regulations
ISS	International Space Station
NRO	National Reconnaissance Office
OTA	Other transaction authority

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