We now know the dominant weapons on the battlefield are the ones that can be mass-produced, operated by motivated fighters, kept in action with spares and supplies, and used in concert with other weapons. In the words of General George S. Patton, "How easily people can fool themselves into believing wars can be won by some wonderful invention rather than by hard-fighting and superior leadership."

Rewind

Readings in Logistics

From First to *Wurst*: The Erosion and Implosion of German Technology in WWII
General Logistics Paradigm: A Study of the Logistics of Alexander, Napoleon, and Sherman
How Logistics Made *Big Week* Big: Eighth Air Force Bombing, 20-25 February 1944
Murphy's Law

In this edition of the *Air Force Journal of Logistics* we continue "Rewind: Readings in Logistics." This continuing feature presents articles and essays previously published in an edition of the *Air Force Journal of Logistics* or one of the Journal-produced books or monographs. The feature includes articles that encompass three areas: historical perspectives, contemporary thought, and studies and analyses. Both the current and future content of the feature were selected for two basic reasons—to represent the diversity of ideas and to stimulate thinking. That's what we hope you do as you read the material. Think about challenges. Think about the lessons history offers. Think about why some things work and others do not. Think about problems. Think about organizations. Think about the nature of logistics. Think about fundamental or necessary logistics relationships. Think about the past, present, and future.

The feature also provides a convenient source of material for mentoring and discussing logistics and logistics issues with new Air Force logisticians.

All of the articles and essays for "Rewind" in this edition were published in *Thinking About Logistics 2009,* Air Force Logistics Management Agency, Maxwell Air Force Base, Gunter Annex, July 2009. Copies of *Thinking About Logistics 2009* may be obtained free of charge from the Journal staff.

Lieutenant Colonel Charles A. Pryor III, USAF

From First to *Wurst*: The Erosion and Implosion of German Technology in WWII

In the Beginning

At the outset of the German buildup for World War II, the Germans were, arguably, the most technologically advanced nation in the world. Despite the limitations in the Treaty of Versailles, they secretly designed and built some of the most advanced aircraft in the world. From research into all metal aircraft, such as the Junkers Ju 52,[1] to the Messerschmitt Me 262, the world's first jet fighter,[2] the Germans were on the technological front lines. Yet, in a scant 10 years, the German nation ceased to exist. After the war, with its country divided in two, the technological advances were divided among the conquering powers. Indeed, the battles 5 years later between the Mikoyan-Gurevich MiG 15 and the F-86 were more among German engineers than among the nations actually at war.[3] The reasons for the implosion of the German state are manifold, two of which are addressed herein.

From a technological standpoint, many of the German designs and innovations remain valid. They were the true innovators of some of the world's current aircraft. Indeed, the Germans pioneered the use of wind tunnels, jet aircraft, pusher propellers, metal aircraft, and rockets in an attempt to overwhelm their Allied adversaries. Under the guise of Operation Paperclip, many German scientists and engineers were brought to America to work their magic on the American industry. Despite all this talent and its potential, few of the German designs were actually used during the war. Although their relevance is unquestioned, especially in view of current American (and worldwide) aircraft, they were untapped by the German leadership.

Many of the lessons from the German experience with technology and management are applicable today to the US Air Force.

The German management system, especially in terms of the technological industry, was a complex and convoluted bureaucratic nightmare. Their system of committees and rings, coupled with a lack of centralized control at the top, served to undermine an economy that was resource-poor, in terms of both monetary and natural resources. This mismanagement, exacerbated by the effects of the Combined Bomber Offensive, transformed the German industry from one of the best to one of the worst, a system ready to implode had it not been helped on by the Allies. Further compounding the situation was the influence of Adolf Hitler. A man with a continental worldview and a penchant for doing things his way, Hitler was more of a hindrance to industry than a help. His constantly changing requirements led to costly and lengthy delays to the production of many aircraft. His inability to look beyond continental Europe from a practical standpoint ensured the German state never had a practical long-range bomber until it was too late. Indeed, the Germans ended the war with the same fighter and bomber with which they began the war, with only minor modifications and a dwindling ability to mass-produce them.

Many of the lessons from the German experience with technology and management are applicable today to the US Air Force. Without a doubt, today, the United States is the technological superpower of the world, yet it is plagued by many of the same problems that the Germans faced. Many of America's technological advances seem to be done for the sake of technology, rather than for an operational military need. Indeed, many of the needs of the American military may be met, in the short term, with existing technology or modifications thereto, rather than new programs. The true transformation of the American military and its

technology will be a departure from the stovepipes of military acquisition, in which each Service acquires its own (often redundant) systems, to a process of standardization among the equipment used to meet each Service's needs. Furthermore, American military management is becoming as complex as that of the Germans. True, Americans have much more to worry about than the Germans; for example the whole, poorly understood realm of space. The United States tends to solve its lack of understanding with additional bureaucracy, which exacerbates the overall situation. Alignment under a specific, overarching unified command could eliminate some of the waste and ensure an interoperable, standardized force for the future. Indeed, if the Department of Defense (DoD) does not learn and heed the lessons of the past, it is doomed to repeat them.

This article examines the efforts and impacts of German technology, both during World War II and today. Furthermore, it examines the impact and folly of German management of the technological industry and that industry's subsequent implosion. Finally, this work draws some parallels between the World War II German system and the current American system, fully recognizing the difference between the totalitarian German state and the democratic American state. Despite the glaring and obvious difference between the two, there are similarities that could have a negative impact on America's ability to wage war.

Technical Marvels

At the outset of World War II, the Luftwaffe was, undoubtedly, the world's supreme air force. It had the most advanced fighter and bomber aircraft and the best trained crews. Despite this, the Luftwaffe suffered severe losses during the course of the war, including the loss of air superiority over continental Europe, which led to the downfall of the Third Reich. Its loss can be attributed to several factors, not the least of which was its inability to take advantage of, or maintain, the technological superiority enjoyed at the outset of hostilities. The technological superiority was not limited to aircraft fielded during the war but includes some interesting technical innovations that arose during the war but not fielded by the Luftwaffe. Many of these technical innovations are just now being exploited to their fullest potential. Indeed, many of the technological innovations taken for granted today were first developed in the factories and design laboratories of Messerschmitt, Heinkel, Arado, Focke-Wulf, Henschel, and Junkers. These companies—and the designers for whom they are named—were at the forefront of technical innovation during not only their time but also current times. Many of their innovations—such as canards, boundary layer control, sweptwings, variable wings, jet engines, and more—are widely used today and accepted as industry standards. By examining Luftwaffe technological innovations, we can see a clear inspiration and technological marvel that transcends the aircraft industry today and whose impact is just being realized.

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Wind Tunnels

One of the most enduring innovations of the Luftwaffe was its pioneering work with wind tunnels.[4] These devices allow an aircraft, or representative model, to be tested under conditions closely simulating those encountered during flight. By using inexpensive scale models of the aircraft, the engineers were able to determine if their design could withstand the rigors of flight across the spectrum of the flight regime. By varying wind velocity, the German engineers were able to simulate high- and low-speed flight regimens. Similarly, by varying wind velocity, they could examine high and low angle-of-attack regimes. By combining the results of these two areas of study, they could determine the robustness and feasibility of the design in relative combat situations. The essential information that arose during these tests was the feasibility of the design, answering several fundamental questions: would the wings remain attached at high speed and high angle of attack; would the aircraft stall at low speed and high angle of attack; what are the impacts of adding externally mounted items to the aircraft; what would happen to the aircraft once an externally mounted device was dropped (would it become unstable, thus unflyable); and what are the impacts on the aircraft center of gravity? These are fundamental questions concerning the flight worthiness of the aircraft that could be ascertained without having to risk the loss of a prototype or pilot.

Additionally, wind tunnels allowed for the testing of new technologies to smooth the flow of air across the wing. The Germans tested boundary area fences, leading-edge flaps, and boundary layer control, all in an effort to affect the flow of air across the wing surface.[5] With the straight, perpendicular wing style of the day, these aerodynamic controls would

ensure the flow of air across the top of the wing was as smooth as possible, thus making the airflow faster and generating more lift. This increase in lift would generate more maneuverability in fighters and more load capability in bombers and more range in both types of aircraft. They tested each of these on many of their experimental designs, but the results of this work only were beginning implementation at the end of the war.

Although the wind tunnels continued to operate throughout the war, their later years' usage was confined to refinement of the V1 and V2 rocket designs. Their staffs were increased in numbers, although those numbers were not used for testing; rather, they were used to mass-produce both weapons. The wind tunnels did stop work during the war after Peenemunde was bombed during the Combined Bomber Offensive, but this was only a brief work stoppage. Once the wind tunnels were relocated to Kochel, they were operational again. Despite this extraordinary testing, the German leadership was determined, by 1944, to focus all efforts on the defense of the Reich. Thus, the tunnels were not utilized to their full potential. The efforts of the personnel assigned to the tunnels were focused solely on one weapon system, not toward testing new technologies or capabilities. This failure to take full advantage of their technological capabilities is a true failure of the German leadership.[6] Indeed, the Germans missed out on several opportunities to exploit fully the wind tunnels, especially in the area of wing design. In this case, the designs were robust and innovative but were not tested by the Germans. Many designs were not tested and developed until long after the war.

The Wings of Man

To increase range and speed, one of the most enduring German technological innovations was the sweeping of wings. During the war, the Germans experimented with a variety of wing sweeps and designs, many of which are prevalent today. Indeed, the most enduring innovation of the Luftwaffe engineers was the rear sweep to a wing, which was found on many of the experimental aircraft designed during the war period.[7] Again, with an eye toward speed and range, the rear sweptwing offers a unique way of increasing lift without increasing weight. By canting the wing aft, the actual lifting area of the wing increased because of the distance the air must flow over the wing. This is done without increasing the surface area of the wing and incurring the corresponding weight penalty, resulting in an aircraft that has greater speed, payload capacity, and range (although all three must be balanced).

The tradeoff with this, however, is limited low-speed maneuverability. The reason here is the specific area where lift is generated. As with all perpendicular and rear sweptwings, the actual lift is generated at the wingtips due to the directioning of the laminar (air) flow over the wings. With perpendicular wings, this lift is approximately abeam the center of gravity on the aircraft, allowing low-speed flight and relatively high angle of attack. With rear sweptwings, the lift is aft the center of gravity, making low-speed flight unstable, thus dangerous. Therefore, by sweeping the wings aft, they were able to gain speed, lift, payload, and range while trading off low-speed maneuverability. The question the German engineers faced then was how to keep these increases without sacrificing the low-speed regime. Their answer was twofold: increase power (without the weight penalty) and change the sweep of the wings in flight.

To increase range and speed, one of the most enduring German technological innovations was the sweeping of wings.

One of the earliest proposals, although the Germans never flew it, was a swivel wing. Designed by Blohm and Voss, the idea was to have a single wing that would rotate from perpendicular to canted, depending on mission flight parameters.[8] This aircraft then would be able to take advantage of the low-speed characteristics of a perpendicular wing as well as the high-speed characteristics of a canted wing (less drag, more lift). This concept, although viable, was not proven until the National Aeronautics and Space Administration flew an oblique wing on the Ames AD-1 research aircraft in 1979.[9] Another wing technological approach to overcome the low-speed and high-speed maneuverability tradeoff came through the use of variable sweptwings. Familiar today for application on the F-14 Tomcat, the variable sweep technology is designed to move both wings from a perpendicular configuration at low speed to a rear swept configuration at high speed for the aforementioned reasons. A similar variation yielded the experiments into a solid delta-wing configuration, which consisted of a swept leading edge with a perpendicular aft edge and solid material in between, which yielded some successes but not until long after the war ended.[10]

One of the technological innovations the Germans actually flew in prototype was forward sweptwings. In this instance, Junkers took a conventional wing and swept it forward instead of rear. Coupled with jet engines, this aircraft more than compensated for the low-speed

maneuverability liability of rear sweptwing aircraft.[11] By sweeping the wings forward, Junkers changed the lift characteristics of the wing. No longer was lift generated at the wingtips, but with forward sweptwings, lift was generated at the wing root, which was adjacent to the center of gravity. The drawback to this design was the directioning of the wingtip vortices. In rear sweptwing aircraft, the vortices generated by the wind movement across the wing (a spiraling whirlwind) are directed across the wing and behind the aircraft causing little effect to the handling. In the case of the Ju 287, these vortices were now directed along the wing toward the fuselage, making high-speed or high-angle-of-attack flight dangerous. During high speed or high angle of attack, the vortices would overcome the elasticity of the wing, causing the wing to twist off. This difficulty was not overcome until the American X-29 program in the 1980s. Although not currently used, forward sweptwing technology provides a short-term capability, one that is already proven.

All these experiments into increasing speed, range, lift, and payload were never incorporated into the German production. Many were exploited after the war, however, and remain in use today. Facing an ever-expanding war situation, Hitler issued a series of Fuehrer directives in September 1941 that curtailed work on nonessential projects.[12] Hitler's continental worldview was coming into direct conflict with his strategic expansions. By attacking Britain and later Russia, Hitler overtaxed his economic capability to conduct a strategic two-front war.[13] His economic focus switched to producing existing technologies en masse to stem the staggering losses of his overreach. In essence, he sacrificed quality and innovation for quantity.[14] This is prevalent throughout the Germans' technological innovations.

In addition to out-of-the-box thinking on aircraft design, the Germans were also the first to field and operate an instrument system, both for their own airfields (a precursor to the current instrument landing system [ILS]) and for directing their planes to a target.

My Grandma Wants to Fly Jets

The second technique available to the Germans for increasing the lift, speed, payload, and range of their aircraft was to couple the rear sweptwings with jet engines. These engines were able to generate much more power than their propeller counterparts and could run on alternate fuels.[15] Although Messerschmitt was the first company to produce a jet aircraft, the first to design and test-fly one was Heinkel.[16] Heinkel actually began his research with the experimental He 178 by coupling jet engines with a perpendicular wing as a planned proposal for a two-engine fighter contract. This never panned out for Heinkel,[17] but Messerschmitt was able to couple the jets with a rear sweptwing design that became the Me 262, the world's first jet fighter. Alas, the Me 262 never entered full production, primarily because of an argument between Hitler and General Adolf Galland over its specific role. Galland argued for the Me 262 to be a pure fighter aircraft, but Hitler was interested in making it a fighter/bomber. This led to a redesign of the Me 262 from fighter to fighter/bomber and back to fighter toward the end of the war.[18] The Me 262 did see some action against Allied bombers, but this was very late in the war, and it did not have much impact on the outcome of the war. Although a successful design, the Me 262 was fraught with powerplant problems. The Jumo 004, the primary jet engine of the time, had a service life of 4-5 hours before it had to be replaced, making the maintenance and logistics of this aircraft cumbersome.[19]

Messerschmitt and Heinkel were not the only ones to experiment with jet engines. Arado had an impact on the US Navy F7U-3 Cutlass of the Korean era.[20] The centrifugal jet engine developed by Focke-Wulf became the primary powerplant for the Yakovlev Yak 15, the first Soviet jet aircraft, used during the Korean war era.[21] Arado also had success with the Ar 234, the first high-altitude, jet-powered reconnaissance airplane.[22] This aircraft was the precursor to the SR-71 Blackbird and the U-2 Dragon Lady. Although these designs had impacts after World War II ended, only the Me 262 was produced in any appreciable quantity by the Germans, and this was late in the war, after the war had been lost.

The Eyes Have It

In addition to out-of-the-box thinking on aircraft design, the Germans were also the first to field and operate an instrument system, both for their own airfields (a precursor to the current instrument landing system [ILS]) and for directing their planes to a target. The first was the Lorenz beam system for blind landing, which consisted of two transmitters located on opposite sides of the airstrip runway. Both transmitted in simplified Morse code, one solely dots, the other solely dashes. The spacing of the dots and dashes was such that, where beams overlapped, a continuous tone was heard.[23] By moving left and right until the continuous tone was heard, the pilot would be aligned directly on the airstrip center line. Thus, in

conditions of restricted visibility, the pilots could find their airfield. The limitations of the system were many. It did not take into account crosswinds or turbulence.[24] However, as pilots became skilled in the operation of this system, they could compensate for these difficulties and keep the continuous tone.

The other disadvantage to this was the lack of altitude information. The beams would guide a pilot to the airstrip, but in conditions of zero visibility, they did not provide altitude. This can be overcome by the directioning ability of the transmitters. Essentially, the overlap portion of the beams (the area with the continuous tone) was conical. As the pilot flew toward the airfield, the cone narrowed toward the centerline. Thus, the absence of a tone could indicate the pilot was too high, and he could compensate accordingly. All in all, it is a risky system, but it is better than nothing. Without this, the pilots would have to divert to another airstrip, one not weathered in, which further added to the distance they needed to fly. This became a significant factor during the Battle of Britain when the German fighter escorts were flying at their maximum radii. Any additional flight time or distance could prove disastrous.

The offensive adaptation of the Lorenz system was known as the *Knickebein* system. Designed to be a long-distance target designator for use during night bombing, the Knickebein system consisted of two Lorenz transmitters, one that looked at the target along the ingress line, the other at the target from the profile. The pilots, using the Lorenz system in reverse, would fly away from the first transmitter while maintaining the steady tone in their headphones. Once they were in range of the target, they would switch to the frequency of the second transmitter, while occasionally checking with the first transmitter to ensure they were still on the proper vector. When the second transmitter gave them a steady tone, they were directly over the target and could release.[25] A subsequent refinement of this system, known as the *X-Geraet*, followed the same logic as the Knickebein system, with some refinements. Instead of using the beam intersection to mark their target, the pilots would fly the original beam toward the target. The second transmitter was actually a collection of transmitters, each of which would broadcast on a particular vector. Where each beam of the second transmitter intersected the first beam, the pilots had to hack a certain distance from the target. The *X-Geraet* pilots then would drop flares to literally light the way for the planes that followed.[26]

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A further refinement of this technique was the Y-Geraet system, receiver and transmitter combination, where the aircraft will fly a designated vector and periodically retransmit a signal from the ground transmitter. A ground receiver would pick up the retransmitted signal. By calculating the phase shift, the difference in time between the transmitted and received signals, ground controllers had a picture of whether or not the pilot was on vector and could correct their pilots accordingly.[27] This type of ground control (although not the *Y-Geraet* style system) is used today by the ground tactical air control squadrons.

The advantages of these systems, despite their drawbacks, are obvious from the German point of view. They had the ability to direct and control their aircraft as well as recover them in less than optimal conditions. These systems also facilitated night bombing, which adds a psychological effect to the physical effect and destruction. From the British point of view, these systems were of import as they were easy to overcome. Radio frequencies operated over long distances are easy to disrupt once the transmit and receive frequencies are known. The Germans kept their systems simple, using dots and dashes on prescribed frequencies, but the British overcame this by inspecting aircraft that had been shot down. The British did not need to know what to listen for once they had the frequency. Using a technique known as meaconing, whereby the British flooded the various German frequencies with extra traffic, the British were able to defeat the Knickebein and *X-Geraet* systems.[28] To overcome the *Y-Geraet* systems, the British merely jammed the frequency.[29] Despite their limited operational life, these systems were the predecessors to the current ILS and radar systems, both of which allowed for night bombing. As the Combined Bomber Offensive demonstrated later in the war, the Allies were able to keep pressure on the German homeland through daylight bombing by American planes and night bombing by British planes. Without radar and ILS, these night bombings would not be possible, providing the Germans with time to reconstitute or continue production without feeling the effects of bombing.

Subsequent Aircraft Technologies

Faced with the challenge of designing aircraft that could outperform their enemies, the German engineers looked at ways to improve the speed, maneuverability, and altitude of

the fighter force. The root reason for this work was the theory that to defeat the Allied bomber streams they would have to attack them at their weakest point, which was from above. Thus, they needed aircraft that could fly at extreme altitudes. In addition to their work on jet engines, the Germans looked at ways to improve propeller-driven aircraft. One of the technical solutions to this problem was fielded in their fighter force. They replaced the old radial air-cooled and liquid-cooled engines with a high-compression piston engine. Essentially a sealed, self-contained engine that was not dependent on a bladder of coolant, this engine allowed fighters to perform negative *g* or inverted maneuvers.[30] This gave them a significant maneuvering advantage when engaging enemy formations. Additionally, this engine would increase the performance envelope of the bomber fleet, allowing them to fly farther than they could with the radial engines. Alas, the performance increase in bombers was not enough to have a significant impact on the war, but the impact of the souped-up fighters was felt. The Allies were able to counter this added threat; however, the Germans succeeded, at least initially, in almost equaling the score with their fighters. Additionally, by examining defeated aircraft, the Allies were able to capitalize on German technological advantages.

Another engine modification fielded by the Germans in limited numbers was a relocation of the engine and propeller. Some of the German aircraft that flew as prototypes had pusher-type propellers. Located at the rear of the fuselage, these pusher propellers were more efficient in terms of fuel usage than traditional puller propellers. The Germans were never able to capitalize much on pusher-propeller aircraft during the war because of their management practices, but the pusher propeller is in use today on long-duration aircraft such as the Predator. Although these were significant technological innovations, ones that have endured and are still in use today, the Germans were unable to capitalize on them because of their failure to properly implement modernization and upgrade their aircraft fleet. As indicated earlier, the German industrial capability was stressed to maintain production of existing aircraft to counter the Allied mass of aircraft. This left nothing for development of new technology.

This led to an explosion of new project activity unequalled in the history of aviation, an explosion that was fueled even further in 1944 by the lifting of all patent protection.

The interwar years saw the rise of Lufthansa as a commercial airline of the Weimar republic. Headed ostensibly by Hugo Junkers, the main workhorse of the Lufthansa commercial fleet was the Ju 52, an all-metal commercial airliner. The Ju 52, pressed into service during the war as both a cargo aircraft (people and materiel) and a limited bomber, had the capability to carry more items than the previous wood and canvas aircraft. To offset the additional weight, Junkers put on a third engine. This venerable aircraft saw service throughout the war, although primarily as a cargo and troop carrier, eclipsed in the bomber role by the He 111 and Ju 88. Nevertheless, most aircraft built during the war were made of metal, thus more robust and survivable than the previous wood and canvas design. The use of metal aircraft also allowed German engineers to examine the possibility of pressurized cabins.[31] During the war, pilots who flew above a certain altitude were required to use oxygen to counteract the effects of altitude. As an aircraft rises in altitude, the oxygen concentration in the ambient air lessens. If an aircraft flies high enough, it can lead to oxygen depravation, causing the pilot and crew to black out. With the advent of pressurized cabins, the aircraft would be able to fly higher without the requisite oxygen aboard. By pressurizing the cabins, the ambient air within the cabin maintains the same oxygen concentration as it would sitting on the ground, negating altitude sickness and oxygen depravation. Although the Germans never fielded this, it is in wide use in all aircraft applications today.

Good Ideas, But…

Throughout World War II, the Luftwaffe sought to maintain its technological superiority over the Allied forces by designing capabilities into their aircraft that would allow them to fly higher and faster than the Allied aircraft.[32] This led to an "explosion of new project activity unequalled in the history of aviation, an explosion that was fueled even further in 1944 by the lifting of all patent protection."[33] The German aircraft industry was populated with some of the premier engineers and designers of the time who were able to come up with some truly revolutionary ideas for designing and building aircraft. The Germans were the first to design and use jet engine aircraft, metal aircraft, instrument navigation, sweptwing technology, and advanced testing through wind tunnels. Some of their more radical designs, such as the Gotha flying wing concept,[34] would not be realized until many years after World War II. Indeed, many of their innovations were picked up quickly by the Allied forces. Bower astutely notes:

> Since 1945, the genesis of weapons by all four Allies has been dominated by the inheritance of Germany's wartime inventions. Indeed, the Korean War can be viewed, on the technical level, as a trial of strength between two different teams of Germans: those hired by America and those hired by the Soviet Union. The aerial dogfights between the Soviet MiG-15 and the American F-86 Sabres—both designed by German engineers—dispelled for many their doubts about the expediency of plundering Germany's scientific expertise.[35]

Thus, the Germans did not lack grand and effective technological innovation. Yet, they were resoundingly unable to take advantage of this situation and were completely unable to bring these revolutionary concepts into operation. The reasons for this are manifold, but the centermost reason for their inability to exploit their technological superiority lay with the complex, convoluted, and inefficient management system in place in Germany during World War II.

Management for Dummies

One of the most overlooked practices in the business of technological innovation is the impact of management on the overall process. Management of technology is crucial to the successful implementation of revolutionary ideas and processes. Management needs to be not only knowledgeable about the designs and ideas of the engineers but also receptive to them. Management needs to provide a roadmap to what is to be accomplished. Without clear-cut direction, meaning a vision and goal, not micromanagement, any technological advance is doomed to irrelevance. An overall strategy will provide the engineers with the proper vector to direct their abilities and ideas. Furthermore, management needs to provide clear and unambivalent boundaries to the efforts of the engineers to ensure the technological innovations and ideas stay focused and attainable. Finally, the management structure needs to be streamlined and simple to allow ideas to flow not only laterally but also vertically. Binding management to a complex and suffocating bureaucracy will have the same effect on the industry as a whole.

Alas, the Luftwaffe found itself in just such a predicament during the war. It had a complicated and convoluted approval process for the technological advances forwarded, one that was wasteful of not only resources but also time. It had little strategic direction and no boundaries on the effort to advance technology. It also had the wrong people in charge of the various agencies that headed up, collectively, the overall effort. The result was a host of revolutionary innovations that would have all but guaranteed they remained technologically superior but were doomed to be merely paper tigers by the bulging management process and poor leadership. These paper tigers were exploited by the Allied powers after the war, but the Luftwaffe was unable to take advantage of them. The overall operational result was an air force that ended the war with the same equipment with which it began, quality equipment at the start but obsolete in 1945 when compared with the equipment of the Allies.

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Who's in Charge?

At the core of the management of Luftwaffe technology was Hermann Goering. As Hitler's duly appointed head of the Luftwaffe, he was responsible for ensuring the Luftwaffe had the necessary tools to prosecute the war. The Luftwaffe was responsible for determining its own requirements to ensure it could fight. Similarly, the navy and army each had that responsibility. While this is to be expected, what was lacking in Germany overall (and the Luftwaffe, in particular) was centralized control. There was no one agency in charge of military procurement. Indeed, "production was pitifully small. The fault lies clearly with the Technical Office whose lack of initiative cannot be ignored and with the Luftwaffe General Staff … which failed completely to provide the guidance expected of it."[36] Thus, there was no direction, no vectoring of the effort to ensure the proper item was developed. In other words, there was no one in charge.

Further complicating the effort was the process for placing something on contract. The Luftwaffe would award a production contract for an aircraft based solely on its design.[37] This essentially skips the research-and-development portion of modern-day acquisitions, with the Luftwaffe assuming the risk that the design will not work. In many cases, the prototypes developed did not meet expectations (or requirements).[38] Thus, large quantities of resources were spent and expended for something that did not work. This is an incredibly ineffective way to manage a contract. Further increasing the drag on the resources was the number of programmatic changes enacted. With the swift progress of the war and the swifter

progress of implementing minor technological changes, the German factories and modernization centers were hard-pressed to keep up.[39]

Finally, to keep the costs from escalating beyond what was already wasted, the Germans enacted price fixing for the industry. Essentially, a contractor could choose one of three pay categories: one which they were not taxed (but had to be a low contract bid), one where they were taxed, and one where they were taxed and some of their costs recouped. The latter only could be chosen with approval from the government.[40] In essence, from a fiscal point of view, German management of the contract process was a shambles. Valuable resources were wasted by betting the design would work, and the designs were changed constantly, costing more resources and further straining an industry that was undermined by fixing prices to the advantage of the government. This poor fiscal policy was further convoluted by the complicated organizational structure of the German industry.

Early German industrial organizational structure was an attempt to maintain centralized control over industry as it attempted to shift to a wartime footing. In each of the industries of the Third Reich was one person at the head. Directly beneath the head was a main committee, made up of the industry leaders. Ostensibly, the function of this main committee was to evaluate the way each of the companies in the industry did business, select the best from each, and have all factories implement these best practices. Further refining this process, there were special committees under the main committees that dealt with specific parts of the whole. These special committees were also responsible for implementing best practices among their subordinate factories in an effort to increase standardization and efficiency and reduce cost.[41] In theory, this seems to be a sound business practice; however, management by committee (or in this case, by many committees) was not very practical. When combined with poor fiscal guidance and a lack of strategic direction, this system merely complicated the problem.

Furthermore, in 1940, a system of rings was introduced into the industry. These rings were essentially committees but not limited to one industry. These rings were concerned with items and issues that transcended all industry. For example, the ring concerned with the making of steel would have an impact on all committees who used steel (which was all of them). The system that finally evolved consisted of "4 main rings for subcontracting and 8 main committees for the finished product."[42] Each of these committees and rings had subcommittees and subrings to them, further increasing the bulging bureaucracy. Known as Self-Government of Industry, this system could be effective in the hands of a skilled manager like Albert Speer. The armament industry under Speer became more efficient and productive[43] despite the complicated system. However, under managers like Karl-Otto Saur, the opposite happened. Indeed, as Goering stated:

> Saur was a man completely sold on figures. All he wanted was a pat on the shoulder when he managed to increase the number of aircraft from 2,000 to 2,500. Then the Luftwaffe was blamed that we had received so and so many aircraft and where were they.[44]

Unfortunately, for the Luftwaffe, this thinking tended to dominate the war-production effort. The result was a gross number of aircraft (quantity), many of which were unusable or obsolete (quality).

Quantity Versus Quality

One of the toughest challenges faced by management in a technological industry is the issue of quantity versus quality. Both are important and must be effectively blended to have a successful program. Unfortunately, for a country whose industry was poorly managed and resource-constrained and faced with an enemy with a seemingly endless supply of high-quality equipment, the natural tendency to fight mass with mass (matching quantities) overrode the necessity to instill some quality in the airplanes produced.[45] The result was a large number of inferior aircraft that could not have kept pace with the Allies, even if they were numerically similar. In mortal combat, quality is often the divide between success and failure. This was proven by the Tuskegee Airmen flying bomber escort from Italy. Although the number of P-51s sent to escort a bomber formation did not change drastically, they still escorted more than 200 missions without a single bomber loss. This is attributed to both the skill of these pilots and the quality instilled in the machines they flew. Alas, the Germans did not have the quality in their aircraft to overcome this.

By war's end, the Germans had lost the technological superiority they owned at the beginning. Although this can be directly attributed to their management system, this issue

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was further exacerbated by their failure to integrate the capabilities of the captured lands effectively. Indeed, rather than capitalizing on the capabilities of the workers in the conquered lands, the Germans merely plundered them and brought their populations into slave labor.[46] They failed to realize and take advantage of what was available to them. The result was a slave workforce that resented its masters. Needless to say, this was another cause of their diminished quality. Finally, as the war progressed, the Germans began conscripting just about any male with a pulse, regardless of his civilian expertise. This led to a lack of skilled workers, without whom quality suffered.[47] This is almost a double tap for quantity over quality—specifically, make the armed forces larger to counter the large force regardless of special (or needed) skills, depriving industry of the skilled workers necessary to instill quality in products sent to the armed forces.

However, equipment was not the only area in which quality suffered. As the war progressed, training for pilots was cut almost in half, primarily because of the need to have replacements for pilots lost in combat. The result was pilots significantly less skilled than earlier groups that entered combat. Poorly trained pilots, flying inferior equipment against a determined enemy on two fronts, is a sure recipe to create an even greater need for replacement pilots. In short, the German economy and industry could not keep up with the demands of a two-front, widely flung war and elected the desperation strategy of throwing everything it had into the fray, regardless of training or expertise. The result is obvious.

Although the complicated nature of industry organization is certainly a contributing factor to the inability of the Germans to exact victory, the lack of management and leadership from the top down definitely compounded the problem exponentially. Without a sound and appropriate strategy or roadmap, anything attempted has the distinct probability of failure. From the beginning, the German strategy focused on Europe and a blitzkrieg style of warfare. As Hitler's aspirations grew (and the war with them), the overall German strategy failed to take these new ideas into account.

Strategizing

From the beginning, the Nazi party rose to power in Germany under the guise of nationalism. Many Germans were still upset over the limitations imposed by the Treaty of Versailles at the end of World War I, in particular the clause that laid the blame for World War I and the resultant carnage squarely on the Germans. Additionally, the German people were adamant about reclaiming the land annexed away from them by the Treaty of Versailles. Undoubtedly, there were also some bad feelings about the French, who were seen as most responsible for the War Guilt clause. Thus, there were some strong feelings of being unfairly and cruelly treated in the aftermath of World War I. This was exacerbated further by the inability of the Weimar Republic to effectively fill the void left by the abdication of the Kaiser. The general disgruntlement of the German people led to a fierce feeling of nationalism and a desire to put someone into power who could actually do something about their situation.

Since many of the battles took place within easy distance of Germany, there was no need to delay the production of aircraft to build and stock spare parts; they would just make another airplane to replace the damaged or destroyed ones.

Enter Adolf Hitler, a recognized and decorated World War I veteran who had the charisma and rhetoric to rouse the population. Simply put, he knew what to say and had a forceful enough presence to ensure the people believed him. After his election to chancellor and the death of President Paul von Hindenburg, Hitler combined the two offices into that of Fuehrer and began to attempt to make good on his nationalism pledges. Realizing one of the reasons for the German defeat in World War I was the failure to generate the economy to a war footing, the Third Reich began increasing its economic capability.[48] Ostensibly, this was to continue the nationalistic regaining of indigenous German lands unfairly removed from them. This included the German pushes into Austria; the Sudetenland; Czechoslovakia; and ultimately, Poland. This desire to increase their *lebensraum*, or living space, was risky, however. At any point, the Allied powers (then Britain and France) could respond.

Hitler was emboldened during the operations prior to Poland by the lack of Allied response to his offensives. He assumed they would continue their policy of appeasement after the Poland campaign, especially after he signed a nonaggression treaty with the Soviet Union. Allied appeasement ended with the invasion of Poland, and both Britain and France declared war on Germany. Hitler was ready for this, however, and ordered his troops into France, occupying, in short order, about two-thirds of France.

From here, things began to go south for the Reich, despite their strong army and technological superiority. Up to this point, every campaign engaged in by the Germans had

been a blitzkrieg-style campaign:[49] hit the enemy hard and fast to overcome their defenses and then bring them into the Fatherland. As such, the German economy was geared to this type battle. There was reconstitution time between the battles, giving the economy and industry time to recoup the losses. Germany's continental focus was driving its blitzkrieg strategy, and its economy was geared to this. Thus, it produced high-quality, short- and medium-range fighters and bombers in large quantities to accommodate the blitzkrieg of the enemy. Since many of the battles took place within easy distance of Germany, there was no need to delay the production of aircraft to build and stock spare parts; they would just make another airplane to replace the damaged or destroyed ones.[50] While this worked well at the outset of the war, its significance grew as the German battlespace expanded greatly. Compounding this, pilot training was limited to tactical training only,[51] as there was no need to think beyond this level. Yet, with the onset of the Battle of Britain, the Germans changed strategy, whether or not they realized it.

Strategy Shift

World War II might have ended differently had Hitler elected to maintain his *lebensraum* policy and restrict his actions to continental Europe. Nevertheless, he attacked Britain, ostensibly to ensure the British stayed out of the war. From a tactical point of view, this was a huge mistake. To attack London, his fighters (upon whom the bombers relied for protection) had to operate at the limits of their range if they were to successfully return to France. In other words, he was now fighting a strategic war with a tactical force. Hitler had arbitrarily escalated things, a precursor of things to come.

As the war progressed, Hitler would return time and again to the concept of changing things to fit his worldview *du jour*, with no apparent thought to the impact on either society or industry. The most glaring example of his inconsistency concerns the Me 262, the world's first jet fighter. Originally designed as a fighter, Hitler ordered it changed to a fighter/bomber against the advice of Erhard Milch and Galland. The resultant delay to retrofit the Me 262 to a fighter/bomber ensured that, when it was ready for use as a bomber, the need was for fighters to defend the dwindling Reich. The Me 262, again at Hitler's insistence, was re-retrofitted back to a fighter, another delay to the program that ensured it was not introduced into the war until early 1945.[52] The argument over the Me 262, in which Goering sided with Milch and Galland, marked the beginning of the end of Goering's favor with Hitler. The result was a complete lack of Luftwaffe representation at future meetings.[53]

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After the loss in the Battle of Britain, Germany took a pause to recoup its losses; then Hitler made another large strategic mistake—he attacked the Soviet Union. Once again, he escalated the war effort to strategic levels with only a tactical industry and military. The results were disastrous for the Reich. They severely overextended themselves on the Eastern Front, which ensured their already fragile logistics support was stretched too thin. Additionally, the demands on industry for a two-front war were too hard to bear. In short, production could not keep up with losses, and there was almost no way to resupply the troops because of a lack of transport aircraft.[54] Finally, the German leadership severely underestimated the Allies' drive and dedication while simultaneously overestimating their own ability.[55] This ill-equipped armed force with little reconstitution ability, fighting a war that was larger than it was prepared for or capable of, with no clear written strategy and numerous changes to the direction of the effort, would have ensured the Reich imploded. However, the Allies were not content to take the time to allow this to happen. They decided to help it on its way through the Combined Bomber Offensive.

Allied Impact on German Strategy

The Combined Bomber Offensive was a massive push by American and British air forces to provide continuous day and night bombardment of the German homeland, focusing on its industrial capabilities. The American forces were responsible for the daylight bombing, the British for nighttime bombing. The Combined Bomber Offensive almost stopped before it started, primarily because of a lack of fighter escorts for daylight raids. The massive formations of B-17 aircraft were susceptible to the German fighter aircraft, and the resulting losses almost ended this aspect of the offensive. This changed with the introduction of the P-51, a highly maneuverable and capable fighter with range to escort the bombers all the way to their targets. These fighter escorts also served a second function, that of *attriting* the German fighter force—essentially a trench-style slugfest in the air. It was extremely successful in this second role,

removing German air superiority over continental Europe and ensuring Allied planes could roam the European Continent with relative impunity.

The effects on the German industry are even more telling. In addition to other targets, the Allied offensive destroyed the German transportation network, severely limiting its ability to operate a dispersed industry. Furthermore, the Allies concentrated their efforts on the critical Ruhr valley, which was the location of German stocks of coal.[56] The coal was used as a power-producing source and critical to the German war industry. The effects of these raids were felt throughout German society and industry as it placed severe hardship on its already overstressed and limited supply of raw materials and transportation. Compounding the German situation, the Allies struck many of its fuel sources. Indeed, in the after-war interrogations, Goering admitted that fuel was a significant limiting factor to production, especially in the production of a four-engine bomber. In discussing the He 177, Goering said, "I had to ground that aircraft because it consumed too much gasoline, and we just didn't have enough for it."[57] Finally, the Allied attacks had a significant impact on the German industry's depots and production facilities.[58] The Combined Bomber Offensive was more than a combination of American and British bombing techniques. It combined with the Germans' inefficient and poorly managed industry to finally break the back of the German war machine.

Summing Up

Throughout the war, the German state was unable to take advantage of many of its indigenous capabilities. Beginning with decentralized control of their procurement process and abetted by a complicated and wasteful fiscal policy, the industry simply could not keep up with the demands of the war. Furthermore, its organizational structure was not conducive to change. Its system of committees and rings with all the subcomponents thereof was an attempt to increase efficiency and reduce cost through standardization of production practices. It actually did not happen that way, as it was a system that could not grow to fit the increased need. The Germans effectively proved that management by committee does not work in a wartime situation. Compounding this further were the people they placed in charge. With a few notable exceptions, the men selected to run the industry were party lackeys who had limited experience and know-how when it came to running an industry.

Strategic direction from the state leadership was completely lacking. What began as a continental campaign to reverse the perceived unfairness of the Treaty of Versailles rapidly expanded into a global strategic battle for world dominance, all with an economy that was geared toward a blitzkrieg-style tactical engagement. German industry was never able to recover from this continental focus, dooming the strategic efforts to failure. Furthermore, the personal and direct involvement of Hitler into all aspects of the war effort only served to confuse and befuddle the national leaders. In other words, absolutely no direction was provided to guide the war effort. This led to numerous production delays as aircraft were constantly fitted and refitted to meet the ever-changing requirements. Additionally, the German leadership had two key misconceptions that may have attributed to their constant change. First, they underestimated the Allies, and second, they overestimated themselves. The added impact of the Combined Bomber Offensive served to exacerbate an already deteriorating situation and helped ensure the 1,000-year Reich lasted a mere 12 years.

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Forward to the Future

As the US Air Force begins its fourth major transformation in 11 years, there are some striking similarities between what it currently faces and those challenges faced by World War II Germany. Notable among them is a strong sense of nationalism. No one can doubt the surge in American patriotism since the 11 September 2001 events, and one cannot overlook the sense of outrage and frustration at the horrific waste of human life and American potential. Yet, a parallel can be drawn between this and the general feelings of the average German during the interwar period. The Germans felt a sense of outrage and frustration at not only the loss of land but also the humiliation that accompanied the Treaty of Versailles. In hindsight, these feelings perhaps are justified, but the results for Germany were disastrous. Fortunately, the American people are not following the same political trend, nor could we, given our process for electing our officials and the constraints and restraints placed upon them.

Currently, there is no real centralized control over the US Armed Forces acquisition program. As it was for the Germans in 1935, the US Armed Forces currently follow separate stovepipes for acquisition of weapon systems. There are separate DoD programs for ballistic missile defense among the Army, Navy, and Air Force, as well as different programs for acquisition of unmanned aerial vehicles. The acquisition programs for the F-35 Joint Strike Fighter follow the same path, each Service pursuing its own agenda to meet its own needs. This was exactly the same at the beginning of the German buildup for World War II. Each service had its own unique requirements, and each pursued them independently of the other. The result was an egregious waste of valuable and limited resources, both natural resources and dollars. In essence, they ended up paying for essentially the same thing three times. It is the same today with the American military. We have separate programs for the X-45 Air Force unmanned combat aerial vehicle and the X-47 Navy unmanned combat aerial vehicle. Both are experimental, and both operate more or less independently of the other. The end result will be two unique systems that meet specific needs without addressing the overall interoperability between systems. While the Germans were not faced with each branch of the service creating its own flying machine, the overall competition between the Services for constrained resources and the inability of the leadership to differentiate, much less prioritize, among the service requirements led to incredible waste and effort.

Similarly, the US Air Force, today, faces much the same challenge as the Luftwaffe, specifically determination of mission and needs. As the Luftwaffe vacillated between a fighter and bomber, the same struggle goes on today in the US Air Force. With the cost of each individual unit escalating rapidly (because of the investment in technology), what is the priority, fighters or bombers, given that the United States really cannot afford both? Further complicating matters is the need to build tankers and lift aircraft. While the Luftwaffe merely ignored this, to its detriment, this remains a central concern for Air Force officials. While not a concern for the Luftwaffe, the American conundrum is compounded by the oft-overlooked integration of space into the battlespace. The items placed in space are extremely expensive and difficult to make, yet, paradoxically, are always there to aid the warfighters. As long as these systems continue to perform, they will be overlooked largely by people who do not understand their mission or importance until it is too late. All these compete for limited resources, those doled out with a medicine dropper by a dubious legislative branch. This merely compounds the larger issue facing the Air Force today, that of identity.

Transformations

Since 1992, the Air Force has undergone four major transformations. The Air Force has evolved from the Cold War hallmarks of Strategic Air Command, Military Airlift Command, Tactical Air Command, and Air Training Command to the current configuration of Air Combat Command, Air Mobility Command, Air Education and Training Command, Air Force Space Command, and Air Force Materiel Command. Designed to be functionally aligned, each command was changed to be a stand-alone force capable of operating within its own unique and nonoverlapping mission areas. The Air Force then transformed to the expeditionary air forces, an idea that creates ten stand-alone composite forces to handle regional situations worldwide. In essence, the expeditionary air forces are a combination of the functionally aligned major commands of today and the geographically aligned major commands of yesterday. Each air expeditionary force contains strategic and tactical elements yet draws from the respective major commands for expertise. Finally, the Air Force is transforming to a task-force-based concept, which is essentially a subset of the expeditionary air force designed to handle a specific contingency as it arises. All this combines to leave a large uncertainty about the mission and function of an air force.

When asked exactly what it is the Air Force does, the answer depends on when the question is asked or what is going on in the world. In other words, there is limited identity within the Air Force about its mission. This is exacerbated by the fact the corporate identity seems to change with each new Chief of Staff. As Goering's Luftwaffe provided little or no unique identity and mission to its members, so the Air Force faces the same dilemma. The result has been a restructuring of the Air Force from one that can fight an outmoded form of war to one that can survive in an outmoded form of peace. American worldview, like that of the German forces during World War II, has remained stagnant. While paying lipservice to a contingency-based, flexible, expeditionary force, the Air Force remains firmly locked in the planning and budgeting of a Cold War, two major-theater-war mentality.

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The one issue the Department of Defense has handled well is the creation of the unified commands. Each command is designed to be a warfighter or a functional command with expertise in either a particular area of responsibility or a particular function. There is no overlap in responsibility (except for the functional commands, which operate somewhat autonomously of the geographic commands), yet each of the unified commands manages to share resources and information without regard to which component provided it. In many ways, this mentality needs to transcend the programmatic stovepiping in each of the military branches.

The issue of technology is becoming the forefront of American procurement and acquisition issues. As the Germans did in 1935, America now enjoys a technological superiority over friend and foe alike. At the present, there is no match for American technological know-how and application. Yet, this technology is only as good as its application. As the Germans found out, developing technology just because you can is a poor reason to carry out a government program. While the Germans had some technological innovations, such as jet engines and wind tunnels, many of their technological advances were not realized until after the Reich had vanished. Indeed, developments such as the Gotha P.60 flying wing-style fighter were not adopted until recently with the advent of the B-2 Spirit. The German programs were mismanaged from above almost from the start, including no boundaries on where technology could go. The American problem is more geared to including technology into *simple* problems, simply because it is possible. Many of the acquisition programs undertaken by the Air Force fail to consider the *low technology* or already existing technology approach, often at a large pricetag for a limited capability.

Further complicating the picture is the management of our acquisition programs. In most cases, for a new system, it can take 10-20 years from identification of the problem to fielding a system to defeat or answer the problem. Often, the items fielded are obsolete before they enter production because of changing world needs. Granted, the Department of Defense has not fallen into the pitfall that awaited the Germans; namely, changing existing programs to meet evolving needs. However, the Department of Defense tends to create a new program to handle a problem, which significantly compounds the ability to field forces capable of responding in the manner in which they are needed. Each of these programs will compete for existing, limited funds, resulting in a compromise that answers neither the existing problem nor the original problem. Additionally, the acquisition process is bureaucratically robust. Very little can overcome the inertia of the albatross (the bureaucracy) surrounding acquisition programs, and nothing gets through quickly. The Department of Defense has so many layers of management to get through that it becomes almost a self-licking ice cream cone when faced with an immediate and unforeseen threat. In certain rare circumstances, this inertia can be overcome, but these are the exceptions rather than the rule.

Finally, the American worldview is stagnant. As the Germans could not see beyond continental Europe, so the Americans cannot see below the strategic layer. The Germans could not see the forest for the trees, and America cannot see the trees for the forest. America still believes, despite the 11 September attacks, that it cannot be touched by a foe. Americans believe the way to counter potential foes is to apply a strategic, precision, lethal force. This may be true when it is a contest between nations, but in a contest between a nation and a nonstate actor, this meets limited success. Thus, America's worldview and its Armed Forces must be ready for strategic and tactical wars, both conventional and unconventional.

The real answer lies in establishing a warfighting entity that is impartial with respect to the Services' ability to handle the acquisition and technology programs for the entire Department of Defense. The logical choice is to place the integration of all military needs under the unified command tasked with determining the training and evaluation needs for Joint forces, United States Joint Forces Command. With its overarching view of all the unified commands, it is in the unique position to determine what is necessary to fight and win America's wars, both in terms of manpower and equipment. Furthermore, it should be charged with ensuring the interoperability of these programs to meet service-specific needs with minimal changes. In this time of limited resources and increasing needs, standardization is required without sacrificing individual service-unique needs. Additionally, a streamlining of the acquisition process is required to ensure timely answers to emerging needs. Without these changes, our system becomes almost as cumbersome as the World War II German

system, a system that can (and in the case of World War II, Germany, did) implode if left alone long enough.

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Core values make the military what it is; without them, we cannot succeed. They are values that instill confidence, earn lasting respect, and create willing followers. They are the values that anchor resolve in the most difficult situations. They are the values that buttress mental and physical courage when we enter combat. In essence, they are the three pillars of professionalism that provide the foundation for military leadership at every level.

—Sheila E. Widnall, Secretary of the Air Force

I cannot trust a man to control others who cannot control himself.

—Gen Robert E. Lee, CSA

When the political and tactical constraints imposed on air use are extensive and pervasive—and that trend seems more rather than less likely—then gradualism may be perceived as the only option.

—Gen Joseph W. Ralston, USAF

Integrity is the fundamental premise for military service in a free society. Without integrity, the moral pillars of our military strength, public trust, and self-respect are lost.

—Gen Charles A. Gabriel, USAF

No form of transportation ever really dies out. Every new form is an addition to, and not a substitution for, an old form of transportation.

—Air Marshal Viscount Hugh M. Trenchard, RAF

Not everything that is faced can be changed. But nothing can be changed until it is faced.

—James Baldwin

Take calculated risks. That is quite different from being rash.

—Gen George S. Patton, Jr, USA

You miss 100 percent of the shots you never take.

—Wayne D. Gretzky

Your current safe boundaries were once unknown frontiers.

—Anonymous

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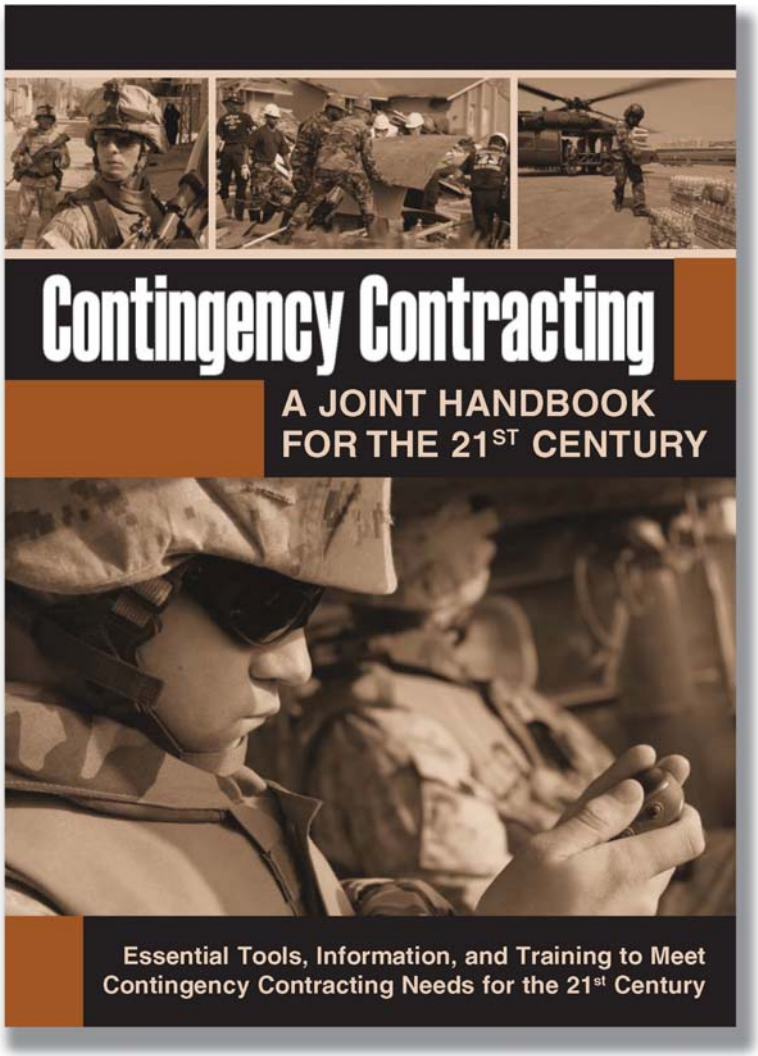

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Alexander the Great

Alexander the Great is rumored to have wept upon the conclusion of his conquests because there were no longer any nations to conquer. To a large degree, it is true that at his height of power, Alexander was the ruler of the known world. The tales of his conquest take on a mythical grandeur in which he is located somewhere between a man and a god. "Alexander was in fact, a living myth, and unless we accept him as such we cannot begin to understand his history."[1]

Generalship and Military Professionalism

The almost superhuman view of Alexander is not a modern contrivance. In fact, throughout most of his life, Alexander was treated with godlike reverence.

> Led by a god they [the Macedonian Army] faced all dangers, and it was their faith in him as a supernatural world-hero, as much as his inborn genius for war, which made him not only the greatest of all the Great Captains, but which distinguishes him from all and each one of them.[2]

This unparalleled allegiance to Alexander coupled with his genius for integrating logistics concerns into every facet of his military theory, doctrine, strategy, tactics, and administration enabled the support of a world-conquering army.

Alexander did not rise through the ranks but inherited his position from his father, Philip. Likewise he inherited a formidable fighting force without equal in the ancient world. Alexander's *professional education* was enviable, to say the least. He received instruction in strategy and tactics from his father and was privately tutored by Aristotle. The negative legacy of Philip and Aristotle's tutelage was their incredible hatred of the Persians, referred to by both Philip and Aristotle as the barbarians. However, Alexander seemed to rise above the hatred of his father and mentor and developed an attitude toward conquered peoples, even Persians, that was key in ensuring logistical support across the vast empire under his control.

To a large degree, logistics concerns shaped Alexander's strategy and tactics. From the time of his initial defeat of Darius at Issus, through his campaign into Egypt, and his final defeat of Darius at Gaugamela (also known as the Battle of Arbela) Alexander displayed an acute awareness of the logistical requirements of his army.

Military Theory, Doctrine, Strategy, and Tactics

B. H. Liddell Hart characterized Alexander's logistics strategy as "direct and devoid of subtlety."[3] Moreover, to a large degree, logistics concerns shaped Alexander's strategy and tactics. From the time of his initial defeat of Darius at Issus, through his campaign into Egypt, and his final defeat of Darius at Gaugamela (also known as the Battle of Arbela) Alexander displayed an acute awareness of the logistical requirements of his army. Alexander considered the logistics implications of every aspect of the campaign, from the route he took to the allies he courted, in successfully moving the Macedonian army across the relatively barren desserts of Asia Minor.

Alexander began his move east from Macedonia, intent upon engaging the Persians at the Gracicus River. He had an estimated 10 days' worth of provisions for his army at Hellespont.[4] Ten days' provisions were ample, given Alexander's close proximity to ports along the Aegean Sea and the relative friendliness of the people of that region. Upon defeating

the Persians at the Gracicus River, Alexander then marched on Sardis. It was on his march to Sardis that he encountered his first great logistics challenge. The direct route to Sardis was across mountainous terrain. However, Alexander elected to take a more circuitous route, moving back toward the coastline rather than southward to Sardis. This move was indicative of his exceptional grasp of logistics requirements and their direct influence upon the fighting capability of his army. Had he chosen the more direct route, not only would the terrain have slowed his advance, but the greater strain of covering mountainous terrain would have increased the consumption of supplies by both his men and horses. In all likelihood, his supplies would have been exhausted prior to reaching Sardis, and his army would have been located in the mountainous region vice the coastal area with its ready access to supply ships. Alexander repeated this strategy of attacking the enemy then quickly returning to the coastal region for resupply throughout his campaign against the Persians. The two exceptions to this strategy were his move on Ancrya (modern day Ankara) and his expedition into Egypt.

Alexander achieved two major logistics objectives in his capture of Sardis. Sardis was the political and economic hub of the entire region, and by bringing it under his control and raiding its treasury, Alexander further increased the resources he could draw. Second, the defeat of Sardis cleared his path southward along the coast of the Aegean. He then *liberated* Ephesus, Caria, Lycia, and Pamphylia. Alexander limited the Persian fleet's ability to move and took away their access to these ports by bringing these coastal cities under his control. A secondary effect of controlling these cities was that Alexander deprived the enemy fleet of a valued manpower resource. The Persians had been recruiting heavily from this area.[5] Alexander continued his coastal movement through Lycia and Pamphylia. While passing through this fertile region Alexander again illustrated his ability to integrate logistics requirements with the gamut of additional concerns facing the leader of a large force. Although the region was fertile and presented an excellent source of resupply for his army, he was well aware the effect mountainous terrain had on the consumption of supplies. Additionally, it was now winter. He chose to grant leave to newlywed members of his army. This act of altruism was, in fact, a brilliant means of reducing the army's consumption of stores, in addition to significantly improving morale. Though it seems unusual to grant leave in the midst of a campaign, Alexander was sensitive to the limits to which this region could support his army, and he did not intend to march on until the end of winter.[6]

Throughout his campaign, Alexander left garrisons of forces at key locations along his route. This practice had three major purposes: it ensured the allegiance of the city was secure, it allowed the city to serve as a depot for the storage of supplies, and it protected his lines of communication.

Throughout his campaign, Alexander left garrisons of forces at key locations along his route. This practice had three major purposes: it ensured the allegiance of the city was secure, it allowed the city to serve as a depot for the storage of supplies, and it protected his lines of communication. In some instances, Alexander was able to send a small force ahead to secure a city's allegiance and support. His emissaries were able to secure logistics support and supplies, simply because the city's leaders desired to be in favor with Alexander.

Alexander's army remained throughout the winter and spring in the region around Pamphylia. He did not make his march to Ancyra until well into summer. The reason for the delay was purely logistical. He would be departing the coastline and heading inland. Given his doctrine of traveling light, his army would quickly exhaust its supplies and be forced to forage. Knowing that, Alexander began his march in late summer to ensure crops within the region between Pamphylia and Ancyra had an opportunity to both mature and be harvested, the latter being performed by the residents of the region, thus sparing his army that arduous task.[7]

En route to Ancyra, the Macedonian army crossed a region best described as an utter wasteland. Given the lack of potable water in this region, Alexander made frequent use of advance depots. He established the depots forward of the main army, with supplies from the rear augmented with whatever else could be secured at the advanced location.

Upon securing Ancyra, Alexander successfully consolidated his position in Asia Minor. He then marched to Issus and once again was forced to rely heavily upon the advance garrisons he had established, in addition to securing supplies from the local population en route. To his advantage, the majority of the cities between Ancyra and Issus were quite unhappy with their subjugation under Persian rule and viewed Alexander's cause favorably. Issus was a coastal city, which enabled Alexander to move forces garrisoned in the rear on the Aegean Sea forward. The army he had partitioned prior to his march on Ancyra was now back in full force at Issus. The partitioning and regrouping of his army aptly illustrates his philosophy of carrying only what was needed and could be supported. This applied to not only his supplies but also his troops.

Upon his defeat of Darius at Issus, Alexander departed from the direct conquest of Persia. He then turned southward through Phoenicia and eastward into Egypt. Although Phoenicia and Egypt were under Persian control, Alexander did not face serious opposition until his return to Asia Minor. Additionally, his logistics philosophy was consistent with his earlier actions along the coast of the Aegean Sea. His route in Egypt followed the coast of the Mediterranean Sea. The majority of the cities, especially those in Egypt, viewed Alexander as a liberator and not a conqueror and were, therefore, generous in their support of his army.

Upon his return to Asia Minor, Alexander again remained near the coast and its valuable seaports. The cities that he passed en route from Egypt were now directly under his control and represented an asset rather than a possible threat. His departure from the coast and march on Arbela was made through the fertile Tigris-Euphrates Valley. Though meeting the logistics needs of an army is no small task regardless of location, Alexander's march through the Tigris-Euphrates Valley was not marked by any significant logistics challenges.

Alexander's defeat of Darius at the Battle of Arbela marked the end of the Persian Empire and Darius as their king. Key to his defeat of Darius was his approach to Darius' main body at an angle and the rapid encirclement of Darius' forces by Alexander's left flank. Alexander's successful use of maneuver is directly attributable to his overarching philosophy of flexibility and mobility, a philosophy integrated into and facilitated by his logistics practices.

Administration and Technology

One of Alexander's logistics strengths, one for which he cannot wholly take credit, was the organization of his army. "Alexander had as a legacy a model instrument—the army which Philip developed."[8] Key to Alexander's combat superiority and logistics prowess was his staff. In addition to the traditional second in command, called the Secretariat, Alexander had Keepers of the Diary, Keepers of the King's Plans, Surveyors and Official Historians. In addition to the more traditional staff functions, he also kept a large number of specialists and scientists on his staff. This wealth of expertise, both operational and logistical, he kept close at hand and without reservation solicited their counsel. Alexander's use of his staff of experts made his army formidable, not only in terms of its ability to execute combat operations but also in terms of its ability to plan and support combat operations.

Under Philip's direction, the Macedonian Army also underwent a significant change in the manner in which troops and provisions were transported. Philip outlawed the use of wagons in the Macedonian Army. This single act gave the Macedonian Army far greater speed and flexibility than any of their contemporaries. Philip's philosophy was expanded by Alexander, who limited the number of followers, civilians who tracked behind an army providing a gamut of services. Alexander only used horses, camels, and mules because of their greater speed and endurance over traditional pack animals such as oxen and donkeys.[9] The speed and flexibility of the Macedonian Army proved to be its greatest asset on many occasions.

Social, Political, and Economic Factors

One of Alexander's logistics strengths, one for which he cannot wholly take credit, was the organization of his army.

Philip, through his victory at Chaeronea, had secured control over Thebes and Athens. He then founded the Corinthian league and, through it, unified Greece. His next and ultimate goal was to destroy the barbarians, the Persians. His plans, however, were cut short with his assassination. Alexander was then left with the goal of conquering the Persians and, in doing so, laying claim to the known world. Despite his father's outright hatred of the Persians and the unbridled hatred of the Persians by Aristotle, his mentor, Alexander took a decidedly different view of his enemy. Alexander, too, saw the necessity of engaging and conquering the Persians. However, his purpose was well apart from the destruction of the barbarians. Under Philip, Greece had been unified, "and though he might have avenged Greece upon Persia, he [Philip] was not the man to carry the idea of *homonia* (unity in concord) into the world empire of his day … this supremely greater task was destined for his son."[10] Alexander's philosophy was not one of revenge and destructive conquest but one of control and ownership. When brought under Alexander's control, either through defeat, or in many cases by self-capitulation, a conquered city was left with a measurable level of autonomy.

His method throughout his reign was always the same. He separated civil administration from military control. The first he handed over to the representative of the conquered people, the second he placed in the hands of one of his chosen Macedonians.[11]

Alexander's goal was not for *homonia* just among Greeks but among all men, including Persians. In addition to the obvious political benefits this policy held, it provided substantial military logistics benefits. Although not completely free to choose whether or not to lend support to Alexander, conquered peoples, on the whole, favored life under Alexander's rule to that under some other conqueror and were generally supportive. On the off chance the *carrot* of semiautonomous rule did not persuade the conquered people, Alexander still had the *stick* of garrisoned troops left behind to oversee military affairs.

Napoleon Bonaparte

Napoleon is widely regarded as one of the premier generals of all time. He brought about numerous reforms in the way in which wars are fought and the very structure and composition of the fighting forces engaged in combat. Napoleon embodied the idea of the professional military leader, not gaining his position through political or familial connections, but earning it by distinguishing himself in combat. Although the focus of this study is on the logistics aspect of Napoleon's 1812 march upon Moscow, it first seems appropriate to recognize Napoleon for what he was, one of the greatest military leaders of all time.

Generalship and Military Professionalism

A major drawback to Napoleon's superior generalship and professionalism during the planning of the Russian campaign was his overpowering need to be involved in every aspect. An even greater problem than this, however, was his tendency to make decisions without consulting with his key leaders. There is a consensus among the accounts describing Napoleon's preparation for the Russian campaign that there were severe oversights regarding the logistic requirements of his army.

A major drawback to Napoleon's superior generalship and professionalism during the planning of the Russian campaign was his overpowering need to be involved in every aspect. An even greater problem than this, however, was his tendency to make decisions without consulting with his key leaders.

Although the planning for the Russian campaign was performed over the span of 2 years and showed some aspects of logistics consideration, it is clear Napoleon did not fully understand the logistical challenges he would face.[12] His misunderstanding, coupled with his reluctance to share information, had an obvious impact upon the soundness of the logistics aspects of his plan. His reluctance to seek the counsel of others was as much a function of "delusion and irrationality clouding his powerful mind" as the lack of any competent advisor. Just prior to the invasion of Russia, "there were few men left in the imperial entourage with sufficient integrity to speak their true minds," and "for the main part, Napoleon was now surrounded by claquers and sycophants."[13] Whether acting out of ego or necessity, Napoleon planned the Russian campaign, to a large extent, entirely on his own. Operating in a vacuum led to numerous logistics problems in terms of military theory, doctrine, strategy, tactics, administration, and technology.

Military Theory, Doctrine, Strategy, and Tactics

Throughout the planning and execution of the campaign into Russia, Napoleon committed numerous errors in terms of strategic focus and tactics, which directly affected the ability of his logistics system to support sustained operations. One of his greatest oversights was his doctrinal belief he could conduct a war on two fronts. When he began the invasion of Russia in 1812, Napoleon's forces were still actively engaged in a peninsular war with the Spanish. Though it is unclear as to his exact reasoning, Napoleon chose not to regard his commitment to the war in Spain. It seems he preferred to have the British involved on the side of the enemy in Spain rather than being involved in some other less convenient sector of Europe. Regardless of Napoleon's exact reasoning, the net negative effect of the Spanish War was the loss of 50,000 French soldiers per year and the consumption of an untold amount of the materials of war that could have been used in the Russian campaign.[14]

Though Napoleon did show some consideration for logistics, he viewed these requirements in a static sense. He failed to factor in the possibility that the support he anticipated would not be available. Similarly, he did not consider the possibility that the enemy he wanted to destroy would not engage him.

Napoleon's strategy did recognize the materiel challenges to be faced by any force marching on Moscow. The date for the start of the invasion, 23 June, was largely chosen for logistics reasons.[15] Napoleon thought the crops in Russia would be sufficiently developed and provide adequate forage for the thousands of horses upon which he relied for transportation and as weapons of war. He also had the horses bear a larger-than-traditional load in an attempt to ensure an adequate supply of food for both man and beast. Unfortunately,

the addition of the extra loads increased the horses' consumption of food, in essence negating or worsening the effect of the additional provisions. In very short order after crossing the Niemen River, Napoleon would see his fleet of horses cut down by a third because of an outbreak of colic, the relative lack of edible forage (on which he was counting), and incredibly hot weather. The loss of those horses had a cascading effect. Men who had been mounted were now forced to advance on foot, and horses were diverted from other details to fill vacancies in horse-drawn artillery teams. The net effect was to distribute the transportation and logistics burden over an ever-decreasing population of beasts of burden. The burden increased with the onset of heavy rains, which turned the Russian roads into impassable bogs. Throughout the campaign, the ever-dwindling supply of horses and the ever-worsening weather contributed to the complete destruction of Napoleon's ability to provide for his forces.[16]

The greatest strain on Napoleon's logistics system proved to be the Russian unwillingness to engage in battle. From the start of the campaign, the Russian forces were quite content in withdrawing and forcing Napoleon to pursue them. To compound this, they would also burn their own cities prior to abandoning them. Thus, the farther Napoleon marched into Russia, the farther he marched into a virtual wasteland. The Russians rarely left behind anything of use. Upon reaching his strategic goal of Moscow, Napoleon found it deserted and generally devoid of any useful supplies. The Russians, after fighting a pitched battle on the outskirts of the city and seeing the city would fall, simply deserted it during the night. The net effect of Napoleon's march on Moscow was that his army, some 250,000 strong when it crossed the Niemen, was reduced to 130,000 because of the lack of supplies, disease, and Russian hit-and-run attacks on Napoleon's rear. The Russian Army, which was outnumbered two to one when Napoleon crossed the Niemen, was now approximately equal in size to his army. Further, the Russian army, in spite of all its retreats, had stubbornly hung on to its artillery and enjoyed a slight numerical advantage over Napoleon's heavy guns. Upon reaching the strategic goal of Moscow, Napoleon was no closer to defeating the Russians than when he began, and he was now in the midst of a vast wasteland, several hundred miles from his stores of supplies in Warsaw.

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In search of both victory and supplies to sustain his army, Napoleon marched on to Kaluga. It was en route to Kaluga that he obtained what he so desperately wanted—battle with the Russians. General Kutuzov made his stand at Maloyaroslavetz, a village on the road from Moscow to Kaluga. Although Napoleon was able to remove Kutzov's forces from Maloyaroslavetz, it came at the cost of 4,000 French troops. Worse yet, Kutuzov's forces still controlled the road to Kaluga. It was at this point that Napoleon began his retreat from Russia. Without losing a battle, he had lost the war.

It was now October, and 200 miles lay between Napoleon and his nearest supply depot, Smolensk. The depot at Smolensk was established on the march across Russia from Poland. Napoleon had charged the garrison commander to secure stores while the main body of Napoleon's army pressed onward to Moscow. Napoleon anticipated that upon the conclusion of the grueling 2-week march from Maloyaroslavetz to Smolensk he would be able to halt there and regroup. There were, however, three tragic flaws with this plan. The Russians were now attacking Napoleon's rear with great vigor. The garrison commander at Smolensk had precious few supplies at the onset of establishing the depot and, being surrounded by a virtual wasteland, had failed to secure any stores of adequate quantity. The weather was steadily deteriorating.

The strain on the weakened transport system was growing. All along the way, the men were discarding the bulkier and less valuable items among their loot. Rations were limited. Horseflesh began once more to be cooked at the evening campfires. Snow began to fall. And on the night of 5 November, the cold came.

No longer were the retreating troops faced with merely the unpleasant chill of frost. This was a cold that could not be held off by the upturned collars of their greatcoats. It could not be pushed aside by stamping in the snow or by holding cupped hands against ears and cheeks. This cold was so terrible that frozen feet, followed by frozen death, came upon men who had done nothing more than momentarily step into the ankle-deep water of some frozen roadside puddle on which a heavy artillery wheel, a moment before, had broken the ice.[17]

Upon his arrival at Smolensk, Napoleon realized his folly. There were no adequate stores at Smolensk, and he must keep moving, or his army would be lost. Throughout the retreat, the Russian Army dogged Napoleon's heels, at times separating the rear guard from his main body and inflicting even heavier casualties. When Napoleon finally returned from the Russian campaign, his army, once numbering 250,000, reported 8,800 men fit for duty.

Administration and Technology

The administrative weakness of Napoleon's army was directly attributable to his style of leadership. Although Napoleon's influence had garnered great success in the past, he made the tragic flaw of assuming what worked in previous situations would work again, despite the dramatic difference the Russian campaign represented from his previous conquests. Most important, Napoleon's army was larger than it had ever been, and the campaign was spread over the vast expanse of the Russian countryside.

The problems of time and distance were to prove too great for the capacity of a single mortal, even when that man was Napoleon. Napoleon's whole idea of warfare was based upon personal supervision of all parts of his army.[18]

His philosophy of direct supervision had proven difficult for him to execute over armies of smaller size that operated over a far more confined area. This philosophy proved impossible during the Russian campaign. Napoleon's inability to oversee his subordinates' preparation and execution of his planning led to significant shortfalls in readiness and synchronization of effort. The army's reliance upon guidance from the highest levels led to poor preparation and logistics support.

Technologically, Napoleon's army was the model of modern arms for the time. However, technological superiority in this case did not ensure battlefield superiority. Specifically, Napoleon's heavy guns required multiple horse teams. The horses in turn required provisions of their own. The only means of replenishing a lost horse was to obtain it from another function within the army. The net result, as mentioned earlier, was the logistics burden continually being spread over a decreasing number of pack animals. Furthermore, Napoleon's wagons were well suited for the relatively passable roads of western Europe but were woefully inadequate in the boggy mire of the Russian countryside. The combined net effect was a technologically advanced force incapable of getting to the battle in force and forced to consume itself in order to keep pursuing an enemy not committed to full engagement.

Social, Political, and Economic Factors

Leading up to Napoleon's invasion of Russia, Tsar Alexander was able to make peace with Turkey, sign a treaty of alliance with Great Britain, and court the favor of Crown Prince Bernadotte of Sweden. The collective effect of this diplomatic maneuvering was that Russia "was able to clear her hands of all outstanding commitments and proved notably successful in her search for new allies."[19] Although Napoleon made similar political attempts to garner support, the vast majority of his support was obtained by force. The Russians were fighting on their own soil, which provided many logistical advantages. Their supplies had shorter distances to travel, and their personnel were well equipped to handle the severe weather. Tsar Alexander eerily predicted the results of the Moscow campaign in a conversation with Armand de Caulaincourt, then Ambassador to St Petersburg.

> If the Emperor Napoleon decides to make war, it is possible, even probable, that we shall be defeated, assuming that we fight. But that will not mean that he can dictate peace. The Spaniards have frequently been defeated; and they are not beaten, nor have they surrendered. Moreover, they are not so far away from Paris as we are, and have neither our climate nor our resources to help them. We shall take no risks. We have plenty of space; and our standing army is well organized. Your Frenchman is brave, but long sufferings and a hard climate wear down his resistance. Our climate, our winter, will fight on our side.[20]

Logistics problems played the pivotal role in Napoleon's failed campaign into Russia. Inadequate transportation systems, reliance upon single sources of replenishment, and improper provisioning for extremes in climate reduced the greatest army of the time, some 250,000 men strong, to a feeble force of 8,800 survivors. Until his retreat, Napoleon had not lost a battle, but he did lose the war.

Logistics problems played the pivotal role in Napoleon's failed campaign into Russia. Inadequate transportation systems, reliance upon single sources of replenishment, and improper provisioning for extremes in climate reduced the greatest army of the time, some 250,000 men strong, to a feeble force of 8,800 survivor

William Tecumseh Sherman

The concept of generalship, a person's ability to be a general, cannot be viewed simply in terms of his conduct and influence upon his surroundings. His surroundings must also be evaluated. The environment in which the general commands has a great deal to do with his success and, in turn, will clearly influence the overall perception of his generalship. An analysis of William Tecumseh Sherman's environment leading up to and during the march on Atlanta provides unique insight into his generalship and military professionalism and how these threads of continuity both influenced and were influenced by his logistics practices.

Generalship and Military Professionalism

Ulysses S. Grant's appointment as Lieutenant General, Commanding the Armies of the United States in 1864, served to solidify unity, not only in terms of command but also in sense of purpose. Grant was the field general under whose leadership Sherman led the armies of the West into the heart of the Confederacy. Sherman's success can, in large part, be attributed to the autonomy with which he was allowed to operate. This autonomy was brought about as much because of Grant's trust in him as because of his geographic separation from Grant. Grant, in his written direction to Sherman, illustrates his belief in outlining what needs to be done, not how to do it. "I do not propose to lay down for you a plan of campaign, but simply to lay down the work it is desirable to have done, and leave you free to execute it in your own way."[21]

This concept of centralized control and decentralized command was especially useful given Sherman's nature as a man of action. His conduct during the preparation for and subsequent march on Atlanta is distinguished by quick and decisive action. His focus was first on the end goal, then on achieving it. In terms of logistics support, Sherman clearly identified his logistics requirements, then obtained the necessary means to meet them. Sherman was not prone to micromanagement. He simply expressed his requirements, established a completion date, and then ensured adequate motivation for completing the task. An excellent example of Sherman's leadership style, as it specifically relates to logistics, was the case in which a subordinate was not providing adequate transportation support. Sherman informed the officer that if he did not supply his army and keep it supplied "We'll eat your mules up." Sherman was far more forgiving of tactical errors than errors regarding logistics planning. He believed tactical errors often "stem from the enemy's resistance and counteractions, which are the most incalculable factors in war," but a failure to adequately prepare was intolerable. Sherman believed "by due foresight, preparation and initiative, material obstacles can always be overcome."[22]

Sherman enjoyed the benefit of the best military education available in the United States at the time. He was a graduate of the United States Military Academy. Despite not holding any cadet positions of authority while at West Point, he graduated near the top of his class, number six in the class of 1840.[23] The military education he received at West Point proved valuable because it provided a sound background upon which to build military command experience and was the same background the majority of the military leaders of the time had. Grant, Lee, Jackson, and numerous other Northern and Southern generals came from the same school of thought, West Point. The classical approach to education at West Point undoubtedly exposed Sherman to the histories of great generals and campaigns of the past. It is then not surprising that there are significant similarities between Sherman's campaign into the heart of the South and Alexander's campaign against Darius.

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Military Theory, Doctrine, Strategy, and Tactics

Sherman, in his memoirs, makes two points clear regarding his planning for the campaign on Atlanta: adequate supplies and maneuverability were key to the success. "The great question of the campaign was one of supplies."[24] Sherman was well aware of the relative length and vulnerability of his supply chain and took many creative steps to ensure he was provided adequate support.

Sherman was adamant about ensuring the highest maneuverability, while still maintaining adequate support.

> I made the strictest possible orders in relation to wagons and all species of encumbrances and impedimenta whatever. Each officer and soldier was required to carry on his horse or person food and clothing enough for five days.[25]

Sherman gave strict orders regarding the number of wagons and ambulances each regiment was allowed in addition to banning the use of tents by his army. The ultimate goal of Sherman was to strike a balance between maneuver and support. Sherman required each soldier to carry sufficient supplies for 5 days, yet he relieved units of the burden of carrying *nonessential items* such as tents, excess wagons, and ambulances. Sherman's key focus during the planning of the Atlanta campaign was to make his "troops as mobile as possible."[26]

Sherman was well aware of the possibility of not receiving adequate support despite the many actions he had taken in preparation for the Atlanta campaign—the increased buildup of supplies at the front, commandeering of the railroads, and strict limitations he placed upon his army. Sherman bluntly informed General Grant of his anticipated course of action should his supply system fail to support him.

> Georgia has a million of inhabitants. If they live, we should not starve. If the enemy interrupt our communications, I will be absolved from all obligations to subsist on our own resources and will be perfectly justified in taking whatever and wherever we can find.[27]

Sherman's strategy and tactics in terms of logistics were then clear: a highly mobile force that would rely upon significant logistics support from the rear; whenever this support was interrupted, whatever was required would be taken from the local inhabitants. The plan of taking what was required from the local population further supported Sherman's overarching doctrine of bringing the horror of war to the people of the South.[28]

From the onset of the campaign into Atlanta, Sherman's strategy emphasized maneuver and focused on logistics. Specifically, Sherman's desire was to feign an attack on the Confederate forces at Dalton while engaging in a rear action to bar the retreat of the Confederate forces farther south to Resaca. If the Confederate forces were allowed to retreat south to Resaca, Sherman not only would face the burden of being farther from his main supply depot but also be driving the Confederates closer to theirs.

Unfortunately for Sherman, his plans for a rear action were not completely carried out. Due to a lack of initiative on the part of one of his subordinate commanders, Sherman's army failed to attack the rear decisively, and Sherman's attempt to execute a rear action failed to reach complete fruition. However, Sherman's actions did have both a negative and positive result. The Confederate forces were drawn away from their fortified position in Dalton to a far less favorable position with their retreat through Resaca across the Oostenaula River.

> It was nevertheless a brilliant achievement to have maneuvered so renowned a master of defense [General Johnston, Confederate commander at Dalton] out of two strong positions against his will and his orders.[29]

The negative result of the Confederate retreat was that Sherman had missed a golden opportunity to trap Johnston's army and attack it from the rear. "Sherman had a lengthening line of communication [and supply], Johnston a shortening and less exposed one."[30]

Throughout the remainder of Sherman's march to Atlanta, he was able to effectively employ maneuver to force Johnston backward while continually supplying his troops from the rear. Essential in the resupply effort was a trailing echelon of 2,000 troops under the command of Colonel Wright, a civil engineer, whose expertise in the repair of enemy-damaged railways enabled virtually uninterrupted resupply to the forward lines beyond Resaca. "Time after time, Sherman's greater army outflanked Johnston's lesser forces, compelling their withdrawal."[31] Sherman eventually won the Battle of Atlanta and captured the city.

Administration and Technology

The Civil War arguably was the first modern war, especially when considering war in terms of the American experience. The North, in particular, was a highly industrialized region capable of producing a variety of both durable and consumer goods. One key necessity of industrialization is the need for rapid, reliable transportation. In the late 1860s, the railroad developed as an indispensable mode of transportation for both military and civil concerns. Sherman, well aware of its importance, made the acquisition and maintenance of rail transportation, while denying it to the enemy, a priority.[32]

Chattanooga, the starting point for Sherman's advance on Atlanta, lay 151 miles from his supply depot at Nashville, which in turn was 185 miles from his main source of supply in Louisville. Given the significant length of Sherman's lines of supply, it was of paramount importance that he secure adequate transportation for supplies and reserves. His first step in ensuring a reliable line of supply was to acquire supreme control of the railroads. Previously, the railroads had been controlled by "the departmental commanders, with consequent friction and uneven distribution of supplies."[33] Sherman, much like Grant had done for the entire Union Army, unified his control over this critical resource. Sherman then decentralized execution while maintaining overall control. His philosophy of overarching control and decentralized execution of railroad operations resulted in two largely beneficial effects. He was able to oversee the flow of supplies to the front without directly involving himself in the *ins and outs* of rail operation, and he eliminated the bickering and supply imbalance between subordinate commands. A secondary effect of Sherman's control of the railroads was his ability to weigh in with the authority of his office should any problems arise.

He further ensured the availability and proper use of railroads by banning civil traffic. Still not satisfied, despite the fact his daily delivery of stores to the front had doubled, Sherman directed that cars and locomotives from other locations be diverted to the Chattanooga line. The decision to ban civil traffic and commandeer additional cars was not

The Civil War arguably was the first modern war, especially when considering war in terms of the American experience.

an attempt to simply bring a valuable resource directly under his control. He had a clear level of support in terms of rail shipments, 130 ten-ton car loads per day, he felt must be met, and taking control of the railroads seemed the logical way to do it.[34]

Sherman also displayed his penchant for centralized control and decentralized execution in both his mode of operation and his army's organization. An excellent illustration was the composition of his staff. His staff included functional experts in artillery, engineering, ordnance, logistics (actually called Chief Quartermaster and Commissary) and medicine. In addition to the functional representatives, Sherman's staff had three inspectors general and three aides-de-camp. Conspicuously absent from his staff was the administrative function. He advocated that clerical work in the field be kept to a minimum and used permanent clerical offices in the rear for daily correspondence. The composition of his staff facilitated the scheme of centralized control by using the staff in a controlling capacity while still leaving the execution to the lower echelons.

Social, Political, and Economic Factors

The political motives behind Sherman's campaign were clear: to bring the war and all its horror to the heartland of the South. "Sherman was eager to teach the people of the South a lesson in the horrors of war, believing that a harsh war would ensure a lasting peace."[35] Sherman further believed he was justified in his laying claim to any and all stores before him, shaking off the "old West Point notion that pillage was a capital crime."[36]

Analysis

Though it can be maintained that the two largely successful campaigns of Alexander and Sherman had many similarities among policies and practices, it cannot further be assumed that there then exists some exacting set of rules or practices shared by the two that will always guarantee success if employed. This study does not attempt to develop a listing of the key logistics principles that will guarantee success but, rather, establishes a logistics paradigm intended to be a guide or a starting point from which current and future military leaders can develop their own policies and practices. By analyzing the commonalities among successful campaigns and integrating those with the lessons learned from not-so-successful campaigns, a logistics paradigm is developed that is based upon practices proven to be valid in antiquity, which forms a starting point from which leaders can tailor their own practices to fit their specific situations. The campaigns of Alexander and Sherman illustrate the good logistics practices, while Napoleon's campaign into Russia provides the lessons learned. The framework for analyzing the commonalities and lessons learned is based upon the threads of continuity approach.

Previously, the railroads had been controlled by the departmental commanders, with consequent friction and uneven distribution of supplies. Sherman, much like Grant had done for the entire Union Army, unified his control over this critical resource. Sherman then decentralized execution while maintaining overall control.

Generalship and Military Professionalism

In terms of formal military education and background, backgrounds of Alexander and Sherman are dramatically different than that of Napoleon. The former represent the aristocratic general, while the latter represents the journeyman solider. In no way does that mean Napoleon was a lesser general. He is arguably one of the greatest generals of all time. What is meant by the distinction between aristocratic and journeyman is that both Alexander and Sherman were taught to be generals and leaders of men, while Napoleon was first taught to be a soldier and, through aptitude and hard work, rose to his position as general. Both Sherman and Alexander received superior education and military training compared to their contemporaries. Alexander's private tutor was Aristotle, and he was taught by his father, Philip, from an early age how to be a general. Sherman attended the United States Military Academy and was commissioned as a second lieutenant, with the focus of the United States Military Academy on teaching men to be leaders and, ultimately, generals. Napoleon, though a graduate of l'Ecole Militaire, did not have the formal military education of Sherman. L'Ecole Militaire during Napoleon's time was not "particularly distinguished for the attention it paid to the proper preparation of its young aspirants for commissions."[37] Similarly, given Napoleon's middle-class upbringing, he was not afforded the tutelage of a great thinker, and his father was not a great general.

Though no direct correlation can be made about the military education received by Alexander, Napoleon, and Sherman and their general logistics practices during the campaigns under study, their backgrounds provide insight into the disposition and character of these generals. It can clearly be seen that by working his way up from his middle-class beginning through the ranks as a junior artillery officer, Napoleon developed a significant sense of

self-reliance and, as was the case during the planning for the invasion of Russia, a need to be involved in every aspect of the operation down to the minutiae. Conversely, both Sherman and Alexander consistently maintained supervisory oversight of their armies while leaving the precise execution of daily operations to their functional experts.

Military Theory, Doctrine, Strategy, and Tactics

Military theory, doctrine, strategy, and tactics, for the purpose of this analysis, are focused at the operational level and can be viewed in general terms as to how each general conducted the campaign. Each of the three campaigns represents dramatic differences in how the conduct of war influences or is influenced by logistics. Alexander's conduct of his campaign was greatly influenced by logistics concerns. Napoleon's logistics practices were greatly influenced by how he intended to conduct his campaign. Unfortunately for Napoleon, how he thought he was going to conduct the campaign was not how he ended up conducting it, and his logistics system proved horribly inadequate. Sherman's conduct of his campaign was influenced by logistics concerns and influenced his logistics practices.

Alexander's foremost concern was the adequate provisioning of his army, as is evident in his route through Asia Minor. Though the defeat of the Persians was the ultimate military goal of his conquest up to the Battle of Arbela, clearly that could not be accomplished without first addressing the logistics needs of his army. Throughout his campaign, Alexander employed three main techniques to ensure adequate provisioning. First, he stayed as close to the coast as possible. His proximity to the coast facilitated easy access to his fleet of supply ships while denying port access to his enemy. Second, he modified the size of his army (flexible sizing) to suit the environment he was facing. An excellent example of this was when Alexander, faced with the onset of winter after passing through the region around Pamphylia, granted leave for all newlywed members of his army. The granting of leave greatly decreased the number of troops he had to supply and undoubtedly had the additional benefit of increasing morale. Finally, when he marched inland, he took great pains to ensure advance logistics support. He sent military envoys ahead with the charter to inform local officials of his approach. The message was clear; surrender yourselves and your property or be destroyed. As was often the case, support was granted without the use of force.

The campaigns of Alexander and Sherman illustrate the good logistics practices, while Napoleon's campaign into Russia provides the lessons learned.

Napoleon's *hubris* was that he failed to fully understand the environment in which he was to conduct war and, therefore, developed a logistics system that was woefully mismatched for that environment. The most popular example was the inadequacy of Napoleon's wagons to effectively negotiate the rough Russian countryside. However, a closer examination indicates the problem was just as much about what he carried and how he carried it as what it was carried in.

Though Napoleon had planned the start of the invasion to coincide with the harvest in western Russia, the availability of crops proved inadequate to support the thousands of horses he relied upon for transportation and as weapons of war. The lack of fodder, combined with an outbreak of colic, decimated his fleet of horses and had the cascading effect of spreading the burden over an ever-decreasing number of horses, which in turn increased their consumption of supplies. Worse yet, as the number of horses decreased, horses had to be shifted from pack details to pulling artillery. The shortage of pack horses meant more was being carried by men, increasing their consumption and reducing their mobility.

Napoleon's greatest misunderstanding was how the Russians would respond to his advance. The Russian willingness to trade land for time proved to be Napoleon's undoing. As Napoleon pressed farther and farther into Russia, he traveled farther and farther away from his main supply reserves in Poland and farther into a vast wasteland. The Russians laid waste to anything of logistical value prior to retreating, leaving Napoleon with little to draw upon from the local population. The Russian *scorched earth* tactic, accompanied by constant attacks on Napoleon's lines of supply, deprived Napoleon of even the slightest relief. By the time Napoleon was able to engage the enemy face-to-face, his 2-to-1 superiority in numbers had vanished. With the onset of winter, he realized the war was lost, and in his desperate march back to Poland, he lost the bulk of his remaining troops.

Napoleon began the campaign with the anticipation of relying upon the available crops within the area to augment the provisions his army carried with them. Additionally, he intended to bring his superior numbers and firepower to bear against an enemy in an army-to-army confrontation for the control of the capital. Unfortunately, what he encountered was something far different. Had events gone as Napoleon expected, it could be argued that he well may have won in Russia. However, Napoleon's logistics plan and practices proved woefully inadequate in the end.

Sherman's logistics policies and practices influenced and were influenced by how he conducted his campaign. Sherman was well aware of the logistics strain and the vulnerability of his lines of supply as he advanced toward Atlanta. He took unusual measures to bolster his lines of supply. From the planning stages through the execution of the campaign, he maintained control of the railways. He diverted locomotives from other locations and aggressively repaired battle-damaged rail lines. His route southward followed the main rail line from Chattanooga to Atlanta. Clearly, in this instance, his conduct of war was influenced by logistics.

Sherman is noted for the destruction that he brought to the heart of the South. The destruction he inflicted was neither solely the result of pillaging for supplies nor the result of pure malice and wanton destruction but a combination of both. Sherman was clear from the onset of the campaign that one of his motives was to bring the war to the people of the South. He also considered himself completely justified in obtaining whatever he required from the local population. He believed if the Confederate forces impeded the flow of supplies to the front he was then perfectly justified in acquiring the supplies he needed from the local population. Whether it be the case that the Confederate forces significantly affected Sherman's supply lines or that he simply needed more supplies than he could provide for himself, before the onset of the campaign, he clearly established his intention to take what was needed from the local population. Sherman allowed his desire to bring the horror of the war to the people of the South, a key element in how he was to conduct this campaign, to influence his logistics practices.

Sherman and Alexander shared one key factor in their conduct of war: the logistics requirements they placed upon individuals during the planning stages of their respective campaigns. Both gave specific instructions aimed at lightening the load of individuals and individual units under their commands. Interestingly, both Alexander and Sherman prohibited the use of tents. Alexander built upon Philip's requirements and minimized followers, while Sherman limited the number of wagons available to individual units. The ultimate end goal was to increase individual and unit mobility by limiting to the bare essentials what was carried. This is not to say that Napoleon did not take measures to increase mobility and in turn increase the army's ability to maneuver, but in the case of Alexander and Sherman, maneuver proved to be the deciding factor in the defeat of their enemy. Sherman was able to outflank Johnston's forces, and Alexander was able to attack Darius' forces at an angle and encircle them. Both victories resulted from the successful use of maneuver, which was directly attributable to their armies' ability to move quickly, a concept integrated into and facilitated by their logistics policies.

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Administration and Technology

A key attribute shared by both Alexander's and Sherman's success, which proved to be a contributing factor to Napoleon's failure, was the use of their staffs. Both Alexander and Sherman had experienced and trusted military advisors to advise them on a multitude of functional areas. Though Napoleon also had a staff, his, to a large degree, was made up of *claquers and sycophants*.[38] It is unclear if the lack of sound advisors resulted in Napoleon's tendency to micromanage or if his management style made a staff position an overly unattractive billet for anyone except a sycophant. Regardless of the cause for his less than competent staff, its lack of competence left Napoleon with little choice but to rely upon his personal involvement in all aspects of the operation of his army.

As discussed earlier, both Sherman and Alexander, to a large degree, dictated what was to be done but not how to do it. Such a philosophy is an excellent indicator of a high level of trust and respect for one's subordinates and indicates a capable and competent staff.

Each of the three armies represented the most technologically advanced fighting forces of their time. They differ, however, in how they adapted their technology to fit the situation at hand. Napoleon had state-of-the-art weaponry, especially artillery, yet he was unable to use it effectively because he could not transport it effectively. The wagons carrying his artillery were well suited for the well-maintained roads of Western Europe but were woefully inadequate in the impassable bogs of the Russian countryside. Alexander, on the other hand, purposefully did not use traditional pack animals, such as oxen and donkeys, but opted for animals with better endurance and speed, such as horses and camels. Alexander adapted his transportation technology to suit the situation. Sherman took complete control of the railways and ensured he had a viable repair activity prior to the start of the Atlanta campaign. He exploited available technology to his advantage while denying the enemy access to it.

Similarly, Alexander made great use of naval resupply and, in doing so, denied the enemy similar access since he controlled the ports. Alexander's and Sherman's ability to adapt and apply logistics technology, specifically transportation technology, rather than their absolute technological superiority, proved valuable in the success of their campaigns.

Social, Political, and Economic Factors

To analyze the effect of social, political, and economic factors, this study examines the interaction between the campaign forces and the indigenous peoples and local environment. Although each of the three campaigning forces interacted differently with local inhabitants, there is one common aspect that defined the interaction. In the case of the successful campaigns, the commander understood the environment he was to operate in, to include not only the tangible factors such as terrain but also the intangible factors such as the resolve and attitude of the people he intended to conquer.

As discussed previously, Napoleon's failure to comprehend Russian resolve and willingness to sacrifice land for time was key in his defeat. In his statement to Armand de Caulaincourt, Tsar Alexander was quite clear about the Russian willingness to use the vastness of their frontier and the severity of their climate as key aspects in their defense. Apparently Napoleon failed to regard these comments or simply thought that even if the Russians did employ these tactics they would be of little impact. Napoleon was also willing to begin his offensive against Russia while still engaged in a war with Spain. He neglected to realize that a fundamental building block to alliances is a common enemy. Unfortunately for Napoleon, the fact that France was engaged in two wars made France far less attractive to any new prospective allies than Russia, who had settled all her other disputes. The net result was Russia was able to form alliances with Great Britain and Sweden and make peace with Turkey. Napoleon failed not only to comprehend the impact of the physical environment upon his logistics plan but also to recognize the political environment's effect upon his logistics plan. Russia had gained new allies and made peace with former enemies, which allowed her to focus on the entire military logistics capability toward a single foe. Unlike his Russian enemy, Napoleon was now actively engaged in fighting a war on two fronts, with the bulk of his allies being former conquered peoples whose support was tenuous at best.

Although each of the three campaigning forces interacted differently with local inhabitants, there is one common aspect that defined the interaction. In the case of the successful campaigns, the commander understood the environment he was to operate in, to include not only the tangible factors such as terrain but also the intangible factors such as the resolve and attitude of the people he intended to conquer.

Sherman understood well the environment he was to encounter during his campaign. One of his specific goals was to change the environment of the enemy citizens he encountered. Atlanta and the surrounding region represented a wealthy and pristine area of the South, particularly in terms of its exposure to the destruction of the Civil War. Sherman conducted his campaign "aimed at defeating the South psychologically as well as militarily."[39] He was dramatically successful in both aspects. Sherman not only successfully completed his campaign to capture Atlanta but also left a lasting mark on the consciousness of the enemy population he encountered. Sherman clearly understood his environment and made affecting that environment a key factor in his campaign.

Alexander, too, was well aware of the environment he was to encounter. He, however, took a decidedly different approach than Sherman. Alexander allowed the conquered people to retain some measure of autonomy with regard to their own civil affairs. Additionally, the people he encountered often surrendered to Alexander without a fight and in some instances viewed him as a liberator from the oppressive rule of the Persians. The conquered peoples' view of Alexander is in stark contrast to how Napoleon and Sherman were viewed during their respective campaigns. Alexander's goal, too, was different from that of Napoleon or Sherman. Where Sherman explicitly wanted to make war on the people of the South and Napoleon wanted to conquer the people of Russia, Alexander, to a large extent, wanted to unify, under his rule, the people he conquered. This distinction between conquering and unification on the surface may seem subtle, but examination of how conquered people were treated by the two generals illustrates the dramatic difference between the two concepts. Alexander retained military control but, to a large extent, left the civilian population to continue their lives as they had done before. Napoleon, in contrast, retained control through the establishment of some puppet civil and military leadership. The net result was those under Alexander's rule, to a large extent, were unaffected by the shift in power, whereas former enemies under Napoleon's control were much the worse for the shift in power. Clearly, Alexander realized that if he was to accomplish his goal of *homonia* he would have to ensure the eventual and lasting support of the people. *Homonia* could not effectively be accomplished at the point of a spear. By understanding and integrating the political and

social environment of the people he conquered, Alexander obtained their support, a factor that played a major role in his logistics practices during the campaign to defeat Darius.

Conclusions

The conclusions set forth in this article result from an examination of the events surrounding the campaigns examined and an analysis of the commonalties among successful campaigns and lessons learned from the not-so-successful one. The logistics paradigm resulting from this analysis has four key principles. Each principle of logistics put forth by the analysis relies upon the use of demonstration by "revealing a necessary connection between the defining properties of the object being compared."[40] Key to the validity of the logistics principles, and in turn the entire paradigm, is the underlying assumptions specifically outlined with the explanation of the principles. The assumptions form the framework in which the application of the principles apply as per the demonstration.[41]

It can easily be seen the four principles of logistics offered by this article are not entirely new to anyone familiar with the study of war. In fact, in some form or another, each of these principles appears in several prominent historians' statements of principles of war and logistics. However, the method with which these principles can be applied distinguishes them from previous theory. The difference between the principles put forth in this article and other theories will be discussed, but the principles themselves must first be described.

Centralized Control, Decentralized Execution

As described earlier, both Alexander and Sherman made extensive use of staffs of functional experts. Conversely, Napoleon, though possessing a staff of his own, tended to be involved down to the lowest operational levels. The logistics challenges Napoleon faced would prove too great for any one man to handle, even if that man was Napoleon.[42] Sherman and Alexander allowed their functional experts to manage the daily operations of their specific area of responsibility, and both generals weighed in with the authority of their office only when needed. Their management philosophies allowed them to focus on the overall management of their armies, while still staying close to the daily operations managed by their staffs.

Although these campaigns involved large armies and the necessity for centralized command and decentralized execution seems well founded, there is just as much applicability of this concept for smaller sized, more modern military units. Given the assumption that logistics concerns are a function of the complexity of the operation at hand, which is, in turn, a function of the people, equipment, and supplies being used, then the challenge of meeting basic logistics requirements has increased in proportion to the complexity of the fighting force. Though the size of the army or military unit may be quite different from that of Alexander, Napoleon, or Sherman in modern times, it is still quite complex. Complexity then implies the need for exacting expertise in numerous, specific fields integrated to support an overarching end goal or mission. In much the same manner that even a general as brilliant as Napoleon could not manage the wide gamut of logistics and nonlogistics issues he faced during the campaign into Russia, neither can a modern military leader expect to have adequate knowledge in the gamut of functional areas of responsibility. Though an extensive staff may be neither practical nor attainable, a leader should be willing and endeavor to consult the functional experts.

The conquered peoples' view of Alexander is in stark contrast to how Napoleon and Sherman were viewed during their respective campaigns.

Key to the validity of centralized control-decentralized execution and its implied reliance upon functional experts is that such experts exist and are available. This assumption seems negligible, but the availability of a competent staff or group of advisors is quite rare in small military units. Of even greater concern is the lack of true functional experts. Though career broadening and the blurring of the lines between logistics specialties in the modern military does provide an increased pool of *trained* personnel from which to draw upon to fill logistics billets, it necessarily results in the reduction of true functional experts who have spent the bulk of their career learning their specialty and honing their skills to a superior level. The greatest challenge to the concept of centralized control and decentralized execution is the loss of true functional experts.

Flexibility

The need for flexibility seems to be an item of consensus among students of military history. Flexibility is analyzed in this article as the degree to which forces can adapt to their environment, specifically, how logistics policies and practices enable forces to quickly adapt

to their environment. Both Alexander and Sherman made advance orders to their armies specifically outlining what they could and could not bring with them, the ultimate goal being the most mobile force they could possibly have. Alexander and Sherman used maneuver as a key tactic in the defeat of their enemies. What is not so well documented, but equally important, is how their ability to move rapidly between battles further enhanced the capability of their armies. Napoleon, on the other hand, was unable to maneuver with any success and was forced to plod along the Russian countryside, enabling the enemy before him to retreat and lay waste to anything of value prior to his arrival. The flexibility to move and maneuver was clearly key in the success of Alexander and Sherman and was integrated into all aspects of their armies, to include their logistics planning and practices.

Additionally, this article examines flexibility not only in terms of an army's ability to respond to the physical aspects of the environment but also in the more intangible aspects of the environment. Napoleon very well may have been able to overcome the hardships he faced crossing the Russian countryside if he had an enemy to fight directly in battle. Ironically, it was the lack of an enemy that led to his eventual defeat. In taking Moscow, Napoleon fully expected the war to be won. When Napoleon marched into the capital largely unopposed, he was no closer to defeating the Russians than when he began his campaign. The Russians simply abandoned Moscow and, after Napoleon's arrival, set parts of the city ablaze. The intangible factor of Russian willingness to trade land for time proved to be the downfall of Napoleon's logistics plan. Though it cannot be said if his logistics plan would have adequately supported his troops had he been able to conduct the war as he had planned, it can be said that his logistics plan based upon the invasion of Russia and the ultimate capture of Moscow was not capable of sustaining his army in the protracted conflict into which he was lured.

It can easily be seen the four principles of logistics offered by this article are not entirely new to anyone familiar with the study of war. In fact, in some form or another, each of these principles appears in several prominent historians' statements of principles of war and/or logistics. However, the method with which these principles can be applied distinguishes them from previous theory.

Flexibility is the key to the success of any organized unit, military or otherwise. If an organization cannot adapt to changes in the physical and intangible factors which encompass its environment, then it will become extinct. The challenge in developing, obtaining, or maintaining flexibility is that it, in some sense, presumes clairvoyance. Clearly, it is easy to identify factors that at present must be adapted to or overcome. It is an entirely a different matter to plan for factors—or contingencies— before they manifest themselves, the mark of true flexibility. The measure to which a unit can respond to unforeseen contingencies is the true measure of the unit's flexibility. Therefore, the principle of flexibility implies the assumption that measurable flexibility is the result of planning for immeasurable and unforeseeable contingencies. Additionally, every contingency that is planned for and not encountered is needlessly planned for. The paradox is there is no way to know with any surety which contingencies will arise and which will not. The lack of a spare tire is only problematic when a flat tire is encountered. Otherwise, the omission of a spare tire represents additional cargo space and possibly better gas mileage. Flexibility then is more an aspect of the art of logistics than the science of logistics. It is both logistically and economically not feasible to plan for every possible contingency, but to the largest degree possible, logistics plans should be adaptable to the gamut of most likely contingencies. Quality planning and experienced logistics leadership can go a long way in the development of viable contingency plans. The major factor in ensuring flexibility, however, is not to attempt to analyze every possible contingency and then plan for it. In fact, this will result in excessive waste, and as pointed out earlier, those contingencies not encountered are needlessly planned for. The key is to develop a logistics plan that at its core is highly adaptive, meaning it requires the minimum possible support from external agencies. By having a highly adaptive logistics plan, the unit's reliance on its environment is minimized, allowing it to function unencumbered in a wide variety of environments, thus enhancing flexibility.

Proper Application of Technology

Both Alexander and Sherman not only properly applied the technology available to them but also integrated this technology into their logistics support practices. Alexander made use of nontraditional pack animals because they better fit the environment in which his army was operating. Additionally, Alexander made use of sealift whenever available. The capture of enemy ports and the coastal route Alexander followed illustrate how he integrated transportation technology into his overall strategy. His route and the ports he captured enabled him to exploit available shipping while preventing his enemy from doing the same. Similarly, the use of shipping enabled better and more rapid resupply, further enhancing his capability to execute his strategy. Sherman, prior to the march on Atlanta, was well aware of

the critical role railroads would play in his preparation and execution of the campaign. He took the unprecedented step of bringing this critical asset under his control to ensure its proper use and application in support of his efforts. Furthermore, Sherman had the foresight to form and utilize a rail repair force of some 2,000 troops. The rail repair force enabled the quick repair of any damaged rail lines and resulted in the preservation of this valuable transportation technology.

It cannot be said, however, that technologic superiority necessarily equates to victory. Napoleon's force at the onset of the Moscow campaign represented the most technologically advanced force of its time. Additionally, it enjoyed numeric superiority over the Russian forces by whom it was ultimately defeated. The key in Napoleon's case was that he was unable to exploit his technological advantage, or in other words, he failed to properly apply the technology available to him. There are numerous instances throughout recent history in which a technologically superior force was defeated by a technologically inferior enemy, but those conflicts are not the focus of this article. In a broad sense, technology can be seen as a single tool. No matter how advanced the tool, if it is used improperly or if it is the wrong tool, it simply will not work.

For modern military leaders, the challenge to the proper use of technology is that in most instances leaders do not have the leeway to determine the technology they employ. This is most true in terms of the actual weapons a unit employs. The critical assumption regarding the proper application of technology is that there is some choice regarding the technology that can be used. The greatest leeway, in terms of technologic choice, is in how the weapons of war, to include troops, are provided. It is true in this case the most technologically advanced method may not always be the best method. Though airlift in its own right might be the fastest mode of shipment, attempting to airlift an entire support package may result in a bottleneck and lengthy delays awaiting available air transport. The ultimate result may be the support package, had sealift been used, would have arrived earlier than by air due to sealift's ability to handle a larger capacity of freight. Similarly, the best way to provide potable water is to employ portable water purification units. However, this application of advanced technology is only of use if some source of water exists. This may not always be the case in extremely arid regions. The examples are numerous and further illustrate that superior technology is only of use if it is applied properly or can even be applied at all.

Understand the Environment

A major function of logistics is the neutralization of the effects of the environment. Clearly, it follows that to neutralize the effects of the environment the environment must be understood first. The paradox is the ability to completely understand the environment is beyond the capacity of any individual or group of individuals. This problem is further compounded by the fact that the environment can be defined in varied terms or at varied levels of precision. For example, the United States can be defined as the 50 states and all territories. An equally valid description is that the United States consists of all those individuals who consider themselves American. Furthermore, the United States can be defined in terms of longitude and latitude. The course of action offered by this article is that, given the environment is at best vaguely defined, the key to understanding the environment is to define as much as can be defined and then integrate control, flexibility, and technology in such a manner as to minimize the effect of any unforeseen factors in the environment. Therefore, the fourth logistics principle offered in this article is as much the integration of the previous three as it is an individual concept in its own right.

A major function of logistics is the neutralization of the effects of the environment.

The environment, though definable in multiple terms, does have basic characteristics of interest to military leaders. Though the physical aspects of the environment, terrain, size of the enemy force, and supply requirements, to name a few, tend to garner the bulk of a military leader's attention and accordingly are addressed by his strategy, tactics, and logistics plans, the intangible aspects of the environment are just as important. Napoleon had a fairly good grasp of the tangible environmental factors that he would encounter during his invasion into Russia. What he failed to consider was the intangible factors that dramatically altered the effect of the physical factors of the environment. The Russian willingness to trade land for time resulted in Napoleon's advancing farther into the interior of Russia without garnering a victory. The Russian willingness to surrender their capital without a major conflict resulted in Napoleon's having to press even farther into Russia in search of an enemy to defeat. These two intangible factors resulted in Napoleon's having to completely change his concept of how he was going to defeat the enemy. Furthermore, Napoleon's logistics plan was not

developed to support a seek-and-destroy mission across the vastness of the barren Russian countryside. Had Napoleon understood Russian resolve—that is to say, understood the intangible aspects of the environment of a war with Russia and integrated proper control, flexibility, and technology into his logistics plans—the outcome of the Moscow campaign could have been dramatically different.

Alexander was attuned to the environment he encountered during his campaign against Darius. His goal of *homonia* for all people had no hope of being achieved unless he could bring the conquered peoples under his control. Alexander knew that he would not maintain lasting control if he relied upon military force alone to keep his newly acquired territories in line. He, therefore, allowed them a large measure of autonomy with regards to their own civil affairs. Interestingly, Alexander was viewed as a liberator in some of the areas that he conquered since life under Alexander was viewed as better than life under the rule of Darius. Alexander was able to exploit his understanding of the environment to gain support from the local population. He successfully integrated his control policies, flexibility, and technology into a plan that exploited the support of the local environment and could be adapted to any adverse factors that arose from the environment. Alexander would gladly accept support from the local population, but should they choose not to support him, he was more than capable of adapting and taking whatever he needed by force.

Sherman, too, was well attuned to the environment. In fact, one of his overarching goals was to affect the environment of the people he encountered. Sherman, from the planning stages of the Atlanta campaign, was clear in expressing his willingness to acquire whatever was needed from the local population if the need should arise. This would serve the twofold purpose of meeting his logistics requirements while further supporting his goal of bringing the war to the people of the South. Sherman, by understanding his environment, was able to integrate control polices, flexibility, and technology into his logistics plan, which not only limited the effect of adverse environmental factors but also promoted one of his ultimate goals.

Modern military leaders face an environment that is extremely complex and consistently changing. Major political events in recent history have significantly changed the political, social, and economic landscape of the world. The potential theaters of operations are now, more than any other time in history, more diverse and geographically separated. Given that, it is impossible to understand every possible environmental factor, both tangible and intangible, that may present a logistics challenge. However, by knowing as much as possible about the people, geography, and culture of many areas and developing logistics plans and practices that integrate proper control, flexibility, and technology, the effect of unforeseen and adverse environmental factors can be minimized.

The paradigm consisting of the four principles of logistics is intended to guide thought, not specify actions. It facilitates creativity while offering a bounded framework for the development of executable logistics plans.

Other Views on Logistics Principles

The four logistics principles put forth by this article—Centralized Control/Decentralized Execution, Flexibility, Proper Application of Technology, and Understanding the Environment—can be found in some form or another in other research. However, it is how this article applies these principles that is quite different from previous research. These principles are not simply a listing of specific *dos* and *don'ts*, they are intended to form a paradigm or framework of thought from which military leaders can draw to develop their own policies and practices. The biggest failing of a list of *dos* and *don'ts* is that it cannot hope to fit every possible situation and, in fact, may be the worst possible course of action for a given environment or situation. The paradigm consisting of the four principles of logistics is intended to guide thought, not specify actions. It facilitates creativity while offering a bounded framework for the development of executable logistics plans. A comparison of Huston's and Thompson's principles of logistics with the four principles of logistics outlined in this article serves to further illustrate the applicability and adaptability of these principles.

In *The Sinews of War: Army Logistics 1775-1953*, Huston outlines 14 principles of logistics: "First with the Most, Equivalence, Materiel Precedence, Economy, Dispersion, Flexibility, Feasibility, Civilian Responsibility, Continuity, Timing, Unity of Command, Forward Impetus, Information, Relativity."[43] It is clear that Huston's principles are intended to be a list of things to do vice a description of how to approach logistics challenges, the latter being the focus of this article's principles. Similarly, Thompson makes use of the *British Principles of Administration* as a reference for general logistics principles in his book *The Lifeblood of War: Logistics in Armed Conflict*. Thompson's principles—foresight, economy,

flexibility, simplicity, cooperation—are fewer and broader in scope than Huston's but still, to a large extent, focus on what to do rather than how to think.[44] If viewed on a continuum with the right being the pragmatic *how to* and the left being the thought-provoking paradigm, Huston's principles would be on the far right, Thompson's somewhere between the middle and the right, and this article's principles would be past the middle and more toward the far left. There is no particular spot on the continuum that is particularly better than the other. However, as one moves from the right to the left, the focus becomes more broad, but the principles' applicability also increases to a larger number of situations. Admittedly, moving to the extreme left of the continuum is of little use because the principles would be so broad that, although they would surely apply to any situation, they would be of little use. The resultant guidance would be broad, with useless principles like *employ sound logistics principles* at all times and *ensure your logistics requirements are met*. Generally, an extreme point on a continuum is of little use. The principles put forth in this article, though less pragmatic than the traditional listing of *dos* and *don'ts*, are still specific enough to provide guidance while enhancing applicability by focusing on outlining a way to think instead of listing specific actions to complete.

Application of the Logistics Paradigm

Operational level commanders should, at the onset, endeavor to understand as much about their theater of operations as possible. Studying history, combined with genuine intellectual curiosity, will go a long way in gaining an understanding of a diverse and often multicultural theater of operations. As the perception of the operational environment becomes more clear, commanders, with the aid of their functional experts, can begin to modify their existing command structure, protocols, and organization to facilitate the proper balance between centralized control and decentralized execution. Certain tangible and intangible environmental factors will lend themselves to either a more centralized control structure or a more decentralized one. For example, a geographically vast theater of operations with diverse climates and terrain lends itself to a decentralized control structure. Therefore, the logistics policies and practices within that theater of operations should support a high level of autonomy between distinct, geographically separate units.

Much in the same manner that the logistics command and control structure should be tailored to the specific theater of operations, so should the application of technology. Advanced technology should not be forced into use in an environment in which it is not well suited. Advanced technology should not be the *square peg* forced into an inappropriate situation's *round hole.* Commanders should use the most advanced technology available that is suited for the theater of operations. For example, no matter how advanced the available motorized transportation is, if the only means of transport through a mountainous area of operations is by donkey, then donkeys should be used. It would be of greater benefit to ensure the best donkeys and donkey drivers are used than to force the use of motorized vehicles in an unsuitable environment.

Much in the same manner that the logistics command and control structure should be tailored to the specific theater of operations, so should the application of technology.

The fine tuning of control practices and technology to best mesh with the environment within the theater of operations is an iterative process. As more information is obtained about both the tangible and intangible factors of the environment, adaptations to existing policies and practices will need to be made. As stated earlier, a major role of logistics is the neutralization of adverse environmental factors and the exploitation of favorable ones. As a better understanding of the environment is gained, policies and practices must be modified to best take advantage of new opportunities or defend against previously unknown adverse conditions. The discovery of a previously unknown water source could result in a change of logistics policy by allowing the practice of drinking locally acquired, fresh water. Similarly, the discovery that a local water source is no longer potable may result in changing logistics policy and banning of the use of any water found in the local area.

An excellent measure of the soundness of existing logistics policies or practices is the speed with which they can be adapted to meet changes in the environment. The speed of change is a direct function of the flexibility of the existing logistics system. It is, therefore, of paramount concern that flexibility be a core characteristic of any logistics plan, policy, or practice. Reliance upon single sources of supply, the belief there is only one way to do something, and resistance to new ideas are key indicators of a lack of flexibility. Without flexibility, the ability to adapt slows, which, in turn, can result in an excellent logistics plan evolving into a dated, useless way of doing things. The highest degree of flexibility should be maintained in all aspects of an operation. By maintaining the highest level of flexibility,

the unit's logistics policies and practices will be able to rapidly adapt to a constantly changing environment.

The previous description of how the logistics paradigm should be applied illustrates the pronounced difference between its application and the use of more traditional, list-type logistics principles. Fundamental to the logistics paradigm is its iterative and adaptive nature. It is meant to guide thought instead of specifying specific actions to take. The shortfall of any list of *to dos* is that there will always be some instance where they do not fit, are inadequate, or are the wrong thing to do. The logistics paradigm focuses on integrating logistics policies and practices with the environment in order to ensure adequate support, exploitation of opportunities, protection against threats, and the ability to adapt to change, all key abilities demonstrated during Alexander's and Sherman's campaigns and woefully lacking in Napoleon's.

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How Logistics Made *Big Week* Big: Eighth Air Force Bombing, 20-25 February 1944

Introduction

The night of 19 February 1944 found England shrouded under a heavy cloud cover, but the weather over Germany was breaking. While the murk might complicate getting away and possibly landing, General Spaatz had made his decision—"Let 'em go."[2] What was to be called the Big Week (20-25 February 1944) had begun. The next day, 20 February, saw the largest force of aircraft up to that time take off and head for targets in Germany. England literally shook under the roar of engines—some 1,004 bomber aircraft plus their fighter escorts.[3]

The primary objective of Big Week was to direct a strategic bombing campaign against the Luftwaffe that would destroy its means to continue the war and, as a result, gain air superiority before Operation Overlord.[4] Bomber operations were conducted principally by the Eighth Air Force, with support from both the Fifteenth Air Force and the Royal Air Force (RAF). In-theater logistics support, the key element that allowed the Eighth Air Force to kick off Big Week, came from the VIII Air Force Service Command (AFSC). An order of magnitude measure of this logistics effort is seen in the number of bomber aircraft generated—VIII AFSC made 1,292 bombers available, an unprecedented number. However, many other facets of logistics support, often on a scale never seen before, were also necessary for Big Week. These include preparation—industrial mobilization, unit buildup and beddown, stateside logistics support, facility expansion and modernization, training and equipping of personnel, and organization of air logistics activities. As is often the case, much of the planning, preparation, and execution of the Eighth's bombing operations was subject to uncertainties that made logistics support difficult and required improvisation on the part of both logistics organizations and logistics leadership.[5]

The Industrial Mobilization Plan of 1924 called for instantaneous industrial mobilization upon declaration of war (M-day), based on the assumption that civilian leadership would not accept gradual mobilization prior to a declaration of war, and for military control of the economy. The plan was revised in 1934.

The Foundations of Eighth Air Force Logistics

> *Armies do not go out and have a fight and one guy wins and the other loses and the winner takes all. Throughout history victorious commanders have been those that knew logistics when they saw it. Before any plans can be made to provide an army, logistics must be provided first. History has changed a lot, but logistics has been the crux of every one of these changes, the nail that was missing, which lead to the loss of a country lead to a lot of those decisions.*[6]
>
> **—Major General Hugh J. Knerr, USAAF**

Industrial Mobilization Planning

Organizations and planning that focused on industrial mobilization were primarily the result of the *National Defense Act of 1920* and the *Industrial Mobilization Plan of 1924*. The Defense Act established the War Department Planning Branch, Army and Navy Munitions Board, and Army Industrial College. It also directed the Assistant Secretary of War to prepare mobilizations plans. The Industrial Mobilization Plan of 1924 called for instantaneous

industrial mobilization upon declaration of war (M-day), based on the assumption that civilian leadership would not accept gradual mobilization prior to a declaration of war, and for military control of the economy. The plan was revised in 1934. A variety of flaws plagued mobilization planning efforts and the 1934 plan itself. These include incorrect assumptions (no civilian support for gradual mobilization), not addressing the needs of the civilian populace or potential allies, and military control of the civilian economy. Further, the operations staff that prepared the plan failed to seek input from either civilian leadership or industry and did not consult with relevant military logistics planning or support activities. Industrial mobilization planning in the post-1920 period was superficial at best and, therefore, "The muddling that had accompanied World War I mobilization was being repeated."[7] Even as late as 1940, when President Roosevelt wanted some 50,000 aircraft produced per year, there was no guidance as to what types should be produced.[8]

Army/Army Air Forces Logistics Planning

In September 1941, faculty from the Air Corps Tactical School drafted *Air War Plans Division Plan No. 1* (AWPD-1) to address what would be needed should the United States go to war.[9] In August 1942, AWPD-1 was rewritten to address the requirements for conducting an air offensive against Germany, and this resulted in a new plan known as AWPD-42.[10] In the fall of 1942, the US Army Air Force (USAAF) staff made aircraft utilization projections by aircraft type—which included allocations for attrition, transit, reserves, training, and modification—for November 1942 through December 1944, totaling in excess of 65,000 aircraft.[11] However, neither AWPD-1 nor AWPD-42 addressed the needs of the RAF, logistical requirements beyond personnel end-strength, or anything more than a generic total of munitions required. Operational planning took precedence over logistical planning, which resulted in war plans that were incomplete at best. "The organization and proper position of the logistical arm had long been a subject of debate in the Army and the Army Air Force (AAF)."[12] Recommendations by the commanding general, Army Service Forces (ASF) for standardizing organizations and procedures to improve efficiency and effectiveness were misunderstood and rejected by the War Department. Lack of doctrine resulted in each theater commander establishing complex, unique logistics organizations. Further, the Army's lack of emphasis on logistics training prior to the war—due to outright neglect—resulted in too few personnel with an extensive knowledge of logistics and its functions. Ultimately, during World War II, "Large headquarters with ill-defined and duplicating functions were the rule and achieved only partial success in coordinating supply.…"[13]

In the summer of 1943, the Bradley-Knerr committee made an extensive study of air force installations in Europe and published the Bradley Plan, which became part of the Air Force Buildup Plan. The plan, largely written by Major General Hugh Knerr, prescribed the manning and organization of air units and installations.

In the summer of 1943, the Bradley-Knerr committee made an extensive study of air force installations in Europe and published the *Bradley Plan*, which became part of the *Air Force Buildup Plan*. The plan, largely written by Major General Hugh Knerr, prescribed the manning and organization of air units and installations. A key feature of the plan was the requirement to establish third echelon maintenance activities (subdepots or service groups) manned by Air Service Command (ASC) personnel at each operational base. Third echelon maintenance would be augmented as necessary by depot field teams dispatched from fourth echelon (depot) maintenance organizations (base area depots and advance depots) to take care of abnormal battle damage repair loads. The *Air Force Buildup Plan* provided for coordinated buildup of combat units, increased flow of materiel, expansion of maintenance and supply installations, and increased stateside Air Service Command personnel. Shortly after the *Bradley plan* was adopted, Knerr was selected to command the VIII AFSC in the United Kingdom (UK), where it became his task to put the plan into operation.[14]

Industrial Mobilization

At the onset of and continuing well into World War II, industrial mobilization was hampered by a proliferation of organizations and procedures.

In 1940, President Roosevelt created an advisory commission to address industrial mobilization. Roosevelt appointed William S. Knudsen, a General Motors executive, as the commission's advisor for industrial production, and the commission reported directly to the President. The commission, however, was largely ineffective.[15] Military efforts to control the mobilization effort and the Army and Navy Munitions Board's autonomy contributed to the commission's difficulties and led to Roosevelt's disenchantment with it.[16] While every effort to gain control of the economy would be thwarted by the President, there can be no doubt this activity behind the scenes created more problems than it solved and negatively influenced civil-military relations. The one bright spot in the commission's performance

was giving industry the incentive to build munitions factories by allowing them to amortize all construction costs over a 5-year period. This was the brainchild of Donald M. Nelson, the chief merchandizing executive at Sears and an advisor to the committee.

The President replaced the advisory commission with the Office of Production Management (OPM) on 7 January 1941 and appointed Knudsen as its director general, undoubtedly contributing to the OPM's ineffectiveness, as he was not considered a strong leader. The OPM lacked authority and was plagued by organizational design defects resulting in duplication of effort, so it could not dictate to industry, which still preferred to cater to the civilian population. Even Roosevelt's declaration of national emergency on 27 May 1941 did not enhance the OPM's clout. However, despite all its problems, the OPM accomplished a great deal. It surveyed industry to determine output by examining the potential to standardize production processes. In March 1941, it prioritized raw material usage and production of nondefense items. At the same time, the Army and Navy Munitions Board prioritized production of specific defense products. Considering the long lead times required for procuring and manufacturing machine tools, the OPM's identification of a shortage in this area early in the mobilization effort is clearly significant.[17] The OPM also initiated retraining programs to increase the pool of skilled labor and encouraged industry to hire women.

In April 1941, the President created the Office of Price Administration and Civilian Supply. However, when the organization's leader decided to end automobile and major appliance production for the civilian population, a decision with which the President disagreed, Roosevelt moved the civilian supply function to the OPM by creating the Supply Priorities Allocations Board. Donald M. Nelson, appointed to head the board, still worked for Knudsen as part of the OPM but possessed particular authority his boss did not—the authority to set priorities. The board set out to first establish an allocation process and then set priorities within the allocations. In late 1941, industrial production rates were stagnating because of prioritization problems with both raw materials and the mix of consumer-to-defense goods produced as a result of the OPM's general lack of authority. Nelson, in his role as head of the Supply Priorities Allocation Board, cut back on production of automobiles, appliances, and raw material for civil sector use. While the reorganization that created the Supply Priorities Allocations Board did prove to be essential to satisfying the defense requirements for the Victory Plan, the board was often rendered ineffective by government officials who sought assistance from department secretaries or the President whenever things did not go their way.[18] In addition, the board was challenged with coordinating with the Services—who still retained their procurement authority—the Joint Chiefs of Staff, and other powerful organizations.

Unfortunately, the WPB, like its predecessors, suffered from the lack of real authority to make decisions affecting the civilian populace. Its authority was further diluted when the President created the Office of War Mobilization.

In January 1942, Roosevelt created the War Production Board (WPB) and appointed Nelson as its chairman. The War Production Board absorbed the OPM, Supply Priorities Allocation Board, and National Defense Advisory Committee. However, these organizations continued to perform a role under the WPB umbrella. During the war, the advisory committee grew to more than 20,000, with many of these people located at defense manufacturing facilities across the country. Throughout the war, Nelson and his staff were occupied by three problems as they tried to increase production.

- Supplying raw materials from which war materiel and essential civilian products were made
- Providing the plants and equipment in the factories to manufacture the *tools of war*
- Staffing the plants with enough people who had the right skills

Unfortunately, the WPB, like its predecessors, suffered from the lack of real authority to make decisions affecting the civilian populace. Its authority was further diluted when the President created the Office of War Mobilization. It did, however, have "the power to compel acceptance of war orders by any producer in the country and could requisition any property needed for the war effort."[19]

A key example of the effect the proliferation of industrial mobilization organizations and procedures would have on operational logistics is seen in munitions production. Beginning in early 1942, General George C. Marshall headed the Combined Chiefs of Staff, with authority over the munitions allocation process; however, Prime Minister Churchill and President Roosevelt retained the authority to resolve disagreements.[20] The Army and

Navy Munitions Board determined military munitions requirements, and the Munitions Assignment Board controlled the assignment of all military hardware. The President and his various civilian organizations controlled resource allocation and the means of production. Clearly, with no fewer than four large organizations involved in munitions planning, the beginnings of major difficulties were created that would hinder the effectiveness of Allied bombing from late 1943 onward.

In spite of many difficulties, the industrial output of the US grew almost geometrically into 1944. However, demand consistently exceeded production because of "overestimation of capacity by those responsible for producing materiel."[21]

In sum, while the military put much effort into planning, plans were often incomplete because they were formulated in a vacuum. Military leadership did not seek advice from industry leaders or consult with elected officials. The proliferation of civilian, civil-military, and military organizations—often with overlapping functions and lacking authority—resulted in duplication of effort, confusion, and frustration. Further, the military attempted to gain control of the economy, contrary to the desires of the President, adding to the problems. Clearly, all of this was counterproductive and retarded the efforts to build and sustain the logistics support necessary to conduct large air operations like Big Week. Major General O. R. Cook, Deputy Director of Service, Supply and Procurement, summed it up well:

> It is, therefore, imperative that advance plans provide for more effective civilian war agencies. Most serious duplications, wasteful methods, and complex procedures existed during World War II, when the organization of these agencies was largely improvised. Their very multiplicity impeded the accomplishment of essential activities.[22]

The Pillars of Support

Several military organizations provided logistical support to the Eighth Air Force and VIII Air Force Service Command in the United Kingdom. The USAAF's Air Service Command provided stateside depot, technical, research and development, and acquisition support to the Eighth, while the ASF Service of Supply (SOS) provided the Eighth with items common to the Army and the USAAF. Although the Eighth and VIII AFSC together had a very large logistics capability and capacity, they depended on the ASC and the ASF for supplies and support and could not have succeeded without their assistance.

The USAAF's Air Service Command provided stateside depot, technical, research and development, and acquisition support to the Eighth, while the ASF Service of Supply provided the Eighth with items common to the Army and the USAAF.

On 17 October 1941, the Air Service Command was activated and made responsible for acquisition of weapon systems and provision of fourth echelon (depot level) maintenance support to the warfighting commands.[23] Headquarters USAAF established maintenance policies and procedures, while the Air Service Command issued technical instructions.[24] However, there is evidence that field commanders occasionally issued guidance without ASC coordination.[25] In early 1942, the Air Service Command also became responsible for providing airbases with third echelon (subdepot or intermediate-level) maintenance support.[26] By June 1943, ASC's work force of 50,000 worked day and night to support the war effort.[27] The expansion of ASC's depots and acquisition effort was vital to the Eighth's ability to generate and sustain Big Week raids.

The aviation industry in America had focused on research and development during the interwar years. This focus tended to result in the production of aircraft in small lots, so the ASC acquisition function faced the challenge of trying to convert the industry to a mass production ethos.

> In 1940, when President Roosevelt set a goal of producing 50,000 aircraft per year and funds were appropriated in large amounts, severe acquisition problems developed. Many of the carefully developed procedures relating to advertising and competition had to be set aside simply because of a shortage of time.[28]

Additionally, on 9 April 1942, Congress simplified accounting and contracting by appropriating funds for war materiel directly to the Service departments.[29]

"World War II demonstrated the importance of scientific research in a spectacular manner. Never in the history of warfare were there more rapid and far-reaching scientific and technological developments in weapons."[30] Some of the most significant technological developments were the identification of suitable material and process substitutions to satisfy military requirements. Synthetic rubber is a good example of a substitution that was made in

World War II. Much time and effort was required to research and develop suitable substitutes, but they played an important part in providing the logistical support necessary to sustain combat operations. In hindsight, Cook observed, "A most important logistic lesson is that our safety depends on the continuation of this close collaboration in the development of new instruments of war."[31]

Improvements in supportability were also gained through the combination of engineering expertise and quality maintenance. "By strict adherence to the best standards of inspection and routine maintenance, it was possible to lengthen the time interval between overhauls and thus to increase the force available for operation."[32] As early as July 1941, greatly reduced maintenance and supply demand resulted from lengthening aircraft inspection intervals by 25 percent.[33] The official history maintained:

> During the earlier years of the war … the desperate need for aircraft in most theaters argued so strongly for repair of the crippled or damaged plane that air depot and service groups were strained to provide the special skills, equipment, and materials to meet the demand.[34]

The spare parts shortages that existed through the end of 1942 made this problem more acute, and the difficulty was not overcome until late in the war.[35]

Between 1931 and 1939, the Air Corps had fewer than 2,000 aircraft, and the depots' small capacity was adequate as they overhauled an average of 166 planes and 500 engines annually.[36] USAAF expansion after the summer of 1940 was so rapid the Air Service Command found it almost impossible to meet the steadily growing maintenance demands. The USAAF did not initiate depot expansion plans until late 1940; therefore, by 1941, the depots were wholly inadequate. From January 1942 through January 1944, depot modernization and expansion, along with the addition of eight depots and many subdepots, meant that capacity outstripped the availability of qualified technicians.[37]

There were just not enough skilled technicians to meet demands, and there was no time to properly train unskilled laborers. The Air Service Command found itself in competition with the more attractive war industry employers in recruiting civilian laborers and generally suffered from a lower priority for civil service personnel fills. A training program for military personnel, which graduated hundreds of thousands of technicians, and special technical training programs for civilian employees recruited to work in stateside depots only partially alleviated the personnel shortage.[38]

The Air Service Command also turned to the private sector for solutions, increasing depot capacity by contracting for training and transport aircraft maintenance and adopting mass production methods to improve productivity.[39] Production line techniques alleviated some problems associated with integrating unskilled labor into depot and flight-line maintenance functions worldwide. A task performed by one mechanic was broken down into several simple steps to quickly make new employees productive. Conveyor belt systems were used to support engine overhaul, repair of parts and accessories, and even some phases of aircraft inspection and repair.[40] Depot management statistically measured and monitored production to identify areas for improved productivity and often adopted the innovative ideas of technicians for improving tools, equipment, and processes. The combination of special civilian training programs, use of military personnel in depots and contractors to augment depot capacity, and process improvements remedied the depot personnel shortage and improved quality and productivity.[41]

The Eighth's performance directly reflected that of the Army Service Forces. General Marshall's reorganization of the War Department as America entered the war had created three separate but equal commands under the Chief of Staff.

ASC acquisition, engineering, research and development, and depot maintenance activities were beneficial to the Eighth Air Force operations. The improvements made within the Air Service Command improved the Eighth's and VIII AFSC logistical support capabilities to some extent. Whether in the form of a new aircraft, a repaired part, an aircraft modification, or a technical directive to maintainers, ASC performance directly impacted the Eighth's performance.

Similarly, the Eighth's performance directly reflected that of the Army Service Forces. General Marshall's reorganization of the War Department as America entered the war had created three separate but equal commands under the Chief of Staff. The new commands were the Army Ground Forces, USAAF, and the Army Service Forces. In the theater, the SOS commander supported the operational USAAF commanders. However, many commanders felt the Services of Supply infringed upon their responsibilities, and many misunderstandings occurred.

The Army Service Forces established command in the UK in 1943, with headquarters functions split between London and Cheltenham, resulting in inefficiency. "This split in

SOS HQ was brought about by the desirability of having SOS planning staffs near the various other planning agencies in London and by the inability of facilities in London to accommodate the entire staff."[42] Communications support was inadequate and travel was time consuming, so the geographical separation caused acute problems.[43]

> …SOS was the "rear area" organization of the theater. Under field service regulations, the rear areas of a theater were organized as a "communications zone," an autonomous theater-within-a-theater. The communications zone commander was responsible to the theater commander for moving supplies and troops from the zone of the interior forward to the combat zone. In this regard, he relieved the theater commander from … rear area activities.… In the European Theater of Operations (ETO), however, there was as yet not a combat zone—the entire theater was essentially a rear area. This geographic coincidence… exacerbated the ambiguities over … logistical roles.[44]

The USAAF maintained its own supply system for things unique to its mission. Therefore, split USAAF supply support responsibilities existed as supply support of common items was provided by the ASF Services of Supply. This split was a source of great contention.[45]

Knerr, commanding general of the VIII Air Force Service Command and later the United States Strategic Air Force (USSTAF) Deputy for Administration, was responsible for all USAAF logistics in the United Kingdom. He hotly contested the Army's tables of organization and tables of equipment that placed artificial limits on authorized manpower and equipment. Knerr wrote in 1945, "The tables of organization and tables of equipment are a convenient and simple means for a staff agency in the United States to do its job easily, but they place the people in the theater of war in a straight jacket."[46] He provided many examples of the impact strict adherence to these tables had on the war. Problems included shortages of vehicles to move ammunition, vehicle maintenance and ordnance equipment, and high-explosive bombs due to increased usage during late 1943. These problems made the execution of Big Week more challenging for the Eighth's logisticians. More important, the latter problem meant that not every bomb dropped would produce the desired effect, increasing requirements to revisit targets.[47] Knerr believed the Army should reinvent its manpower and equipment authorization policies. He wanted the Army to use authorization tables more flexibly, like the USAAF supply tables, treated more as guidelines than strict policy.[48] Although Knerr tried to resolve many of these problems before February 1944, the Army did not adopt his suggestions.

ASC and ASF Services of Supply support was critical to the Eighth and VIII AFSC, but the theater logistics organization evolved throughout the war and was characterized by functional overlaps and power struggles. Even after the VIII AFSC shouldered the responsibility for supply distribution, the Army Service Forces provided it some supply support.

ASC and ASF Services of Supply support was critical to the Eighth and VIII AFSC, but the theater logistics organization evolved throughout the war and was characterized by functional overlaps and power struggles.

Eighth Air Force Logistics

> *Let us, the next time, have our logistics prepared before we plan to operate. We managed to skin by, in this last war, particularly in training personnel, on the logistic side by pulling ourselves out by our bootstraps…. Here 273 groups were set up but not a Depot Group was thought of. That meant that the very late start that was made had to be taken care of in the theater, and in the European theater our logistic establishment in the Burgenwood (sic) area was simultaneously a training school and the support for the operating pilot. But that is a bad situation to be in.*[49]
>
> **—Major General Hugh J. Knerr, USAAF**

An enormous effort was required to receive, support, and sustain the US bomber units, and British support was the key to success in massing strategic bombardment forces within striking distance of Germany. The British provided the materials for and constructed 91 of the 138 airfields required for American flying operations, allowing the forward deployment of USAAF units.

> The buildup of American air and ground forces in Britain (Operation Bolero) was determined by the logistics constraints the British-American coalition faced before the Normandy invasion. During the first year or so of its operational status from August 1942, Eighth Air Force's buildup was greatly helped by Britain's industrialization and the RAF's maturity.[50]

However, logistical sustainment of the deployed units was also critical in order to increase pressure on Germany and step up those efforts during Big Week. These efforts could only be made if flyable airframes and the right munitions were available. Unfortunately, the emphasis

at home on aircraft acquisition overshadowed problems of supply and maintenance, which received inadequate attention from USAAF senior leadership until they became acute.[51]

As evidenced by the data in Table 1, the in-theater logisticians found a way to conquer obstacles and get the kind of results necessary to support an effort with the magnitude of Big Week. Although some of the success is attributable to the improvements made stateside, most of the credit goes to the American and British logisticians in the UK and those braving the Atlantic sea lines of communications. Dramatic improvements across the spectrum of logistics were made in less than 1 year, enabling the Eighth to sustain crippling bombing missions against Nazi Germany from Big Week onward.

Leadership and Organizational Evolution

The USAAF established the VIII AFSC to provide the Eighth's combat units with supply, intermediate- and depot-level maintenance, and transportation support. However, in many respects, the AFSC concept was in direct conflict with the ASF Services of Supply.[53]

Air service groups provided intermediate-level maintenance support for two combat groups, possibly with the squadrons dispersed. One air depot group supported two air service groups. However, in Europe, an entire combat group, sometimes two groups, usually operated at a single airfield, complicating intermediate-level maintenance operations.[54]

VIII AFSC established two depots in England and one at Langford Lodge, Ireland.[55] A government contracting oversight gave Lockheed control of all personnel working at the depot in Ireland, which further complicated operations.[56]

General Knerr spearheaded the logistics efforts within the Eighth up to and beyond Big Week. His past experiences in corporate America, combined with those gained while part of the Bradley-Knerr Committee, did much to influence the logistics organizations and processes supporting the Eighth flying operations. Knerr arrived in Britain in July 1943 as the deputy commander, VIII AFSC.[57] AFSC was separate from the Eighth and subordinated to the numbered air force A-4 (logistics) staff, resulting in conflicts between staff office and operating agency. Knerr pressed for a reorganization of the Eighth, consistent with the recommendation he made to the Bradley Committee, elevating AFSC to a status equivalent to other staff functions. He also sought to consolidate A-4 and AFSC headquarters and reorganize Headquarters Eighth Air Force around two deputies—one for operations and one for logistics. Knerr believed a commander in constant contact with his two deputies could eliminate the need for much staff work and get results by being able to make major decisions quickly. Knerr took control of the Eighth A-4 staff on 11 October 1943, while still acting as deputy commander of VIII AFSC. Shortly after that, he took command of the AFSC. Knerr, by December 1943, "absorbed the personnel and functions of A-4 to become, in effect, the sole logistical agency entitled to act in the name of the commanding general, Eighth Air Force."[58]

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Unfortunately, the Eighth took staff and other resources from VIII AFSC, without warning, to stand up the Twelfth Air Force in October 1943. This unforeseen loss of resources degraded VIII AFSC capabilities for some time.[59] VIII AFSC anticipated the activation of IX AFSC, so when this occurred, it did not affect VIII AFSC as the need to support the Twelfth had.[60]

Reestablishment of the Ninth Air Force in Britain prompted further organizational changes. In late December 1943, General Carl Spaatz, commander of the newly created US Strategic Air Force, established a two-deputate structure, administration and operations. The deputy for administration would direct the logistics efforts of the Eighth and Ninth, while the deputy for operations would direct the strategic operation of both the Eighth and

Activity	Dec 42	Nov 43
Aircraft Assembled	12	463
Engines Overhauled	35	714
Aircraft Modified	5	619
Tons of Bombs Delivered	2,329	18,000
Propellers Repaired	65	375
Supply Tonnage Received	4,000	20,600
Truck Tonnage Hauled	2,700	22,194

Table 1. VIII Air Force Service Command Production Comparison[52]

the Fifteenth.[61] With the birth of the USSTAF organization, Knerr became the deputy for administration. Knerr stated, "We had a good demonstration of the smooth operation of that partnership thesis during this war in Europe, and we should never forget that lesson because it produced results."[62] Under this new command structure, Knerr made the final preparations and executed support of the Eighth bombing operations during Big Week.

Workloads resulting from initial combat operations, however, were greater than anticipated. In April 1943, VIII AFSC modeled itself after the Air Service Command by establishing three operating divisions—supply, maintenance, and personnel. This organizational change replaced the traditional general staff structure and produced a more effective operation. AFSC also decentralized operations in conjunction with this reorganization, allowing headquarters to focus on management and process improvement. In 1943, logistics organizations and processes were specialized and optimized, and the reduced threat of bombardment in the UK allowed for more efficient centrally located functions. However, VIII AFSC sustainment of the Eighth's combat operations became a major problem, and the "anxious examination of the factors affecting the rate of bombing operation in the fall of 1943 had emphasized anew the basic importance of its varied functions."[63] VIII AFSC had not addressed all the organizational overlaps, inefficiencies, and difficulties. Despite great organizational improvement, its effectiveness suffered.

Although the number of USAAF personnel in Britain increased by 300 percent in 1943, buildup of AFSC personnel lagged behind that of combat forces and handicapped logistics.

Infrastructure, Personnel, and Training

"Britain contained a core of civilian workers with maintenance and supply management skills" but "logistics met with an immediate shortage of British labor at ports and construction sites."[64] Although the number of USAAF personnel in Britain increased by 300 percent in 1943, buildup of AFSC personnel lagged behind that of combat forces and handicapped logistics.[65] Despite the fact that 1,000 Eighth Air Force personnel completed technical schools each month in 1943, Knerr noted the biggest problem he faced in 1943 was a shortage of personnel, and those he did have required training. He solved the problem, at least for the maintenance function, by cycling personnel through the air depot groups for formal training. Once trained, they were reassigned to air service groups, and "maintenance was no longer a problem."[66]

In late 1943 and early 1944, thousands of unskilled and untrained workers were shipped to the UK to help man rapidly expanding depots. In order to use new personnel quickly, production-line methods were instituted. Although this approach was not efficient, there was no other way to productively employ these people more rapidly.[67]

In June 1941, a factory representative section was established in London, and when the VIII AFSC was activated, it became responsible for the section. The factory representatives assisted the RAF and the USAAF with technical problems in the field and at depot. By May, it had 222 civilians representing 34 different American manufacturing companies. Then, as now, the factory representatives were invaluable in sustaining operations.[68]

Supply

"The decision in 1939 … to put almost all of the funds made available to the Air Corps into complete aircraft explains in large part the critical shortage of spare parts which persisted through 1942."[69] Throughout 1942, aircraft grounded for lack of parts was a concern throughout the USAAF.[70] To make matters even more stressful for VIII AFSC, on 1 December 1942, the unanticipated withdrawal of supplies and essential personnel to support the Twelfth created much chaos.[71]

Through most of 1943, the Eighth's logistics system suffered shortages because of shipping losses and the support it provided to the Twelfth. "Shortages of spare parts for such items as superchargers, bombsights, and trucks (which themselves were in short supply) were frequent."[72] However, by the beginning of 1944, more than 190,000 supply items were cataloged, spares were at satisfactory levels, and "no aircraft was long on the ground for lack of spare parts."[73] The improvement is attributable to the synergistic effects of:

- Decreases in shipping losses
- Redeployment of Ninth Air Force to Britain
- Local purchase and manufacture
- Improved transportation, maintenance, and supply distribution processes

- The learning curve
- ASC service life extension and economic repair policies

US forces in the UK relied on merchant shipping that was subject to German U-boat attacks. U-boats caused the loss of 6.3 million tons of cargo in 1942, but losses steadily declined in 1943 and afterwards. Cargo reaching the UK increased from some 50,000 tons in May 1943 to about 1 million tons in December 1943, while monthly losses decreased from more than 700,000 tons in November 1942 to approximately 100,000 tons in June 1943.[74]

Although cargo losses subsided, problems with manifests and cargo markings often delayed deliveries to units. In 1942, ships commonly arrived in the UK without the SOS having received a copy of the manifest or loading information. Even when documentation was received in a timely manner, it was often too general, making planning almost impossible.[75] Actions were taken to standardize markings and documentation, and dramatic improvement was realized.

> As late as the first quarter of 1943, only 46 percent of the manifests and Bills of Lading were being received five or more days before the arrival of the ships, and 24 percent were not received at all. However, during the month of April 1943, 80 percent were received five or more days ahead of ships, and in May 90 percent. Thereafter, delays in receiving documentation ceased to be a serious problem.[76]

SOS unfamiliarity with USAAF markings and procedures delayed distribution of supplies and prompted VIII AFSC to establish intransit depots at sea and aerial ports. Further improvements in distribution were realized by dividing the British Isles into two geographic zones. Northern Ireland was later established as a third zone. Intransit depot zoning was based on the capacity of the geographic area to receive supplies, and ships in the United States were then loaded with supplies based on zones, reducing the amount of intratheater transportation required within the UK.[77]

Consequently, VIII AFSC distributed all USAAF supplies received in the UK. With respect to the Eighth, the Services of Supply provided wholesale supply support, and VIII AFSC provided retail supply support.[78] On 14 December 1943, VIII AFSC reported that intransit depots could deliver bulk supplies from the port to a depot or base within 72 hours. They also reported that 88.5 percent of requisitions were satisfied immediately and requisitions for items not on hand were being filled in less than 24 hours. These process improvements may seem simple, but they did wonders to make the flow of USAAF supplies to and within the UK more efficient and reliable.[79]

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It took the USAAF nearly 2 years to develop an effective supply statistics system to aid in spare parts requirement forecasting. As early as 1942, supply planning was accomplished using automatic supply tables based on peacetime consumption rates for 30-, 60-, 90-, and 180-day stock levels in 20-, 40-, and 80-aircraft units. The tables were developed and implemented to help reduce pipeline times for high demand parts with low availability—some were, in fact, taking up to 2 months to obtain from the United States.[80] Supply conferences were held in April and November 1943 to fine tune the tables.[81]

In September 1943, the Air Service Command discontinued automatic resupply shipments for all but new aircraft types. An agreement to ship 50 percent of the 6-month requirement as soon as possible and the remainder 60 days later resolved the problem. Further process refinement averted both shortages and overstocks, and depots were authorized 90-day stock levels of specialized aircraft parts. Subdepots were authorized 6-month levels of common supply items. The prepositioned pipeline stocks were used to fill supply demands at all echelons of maintenance.[82]

In October 1943, the VIII AFSC began to use 3-month forecasts to account for the effects of sortie rates, enemy opposition, repair facilities, and other factors that were not accounted for by the automatic supply tables. Supply transactions were recorded manually, and by late 1943, the aircraft fleet size made it evident that automation was necessary. However, automation did not occur until after 1944. As a result, Big Week did not enjoy the speed and efficiency of an automated supply demand forecasting process.[83]

The amount of equipment being shipped to support the Twelfth caused acute equipment shortages in the Eighth, hampering beddown and support of new units arriving in theater.

> During the early part of 1943, the movement of air echelons to the United Kingdom prior to the movement of ground echelons, service units, and their equipment, contributed to low serviceability. A new unit, for example, seldom reached a serviceability rate higher than 50 percent during the first month of operations.[84]

To alleviate theater shortages, the USAAF began to require units deploying to the UK to ship their own equipment 1 month before deployment.[85] Given the lead times associated with the manufacture of peculiar support equipment items, this policy maximized the number of combat ready aircraft during Big Week.

Before February 1943, all requisitions were passed through HQ VIII AFSC, slowing the process and making it inefficient. After February 1943, the supply channels for Air Force-unique supply items were decentralized. Only those needs that could not be satisfied by military supply within the theater were passed to HQ VIII AFSC and filled, preferably by stateside ASC depots. If ASC could not satisfy the demand, local purchase was used as a last resort.[86] Supply stocks after the winter of 1943-1944 were adequate, and overages were shipped back to the United States.[87] Reinvention of supply demand processing procedures, beginning in February 1943, improved supply support.

In a fine example of cooperation and teamwork, the "British dispensed all the petroleum, oil, and lubricants (POL) in Britain, even though most of it came from the United States under lend-lease."[88] Further, British POL manpower brought some relief to VIII AFSC personnel shortages.

By May 1942, it was apparent that operational requirements would not permit the delays associated with waiting for parts from the United States, so local procurement was begun. The Army SOS established the General Purchasing Board in May 1942 for the purpose of locally procuring goods and services.[89] Shortly thereafter, the SOS commander granted VIII AFSC limited procurement authority.[90] This decentralized procurement tool gave logisticians powers similar to today's International Merchant and Procurement Authorization Card program.[91] Also, by early 1943, local manufacture of some spare parts by European theater of operations depots aided in partially alleviating shortages.[92]

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A mutual aid agreement establishing reverse lend-lease with the British was signed 23 February 1942. In the first 2 years of the war, approximately 422,721 tons of supplies were procured from the British.[93] "From June 1942 to July 1943, the British provided US forces in the UK half or more of their quartermaster, engineer, Air Corps, medical, and chemical warfare service supplies."[94] During the war, the United States received more than $6.7B worth of goods and services from the British through reverse lend-lease.[95]

The supply support received from the British was significant as the United States suffered losses of 100,000 to 700,000 tons of shipping per month from late 1942 to mid-1943. Logistics personnel made good use of local purchase, local manufacture, reverse lend-lease, and pooled common supplies. These resources brought relief to weary maintainers by reducing the number of aircraft part cannibalization actions required to satisfy supply shortfalls while maximizing the mission capable rate. The RAF's extensive use of US-built aircraft allowed the RAF and USAAF to create a large pool of common supplies in early 1943. VIII AFSC eventually took over procurement responsibility for the common supply pool, and many items were obtained from UK sources, reducing pipeline time and transport burdens.[96] It would not have been possible to execute Big Week in February 1944 if it had not been for the materials the United States received from the British through local purchase and reverse lend-lease, coupled with the synergistic effect of pooling common aircraft supplies and local manufacture capabilities.

Maintenance and Munitions

During 1943-1944, the average life of an Eighth Air Force heavy bomber was 215 days, during which it flew missions on 47 days and was undergoing maintenance, repair, or modification on 49 days.

> The quality of maintenance was often the margin of difference between the life or death of an aircrew or the success or failure of a mission. The greatly increased rate of operations, the high incidence of battle damage, and the growing complexity of military planes during World War II made maintenance one of the most vital functions in waging of air war.[97]

Maintenance system operations were flexible, and the amount of maintenance was determined by the availability of equipment, supplies, and manpower.[98] Prior to mid-1944, heavy bomber maintenance organizations were constantly challenged by having to expend

labor and parts to keep war-weary aircraft flying, since replacement aircraft were not available in sufficient quantities to stabilize aircraft availability with respect to losses.[99] Fighter and medium bomber serviceability was higher than that of heavy bombers "primarily because of a much lower percent of battle damage and less extensive modification requirements."[100] Large theater depots also put increased flexibility into theater maintenance, relieving VIII AFSC organizations on the airbases of a wide variety of labor intensive tasks.[101] In late 1943, General Knerr established subdepots at various operational bases to enhance field maintenance capability. He also implemented a mobile aircraft repair team concept to support onsite repair of aircraft too badly damaged to fly to the depot. In existence between 1943 and 1945, mobile repair teams comprised of supply and repair trucks and specially trained personnel were very important to base maintenance activities. Because the mobile repair teams repaired damaged aircraft that landed off station and aircraft damaged beyond the bases' maintenance capabilities, base maintainers could concentrate on minor repairs and aircraft regeneration.[102]

Further, Knerr reorganized the VIII AFSC and instituted a system to monitor and control aircraft production. He established "statistical reporting and control procedures at all bases" so commanders knew what the situation and requirements were.[103] This included, beginning in September 1943, collecting 3-month sortie forecasts from the combat commands to forecast and adjust depot workloads in order to reduce backlogs.[104] Late in 1942, the British agreed to let Americans replace British workers at the Burtonwood depot, and "under American leadership and production methods the production of engines and instruments increased at a rapid rate."[105] Depot capacity was also increased when Warton Air Depot was activated in September 1943. Several smaller subdepots, known as advance depots, were activated at selected operational airbases to further enhance field capabilities.[106] Knerr's reallocation of repair and modification work in December 1943 took advantage of the efficiency of specialization by spreading backlogs and making the depot in Ireland responsible for aircraft modification kits.[107] The necessity of modifying all incoming aircraft frequently reduced theater aircraft serviceability rates as much as 16 percent.[108] "Following this reorganization, the volume of work accomplished was vastly increased."[109]

Lockheed Corporation, under US contract, manned the Irish depot. Lockheed's depot support was considered advantageous because it provided in-theater specialized engineering work, modifications, development of special tools, design changes, and kit manufacture for all types of USAAF equipment.[110] Finally, "Between 12 and 20 February 1944 no bombing missions had been flown; hence the backlog of aircraft in repair had been diminished, and an unprecedented number of bombers were available."[111] This period of inactivity was the result of poor weather conditions that restricted flying operations. Maintainers took advantage of the situation to generate the 1,292 aircraft that were available entering Big Week.[112]

The Eighth had a sufficient tonnage of munitions and quantities of ammunition available to support Big Week. However, disagreement centered on the types of munitions available and the types the flying units needed to destroy the targets assigned. Knerr believed the disagreement was due to improper communication of field requirements to munitions production plants in the states. The shortage of desired bomb types began in December 1943 and was not corrected by 1 April 1945. The lack of proper bomb types to support Big Week, given the bombing accuracy of the B-17 and B-24, degraded mission effectiveness.[113]

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Transportation

Knerr attempted to address airlift problems, which he had foreseen, by trying to secure the dedicated airlift he had apparently been promised. In the summer of 1943, he wrote, "Not more than 3 percent of the required airlift has ever been forthcoming in the United States from that promised service."[114] With the exception of inter- and intra-island air service, the Eighth was relieved of airlift functions. These functions had been placed under the Air Transport Command sometime in the summer of 1943. Knerr later wrote in his lessons learned, dated 10 May 1945, that air cargo had been delivered to places where it was "extremely difficult to assemble and process" and that units and equipment were separated from each other, delaying unit mission execution in the theater.[115] A military airline was formed by the Eighth for moving troops and supplies throughout the UK and proved its merit by moving an average of 300 tons of cargo and 2,500 personnel per month in 1943.[116]

The Army Service Forces controlled what was shipped via sea to the UK. Knerr felt the Army Service Forces mismanaged sea shipments, and although it never happened, he believed the Air Force should have been allocated dedicated sealift.[117]

Knerr addressed many key logistical problems in 1943. Not the least of his efforts included resisting the return of the Truck Transport Service to the Service of Supply because "until the Air Forces took over segregation and distribution of their own supplies from shipside (sic) to consuming unit, they starved."[118] A shortage of vehicles added to interservice squabbles over control of the ground transport function. "A truck shortage adversely affected distribution, although it was mitigated by Britain's fine transportation system."[119] In addition, the Eighth's trucks were pooled into a single organization and were effective and efficient in moving supplies from port to base and laterally between bases.[120]

Concerning transportation, the Eighth made the best of a bad situation. It operated an intratheater airlift service but depended on Air Transport Command for intertheater airlift. This combination of intertheater and intratheater support apparently satisfied the Eighth's airlift needs despite its dependence on another command. Despite the sealift problems Knerr believed the ASF created, he never was able to secure dedicated sealift.

Eighth Air Force Logistics—The Bottom Line

World War II, as exemplified by the Eighth's tremendous efforts up to and through Big Week, "dramatized as never before the importance of the essentially undramatic functions of transportation, supply, and maintenance and lent new strength to calls for centralization of responsibility."[121] From 1942 right on through Big Week, improvements were constantly sought in all logistical functions to make them more responsive and effective. Many of the accomplishments were achieved because of Knerr's leadership. Although logistics organizations and process deficiencies still existed in late February 1944, many problems had already been addressed and yielded the logistics capability to initiate and sustain operations the size of Big Week. The improvements made within all the logistical functions, combined with continuous process improvements, put the *big* into Big Week.

Perhaps the most significant lesson of World War II is that the military potential of a nation is directly proportional to the nation's logistic potential.

Success Reaped the Hard Way

> *Perhaps the most significant lesson of World War II is that the military potential of a nation is directly proportional to the nation's logistic potential. The first hard fact to be faced in applying that lesson is that our resources are limited. The next is that the slightest delay or inefficiency in harnessing our logistic resources may cost us victory.*[122]
>
> **—Major General O. R. Cook, USA**

Logistics indeed made Big Week *big* with respect to the Eighth's bombing operations. The Eighth generated 3,880 bomber sorties that delivered 8,231 tons of bombs to targets throughout the Third Reich. The number of operational bombers declined to about 900. However, within 5 days after Big Week ended, maintainers had returned about 150 of the approximately 200 bombers with battle damage back to a combat ready condition.[123] Big Week was *big* because, although Allied air superiority was not won until later, as General Spaatz noted, it did spell the beginning of the end for the Luftwaffe daylight fighter force.[124]

Leadership greatly influenced the logistics capability and support the USAAF was able to establish in the UK. On the negative side, it took a long time for the civil-military organization to evolve into an effective one, and it appears the military spent more time trying to take charge of the economy than to work within the President's system.

General Cook remarked:

> Time is the most precious element in logistics preparation for military security. Measures must be prepared in advance for the all-out, logistic mobilization that must be completed between the time when the danger threatens and the time that war actually strikes.[125]

Indeed, the military did not adequately plan for industrial mobilization, which contributed to the myriad of problems encountered.

Congress' streamlining of acquisition procedures and granting of obligating authority to the armed services greatly reduced lead times associated with the major procurements necessary to prepare for and prosecute the war. However, military management of acquisitions was not perfect. In 1942, there was an imbalance between the number of whole aircraft procured and the spare parts required, resulting in a parts shortage. Fortunately, the spare parts situation improved by 1943, and maintainers had the spares needed to support Big Week.

ASC research and development activities enabled technologies to be exploited and, thus, improved combat capability through a controlled aircraft modification program. Technology insertion was a positive influence on logistics.

Functional overlaps, process inefficiencies, and what could be labeled *intraservice rivalry* between the VIII AFSC and AFS Services of Supply caused many of the processes critical to providing and sustaining aircraft maintenance to break down. VIII AFSC addressed most of the problems during 1942 and 1943, but Knerr, because of his overall dissatisfaction with ASF support, made every effort to make the Eighth as logistically independent from the Army as he could, and he got results.[126]

VIII AFSC suffered personnel and training shortages. The leadership's adoption of production-line maintenance processes was not the most efficient use of personnel, but it did allow for speedy incorporation of unskilled workers into the depots and service groups.

"Host nation support, or whatever resources happen to be in the place one fights, can contribute greatly to a logistics system's capability."[127] British airfield construction allowed the United States to mass bomber units on the island. Interservice supply support was critical to the Eighth's maintenance. Finally, British dispensing of POL made efficient use of manpower, which was important to the undermanned VIII AFSC.

Civilians also provided critical support to the logistics team. Civilians in ASC worked acquisition programs and provided supply and repair support. The Lockheed employees at Langford Lodge depot provided in-theater support in a much more timely manner than would have been possible had they been located in the United States. Factory representatives further enhanced theater maintenance capabilities. In-theater depots, subdepots, and intermediate-level maintenance organizations provided in-depth aircraft repair service independent of stateside organizations. In addition, they developed and provided limited but valuable local manufacture capability, alleviating parts shortages. By the time Big Week arrived, these organizations had evolved and could provide effective logistical support to the combat units, thus enabling sustained bombing raids of 1,000-plus bombers.

Knerr was the single greatest influence on the capabilities and effectiveness of the Eighth's logistics. From the time he served on the Bradley-Knerr Committee to plan the organization and buildup of forces through his tenure as the US Strategic Air Force Deputy of Administration, he constantly improved all logistical functions. His institutionalization of statistical monitoring and requirements forecasting was used effectively to minimize depot backlogs. His implementation of mobile repair teams for battle-damaged aircraft helped sustain the bomber fleet. Finally, he championed making the logistics and operations functions equal at the headquarters level, giving logistics the clout needed to ensure their logistics considerations were taken into account and that logistics and operations were synchronized. "Responsiveness and flexible logistics support requires a management system that consciously links operations and logistics."[128] A good example of Knerr's effort to synchronize operations and logistics was his ability to get 3-month sortie forecasts that were used to plan logistical support.

Knerr was the single greatest influence on the capabilities and effectiveness of the Eighth's logistics.

The processes of producing or allocating munitions, or both, were broken because units did not always have the types and quantities of munitions needed to destroy the assigned targets. Big Week was *big*, but it did not pack the punch it had the potential to because of the many munitions substitutions.[129]

Ship escorts, establishment of distribution zones, ship loading based on destination of goods, improved documentation and communication, establishment of intransit depots, VIII AFSC's pooling of trucks for supply distribution, and theater controlled intratheater airlift were very positive influences on operations.

Eighth Air Force logistics prior to Big Week was the story of *brute force* logistics. Knerr's effort to synchronize logistics and operations and provide responsive, effective, and efficient logistics serves as the benchmark for all airmen. At the end of the day, the logisticians conquered many challenges through innovation and adaptation that yielded improved productivity and paved the way for Big Week. Indeed, Big Week would not have been *big* were it not for the dedicated efforts of the logisticians for months and years prior to 20 February 1944.

Notes

1. Maj Gen O. R. Cook, "Lessons of World War II," Lecture to Air War College USAF HRA, K239.7162241-22, 10 Dec 1947, 4.
2. Edward Jablonski, *Airwar*, Garden City, New York, NY: Doubleday and Company, Inc, 1971, 52-53.

3. USSTAF, "Materiel Behind the 'Big Week'," *USAF HRA, 519.04-1*, 20-25 Feb 1944, 4. On 20 February 1944, Eighth Air Force had fighter escort support from both Eighth and Ninth Air Force units, totaling 902 sorties.
4. Stephen L. McFarland and Wesley Phillips Newton, *To Command the Sky,* Washington, DC: Smithsonian Institution Press, 1991, 168-169.
5. Jacob A. Stockfisch, *Linking Logistics and Operations: A Case Study of World War II Air Power,* Santa Monica, CA: RAND, 1991, v.
6. Maj Gen Hugh J. Knerr, "Strategic, Tactical, and Logistical Evaluation of World War II," Lecture to Air War College,USAF HRA, K239.716246-18, 19 Oct 1946, 3.
7. Alan L. Gropman, ed, *The Big "L": American Logistics in World War II*, Washington, DC: National Defense University Press, 1997, 10-15, 94, 98-100. The War Industries Board, established in 1917, was the focal point for the nation's resource and acquisition management. The Board, short-lived, was abolished in the wake of post-World War I acquisition reform that replaced streamlined procedures with peacetime bureaucracy.
8. Gropman, 21.

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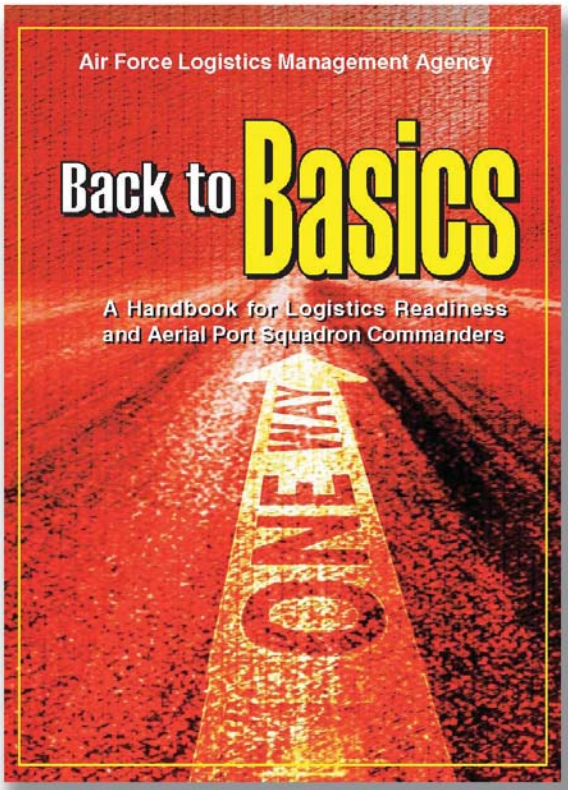

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9. Maj H. Dwight Griffin, et al., *Air Corps Tactical School: The Untold Story,* Washington, DC: US Government Printing Office, 1995, 45.
10. Haywood S. Hansell, Jr, *The Strategic Air War Against Germany and Japan, A Memoir,* Washington, DC: Office of Air Force History, 1986, 62-63. AWPD-1 called for 61,799 aircraft, of which 4,328 were to be based in Britain, and required 2,118,625 Army Air Forces personnel. AWPD-42 included munitions requirements and called for a total of 8,214 aircraft, including a 50 percent reserve, to be based in Britain.
11. "AC/AS Plans: 1942-1945," *USAF HRA, 145.92-18,* 1943.
12. USASF, *Logistics in World War II: Final Report of the Army Service Forces,* Washington, DC: US Government Printing Office, 1947, 247-250.
13. *Ibid*.
14. "Materiel Behind the 'Big Week'*,"* 1-2.
15. Gropman, 9-31.
16. *Ibid*.
17. Gropman, 23-25.
18. Gropman, 25-31.
19. Gropman, 31-35, 38, 55.
20. Gropman, 265-283.
21. Gropman, 31-35, 38, 55.
22. Cook, 7.
23. Lois E. Walker and Shelby E. Wickam, *From Huffman Prairie to the Moon*, Washington, DC: Office of History, 2750th Air Base Wing, Wright-Patterson Air Force Base, Ohio, 1986, 146-147.
24. AAF Historical Office, *"Army Air Forces Historical Studies No. 51: The Maintenance of Army Aircraft in the United States 1939-1945," USAF HRA, 101-51* (1945), 133. In February 1942, improvements in engine construction enabled overhaul schedules to be changed. Only when inspection revealed it was necessary were aircraft reconditioned. In 1943, the *obsoletion* policy requiring the retirement of combat aircraft after 6 to 8 years of service was changed and replacement was not required until "whenever superior equipment was available."
25. Maj Gen Hugh J. Knerr, "Knerr Correspondence," USAF HRA, 519.1613, October, November, December 1943. Although the commanders who did this probably felt operational necessity justified their actions, they increased the complexity of logistics support by creating nonstandard configurations. Their actions negated the advantages of interchangeable parts and lengthened the time it took for VIII Air Force Service Command intermediate and depot maintenance activities to return affected aircraft to service.
26. Wesley Frank Craven and James Lea Cate (ed), *The Army Air Forces in World War II, Vol 6, Men and Planes,* Chicago, IL: The University Press of Chicago, 1955, 391.
27. Walker and Wickam, 145.
28. Gropman, 123.
29. Gropman, 122, 282.
30. Cook, 18.
31 *Ibid*.
32. Craven and Cate, *Vol 6, Men and Planes*, 389-392. "The basic data from which policies and instructions were derived came from reports which flowed in from the depots and stations and from various inspection activities.… Although jurisdiction of ASC did not extend overseas, it was responsible for providing service units, equipment, and supplies for all AAF commands."
33. *Army Air Forces Historical Studies No. 51,* 134-135. The suggested overhaul time for the B-17 increased from 4,000 flying hours or 30 to 60 months of service in 1940 to 8,000 flying hours or 84 months of service in 1944.
34. Craven and Cate, *Vol 6, Men and Planes*, 393.
35. *Ibid*. By 1944, aircraft production allowed replacement of heavily damaged planes by new ones, and battle damage repair became less critical. ASC was then able to establish criteria for determining whether or not it was more cost effective to repair or replace badly damaged aircraft, and the job of the depots "became mainly one of modification and overhaul."
36. Craven and Cate, *Vol 6, Men and Planes*, 389.
37. *Army Air Forces Historical Studies No. 51*, 121, 124, 136-139.
38. Craven and Cate, *Vol 6, Men and Planes*, 395. In 1941, there was an urgent need for more and better maintenance, and the quality of maintenance continued to be low during the early months of the war due to a lack of adequately trained engineering officers and civilian mechanics to man the depots. In part, this was caused both by the increased production pressure associated with the parts shortage that existed through 1942 and the fact that ASC was the lowest priority command for personnel fills.
39. Craven and Cate, *Vol 6, Men and Planes*, 391, 395.
40. Craven and Cate, *Vol 6, Men and Planes*, 396.
41. *Army Air Forces Historical Studies No. 51,* 118-122, 127-128, 135. During the period Jan 1942 through Jan 1944, stateside depot maintenance facilities returned approximately 25,000 aircraft and 90,000 engines to service. In 1943 alone, 236,622 aircraft visited the 200-plus subdepots for repair and other work. Finally, an Air Inspector survey conducted in the summer of 1943 attested to the fact that the Eighth Air Force was satisfied with the third and fourth echelon maintenance support it was receiving from ASC.
42. General Board United States Forces, European Theater, *"Logistical Build-Up in the British Isles," USAF HRA, 502.101-128, 9 Jun 1953*, 4.

43. *Ibid*.
44. Gropman, 345.
45. *Logistics in World War II*, 248, 341. Within the ASF, "there was an unnecessary overspecialization in types of service troops, thereby making it difficult to secure maximum flexibility in the utilization of service personnel." Although it was believed units comprised of both USAAF and Army personnel would improve the situation and some experimenting with this type of organization was done, the idea "was not pushed vigorously."
46. Maj Gen Hugh J. Knerr, "Air Force Logistics," *USAF HRA, 519.8086-1*, 10 May 1945, 2.
47. "Air Force Logistics," 6-7
48. "Air Force Logistics," 2.
49. Knerr, "Strategic, Tactical, and Logistical Evaluation of World War II," 4-5.
50. Stockfisch, 18.
51. Craven and Cate, *Vol 6, Men and Planes*, 390.
52. USSTAF, "*Notes for Supply and Maintenance Chapter,"* USAF HRA, 519.057-4, 1942-1945, 10.
53. *Ibid*.
54. Stockfisch, 19. Further complicating an already complicated task, commanders of combat units wanted command of Air Force Service Command intermediate-level maintenance (air service group) activities on their bases. This quickly became the practice, diluting the authority but not the responsibility of the VIII Air Force Service Command commander.
55. Knerr, "Knerr Correspondence."
56. "Notes for Supply and Maintenance Chapter," 6.
57. *Biographical Data, Personnel Index, USAF HRA, 519.293-1*, 1945. Knerr, a graduate of the US Naval Academy, became an Army artillery officer in 1911. He joined the Air Corps near its birth and retired from active duty in 1939 only to be recalled in 1942, having spent the interim years at the Sperry Gyroscope Company "in work that … proved invaluable both to him and to the Military Service."
58. Craven and Cate, *Vol 2, Europe: Torch to Pointblank—August 1942 to December 1943,* 742-743. As a member of the Bradley Committee, in the spring of 1943, Knerr had prepared a special report on air service in Africa. In the report, he advocated the elimination of the problems caused by the logistics function being subservient to the staff and operations functions by the simple expedient of elevating the agency to the staff level of command.
59. Stockfisch, 18-19.
60. Notes for Supply and Maintenance Chapter, 6-11.
61. Notes for Supply and Maintenance Chapter, 752.
62. Knerr, "Strategic, Tactical, and Logistical Evaluation of World War II," 5.
63. Craven and Cate, *Vol 2, Europe: Torch to Pointblank—August 1942 to December 1943*, 742.
64. Stockfisch, 18, and Gropman, 346.
65. Gropman, 364.
66. USAF Historical Research Agency, "Notes on an Interview with Maj Gen Hugh J. Knerr," USAF HRA, *168.2-12*, 24 Nov 1947, 1-2.
67. Craven and Cate, *Vol 6, Men and Planes*, 395-396.
68. "Civilian Technicians and Representatives," *USAF HRA, 519.8023*, 1941-1945.
69. Craven and Cate, *Vol 6, Men and Planes*, 390.
70. Craven and Cate, *Vol 6, Men and Planes*, 394.
71. Notes for Supply and Maintenance Chapter, 2.
72. Stockfisch, 19. "During early 1943 spare parts for 50-caliber aircraft machine guns became so scarce that the total supply was pooled in a single depot with telephone requests being doled out by special truck delivery."
73. "Materiel Behind the 'Big Week'," 3.
74. Gropman, 347-348, 359, 361-363, and Maj Gen William E. Kepner, "Supply (Congressional Committee)" Kepner Collection, USAF *HRA, 168.6005-84*, 3 Jun 1945, 2.
75. "Logistical Build-Up in the British Isles," USAF HRA, *502.101-128*, 9 Jun 1953, 25-26. "Entries on the manifest such as '1000 boxes of Quartermaster Class I supplies' were not uncommon."
76. *Ibid*.
77. Notes for Supply and Maintenance Chapter 3, 128.
78. Notes for Supply and Maintenance Chapter 3, 3.
79. Knerr, "Knerr Correspondence."
80. Notes for Supply and Maintenance Chapter, 3.
81. "Stock Control in the ETO," USAF HRA, *519.8024-1*, 1945, 1, 8-9.
82. "Stock Control in the ETO," 25, 31.
83. "Stock Control in the ETO," 3-5, 10.
84. Notes for Supply and Maintenance Chapter, 5.
85. Notes for Supply and Maintenance Chapter, 4.
86. "Stock Control in the ETO," 15-16, 19-23, 36-37. Combat group demands not met were first sent to the air service group, then the depot. If neither organization could satisfy the demand, it was then sent to headquarters VIII Air Force Service Command. A three-tier supply priority system was established, in which priority was based on urgency of need. Aircraft grounded for lack of parts were given highest priority, and those requirements were sent via teletype to the air service group. If the air service group could not fill the request, a teletype was sent to the air base depot, and if it still could not be satisfied, a cable was sent to the responsible stateside depot.

87. Notes for Supply and Maintenance Chapter, 5. AOG rates fell from 5 percent in Dec 1942 to 2.3 percent in Nov 1943.
88. Stockfisch, 19.
89. General Board United States Forces, European Theater, *Logistical Build-Up in the British Isles,* 15.
90. "Stock Control in the ETO," 22-23. Local purchases were limited to 25 pounds sterling ($100), required written approval of the station commander, and could only be done when urgency of need did not permit procurement through the British Equipment Liaison Officers. Station purchase (for example, contracting) officers had standing authority to make purchases not exceeding 5 pounds sterling.
91. Deputy Assistant Secretary of the Air Force (Contracting). *Contracting Toolkit: IMPAC,* 5 Jan 2000 [Online] Available: http://www.safaq.hq.af.mil/contracting/toolkit/impac/.
92. Notes for Supply and Maintenance Chapter, 2.
93. "Stock Control in the ETO," 19. Reverse lend-lease arrangements were used to make routine purchases exceeding 25 pounds sterling and were processed through the commanding general, VIII Air Force Service Command and the RAF Equipment Liaison Officers.
94. Stockfisch, 18.
95. Gropman, 273, 277.
96. Notes for Supply and Maintenance Chapter, 4.
97. Craven and Cate, *Vol 6, Men and Planes,* 388, 394.
98. Craven and Cate, *Vol 6, Men and Planes,* 389.
99. Stockfisch, 43-44.
100. Notes for Supply and Maintenance Chapter, 4. For example, medium bomber serviceability went from 29 percent in July 1943 to 92 percent in Nov 1943.
101. Craven and Cate, *Vol 6, Men and Planes*, 391.
102. "Notes for Supply and Maintenance Chapter, 6, 11. Transport of aircraft via truck to depot in the UK was infeasible due to the physical constraints associated with humpback bridges, narrow winding roads with reverse camber, and bridge clearances.
103. "Materiel Behind the 'Big Week'," 2-3.
104. Knerr, "Knerr Correspondence."
105. Notes for Supply and Maintenance Chapter, 6. Although it is not clear from the historical account if VIII Air Force Service Command sought to replace British personnel at Burtonwood depot with Americans because the British were not productive or if the decline in British employee productivity was caused by the agreement, it is clearly documented that productivity increased.
106. *Ibid*.
107. "Materiel Behind the 'Big Week'," 3-4.
108. Notes for Supply and Maintenance Chapter, 5. The shortage of station overhead personnel also necessitated the use of skilled service personnel for overhead functions.
109. "Materiel Behind the 'Big Week'," 4.
110. "Materiel Behind the 'Big Week'," 6. Despite initial USAAF reservations regarding Lockheed's control of depot personnel at Langford Lodge, which occurred due to an error made by the government in writing the contract, it appears the contractor managed the personnel satisfactorily.
111. "Materiel Behind the 'Big Week'," 4.
112. *Ibid*.
113. Maj Gen Hugh J. Knerr, "Letter from USSTAF in Europe Deputy Commanding General, Administration to Commanding General," USAF, HRA 519.8671-3, 1 Apr 1945.
114. Knerr, "Knerr Correspondence."
115. Knerr, "Air Force Logistics," 7.
116. "Notes for Supply and Maintenance Chapter," 12.
117. Knerr, "Air Force Logistics," 7.
118. Knerr, "Knerr Correspondence."
119. Stockfisch, 19.
120. Notes for Supply and Maintenance Chapter, 12.
121. Craven and Cate, *Vol 2, Europe: Torch to Pointblank—August 1942 to December 1943*, 742.
122. Cook, 6.
123. "Materiel Behind the 'Big Week'," 4.
124. Richard G. Davis, *Carl A. Spaatz and the Air War in Europe,* Washington, DC: US Government Printing Office, 1993, 327.
125. Knerr, "Strategic, Tactical, and Logistical Evaluation of World War II," 7.
126. Knerr, "Air Force Logistics," 1.
127. Stockfisch, 52.
128. *Ibid*.
129. Knerr, "Air Force Logistics," 6-7.

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Colonel Logan "Jay" Bennett, USAF, Retired

Murphy's Law

Colonel Crawford O. Murphy was my boss for 1 very remarkable year in the late 1970s. I was in a very comfortable assignment at the Military Personnel Center, Randolph AFB, Texas, but chose to go to Osan AB, Korea, for my second remote assignment in 15 years. About a month before departing, I received my first correspondence from the unit's deputy commander for maintenance (DCM), Colonel Murphy. It was a handwritten note stating, "Don't bring your golf clubs; we don't have time for it here." I'd heard all sorts of stories about this intrepid character (most recently from a friend, Major Luke Gill, who had arrived at Osan AB months earlier), so my anxiety was heightened with this caustic note. In the next 12 months, I was to receive many of these notes.

My assignment, on paper, was to command the component repair squadron (CRS). However, when I arrived, the departure of several field grade officers meant the maintenance control officer, CRS commander, aircraft generation squadron (AGS) commander, and quality control (QC) jobs were all up for grabs. Murphy wanted time to evaluate the possible replacements before selecting them. He insisted that departing incumbents remain in place until the very end of the month they were eligible to return from overseas. (All incoming field grade officers arrived at the beginning of the month. A year later, they left Osan at the end of the month, making this nearly a 13-month tour of duty, a Murphy policy.)

Colonel Murphy interviewed all senior noncommissioned officers (NCO) and officers one-on-one within days of their arrival. This interview was strictly a one-way conversation. Here's the nature of my interview, as I've kept my notes over the years and used them myself.

- Be happy and aggressive.
- Know the *-6*.
- The squadron maintenance supervisor runs maintenance.
- Production belongs to the senior NCOs, not the officers.
- Identify weak people and press them to become stronger.
- Don't accept anything short of perfection.
- No battles, period.
- Quality assurance (QA) reports are to be answered with what we're doing to correct the problem.
- Know at what level decisions should be made and hold those people responsible.

In about 2 weeks, Murphy made his decision on assignments, and I was extremely fortunate to be selected to command the AGS, replacing the extremely popular and very competent Major Dick Rose.

In those days, Osan (51st Composite Wing) had 24 F-4Es, 16 OV-10s, and a full-time detachment of 6 RF-4Cs. The maintenance organization was an early production-oriented maintenance organization (POMO), with a DCM—Colonel Murphy, also known as *Alpha One*. While the tour of duty was nearly 13 months for most of us, certain key staff members served longer tours (Murphy served for 3 years).

My memory is very clear about those events 22 years ago, serving as AGS commander under Alpha One, and I would like to share some of those experiences with you.

Permit me to describe a standard day. It always began at 0430 (except for Sunday) with a phone call to my quarters. I was usually in the shower at that time and kept a close ear for the ring. It was Colonel Murphy. "Good morning, are you the commander of the *Animal Gathering Society* (sometimes it was the *All Girl Squadron*)?" This was followed by a long

TIt always began at 0430 (except for Sunday) with a phone call to my quarters. I was usually in the shower at that time and kept a close ear for the ring. It was Colonel Murphy. "Good morning, are you the commander of the Animal Gathering Society (sometimes it was the All Girl Squadron)?" This was followed by a long pause. "Major, why aren't your crew chiefs getting their paychecks on time?" Or, "Why do your crew chiefs need haircuts?" Or, "When are you going to insist on clean forms on your airplanes?"

pause. "Major, why aren't your crew chiefs getting their paychecks on time?" Or, "Why do your crew chiefs need haircuts?" Or, "When are you going to insist on clean forms on your airplanes?" Then, before I could answer, he would hang up. After a few of these calls, I became very annoyed, with him and with my inability to anticipate his daily questions. It soon became apparent that Alpha One cruised the flight line every morning from 0300 on, searching out *his people*, my crew chiefs. After several weeks of this, I eventually got used to it and followed up during the day, unless it was an airplane problem, which I investigated before I left my quarters in the morning.

I always stopped by job control before starting my rounds. Murphy's job control was unique, as were his expectations. Every decision that could be moved from job control to the flight line was, letting the AGS expediter work the problem through the specialist supervisors on the line and work out a course of action. Job control was to let that course of action stand unless they could prove it impacted future schedules—or other priorities to the on-scene bosses—to prepare aircraft to fly. Job control should keep reminding the flight line of considerations, and they should obtain the help on-scene bosses needed. Colonel Murphy considered the AGS expediter the orchestrator of the ongoing maintenance effort. He spent lots of time needling the specialist dispatchers for failing to keep the workforce occupied when there was something productive they could be doing, such as dispatching avionics specialists to clear delayed discrepancies. He never let the shop chiefs forget they were the ones who should be bugging job control for an airframe or to do what needed to be done.

After establishing how the schedule was being met for the day, I usually visited each shelter that housed an aircraft on the day's flying schedule. Over time, you could tell just by looking at the activity (or listening to the radio) whether the bird was coming together or not. It was especially nice to have fewer than 50 airplanes—knowing tail numbers, locations, names of the crew chiefs, and the aircrafts' history wasn't difficult.

Colonel Murphy's reputation, integrity, and work ethic centered on scheduling. With 27 F-4Es authorized and 24 or so on station (2 or 3 were often at programmed depot maintenance), his ironclad policy was to keep half of them on the ground for scheduled, unscheduled, and delayed maintenance; time compliance technical orders; washes; paint; weapons load training; and so forth. He forbade any tail number *swapping,* with the policy concurrence of the deputy commander for operations and the wing commander. In short, if aircraft 421 was scheduled to fly on Monday, Tuesday, and Thursday, it damn well flew on those days. No one substituted one airplane for another, or they would have been fired. Case closed. If the wing commander took aircraft 551 to Kunsan for a conference on Monday and returned that evening with it out of commission, it was not substituted if it wasn't able to fly as scheduled on Tuesday. That's what spares were for. On a typical day, using 11 jets, the schedule called for 9 + 3; that is, 8 + 3 spares on the first go. The turn was a diminishing rate, 8 + 4, then 7 + 5, and so on. I recall, quite early one morning when driving down B-ramp, seeing two crew chiefs scuffling in front of a shelter. I broke it up and asked why they were fighting. Colonel Murphy had been by that morning and said the crew chief of the aircraft flying the most sorties that day would get something special from him (probably a six-pack if memory serves me.) The scuffle broke out because one crew chief's airplane was a spare that day and he was being teased by the other guy because the spare would never be flown and was thus ineligible for the Alpha One *special*.

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Combat turnarounds occurred almost every day. A special location was set up where returning jets were *combat turned*, engines running, weapons loading, refueling (engines were shut down), and overall servicing, including the through-flight inspection. We often *turned* aircraft in less than 30 minutes. Given the scheduling scenario of a diminishing number of follow-on sorties with each turn, there were always plenty of airplanes available, mainly because of the discipline Murphy had established for scheduled maintenance on nonfly days. That was the key to his extraordinary success. (From July 1978 to July 1979, the wing had an astonishing 1.02 sortie rate for the F-4E.) I cannot emphasize enough the discipline that made this system work. No one changed the weekly schedule, where tail number assignments were published. It was common at the end of the flying day to have airplanes fully mission capable and no pilots to fly them. There were no exceptions to the *no change* policy unless we had an operational readiness evaluation or operational readiness inspection (ORI), and obviously, the wing then had to generate *all* aircraft.

Perhaps now would be an appropriate time to share an event that occurred on 9 November 1978 during an ORI. At about 1700, following an especially tough flying day (one F-4 needed

an engine change, and one had a serious fuel leak), the Pacific Air Forces (PACAF) ORI team landed after holding on final for an F-4 to be removed from the barrier. The senior maintenance inspector, Lieutenant Colonel Harry Blue, went directly to job control where the commanders and maintenance supervisors were assembled. Harry walked in, checked the status, got the *brief* from the maintenance control officer, and commented to me when he walked out, "You'll never make it." We had 24 F4-Es and about 15 OV-10s, and no one knew how many RF-4Cs Kadena would send us. Of the F-4s, five were in very serious shape, including one in phase and one in phase prep, besides the two with major problems mentioned above. We needed to generate all 24 F-4s in 12 hours, or by 0500 the next morning, to get the top rating. We returned to our squadrons, established the shifts, and subconsciously fretted over how in the *Sam Hill* we would get it done. Murphy always went to the officers club for dinner at about 1800. Always. There was a special maintenance table at the club in those days that sat about a dozen people. The head seat was Alpha One's. No one else sat in that seat, unless it was a tourist (upon which Murphy would exit the club and go to his quarters). That infamous night, Murphy went to the club as usual, ate alone (the rest of us were sweating bricks on the flight line), and then went to his quarters on the hill. All night, we watched the activity on the line, and one by one, the jets came together. Murphy showed up at about 0400, just in time to watch the last of the engine changes—the engine run and the preflight completed about 5 minutes before the 12-hour generation expired. All 24 F-4s, OV-10s, and RF-4Cs were in-commission and preflighted. The ORI report read in part:

> The professionalism displayed throughout the maintenance complex was the best observed in PACAF.… "Excellent" rating for the DCM complex … and, "highly commendable" on the unit's miraculous recovery from severely degraded maintenance following an especially tough flying period.

Months later, during a rare post-dinner exchange with Alpha One, I asked him about that evening. "Colonel, during the most important period of time during our assignment here at Osan, you were in your quarters. I don't understand." His comment was enlightening, "Jay, I spent months preparing you and the other members of my team to go to war. My goal was to put you all in a position to lead the effort, and you did. I wasn't needed, and my presence would have had a negative impact on your efforts."

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Aside from the normal, day-to-day activities of a flying unit, our role as commanders was to deal with our people and their problems, with an unrelenting eye (and ear) on generating airplanes. Not that we had to have the job control net in our office (we didn't), but our maintenance supervisors were always keeping us informed. Murphy made it very clear to all of us that *production* meant senior NCOs and *management* meant officers. The real power belonged to the E-6/E-7 line chiefs and our superintendents. The officers provided the wherewithal for them to do their job.

Which brings me to the subject of meetings under Alpha One. He believed big meetings with lots of people invited decisions to be made at too high a level. He felt that hardly ever in a meeting atmosphere does the DCM make a decision that couldn't be made better by someone below him. He also said that because the boss in those circumstances seldom had enough information to make the right decision the decisions made were "usually unmade by sundown." He believed the DCM should do only those things that only he could do. For example, he thought it was most absurd to have people call him to get approval for cannibalizations. Most of the decisions traditionally reserved for DCMs were, in his view, inappropriate because they were decisions dealing with the minutiae of executing plans, programs, or schedules. Murphy decided, with advice, how many sorties to fly in a period and what patterns to use in scheduling. He would set the policy on what types of things to cann or what types of missions to support. That would allow others to make the right decisions on each occasion. So what about his meetings? There was only one, the *Seventeen-ten* (1710). The meeting was called by the noncommissioned officer in charge (NCOIC), Deficiency Analysis (an E-7) whenever there was a deviation from the day's flying schedule (air abort, ground abort, maintenance nondelivery). It didn't matter if it was triggered by a deviation at 1700 that day or 0730, and if there wasn't a deviation, there was no 1710. Each commander; maintenance supervisor; complex superintendent (a chief); QC officer; maintenance control officer; job control officer; and NCOIC, Deficiency Analysis showed up in Murphy's small office. There weren't enough seats, so one person stood (usually Captain "Bubba" Parker, my maintenance supervisor). The meeting began promptly at 1710. Murphy wanted the entire wing complex, most of whom had gone to their quarters by then, to know that the

DCM complex was on *point*. The NCOIC, Deficiency Analysis opened the meeting by saying something like, "Aircraft 330 had a ground abort for a leaking brake," upon which Murphy would look right at me with hawklike eyes and ask why. Bubba would tell him the brakes had been changed in phase the day before, and Murphy would look at Luke and ask why. Captain Steve Smitherman, the Equipment Maintenance Squadron maintenance supervisor, would say, "Sir, the brake stack was installed backwards and Airman so-and-so was unsupervised, and Staff Sergeant Smith or Jones failed to do an IPI." Murphy would then look to the QC manager (Major Rich Romer) and ask why QC didn't catch it. Sometimes this dialog would last half an hour on each deviation until he was satisfied the root causes were discovered. Days with more than one deviation often had the 1710 go way past 1830. After deviations were discussed, every repeat and recurring writeup written since the last 1710 meeting was discussed. Sometimes, we hashed over scores of these with the same dissecting inquiry used on the deviations. At least we had time to prepare for these. I recall never going more than a couple of days without a 1710 that year with mixed emotions, because if we had, it would have allowed a lot of repeat or recurring writeups to pile up.

After the 1710, most of us returned to our offices to wrap up the day and make sure the swing shift course was set. Then off to dinner at the officers club, where we would probably find Alpha One finishing his meal and others in various stages of dinner. The dinner period was enjoyable—not a lot of shoptalk—rather, poking fun at each other and once in awhile taking a fun shot at Colonel Murphy.

Once during our tour, each officer was invited to Murphy's quarters for homemade soup. That was a very special occasion, and surely, all of us have special memories of that event. The setting was a little awkward given the circumstances—a bachelor colonel's quarters—with classical music. The soup was superb. The evening lasted about 90 minutes, and then it was time to go. No shoptalk, just listening to him read some favorite poems or inquiries about our family and life.

Saturdays were like every other day for the most part, occasionally with only half a day flying. We never flew on Sunday. I used Sundays to spend quiet time with each airplane, without any company, to review the forms and evaluate the overall condition of the airplane. Dirty airplanes were not acceptable, and had Murphy found one to be unacceptable, I would catch hell. That included faded paint or greasy fingerprints on access panels. The crew chiefs knew it, too, as they were pampered by Alpha One almost to the point of fraternization. He knew them all by name, often their backgrounds and individual personalities. I recall the image of a crew chief leaning in the open window of Murphy's pickup truck at 0500 or 1000 or 1430, joking with their big boss. He loved those crew chiefs. He often had lunch with them in the flight-line cafeteria, a facility that he insisted on having near the troops.

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I saw Colonel Murphy cry one time, and I hope he forgives me for bringing it up, but it shows the compassionate side of this special person. One of his favorite crew chiefs was a staff sergeant who was on his third year at Osan. He was married to a Korean national and was also one of the most respected mechanics in the complex. This sergeant was indicted for black marketing activities (he sold a washing machine to a Korean). When Colonel Murphy learned of this, he cried like a baby. He was devastated. Murphy spoke on his behalf at the court martial in emotionally muted tones you could barely hear in the courtroom.

There are, of course, far too many memories to capture in this narrative about Alpha One. Each one of us was pushed to our full potential, and in my case, I carried his intensity and focus on to greater challenges in subsequent assignments. It became natural in the years following Osan, when faced with problems and decisions, to find the clear and correct course of action using the foundation provided by him. He was outspoken and light-years ahead of his time, but his focus was always the same. In my later active duty and Boeing years, some of my decisions were challenged and criticized, often by government agencies with a different agenda, but my bottom line was always a clear conscience with the knowledge that I had done the right thing. I owe that to Crawford O. Murphy.

Some of us stayed in touch with our old boss over the years. He retired in the early 1980s and returned to his birthplace and home in Cambridge, Maryland. There he was affectionately known as Neal. I visited him twice and found him to be very happy and comfortable. He remained a bit curt and always the disciplinarian but very modest and full of life. He passed away in the early 1990s.

Crawford Murphy should have been promoted again. He made colonel in less than 15 years, as a nonrated maintenance officer. His downside, I am told, was his impatience with

higher headquarters and the reorganization of aircraft maintenance that was occurring in the Air Force. His attitude on that was unacceptable to his superiors, but he, nevertheless, voiced his objections at every opportunity. His messages were infamous. One I will never forget was known as the *Shah of Iran* message. It started out in a message to Third Air Force and PACAF. "I feel quite certain that the Shah of Iran thought the only obstacles to his program were some older supervisors who were resisting change." He then went on to outline two major logistics initiatives (POMO and centralized intermediate repair facility [CIRF]) in PACAF that he felt were detrimental to "flying plenty of safe and effective sorties," his motto. He believed the idea of a self-sufficient aircraft maintenance unit (AMU), the heart of POMO, was an appealing idea. However, he also felt it took far more fully qualified and experienced technicians than we could afford, working in a more stable environment than we could provide. Additionally, he felt that the specialists, under POMO, were fragmented and that led to instability. Constantly moving and borrowing specialists between shops and other AMUs turned out to be an unsupervised nightmare and led to poor quality work. He also believed the quality of troubleshooting was reduced under POMO because complete malfunction histories were not readily available to supervisors. Finally, he believed qualified supervision was seriously reduced, primarily because the system would not provide the smaller work centers with the higher NCO grades previously authorized in the larger organizations.

Crawford Murphy worked with CIRF for 3 years. He didn't believe it enhanced our combat capability in Korea; he felt CIRF degraded it. Remember, he was managing F-4 and OV-10 aircraft with considerable intermediate-level maintenance requirements. The loss of a reparable asset out of the base-level maintenance system was unacceptable. He also felt that airlift, absolutely critical to a functioning CIRF, made the whole process extremely vulnerable in wartime. The loss of the base-level pipeline, from shop to flight line to supply, was simply unacceptable. His arguments continued with challenges to the economics of the system, the increased damages to avionics line replaceable units, and loss of the capability to rapidly fix bad boxes during wartime.

In his end-of-tour report, he credited the "unparalleled cooperation of the aircrews and their bosses … who willingly did the mission in a fashion that provided us the best chance of success regardless of their personal druthers."

Some Murphyisms:[1]

Crawford Murphy should have been promoted again. He made colonel in less than 15 years, as a nonrated maintenance officer. His downside, I am told, was his impatience with higher headquarters and the reorganization of aircraft maintenance that was occurring in the Air Force.

- Commanders are supposed to command—maintenance control officers are supposed to stay in maintenance control and not bother anybody.
- Maintenance control officers are not supposed to be out on the flight line—that is squadron business, not maintenance control business.
- First of all, it's [maintenance] going to have one boss—me. I will not ask and do not expect either my assistant, my maintenance control officer, or my squadron commanders to set maintenance policy. I want one clear source of policy—me. However, I want my commanders to command. I do not want my staff to interfere in that command.
- The single most important thing controllable at wing level that will advance the sortie-production goal is to follow the weekly flying schedule. Once it has been decided which aircraft will fly on which days, do not change it. If you think just a few changes will be acceptable, you are wrong. When your people realize they can count on the schedule about as well as a sunrise, you can be sure they will fight to fly that schedule.
- I hear officers shy away from field assignments because the risks are high, exposure low, and the work hard and less forgiving. Base-level jobs were, in my opinion, the most difficult—and for me the most rewarding—and they were the ones where the rubber meets the road and the flying and fighting are done.
- Probably the most frustrating job is being my maintenance control officer. Most maintenance control officers think they control maintenance. I don't want that. I want him to coordinate all operations staff and supply matters and coordinate maintenance schedules. The NCOs on the flight line do a marvelous job controlling maintenance and do not need lots of direction. There is no need for directions from job control, just information and outside support.
- I expect being my assistant DCM must be a frustrating affair. I always instruct my assistant to not give any instructions or directions to maintenance people about the job of maintaining aircraft. I never ask him to catch the overflow and do things that I don't

have time to do. The assistant is responsible for civil engineering programming, manpower changes, communications, budget, programs and plans, and training. He is in charge of ORI procedures and maintenance manning in the command post during exercises and preparing nominations for unit and individual awards. Two areas that make me the most money are his actions in manpower and civil engineering matters. No one is usually working those areas daily to get results; he does and gets results.

- I think all squadron commanders who work for me would agree there really are only a few things that I insist be done my way. They have more decisionmaking power than any maintenance squadron commander I know. One of my favorite answers to a question is, "I don't plan to answer that—you do what you want to do." If I think they made a dumb decision, I tell them, but I don't pull the decision up to my desk when they make a dumb one.
- I ask commanders to tell me why we have holes in the schedule and what they are doing to prevent it from happening again. It is useless to discuss preventive action unless you know who did what wrong. Only then can you find out why it is done wrong, identify the cause, and develop a good corrective action.
- Insist that your people be aggressive supervisors. Ask them to do the maximum, not the minimum acceptable. If they are the type person who will do only those things that, if left undone, you could prove they should have done, then they are meeting the standard. To be outstanding, they must do the things their bosses wouldn't even know they had the opportunity to do until they saw it done.
- I warn incoming supervisors they have two tasks anytime they receive a QA report: one, identify deficiencies and, two, do not debate the validity of the report. Once the report is written, the owner of the deficiency needs to fix the problem and prevent it from recurring as best he can. Reporting deficiencies is not a happy business. I want a ranking officer in QA. Only my assistant and I outrank him. Each morning before 0700, I have my QA officer bring me the results of the on-aircraft inspections of the last 24 hours. I want to be in a position to mention success and failure to those responsible as I visit them during the day. I see all QA reports when they have been completed to show cause and corrective action and preventive action. Most failures of QC control inspections are directly attributable to first-line supervisors; either they did not teach the failed technician how to do the job, or they did not insist that the technician do the job he was trained and directed to do.

Notes

1. Taken in part from "Compendium of Things," authored by Colonel Murphy, and sent to me in 1979.

One machine can do the work of 50 ordinary men. No machine can do the work of one extraordinary man.

—Elbert G. Hubbard

Our military culture must reward new thinking, innovation and experimentation.… Every dollar of defense spending must meet a single test—it must help us build the decisive power we will need to win the wars of the future.

—George H. W. Bush

Let it be admitted that the modern technological revolution has confronted us with military problems of unprecedented complexity, problems made all the more difficult because of the social and political turbulence of the age in which we live. But precisely because of these revolutionary developments, let me suggest that you had better study military history, indeed all history, as no generation of military men have studied it before.

—Frank Craven