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AFIT/GIM/LAC/99S-1

AN EXAMINATION OF THE UNITED STATES AIR SERVICE'S LOGISTICS OPERATIONS

THESIS

Andrew W. Hunt, Captain, USAF

AFIT/GIM/LAL/99S-1

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AN EXAMINATION OF THE UNITED STATES AIR SERVICE'S LOGISTICS OPERATIONS

THESIS

Presented to the Faculty of the Graduate School of Logistics

and Acquisition Management of the Air Force Institute of Technology

Air University

Air Education and Training Command

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Logistics Management

Andrew W. Hunt, B.A.

Captain, USAF

September 1998

Approved for public release, distribution unlimited

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Andrew W. Hunt

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Abstract

This historical study details the U.S. Air Service's logistics operations at home and abroad in an attempt to determine the relationship between the process and more recently established logistic principles. The information in the study was collected through an extensive review of both first hand accounts and historical compilations of the nature of World War I aviation logistics. Information regarding the production of the De Haviland DH-4 and Liberty Engine serve as the primary case examples of the operation of the logistics system. The established principles required for comparison were extracted from the writings of a number of expert military logisticians. After a careful review of the information, it seems that the production, transportation and supply aspects of the Air Service's logistics system are in accordance with established principles while he area of domestic production was not. The establishment of a satisfactory domestic transportation infrastructure and a depot system allowed for flexible and timely logistics support. The initial lack of a viable production system nearly grounded the air effort. The Air Service was able to design a fully functioning logistics system in less than two years, and the experiences in World War I provided U.S. military aviation leaders with the knowledge needed to prepare itself for future military engagements.

AN EXAMINATION OF THE UNITED STATES AIR SERVICE'S LOGISTICS OPERATIONS

I. Introduction

This research study focuses on the mobilization of the U.S. Air Service and its accompanying logistics support structure used during World War I. More specifically, it details the processes and systems used to support both inter and intra-theater operations. The purpose of this study is to determine the significant impact of the development of a new system to support a new branch of the armed forces, using comparisons between the system used during World War I and some established logistics principles employed in practice since. There is no definitive work in this area, and it is an area worth investigating since this is the first example of United States air force logistics.

World War I produced fundamental changes in the way the United States prepared for and waged war. Many "firsts" were realized as a result of the scope of the war in Europe. This was the first time that the United States military responded to taskings for substantial amounts of both combat troops and supplies and equipment outside American borders for use on foreign soil. This was also the first conflict in which military aviation played a definable role in the outcome of a military operation. With the inception of combat aviation as a viable tactical tool for use by a nation, a number of obstacles hindered the efficient employment of airpower. Nowhere were the obstacles more evident than in the arena of logistics. No longer could the United States focus solely on supporting ground troops, but the production sector had to augment the nascent

aviation organization as well. A more flexible logistics system had to be designed to address this concern. Without a new system, combat aviation could not evolve into a decisive military instrument.

The United States severely lagged behind the other nations involved in the Great War in terms of both aviation production and aviation logistics support. As late as 1917, nearly three full years into the war, the United States had yet to form an Air Service, and had shown little promise that there would be any help in the form of a fledgling Air Service in the war. As it became increasingly evident that there would be little choice for the U.S. but to enter the war, rapid mobilization and organization of an air arm became a key concern.

Research Question

The issue that this study seeks to answer to determine the link between the logistics practices and systems employed by the Air Service and modern logistics principles. *Were the practices and procedures used by the Air Service to conduct logistics operations consistent with modern military logistics principles?*

Investigative Question #1

To adequately answer this research question, certain specific investigative questions need to be examined. First, *what are the existing logistics principles?* This section is vital, as it provides the basis for subsequent comparisons and discussions regarding the nature of WWI aviation logistics and any possible correlation to modern practices. The views of Admiral Henry Eccles in Logistics in the National Defense and of Army General Carter Magruder (Recurring Logistics Problems as I Have Observed

Them) are relevant, and provide a general understanding of the desired functions of military logistics systems in major engagements. While other views exist, these selections provide a satisfactory look at all relevant aspects of logistics, and are generalizable to different organizations.

Investigative Question #2

The remaining investigative questions deal specifically with the logistics operations during WWI. The first of these investigative questions is based on the birth and evolution of the aircraft industry in the United States, and the effects on mobilization. *What steps did the U.S. take to prepare itself for war in the skies?* What were some of the difficulties in production that arose, and how were they overcome (if at all)? The involvement of the industrial sector in preparing to fight a flying war was immense, and it is critical to note the chronology and methodology of aircraft production in America. The relative lack of a modern infrastructure in the aircraft industry was a significant obstacle, and, in addition to other factors, prevented the Air Service from contributing to the war effort until 1917. While the actual acquisition of the aircraft is not examined in detail, the roles of major builders (i.e. Curtis, Packard) are worth noting. An examination of the production and lead times and the need for raw materials combined with the calculation of perceived requirements sheds some light on the mindset of U.S. Army thinking.

Investigative Question #3

The second logistical question revolves around the US's contribution to the aerial efforts in France. *Why did the United States choose the De Haviland DH-4, and how was*

it produced? How did the United States build a successful airplane engine in the Liberty? Even though the Air Service relied heavily on foreign-built platforms, an American-made derivation of the British designed De Haviland DH-4 played a major role in the Air Service's mission in France. This aircraft was the only mass-produced combat platform built in the United States.

Investigative Question #4

What was the nature of the transportation infrastructure (both in the United States and in France) during the crucial years of 1916-1917? How was the transportation system organized to send and receive material and men from overseas, and was this system adequate? Since the United States had not been involved in a major conflict beyond its borders (at least to the extent of WWI), the shipment of materiel needed to support the initial beddown of the Air Service was a new challenge. As transportation is nearly always a limiting factor, the availability of ocean going vessels greatly influenced the amount of cargo shipped, and consequently, the ability of the Air Service to quickly establish an operational base in theater. In addition, a cursory look focuses on the port operations in France.

Investigative Question #5

What system did the Air Service use to supply its units, and what was the effect of the reliance on foreign equipment? The movement of materiel within the European Theater was vitally important, and is examined. Since the US (and its allies) had never had to support combat aviation prior, all situations encountered in the war were new, and the methods employed to deal with them are certainly of interest. The supply of

airframes was severely limited, so the maintenance of the frames must have been crucial. The method used to redistribute assets to the units that needed them is a vital piece of the logistics system. Further examination determines how, if there was a way, the Air Service proposed to have the right parts at the right place at the right time. In this section, a detailed description of the influence and support lent to the Americans by both the British and (primarily) the French is provided. Increasingly, it becomes evident that the bulk of our logistics system was either based on, or heavily reliant on, our allies' methods and resources. This reliance created both opportunities and obstacles.

There are other activities that were important in the resupply of the aero squadrons. Specifically, the aspects of the salvage and repair operations are worth noting. Since the supply of both engines and airframes was limited, other resources had to be used to keep the airplanes flying. Many of the units relied on parts from downed aircraft or even farm equipment to keep the unit operational. This section illustrates the procedures used to either fix or salvage aircraft damaged on the front.

Outline

The next chapter discusses the methodology used for the study. Chapter III presents a discussion of certain logistics principles outlined by previously named experts in the field. This breakdown includes principles of production, transportation, supply, logistics planning and logistics organization. Chapters IV and V detail the specifics of the logistics operations used to support the Air Service.

Chapter IV examines the pre-war environment of the airplane industry in the United States and details chronology of the production of both the DH-4 and Liberty Engine. The chapter also illustrates the domestic transportation system used to send the

necessary supplies and airplanes overseas. Chapter V discusses the intratheater logistics operations used to support the Air Service in France. This chapter includes sections on the Air Service supply system, as well as the periphery operations, including salvage and repair. Each chapter includes a summary section that identifies general themes in the actual events, and compares and contrasts them to the principles outlined in Chapter III.

The final chapter of the research study answers the overall research question by summarizing the findings of each of the specific investigative questions. In this chapter, the principles visible in each area of the Air Service's logistics support structure are identified and compared to the established principles originating, for the most part, after the Second World War. Of particular interest is determining if the logistics decisions and systems used from 1917-1918 are concurrent with these established principles.

The logistics challenge that the United States tackled during World War I was daunting. The inception of a brand new combat arm produced a large number of obstacles. Support of ground-based combat troops was an established practice; however, never before had the United States had to develop a system specifically to provide for combat aircraft. The obtaining of aircraft and transporting of materiel to support them were initial hurdles. Once established in the European Theater, the Air Service's focus shifted towards the re-supply and regeneration of these same aircraft. This research study details the process used during the war to ensure that the United States Air Service was able to uphold the tenet that would officially be adopted with the formation of the United States Air Force: to fly, to fight, and to win.

II. Methodology

To determine if the logistics processes used by the Air Service were similar to the theories stated in modern logistic principles, certain data was needed to assess the specific nature of those processes. Three data categories are used in this study. Generally, any information pertaining to the areas of production, transportation, supply and logistics planning and organization was extracted from a variety of first hand sources. Specifically, one category of data includes raw data associated with both the domestic and overseas logistics operations. Numbers representing tonnage sent, production rates and repair output, among others are important in understanding the situation facing the Air Service. Particularly, information about the De Haviland DH-4 and the Liberty Engine are of interest, as these two items represent the bulk of the U.S. production contribution to the war effort. A second category of data consists of conceptual data. The production environment, the transportation system and the supply structure are among the concepts required to create an adequate image of the Air Service logistics system. The third category of data includes a breakdown of established logistics principles offered by military logistics experts.

To obtain the numerical and quantitative data specific to the logistics operations, an extensive review of first hand accounts was conducted. Certain accounts were written in 1919, immediately after the end of the war, while others are more modern compilations of relevant data. While there are discrepancies in certain areas (in terms of numbers), the discrepancies are minimal and do not detract from the significance of the data. A separate review was completed to gather the accepted logistics principles. These sources

are selections from different time periods, but each of the principles presented can be generalized.

The first task in the study is the synthesis of these principles to determine if there are consistencies between each author. The wording may be different, but the concepts and the themes are similar, and easily detectable. The second task is to determine which, if any, of these principles is evident in the specific logistics operations used during World War I. A detailed account of the logistics operations is provided, and from that, general comparisons between the operations and the principles are diagrammed. The third and final task is to provide a comprehensive analysis of the logistics operations and associate them with the appropriate principles. Using this analysis, the study attempts to determine the significance of the formation of the Air Service logistics system as it pertains to the accepted logistics principles.

III. A Brief Review of Logistics Principles

To accurately discuss the effects of the formation and evolution of the nascent US Air Service logistics support structure on the area of military logistics, a review of basic principles is necessary. While there are many experts in the area of the efficient organization of the logistics arena in conflict, this study focuses primarily on the writings of select leaders in military logistics. Rear Admiral Henry Eccles (author of Logistics in the National Defense) served in the United States Navy during World War II and Korea, and is considered to be a leading military logistics expert. General Carter Magruder served with the US Army in World War I, II, Korea and Vietnam. He served as the top army logistician prior to his retirement. While Eccles and Magruder are the predominant sources for this section, each author presents a view of logistics lessons and limitations applicable to and derived from engagements, including those in World War I. What will be interesting to determine in this study is what type of impact the logistics support structure had on these lessons and limitations, and how much of what Eccles and Magruder (and others) have written are consistent with modern logistics operations, specifically the US Air Service portion of it, during World War I.

The 1996 Joint Chiefs of Staff Doctrine defines logistics as "The science and carrying out of the movement and maintenance of forces" (Joint Publication 1-02). Basic to this "movement and maintenance of forces" stated above are the key components of the logistics system: production/acquisition, transportation, supply/materiel, planning/organization and repair/regeneration. As will become increasingly evident, the principles governing these areas, while worded differently, possess nearly identical meanings. Magruder and Eccles, and others, offer their respective thoughts on each of

these aforementioned topics. This section of the study outlines each perspective on these areas vital to effective logistics support.

Production

Magruder mentions extensively the importance on national production and procurement as a key to successful support of military operations. Specifically, Magruder writes that it is necessary to possess "a flow of material from new production that as soon as practicable, will become equal to the expected rate of consumption by all theaters" (Magruder, 1991:120). He notes that this is key to an adequate system of resupply from the United States, and infers that it eliminates an unhealthy dependency on foreign aid in this area (Magruder, 1991:3). While domestic production is vital, Magruder does seem to understand that the initial involvement of a military force in a conflict will place heavy burdens on organic production facilities. He states that it is important for there to be a certain level of reserves, domestically, to satisfy supply requirements until production capabilities are either expanded or developed to meet the needs of the operation (Magruder, 1991:120).

Like Magruder, James Huston, author of Sinews of War, notes that during times of large-scale military engagements, the American industrial economy is heavily tasked to support the production of materiel. Huston notes that in a conflict with the implementation of new weapons of war, there are concerns in the production sector. He observes that a new weapon (or piece of equipment) may incur "delay(s) in production," and experience supply difficulties (Huston, 1966:660). This phenomenon is evident in the early days of combat aircraft production in the United States in the months preceding total American involvement in WWI. Along these lines, Huston notes that ease of

production of certain equipment may be just as important as, if not more important than, battlefield performance (Huston, 1966:660). Historically, Huston acknowledges the advantages gained by the United States' superior production. Both in World War II and Korea, domestic production capacities were large enough to offset the production capabilities of the enemy in the initial stages of the conflict (Huston, 1966:617). Of interest is the United States' ability to increase its production levels. Now the U.S. had to accommodate not only its own new war interests in 1918, but also to continue to meet the increased demands of the allies during the war.

Finally, in regards to the importance of domestic production capabilities, Richard Heiser echoes these sentiments. Author of A Soldier Supporting Soldiers, Heiser, like Magruder a top Army logistician, notes explicitly that production capacity is a "key element," and its requirements "are a mandatory element when planning mobilizations" (Heiser, 1991:263). He also states that "logistics processes should be established in peacetime to assure prompt support for critical items in war in order to minimize production lead times" (Heiser, 1991:262). Heiser states that the production capabilities of a nation determine the logistical support available (Heiser, 1991:263).

Transportation

Many experts agree that transportation can be the most problematic area in the arena of logistics. While efficient transportation systems allow the timely and accurate transfer of personnel, equipment and other war-fighting materiel vital to the success of military operations, an inadequate system will doom any operation. Encompassed in this subject are two main areas: 1) domestic and overseas transportation and 2) intratheater transportation. Domestic and overseas transportation includes the movement of materials

from the source of production (for materials) or bases (personnel) to the port of embarkation to a port of debarkation somewhere in the theater of operations. Intratheater transportation is concerned with the port operations in the host country, the movement of materials to a forward reception area, and the dispatching of those materials to operational units. During World War I, the national transportation systems of the United States, Britain, and France were severely tested.

Magruder illustrates the overall importance of and reliance on transportation in carrying out operations. Magruder states that "if the transportation system will support, or can be developed in time to support, the forces necessary to carry out the operational plan, the rest of the logistics can usually be brought into line in a reasonable time" (Magruder, 1991:42). In World War I, this system starts with organic, domestic transportation, crosses the ocean in large ships, and ultimately ends (for Air Services purposes) at the using airdrome.

A specific and major transportation hurdle is the arrival at and departure from, the port of embarkation. Smooth port operations are key to an overall effective overseas transportation system, as noted by both Eccles and Magruder. "Major congestion at ports of embarkation," Magruder notes, "can disrupt the national land transportation system, and can lead to disruptions to basic industry" (Magruder, 1991:181). During the initial stages of involvement, the strain on the domestic ports is at its highest. As the rapid mobilization of personnel and materiel descend upon the major ports, the operations at the port are under strict observation. Again, Magruder illustrates the fact, stating that "outgoing flow of cargo increases rapidly and...in major crises, this has always overloaded the receiving and distributing capacity of the overseas (and domestic) ports"

(Magruder, 1991:181). Heiser echoes the statements of Magruder and adds that "transport capability **must** [emphasis added] be balanced against CONUS output of personnel and materiel and all necessary retrograde [repair parts]" (Heiser, 1991:142). Eccles adds his thoughts in the form of a transportation objective, notes that "If the overall cargo operation can be designed so that cargo can be unloaded direct from a point to point cargo ship to a using combat ship or to a fleet issue ship, a great saving in cargo handling facilities" can be realized (Eccles, 1947:176). Again, the relevance of this issue to the initial stages of American mobilization in 1917 is evident. Never before had the United States had to send a significant amount of war materiel, and simultaneously, never before had her allies had to make provisions to receive such a quantity of equipment.

Supply/Materiel

The efficient and effective supply of operational units and the resupply of rear echelon organizations are critical components of waging war. It is an even greater challenge to conduct these supply operations in a foreign country, relying on assistance from the host country. To accomplish this effective supply goal, an organization must focus on three key areas: 1) forward supply and distribution, 2) resupply, and 3) use of local resources (meaning organic spare parts, facilities, and so on). The domestic aspect of resupply is covered, initially, in the production phase of the logistics spectrum. This section focuses on principles regarding supply and resupply of troops already in the theater of operations.

Both Eccles and Magruder explain the details of generalized forward supply operations, noting the importance of forward-stocked inventory on capability. Eccles says that a forward supply system limited to "fast-moving military essentials" will

provide better efficiency at lower costs than trying to stock every item used (Eccles, 1947:186). Additionally, Eccles claims that a supply system stripped to a minimum will prevent "logistic snowballs," an uncontrollable spiral that quickly renders a logistics system untenable (Eccles, 1947:187). This stripping allows the supply system to remain "resilient" and provide the best support to the logistics structure possible (Eccles, 1947:187). Determining what (and how much) to stock, Eccles notes, should be based on experience (Eccles, 1947:188). This point is of interest, since the Air Service had no previous experience to draw from at the time of involvement.

A separate aspect of forward supply is the presence, operation and resupply of depots. These centers served as receiving, repair, adjusting and distribution operations, and (at least in WWI) are an important piece of the logistics puzzle. Magruder and Eccles mention these centers, Magruder focusing on requirements and Eccles focusing on management. Magruder calculates that the correct design of a supply system "must take into account the levels or capacity to supply at each point of storage and issue" (Magruder, 1991:143). Eccles states that to efficiently manage depot supply requests and inventory levels, a system of dispatches must be correctly used (Eccles, 1947:188). These dispatches will enable commanders to reference an accurate record of usage, and facilitate the calculation of supply requirements. Meanwhile, Heiser offers a similar point of view on forward located depots, stating that depots "must be eliminated in objective areas and replaced by mobile logistics general support to back up direct support in supply" (Heiser, 1991:262). Heiser believes that a rapid transportation system will eliminate the need for these centers. As we will see during WWI, the French

transportation system was not adequate to warrant the total removal of supply depots, but the Air Service was able to minimize the need for fixed centers near the front.

Always a pivotal factor in the success of combatant forces, the resupply of operational units on the frontline depends primarily on two areas: 1) transportation and 2) allocation procedures. As mentioned earlier, Eccles emphasizes the need for an efficient and responsive transportation system to reduce the amount of forward stocked materials and to provide lean, cost effective logistics support. However, a large forward-stocked inventory policy can render this fast transportation system irrelevant. Eccles describes in detail the use of a firm allocation plan during World War II to distribute material to the proper place at the proper time. Eccles states that "each commander should have enough capability in each logistic category to handle those small but vital day to day tasks on which his flexibility depends" (Eccles, 1947:156), and that the development of a priorities system in 1944 attempted to regulate the "flow of personnel and material" (Eccles, 1947:149). Magruder puts an operational slant on allocation, noting that "the criticality of operations being conducted will dictate the allocation of munitions to theaters and the rationing of ammunition within theaters" (Magruder, 1991:121). While he specifically mentions ammunition, the statement is most likely applicable to all materiel. The importance of logistics planning and discipline is revisited later in this chapter.

The final area of supply examined in this section is the utilization of local resources to increase the efficiency and readiness of combatant forces in a foreign country. Though not nearly as well documented as the previous areas, the use of local resources proved to be a necessary tool for the Air Service in France. Magruder

discusses the necessary evil of using local resources, but caveats the use by stating the need for eventual increase in domestic production to limit our reliance on these local resources (Magruder, 1991:3). He believes that heavy reliance on foreign suppliers limits the capability of a soldiering body if the level of support changes abruptly. During the French campaign, numerous passages were written by first hand sources detailing the reliance of the United States on both the French and the British for aircraft production, pilot training, spare parts and other necessary material.

Logistics Planning

Without adequate planning, the previously addressed components of military logistics are useless and irrelevant. Eccles provides an excellent definition of logistics planning: "[Logistic planning] is the incorporation of logistic consideration into the formulation of strategic and tactical plans" (Eccles, 1947:69). He also notes that "if, in the early stages of an operation, the logistic support is deficient, it will not be possible to fully exploit an early or unexpected tactical success" (Eccles, 1947:108). He suggests that two fundamental concepts behind successful logistics planning are accurate estimation and realistic capabilities planning.

According to Eccles, estimation (and, in turn, a vital part of Logistics Planning) is "detailed planning for the logistic support of the combat forces which are carrying out the decision reached through the estimate of the situation" (Eccles, 1947:69). Eccles infers that once the conflict or operation is in progress, it is too late to begin initial planning. Initial planning may not, and most likely will not be precise, but must have a degree of feasibility consistent with the scale of operation that has been executed. A key to the suitability of a successful initial logistic support plan for a contingency is the primary

ability to recognize far enough in advance all requirements in the transportation field and any special requirements for service troops or materiel beyond those provided (Eccles, 1947:49). Heiser provides more input, citing that "discipline in establishing requirements ensures the optimum economy of the logistic support force to meet combat readiness and effectiveness" (Heiser, 1991:261). Again the focus is on the economics of the support provided given fixed inputs. This area of concentration is evident in the second component offered by Eccles, capabilities planning.

Capabilities planning is another facet of the logistic support plan that can accelerate either the success or the failure of an operation. Eccles takes a common sense approach to the subject by relating the forces employed with the materials used to support them (Eccles, 1947:69). Eccles notes that the amount and type of resources an organization has available will determine the strength of the body sent to wage war. It is imperative to employ only those troops that can be adequately provided for given a fixed amount of resources. Decisions made at the strategic level, Eccles notes, must make sense at the capabilities level as well.

Logistics Organization and Procedures

Prior to the actual planning of logistics operations is the tangible, organizational set-up of the logistics support structure. Eccles offers insights into the relationship of the logistician to government officials, as well as to the foreign national equivalent. With regards to the interaction of logistics and national strategic policy decisions, Eccles suggests that "international and national situations and decisions...must be continuously interrelated. Therefore, our own governmental organizations must work with their

opposite numbers in other nations and with various special or permanent international organizations" (Eccles, 1947:63).

Eccles also notes that organizational flexibility is key in successful planning and reaction. As an example, he cites Hitler's resistance to tactical retreats as the antithesis of the inherent need for flexibility in an organization, and subsequently asserts that a "single chief of staff...will almost inevitably become the slave to an inflexible and dogmatic strategy" (Eccles, 1947:117). He stresses the need for increased communication between individuals of different countries, and notes that all senior logisticians responsible for theater operations must have "global" experience in order to fulfill the position's extensive requirements. While directly linked to the above statement of interrelationship, this point of view is decidedly post-WWII, as there was no formal theater (or component) commander for logistics in WWI.

In terms of detailed organization, Eccles gives little guidance except to say that the goal of establishing an organizational structure should be stability. That is, modifications of organizations during times of war "should not be such as to require a major shift in command structure on outbreak of war" (Eccles, 1947:118). This desire to possess stability and operations no matter how difficult the situation is a view shared by Heiser. Heiser agrees that, within reason, logistics policies and procedures should be the same in peacetime as they are during times of conflict. Specifically, Heiser states that soldiers "should have a single source of logistic support" (Heiser, 1991:262).

Summary

The previous sections have presented a basic outline of major logistics principles. While the views of each of the authors primarily result from their own personal

experiences, it is evident that no matter the situation, the ground rule tenets of logistics apply. As mentioned earlier, the goal of this study is to identify the nature of the logistics operations in World War I and their relationship to subsequent theoretical formulations. Since World War I was the first opportunity for the United States to deploy troops and materiel in large quantities overseas, the obstacles and challenges faced and (perhaps) overcome during her involvement are of great interest. Undoubtedly, the lessons learned during the mobilization, execution and demobilization during this war had far-reaching implications in logistics planning, organization in an inter-allied structure and overall policies and procedures.

While examining the specific transpiration of events from 1917 to 1918, these principles will be revisited to determine if the logistics principles demonstrated by the American Expeditionary Force (AEF) and more specifically, the Air Service are similar to those articulated by Eccles, Heiser, Huston, and Magruder.

IV. From Production to Operations: 1916-1918

Introduction

Understanding the initial overwhelming magnitude of the task facing the organizers of the Air Service is key to understanding the meteoric rise in the development of American military aviation. In the years preceding total American involvement in the war, the aviation industry in this country was, for all intents and purposes, nonexistent. In 1908, the Wright brothers presented the idea of using their new flying machine for military purposes to the Army. After that meeting at Fort Meyer, Virginia, continuing efforts to increase the viability and utilization of the airplane in a military role were minimal, at best. The outbreak of the First World War in 1914 did seemingly little to rekindle a fire that had for six years been barely flickering. As American intervention in the war became more and more likely, politicians and generals alike sought to determine where the U.S. could help the most. Undoubtedly, the U.S. Army would send troops and tanks to the front, but an opinion gaining momentum in Washington was that America might prove a better ally if she were to provide an Air Service to the theater.

The role of the airplane in the war had evolved quickly from simple scouting and artillery spotting to aerial troop support and bombing missions. No longer was the airplane a novelty; now it was a military necessity. In an impassioned statement to the U.S. government in the spring of 1917, French Premier Ribot urged that the U.S. make a sizeable contribution to the production and deployment of aircraft in the European theater (Sweetser, 66). Seeing an opportunity to have a greater impact in the war not only on the battlefield, but also above it, the government began a renewed effort to establish a legitimate aircraft production base in the United States.

Unfortunately, the apathy pervasive in the industry until 1917 meant that serious obstacles existed. Little had been done to advance the technology of the airplane to the same level as that of the airplanes flown by the combatants as early as 1914. There was a limited production base that initially proved totally inadequate to the challenge of contributing any meaningful, in terms of aircraft production, to the war. There was no significant information base from which to draw technical expertise in the construction of these new, military-specific airplanes. And, there was no prior experience available to direct and guide those in charge of managing this Herculean task. This was most evident in the arena of logistics. Never before had the U.S. had to plan for a production and movement of this size, nor had there ever been an obstacle the size of the Atlantic Ocean to hinder the efforts of planners to sustain such an operation. Nevertheless, failure was not an option. The United States ***had*** to provide a sufficient (in both capacity and ability) air arm if the allies were to have any increased chance in winning the war above the trenches. As a member of the newly formed Aircraft Production Board said, "the eagle must win this war" (Sweetser, 1919:77).

Each area of logistics, from production to repair, presented a relatively new challenge to the individuals in Washington, and on the Western Front. In as little time as possible (roughly 14 months), an intricate system was established to deploy airplanes, and then to provide the battlefield logistics support necessary for the Air Service to keep the allied skies clear.

This chapter examines the state of the aircraft industry (and the associated logistics issues) before and during the First World War. Specifically, the chapter is divided into four separate sections. First, there is a discussion of the state of the industry

in late 1915 and early 1916 to include existing aircraft, facilities and production centers. A second section examines the logistics methods used and hurdles faced in attempting a rapid mobilization that had never been done before. In this section, the formation of the organizations responsible with the forming of the Air Service is mentioned briefly. The majority of this section, however, focuses on the trials and tribulations of actual aircraft production, specifically of the American version of the British De Haviland DH-4. From raw materials to finish goods, the generation process of a satisfactory aerial platform was expensive, untested and time consuming. As aircraft were needed in large numbers in a minimum of time, this process is worth investigating. The lack of an existing infrastructure in the airplane industry meant that the production process was created from no prior models. A third section of the chapter focuses on the planning and construction of the Liberty engine. Like the DH-4, the production of this powerhouse required logistics efforts not seen prior to 1917. Finally, this chapter examines the transportation operations used in sending both planes and motors (along with the men to support them) to the European Theater. The extent of the mobilization required changes in the domestic and international transportation practices used by the United States.

Hopefully, it will become clear that certain practices employed during this time actually set the standard on how to prepare for an air war, while other practices necessitated the need for improved methods that are now essentially the operating standards.

The "Air Service" Before the Americans Entered the War (1915-1917)

While the war raged in Europe, no appreciable steps were taken in the U.S. to increase the capacity of its air arm. In 1915, the entire inventory consisted of 55 airplanes, all of the training variety. Of this astounding number, General John Pershing, commanding officer of the Army commented that "51 are obsolete, and the other 4 are obsolescent" (Hudson, 1968:3). James Hudson, author of Hostile Skies, stated that even though the primary need for airplanes was of the training variety, it should be noted that the inventory included not a single combat (bomber or pursuit) plane (Hudson, 1968:3). While there were aerial operations in the Mexico campaigns, none were considered combat missions; airplanes flew observation missions in support of the soldiers on the ground.

Additionally, the military possessed and operated only two dedicated flying fields, one in Texas and one in New York (Hudson, 1968:3). More fields would, however, be in service as American preparation for the war increased. In terms of personnel at the time, the Air Corps was just as lacking. Of the 131 officers in this branch of service, only 26 were considered "fully trained" and not a single member of the U.S. military had "had actual combat flying experience" (Hudson, 1968:3).

While the aircraft situation before the U.S. entered the war was dire, few options available were available to correct this problem. During 1915 and 1916, the Curtiss Company was, for all purposes, the sole production-oriented company capable of contributing anything substantial in terms of airplane output. According to Arthur Sweetser, author of American Air Service, the company was producing 100 training planes per month for the British (Sweetser, 1919:187). Within a year, the number of

contractors that the government employed to construct airplanes increased to nine companies, tasked to produce 366 planes (of which only 64 were ever delivered) (Hudson, 1968:3). It is evident that the United States was woefully unprepared for the events that would transpire in the coming years.

American Aviation Prepares for War

In late 1916, it was apparent that the United States would soon be a major participant in the war in Europe. As such, it would undoubtedly send its Army to fight along side the British, the Italians and the French. But its contribution would not be limited to the role of the doughboys. With louder and louder voices, the American allies embroiled in the conflict across the ocean urged the United States to contribute a sizeable air arm. As the U.S. was the pioneering nation in the frontier of flight, it should be able to accomplish this task fairly easily. However, as mentioned earlier (and a statement that will be a recurring theme), the apathy in American aviation made this request a Herculean one. Before 1917, in the United States, civil aviation activities were not at a level that could be considered significant (Hudson, 1968:6). "America, with the apathy of peace had been outdistanced by the belligerents in the science of aviation" (Sweetser, 1919:46).

Formation of National Committee on Aeronautics and the Aircraft Production Board

The first signs of life in the dormant military aviation sector surfaced in the late winter of 1917. On the 5th of February, the air arm of the army decided to prepare an initial estimate on the aviation requirements needed to support an organization of regulars, volunteers, and National Guard. Initial dollar amounts neared a staggering $49

million (Sweetser, 1919:43). Again, the capacity of the industrial sector to handle these requests was unknown. In the first few months of 1917, the number of contractors utilized by the government stood at 11, and nearly 300 planes were on order (Sweetser, 1919:45). For the first time, thought was given to managing the production and acquisition of these materials. The National Committee on Aeronautics was established in March of 1917; its mission was to bring together the manufacturing sector and the government due to a noted "lack of cohesion" (Sweetser, 1919:45). This bureaucratic body was designed to prevent possible duplication of efforts and keep costs under control, among other things. The committee, headed by Dr. Charles D. Walcott, recognized the absolute lack of airplane manufacturing capability, and suggested that to speed up production and mobilization, a standardized training plane for use by both the Army and the Navy be adopted as soon as possible (Sweetser, 1919:47).

In April of 1917, the government formed the Aircraft Production Board (APB) to oversee the production plans and projections for the Army Aviation Sector. This organization was the focal point for all military aircraft production, and was solely responsible for ensuring that the United States could field a viable air contingent. Headed by Howard E. Coffin, an automobile manufacturer from Detroit, the APB began its crusade on 12 April, six days after America formally entered the war, with the announcement of a 3-year production plan: 3,700 aircraft in 1918, 6,000 aircraft in 1919, and between 9,000-10,000 aircraft for 1920 (Sweetser, 1919:49). Initially, the main focus of the Board was the production of trainers. The rationale behind this decision was that there was little or no knowledge of battle planes in this country, and that the gathering of information over the "next 6 months" (April-October, 1917) from the allies

would slow production to the extent that the output realized by manufacturers would be of little use in the war effort (Sweetser, 1919:52).

Since the airplane production sector was so far behind, the Aircraft Production Board proposed a deal with the French that would allow the military to make a more immediate impact in the air war in Europe. In May 1917, the U.S. proposed a 16,500-ton shipment of men and materials to France in exchange for airplanes, motors and land for airfields (Sweetser, 1919:61). In August of the same year, the deal was revised to read that France would send 5,000 planes and 8,500 engines in return for tools and materials needed (U.S. Air Service, 54). This deal seemed feasible, as at the time, the United States had greater quantities of human and material resources, while the allies had a greater capability to produce combat ready aircraft (Sweetser, 1919:61). This early reliance on the French would be a pervasive theme throughout the war.

American Intervention Requested

In the summer of 1917, the French and British governments applied the most direct pressure to the American aviation sector. In a meeting between former French Premier Vivani and Britain's Lord Balfour, the common sentiment was that the United States could do more to help the allied effort by "sending a powerful air force to the Western Front in time to participate in the 1918 campaign" (Hudson, 1968:4). Soon after that meeting, a statement issued by Premier Ribot on May 26 urged the U.S. to furnish a flying corps of 4,500 aircraft, 5,000 pilots and 50, 000 mechanics (Sweetser, 1919:66). After this initial requirement, Ribot requested that there be 2,000 planes and 4,000 motors built in the American factories each month until early 1918 (66). The extravagant problem may have been given to Ribot from an adamant proponent of military aviation,

Lt. Col. Billy Mitchell (Hudson, 1968:5). Amazingly, these requests were deemed by the Aircraft Production Board to be accessible, and they "laid the foundation for aviation as it exists today [1919]" (Sweetser, 1919:66).

The sentiments for American air involvement were echoed by many. Secretary of War Newton Baker said that the formation of an air arm "seems...the most effective way in which to exert America's forces at once in telling fashion" (Hudson, 1968: 6). Said Orville Wright, still an active participant in the aircraft industry, if the allies have a sufficient number of airplanes to keep the enemy planes back, and their "eyes can be put out—it will be possible to end this war" (Sweetser, 1919:81).

Aircraft Production-Initial Efforts

Now that a crude production projection was in place, the military began to tackle the immense logistics effort required to support this massive mobilization. Not only were the engineers and manufacturers under a severe time constraint, but there was also no experience in the production of battle planes from which to draw to make this process any easier. Unfortunately for the United States, the Army had not sent observers to Europe to get the necessary technical information for the construction of these aircraft (Hudson, 1968:3). "Much of it [the project] had to be drafted in the dark," and there was a "supreme need for haste" (Sweetser, 1919:67).

The journey of aircraft production began on the 24th of July 1917, with the passing of the Aviation Act in Washington. This legislation provided $640 million (although this number would decrease dramatically in the year ahead) for the research and design, supplies and manufacturing and procurement of airplanes (Sweetser, 1919:88). The initial projections for having 2,500 operational DH-4 aircraft by January

1, 1918 available for training were deemed "totally within reach...and immediate efforts were taken to build 500 training machines" (67). The idea that actual production of airplanes in these numbers may have been extremely optimistic.

Obstacles to Initial Production—Inexperience and Raw Materials

Perhaps one of the biggest obstacles facing the military in the pursuit of airplane production was the lack of experience in the logistics arena. No one involved had any appreciable expertise in this area, and the events that transpired in the late summer of 1917 brought this fact to light. The years of inexperience prior to this time proved nearly fatal to the initial efforts of the Army. Although the allies had previously turned to the United States for assistance in the supply of ammunition, they did not rely at all on the U.S. for the production of airplanes (Hudson, 1968:3). That being said, the airplane industry was nowhere near capable of responding to the initial requests, and even the work done since America entered the war had been "wholly inadequate" (Sweetser, 1919: 94). Not only was the industry incapable of significant production, but the raw materials needed were also difficult to procure (Hudson, 1968:12).

The WWI airplane was constructed mainly of wood and linen held together by a series of wires, stitches and adhesives. The wood used in the production of the airplane had to be lightweight, as the power of the available engines was not sufficient to lift heavy weights. The wood had to be flexible and durable to withstand the repeat poundings administered by both the wind and the ground (landings could be quite rough). It was determined that spruce would be the best wood suited, as it was the "toughest of the softwood" (Sweetser, 1919:150). The difficulty facing the government was the collection and processing of this raw material, and its delivery to the necessary

production plants. The spruce reserves were located in the remote forests of the Pacific Northwest, and access in that area was limited, as the roads were often unpassable. The government embarked on a large lumberjacking operation, sending approximately 15,000 troops to harvest the valuable wood to the forests of Oregon (158). This was an unplanned deployment, as it was unthinkable that troops would be used to collect raw materials.

Since spruce was deemed perfect for aircraft production, the government sought to keep it out of the hands of the Central Powers, and the APB announced that "all spruce would be bought by the government" (150). Here, the government exercised its right to act in the interest of national security by basically monopolizing the spruce industry, setting the price that the loggers and lumberjacks could charge per long ton of wood (151). As Huston notes, the government has always had the option of using various types of contracts depending on the circumstances present. In this case, the government utilized a fixed price contract for spruce, and did so in a complete manner (Sweetser, 1919:151). The spruce was milled (using roughly 4 ½ % of each tree cut), and sent by truck to the production plants for further refinement to make it suitable for airplane usage (Sweetser, 1919:150).

Not only was the wood a main concern, but the availability of linens (for wings, and fuselages) and dopes (a material used to coat the wings to render them inflammable, waterproof and to tighten them) was also in question. The need for these two materials was immense. In 1918 alone, the Air Service requested nearly 10 million yards of linen and 204,000 gallons of aircraft dope. The production of these materials was already at the maximum levels available. "Supply could not be increased by existing plants, nor by

building new plants" due to the lack of precious wood (Sweetser, 1919:162). Another example of the shortage of raw materials was the lack of castor oil; a lubricant used in aircraft systems. To combat this problem, the U.S. actually imported castor beans from Asia to seed farmland in this country, thereby actually creating raw materials (Crowell, 1919:243).

Raw materials are the first key to production, and therefore also to any logistics operation. Huston notes that the availability of raw materials for an item (and the subsequent ease of production for that item) is as important as the battlefield performance of that item (Huston, 1966:660). Little thought was given to the fact that the lack of any material, no matter the size, could lead to the grounding of any production process. As one observer noted, "no one ever thought that the production programme...could be held up by the lack of small items, such as acetate lime for aircraft doping" (Sweetser, 1919:96). To ensure the availability of these necessary materials, the government decided that it must manage and finance these different industries (Sweetser, 1919:149). The mobilization of these resources was one of the most important factors facing the government in 1917. Even with the active participation of the government, many asserted that "satisfactory aviation material would not be available until 1918" (Maurer I, 1978:54).

Aircraft Production-Later Developments

As mentioned earlier, when the United States entered the war, the need for domestic aircraft production was solely for training aircraft. The Curtiss Company and the Standard Aero Company, with the production of the JN-4 'Jenny' and the SJ-1 respectively, adequately fulfilled this need. However, the real challenge rested in the

ability of the American industry to produce combat-specific planes in a short enough time span to render them available for the 1918 campaign. At the time, there were four major problems facing the United States in this venture (Sweetser, 1919:189). First, there was no existing knowledge of battle planes or their construction. As noted early in this chapter, the U.S. inventory consisted of not a single battle plane at the time this country entered the war. Said Sweetser, "at the outbreak of the war, no one in this country had any knowledge of what a battle plane was" (189). Second (again a prevalent theme), the "utter" lack of any appreciable manufacturing and engineering facilities and capacity prohibited the advancement of airplane technology. Third, the United States was geographically removed from the fighting which prevented timely communications and the expedient flow of information with the combatants on the front. And finally, no one in the industry was prepared to handle the intricate nature of the problems that would undoubtedly arise with the employment of these new machines (189).

Specifically addressing the first area of concern, the government sent observers to Europe to obtain the necessary technical data to begin construction of the airplanes. The representatives, led by Major R.C. Bolling, arrived in Europe nearly three months after the United States entered the war. As a result, production efforts did not begin until early summer of 1917 (Sweetser, 1919:65). Still, the entire production process would be of the trial and error type, with most improvements made after "bitter experience and disappointments" (96). The lack of manufacturing, the distance from the front and the inability to solve technical problems all surfaced in the determination of what planes the U.S. would actually produce.

Selection of the DH-4 "Liberty Plane" as the American Contribution

Originally, the military decided that the construction of combat planes would focus on an American redesign of the immensely capable and extremely popular SPAD fighter. However, the life span of the single-place plane produced in the U.S. was short-lived. On December 15 1917, General Pershing ordered that production focus on the two-seat variety of airplane, and that the production of the single seat planes ought to be left to the Europeans. Subsequently, the reproduction of the SPAD was cancelled (Sweetser, 1919:192). The military then decided that the DH-4, a daytime reconnaissance and bomber platform, was to be the focal point of the American Air Service and its aircraft production efforts.

The production of the DH-4 was delayed until August 1917, as a model plane had not yet reached the U.S.. The model arrived in Dayton on the 26th of the month, and was now available for production use (Sweetser, 1919:192). The production facilities housing the DH-4 operations were literally built as the plane was constructed (Sweetser, 1919: 190). In two short months, the first DH-4 was rolled off the assembly line, and made its first test flight on October 28, 1917. Powered by a Liberty engine, the plane passed all initial tests, and was now ready for mass production.

The manufacturing processes used in the United States were markedly different than those used in Europe. The United States mastered the assembly line technique, suited best for items that could be made the same way over and over again. In Europe, the production process was highly specialized, where each item was manufactured in whole, one item at a time.

After the successful test flight of the DH-4, the APB awarded a contract for 2,000 aircraft to the Dayton-Wright Company (Sweetser, 1919:193). Initial projections for aircraft production showed that 1,475 aircraft would be ready by January 3, 1918. However, nearly three weeks after that projected completion date, the DH-4's production life had just started (193). The problems of production were not due to a lack of raw materials, as those requirements had long since been met, but were due to the continued lack of experience and technical knowledge in the area of production. Fitting the aircraft with the necessary internal equipment was not difficult for two main reasons. First, the government, as it had with raw materials, monopolized the component industry; the government would sell the specific components to the manufacturers upon completion of an airplane (167).

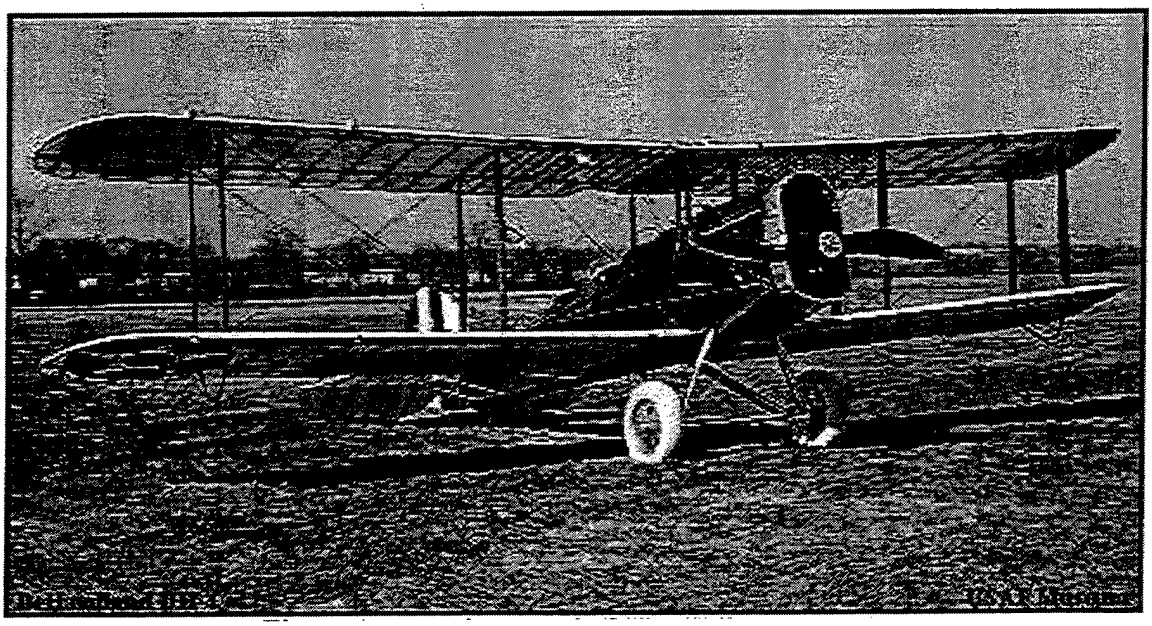

Figure 1. American-made DH-4 "Liberty Plane"
(www.wpafb.af.mil/museum)

Second, the Signal Corps was responsible for supplying the "delicate instruments," eliminating the reliance on private industry (and the high costs associated with it) for these pieces (167).

It was not until February 5, 1918 that the first DH-4 aircraft left the Wright plant, arrived in Hoboken, NJ. On March 15th, the aircraft was then packed aboard a steamer destined for France (Sweetser, 1919:195). On the 8th of April, the first U.S.-built DH-4 arrived in France. Nearly a month later, the aircraft flew its maiden voyage, armed as a combat plane should be. Although the results of the test flight were deemed satisfactory, certain changes had to be made to the airframe, which further slowed production and deployment. Specifically, the munitions stations of the aircraft were not capable of holding U.S. ammunition, and new bomb racks were needed (Sweetser, 1919:198). These were easy corrections, and by the end of 1917, the DH-4 was in "appreciable production" (Sweetser, 1919:197) and by the spring of 1918, it was a viable aerial addition to the allied efforts. The production rate of the DH-4 was unrivaled for the time period. Said Secretary Ryan, "we built more airplanes from month to month from the time we began than any other nation in the war built from the time *it* began" (131).

While mass production of the DH-4 was ultimately successful, the aircraft production efforts in the United States included other efforts. The government redesigned both the Italian designed Caproni heavy bomber and the British Handley-Page bomber. Three Capronis were ultimately assembled, while the Handley-Page never progressed past the prototype stage until after the war (Crowell, 1919:262).

The Liberty Engine

Although the DH-4 is a remarkable story of time-constrained manufacturing of an unproven commodity, the simple fact is that a plane will not fly without a powerplant. In fact, the size of an air force is contingent upon how many quality motors it can acquire (Sweetser, 1919:168). Coinciding with the development of the combat airplane was the aggressive production of the Liberty Engine. So named to represent the principle by which it was constructed, the Liberty Engine was the shining achievement of American industry during World War I. The road to realization of the engine was not smooth, as the same pitfalls that slowed production of the DH-4 were also present in the engine-manufacturing sector. At the time of American intervention, four separate manufacturers were capable of building, and had built airplane engines. However, as there were no combat planes in the U.S. arsenal, all engines previously constructed were used for training planes only. Therefore, they lacked the power and lightness required for use in bombers and pursuit planes (Sweetser, 1919:168). The major challenge, then, was to accomplish two goals: 1) enable the existing manufacturers to increase their capacity to a sufficient level that would allow them to continue producing these engines to meet the growing need of the aviation training program, and 2) require the manufacturers to design and build an engine capable of supplying the necessary power to lift the heavier aircraft (168). The first part of the challenge was solved by the end of 1917 as the Curtiss OX5 and the Hall-Scott A7A were produced in sufficient numbers to meet all training requirements. The second part of the challenge would be more difficult to accomplish.

Since an engine takes nearly twice as long to roll through production as an aircraft (Sweetser, 1919:168), it is no surprise that conceptualizations of a new engine occurred

shortly after the U.S. entered the war. In May, designers and engineers met in Washington D.C., determined to leave with the plans for a new, standardized motor. Unlike their decision to redesign the DH-4, the government decided that this engine should be domestically designed and produced, as the design differences among engines would not be easily reconcilable (175). The goal for this new motor was to meet all repair problems overseas using a set of standardized, interchangeable parts, while allowing for a marked increase in horsepower over models already available (175). After only four days in Washington, the plans for the Liberty motor were completed. The motor was to be an 8-cylinder motor, capable of producing 400 hp. And, of utmost importance was that the Liberty motor would have a single stream of spare parts to facilitate the inevitable repair overseas (184).

In determining who would build the motor, the government turned to the automobile industry, which had the existing technology base to begin the task. Lincoln, Packard and Nordyke and Marmon were selected for the contract, which was awarded on a cost-plus basis; the contractor would be reimbursed for their costs, plus some portion for incentives (Sweetser, 1919:177). The first engine was assembled at the Packard Plant in Detroit, and sent to Washington for testing on the 3rd of July 1917 (Sweetser, 1919:176). Shortly thereafter, the development and testing of a 12-cylinder version of the engine, designed to better fit the aircraft that were on the production lines, were completed.

As promising as the future of this new engine was, there were still major problems in the production process. As with the DH-4, the projections on production for 1918 were overly optimistic, and the associate production dates were pushed back

repeatedly (Sweetser, 1919:180). Specifically, the plan was to have over 9,400 motors produced by the beginning of June 1918. In actuality, the number available by the end of May 1918 was just over 1,100 (Sweetser, 1919:180). These problems in production resulted in (as in the aircraft industry) the total inexperience in the manufacturing of this type of machine in both large numbers and in the shortest of times. Additionally, those in Europe believed that the American method of standardized production could not be applied to the construction of a precise instrument such as an airplane engine (Knappen, 1919:113). The construction of the airplane engine placed more demands on the manufacturers than did the automobile engine. Manufacturers were forced to expand their capacity (facilities, and so on) to handle these demands (Knappen, 1919:108).

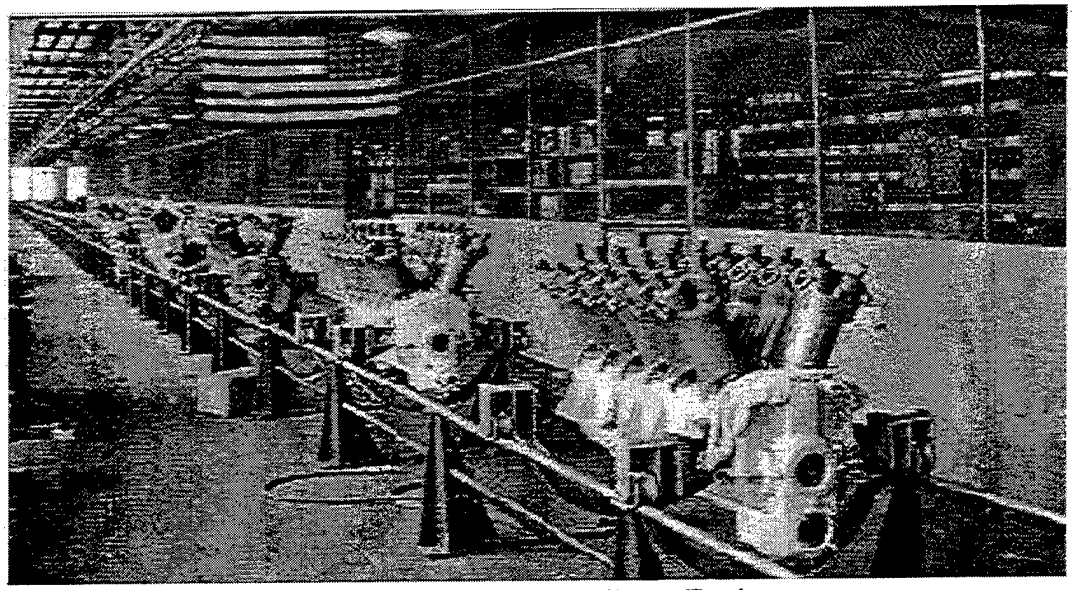

Figure 2. The First Five Liberty Engines
(Sweetser, 1919)

Manufacturers had to design new machines and tools, which took time. In addition, obtaining materials for the production of this engine was not easy. The Liberty 12 was roughly 25% lighter than a 12-cylinder automobile engine.

Despite these roadblocks, production of the Liberty engine reached 15,572 engines by the end of the war, with production reaching an astounding rate of 150 engines per working day (Knappen, 1919:109). The engine was popular with the allies, as it possessed power far greater than any other aerial engine. The demand for Liberty engines was "far greater than the Air Service's demands alone" (Sweetser, 1919:181). Italy ordered 3,000, the British ordered 300 and France requested the engine as well (Sweetser, 1919:181). In terms of raw numbers at the time of the armistice, the production of Liberty Engine has "never been remotely touched in the production of any like complex mechanism" (Knappen, 1919:111).

Transportation

While the production developments of the DH-4 and the Liberty Engine were of paramount importance, logistically nothing can lose a war faster than inadequate transportation. Without the means to get the raw materials from the source to the manufacturers and likewise the finished product overseas, all the efforts expelled by the industrial sector would not matter. And, it is likely that the transportation infrastructure of the United States was never tested as it was from 1917-1918.

The government realized quickly that transportation must be made available, and that those resources were scarce in the country already. As the production tempo increased throughout 1917, the means of transporting aircraft, engines, men and material had to be made accessible. Therefore, in December 1917, the War Department

established the Inland Traffic Service. This organization immediately seized the existing railroads, and designated them for war support use only (Schrader II, 1997:406).

Domestic transportation was only half of the challenge facing both the airplane and engine manufacturers and the military. Timely delivery of the planes and the material to support them was still unproven. Ocean transportation was the lone option, and, in a resurfacing of a common theme, the United States lacked the capacity for this logistics arm, too. Also important is the fact that the U.S. had never attempted to ship instruments as complex and delicate as these new planes and motors. Whether or not they would stand up to the rigors of transoceanic shipping was unanswered.

In 1916, the United States accounted for less than 6% of the world's 35 million tons of shipping (in terms of vessels) (Schrader II, 1997:403). Efforts were made to charter merchant marine ships, and it wasn't until the summer of 1917 that there were seven ships in the fleet dedicated to the movement of materiel (Ayers, 1919:38). By the end of the war, the transport fleet was capable of shipping 2,310 deadweight tons (Ayers, 1919:39). The initial lack of tonnage further complicated the port operations in this country. Coastal ports were with material waiting to be shipped with no ship to take them. Reliance on foreign shipping was prevalent throughout the war. The ports used in the United States were mainly located in the Northeast. New York City (including the separate ports of Hoboken, New York and Brooklyn) and Newport News, Virginia were the two largest ports of embarkation (Ayers, 1919:41). These facilities ran at or near peak capacity throughout the war. From August 1917 to the cessation of hostilities, nearly 2,000 tons of various materials left American ports daily in support of the war effort (Schrader II, 1997:418). Tonnage shipped to support the Aviation Corps in Europe

totaled 61,000 short tons. Not included in this total are the quartermaster and engineer supplies used by the Aviation Corps (to include clothes, food, rail improvements, and others) (Ayers, 1919:46).

Summary

The pre-war environment seriously hindered the initial mobilization of the aircraft and motor production industries. According to established logistics principles, the initial industrial capacity of a nation is one key to conducting successful operations. At no time before the war did the United States possess the required reserves needed to supply an air arm until the production in this country reached adequate levels. This lack of reserves prohibited more timely entry into the conflict, as there were no means from which to fill "unforecasted theater requirements" (Magruder, 1991: 120). In addition, the initial planning for production was far too idealistic to be feasible, given that there was little or no prior experience in this field of manufacturing. From a planning standpoint, the ability to determine what equipment was needed to fill existing (or planned) requirements was immature, as the planning for such extended operations was late in coming (Magruder, 1991:120). Even as the production of both aircraft and motors improved, the level of production reached the level of consumption only at the tail end of the conflict

The domestic transportation system was vital to the success of the U.S. mobilization and deployment of an Air Service in an efficient manner. In 1917, the domestic transportation system in the United States was entirely adequate for supporting the mobilization effort. Generally speaking, a nation's transportation system is primary in determining the ability of a nation to conduct efficient operations. If the transportation system can be developed, or is in place to support the necessary force requirements, then

the rest of the logistics system can be brought in line in time to be of value (Magruder, 1991:42). While the logging operations in the Pacific Northwest encountered problems in road conditions and weather, the ability of manufacturers to send the finished goods to the ports was, on the whole, satisfactory. The government's involvement in railroad operations (the Inland Traffic Service) provided the military with the means to transport large amounts of men and material in a timely manner. Overseas shipping capabilities lacked, initially, but were soon made sufficient through appropriation of a larger fleet and international cooperation. By the end of the war, the techniques used to deliver troops and cargo were among the best available.

V. Intra-Theater Operations

Introduction

The United States continued to improve its domestic logistics operations throughout the war. Both airplane and motor production rates, though not nearly as high (especially in the number of DH-4s) as originally projected, continued to increase, as the practices employed became more refined and efficient. The procedure of trans-oceanic delivery also improved. The shipment of the first DH-4 airplane in March 1918 was the first major step in deploying the Air Service. This voyage, nearly a month in duration, proved that the United States could send these new machines overseas in a manner that resulted in relatively little damage to the property en route (Sweetser, 1919:198). However, a second massive challenge awaited the Air Service. The supply, repair and transportation systems used to support an Air Service in a foreign country were basically untested. Like the steps taken to develop American aviation technology, the establishment of these systems resulted from a system of gradual trial and error. Fortunately, the Air Service was able to use the existing structures of both the U.S. Army and the French Air Corps for guidance.

This chapter examines the logistics operations used to support the aviation organizations engaged in combat in France. First, there is a brief carryover discussion of the transportation of aviation material and the troops accompanying it. Like the port operations in the United States, the French ports were constantly busy. Efficiently managed ports were the first vital component to the timely distribution of men and material to the front lines. The inland traffic system was also important in this respect, and will be discussed briefly in this section, and referred to throughout the chapter. The

second section of the chapter examines the supply operations used by the Air Service in France. The establishment of the Depot/air park structure was designed to keep as many aircraft in the air as possible. From the immense production center at Romorantin to the acceptance fields at Orly to the individual airdromes, each major center had a specific function in keeping the Aero Squadrons fully (or as close as possible) operational. Included in this section is a discussion of the procedures used to requisition spare parts and planes, to repair planes and engines, and the extremely heavy reliance of the Air Service on the French for both airplanes and parts.

Material/Troops Arrive in Europe

The arrival of personnel and material to support the Air Service began long before the first American-made airplane was shipped from New York City in March 1918. Showing uncharacteristic foresight at the time, Assistant Secretary of War John Ryan authorized the Army to send material that today could be considered initial beddown equipment. On July 16 1917, three vessels from the United States left New York laden with the equipment necessary to build a rudimentary aviation infrastructure in France (Sweetser, 1919:302). This equipment included hangar material, mess tents, machine-shop equipment and roughly nine miles of railroad track (Sweetser, 1919:302). Two days later, the 200 men responsible for transforming these materials into a working flying center left the United States.

Two separate ports handled the arrival of men and aviation material destined for service in the Air Service. The troops landed at one of two French ports, either at the port city of Le Havre or Brest, and then were deployed to an Air Service Replacement Barracks station at St. Maxient. Aviation material usually arrived at the Port of Brest, on

the Northwest coast of France, and was shipped to Toul, location of the general headquarters (Toulmin, 1919:23). Former AEF Chief of the Coordination Staff, H. A. Toulmin, author of Air Service: American Expeditionary Force, noted that the nature of transportation overseas caused by the geographical separation between the United States and France was a major obstacle. He observed that the majority of vessels that carried American supplies and men were foreign-owned (21). And, once the material was offloaded, the situation did not improve much. Toulmin stated that the transportation used by the Air Service in country was almost entirely by way of foreign railroads, and he observed that it was operated by individuals who "did not speak our language" (21).

It is not clear as to the specific nature of the port operations at either Brest or Le Havre (or England's main port of Liverpool). It is clear, however, that the arrival of materials steadily increased until the signing of the armistice in November 1918 (Figure 3 presents a graphical illustration of this increase in cargo). Therefore, it is possible, and probably likely, that the capacity of both the ports and the men that worked them were severely strained. In a later major conflict, a general noted that the supplies landed at the ports "in an excess of tonnage of the local organization," and as a result, items were lost (Eccles, 1947:172). While the overall tonnage sent to support the Air Service was relatively small (.82% of all material shipped), the problem of lost equipment may have been a tangible hindrance.

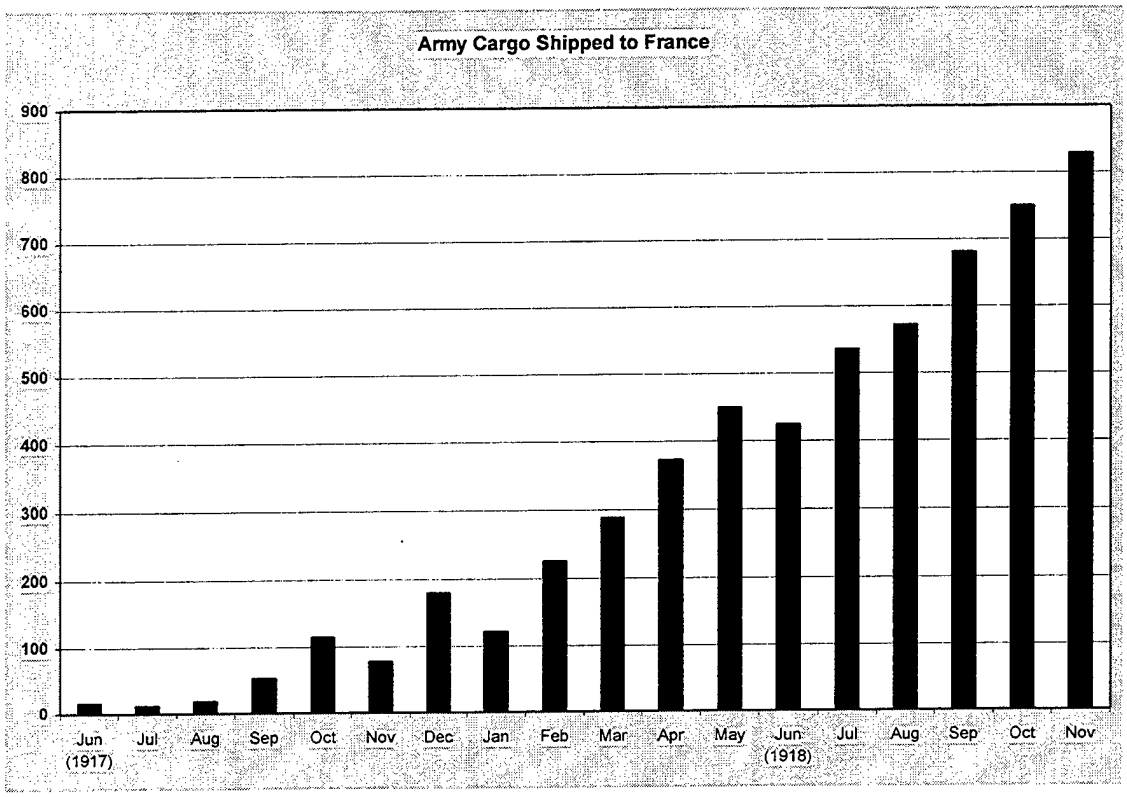

Figure 3. Army Tons Sent to France (1917-1918)
(Ayers, 1919)

As a whole, the operations at the French ports appeared to be relatively efficient given the diversity of men and equipment that passed through these coastal cities.

The French inland transportation situation was less than favorable. According to Toulmin, there was a limited availability of motor transportation and almost no availability of transport by rail (Toulmin, 1919:25). As mentioned in the section discussing domestic (U.S.) transportation, the lack of transportation resources was considered one of the most severe problems facing the Air Service and the Allies in general. The shortage of vehicles, rails, and horses caused major delays in troop and material movements. Additionally, the overall road conditions in the theater were

difficult, further complicating matters (Schrader II, 1997:431). As time elapsed, the use of 60 cm rails was determined the best alternative to motor transport (Schrader II, 1997:432) and were run to the airdromes if possible (Maurer II, 1978:149). Transportation of spare parts was also a major challenge. All parts could not be sent on the same routes. Bridges have a nasty effect on wing chords and other oversized items. Therefore, routes were chosen which permitted the transport of all sizes of spares (Maurer I, 1978:149). 1st Lieutenant Andrew Anderson lamented that the lack of transportation and spares for transportation resources was the "worst difficulty" (Maurer III, 1978:273).

Supplying the Air Service

The construction of the infrastructure used to support the Air Service in France began in the fall of 1917, with the construction of the 1st Air Depot at Colombey-les-Belles. However, as late as May 1918, there were no tangible plans for assembling supporting units such as Repair Depots, air parks and the like. In short, there was "no mobilization plan," and the Air Service was, in the opinion of Gen. Toulmin, a "complete failure" (Toulmin, 1919:75). In June 1918, Major General Mason Patrick assumed command of the Air Service, and from that time until the end of the war a year and a half later, the Air Service utilized a well-organized, geographically-based supply system to keep its flying squadrons on the front fully operational.

On July 16, 1918, Air Service leaders conceived a plan for the Service's supply system (Toulmin, 1919:124). The structure of this supply and repair system designed by the Park Mobilization Branch consisted of warehouses, airdromes, mobile parks, Air Depots, Intermediate Depots, Depots and Acceptance and testing facilities. According to

the Branch, the Supply Section would designate the warehouses, and one such facility was located at the acceptance field at Orly. These warehouses served as the assembly point of all specified squadron equipment destined for the front (126). Additionally, all rolling stock and transportation were assembled at the warehouses for delivery to the squadrons in the Zone of Advance (126).

The initial echelon of the supply structure was located at the airdromes near the front. Here, supply and maintenance officers coordinated efforts to keep the airplanes flying. Each squadron sent requests for supplies and spare parts to the appropriate group officer, who then, if the request was unmet, sent the request to the mobile park responsible to the group.

The mobile parks were one step removed from the squadrons at the front, and served as the immediate supply reservoir for these units. Each mobile park was responsible for supporting three air groups (usually consisting of a total of 4-6 squadrons per group). The park carried, at most, three days of supplies; the emphasis was on mobility. Mobile parks were required to have the ability to move within 24 hours, in conjunction with military operations (Toulmin, 1919:133). Each park consisted of supply and repair and salvage sections. All salvaged planes and motors were forwarded to the appropriate Depot for either repair or redistribution. Due to the limited amount of resources (spare parts), salvage operations were a key supply function.

The mobile parks received supplies from the Air Depots. Each Air Depot supplied at least three mobile parks, often more. While the mobile parks carried only three days of supplies (emphasizing the need for mobility), the Air Depots carried up to 30 days worth of replacements (Toulmin, 1919:133). This quantity of supplies furnished

anywhere between 30 and 54 squadrons with spare parts, spare engines, and ammunition (133). The Air Depots repaired aircraft with minor battle damage that couldn't be fixed at the airdromes or mobile parks. These centers were also responsible for the installation of replacement or rebuilt engines. As mentioned with the mobile parks, all salvaged planes and motors were sent to the Depot for further disposition orders. Each Air Depot possessed a flying field for the reception and distribution of airplanes from the Intermediate Depots or acceptance fields (134). Like the mobile parks, the Air Depot consisted of a supply and repair and a salvage division. Unlike the mobile parks, the Air Depots were located much further from the front (usually 20-50 miles behind the mobile parks) (134). Examples of Air Depots were the facilities at Colombey-les-Belles, Orly and Latrecey.

The next level of the system was the Intermediate Depot. There were two distinct types of Intermediate Depots. The first stored completed aircraft that were waiting to be dispatched to the Air Depots and then on to the flying units. The second type served as the storage and distribution point for general supplies (Toulmin, 1919:135). These Intermediate Depots served as a buffer within the system. When domestic production (or overhaul repairs) fluctuated, there were often surplus supplies. Often, production centers and acceptance fields were unable to house these supplies until they were needed at the Air Depots (135). The surplus was sent to the Intermediate Depots to await further distribution instructions. Little repair or salvage was accomplished at these locations. The location of these facilities in relation to the Air Depot (aside from being further from the front) was determined by available rail and road transportation (135). Timely deliveries to the Air Depots and mobile parks mandated that

these centers not be too far removed from the front line units. It was vital that there be adequate transportation at all times to transport gas, motors, and wings, since the lack of these materials render it unfeasible to store these items in quantities at the rear echelons (Maurer II, 1978:273). Examples of these facilities included Poincon and Is-sur-Thille. Poincon stored completed airplanes, while Is-sur-Thille stored general supplies (Toulmin, 1919:136).

The main supply centers, the Depots, possessed larger warehouses and carried more supplies than the Air Depots. Each Depot stocked 60-90 days worth of supplies (135). However, the Depots were not responsible to individual squadrons the way the Air Depots and mobile parks were. These Depots supplied the entire Air Service. Each Depot had a specific function; one would handle spare parts and technical equipment, while another might handle general supplies and clothing. As mentioned earlier, transportation was key in determining the location of these Depots. It was essential that they be located near existing rail lines (to make deliveries to the Intermediate Depots or Air Depots). However, should rail operations not be available (due to problems with the track, etc.), the Depot had to be within convenient trucking distances (135). The primary aviation Depot, Chaneny, was used for the storage of both airplanes and spare parts (136).

Acceptance fields and production centers were the final main components in the supply system's structure. At the acceptance fields, all completed airplanes were received and inspected. Any changes on the aircraft, including the fitting of armament, were accomplished here. Once deemed fit for service, the airplanes were sent to either the Depots or to a point closer to the flying units (Toulmin, 1919:135). Orly was the

prime example of the acceptance fields. All airplanes received from the French were tested and accepted by the United States at this field (Sweetser, 1919:304). Orly was designed to receive and process up to 25 airplanes daily, but at times, that number jumped to 91 airplanes (Maurer I, 1978:318). Of nearly 4,900 aircraft supplied by the French, only 2,100 were accepted with no need for corrections (Maurer I, 1978:122). Sometimes as many as six inspections were required before an aircraft was deemed fit for service (Maurer I, 1978:123).

The production centers received all supplies sent to the theater from the United States. Here, aircraft were assembled, and major repairs were completed. Salvage operations also existed at these centers. Perhaps the best example of a production center used by the Air Service is the center located at Romorantin.

The production center at Romorantin might have been the "most important" establishment of the Air Service (Sweetser, 1919:303). The facility itself was immense. An unidentified American correspondent described it as a "mammoth Air Service production center with huge shops and warehouses" (Sweetser, 1919:303). Sweetser states that as of October 29, 1918, the grounds consisted of a motor-transport park, fabrication shops for night-day bombers, repair and salvage facilities and three flying fields (303). All airplanes sent from the United State (namely the DH-4) were assembled here. Furthermore, the repair of all kinds of motors and of all badly damaged or salvage planes was performed at this location (303). The repair operations occurred in six bays, with the capacity for 18 airplanes in each bay. The parts were brought up in nine boxes. Assembly began with the fuselage, then the installation of the motor, an adjustment of the landing wheels, tail and wings, and finally the attachment of the armament (304).

The numbers associated with the operations at Romorantin are impressive. On average, the Center dispatched 13 airplanes daily (Toulmin, 1919:201). From the time the first American-built airplanes arrived on May 11, 1918 until the close of the war, 1,087 DH-4 airplanes were assembled at Romorantin, 563 were sent to the front, and 308 were salvaged (207). The quantity of aviation material handled by the Supply Section from initial receipt to final distribution neared 500 tons daily (207).

Supply Requisitioning Process

At this time, it is useful to look at the requisitioning and repair procedures used by the Supply Section to secure spare parts for damaged aircraft, ammunition, and so on. For general spares (not including engines and completed airplanes) and supplies, the supply or maintenance officer in the Aero Squadron forwarded a request for material to the group supply officer. The request was then sent to the mobile parks. Since the mobile parks held little reserve, it was highly probable that the requisition would go unfilled at that level. Subsequently, the request was forwarded to the Air Depot. If, at this level, the request was still not met, the Air Depot commander forwarded the request to the Assistant Chief of the Air Service in the Zone of Advance. At that level, the Chief (through the staff's supply officer) issued instructions to the other Air Depots in the Zone of Advance regarding the allocation of the material requested, if available. If no Depots in the Zone had the material needed to fill the requirement, the Assistant Chief sent a request directly to the Supply Section (in Tours) (Toulmin, 1911:135). The Supply Section then determined the priority of the request.

The requests for completed engines were made by the mobile parks, and sent directly to the Depot, bypassing the Air Depots and Intermediate Depots. Requests for

replacement aircraft passed directly from the Chief of the Air Service to the Chief of Supply in Paris (Toulmin, 1919:137). If the 2nd Army needed replacement planes, the request was placed on the 1st Air Depot (Toulmin, 1919:137). According to a memorandum dated 30 August 1918, units west of St. Mihiel requesting airplanes would send pilots to the Vavincort Airdrome (an airplane reserve facility) (Maurer III, 1978:70). East of St. Mihiel, requests were forwarded to the 1st Air Depot (73). Unofficially, according to a Major in the 1st Pursuit Group, daytime planes had the highest priority in securing supplies (29). Figures 4 and 5 detail the flow of airplanes and spare parts, respectively, within the European Theater.

The airplane delivery process was logically designed. Crated airplanes arrived at the production centers, where they were unpacked and assembled. The planes were then flown to the acceptance fields. After inspection and adjustments were made, the aircraft departed for either the Intermediate Depots, the Air Depots the mobile parks or to the airdrome directly (depending on the need) (Toulmin, 1919:138).

Salvage and Repair Operations

As mentioned earlier, salvage was a key logistic function in the Air Service. Salvage of material from the battlefield became a "major supply effort" (Schrader II, 1997:135). The actual salvage operations centered primarily on the mobile parks (Toulmin, 1919:137). All salvaged planes and motors were delivered to the production centers, where they were either refurbished or used for spare parts. However, the lack of ground transportation limited the scope of these types of operations. It was directed that only if transportation was available would salvaged material be brought back to the production centers (Toulmin, 1919:138).

Repair of damaged airplanes and engines was of the utmost concern. Lack of both items mandated that the repair processes be efficient. As is the case today, most minor repairs were conducted on-site at the airdromes. As the repair work became more time and resource intensive, responsibilities became removed from the front-line maintainers. In the case of engine repair, all major engine overhauls were accomplished at the mobile parks. If it was determined that the engine could not be fixed at that level, it was sent back to a production center where it was either rebuilt or repaired. Engines were then placed in stock at the Air Depots until needed by the squadrons (Toulmin, 1919:136). The shortage of engines probably meant that the engines didn't remain on the shelves very long. Airplanes needing more serious repairs were also sent to the mobile parks.

Here, major assemblies (for example, wings) could be substituted. Serious repairs beyond the scope of replacement were conducted at the Air Depots. At this point in the repair cycle, the completed plane received (if necessary) a repaired engine (Toulmin, 1919:137). The center at Issoudun served as an Aero Repair Depot tasked with engine and airplane component repair. At the height of operations, the facility overhauled between 100-120 engines weekly (Sweetser, 1919:318). Additionally, workers repaired wings, struts and cables, and ultimately rebuilt 20 airplanes per week from salvage (Sweetser, 1919:318).

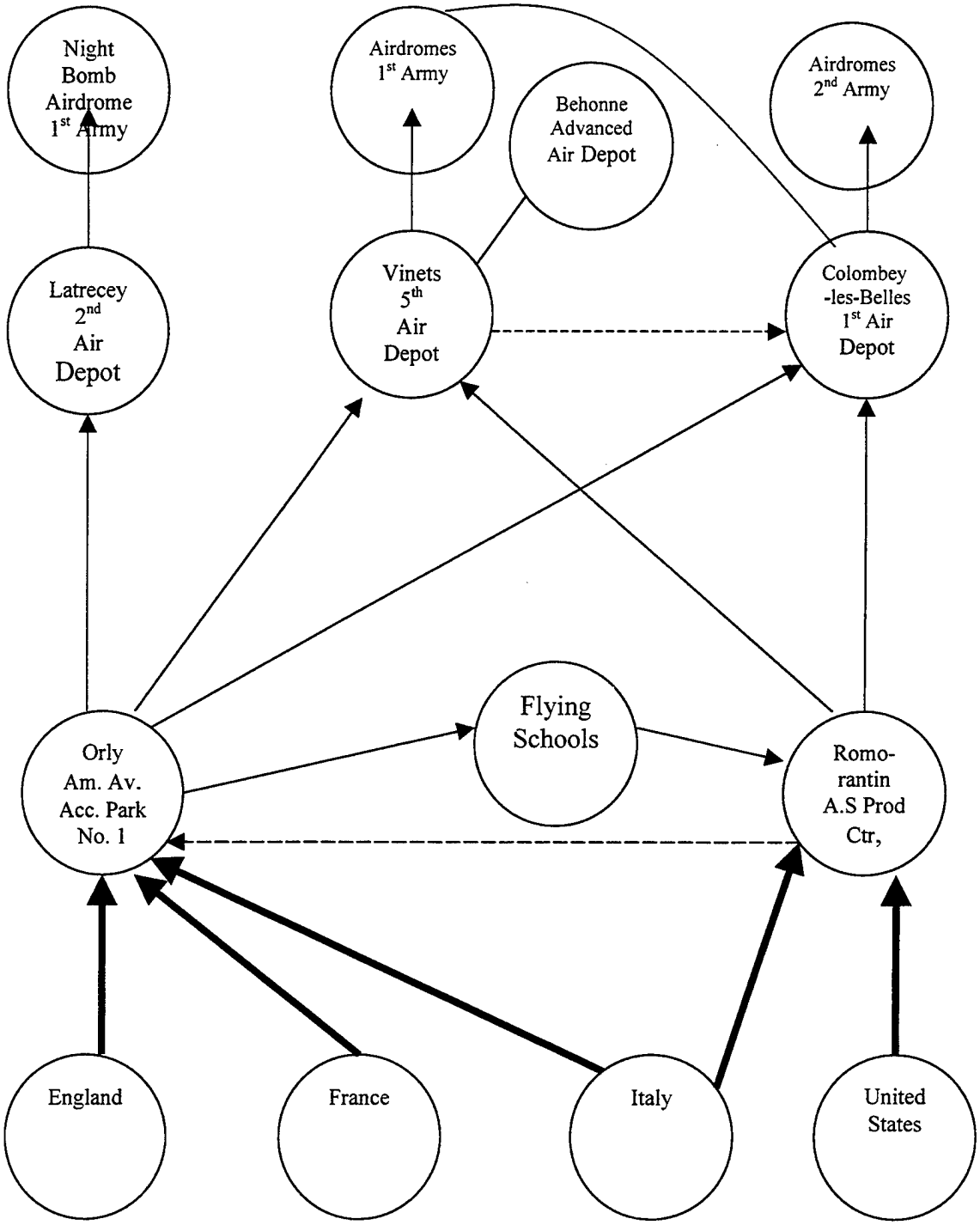

Figure 4. Airplane Delivery Flow Diagram
(Toulmin, 1919)

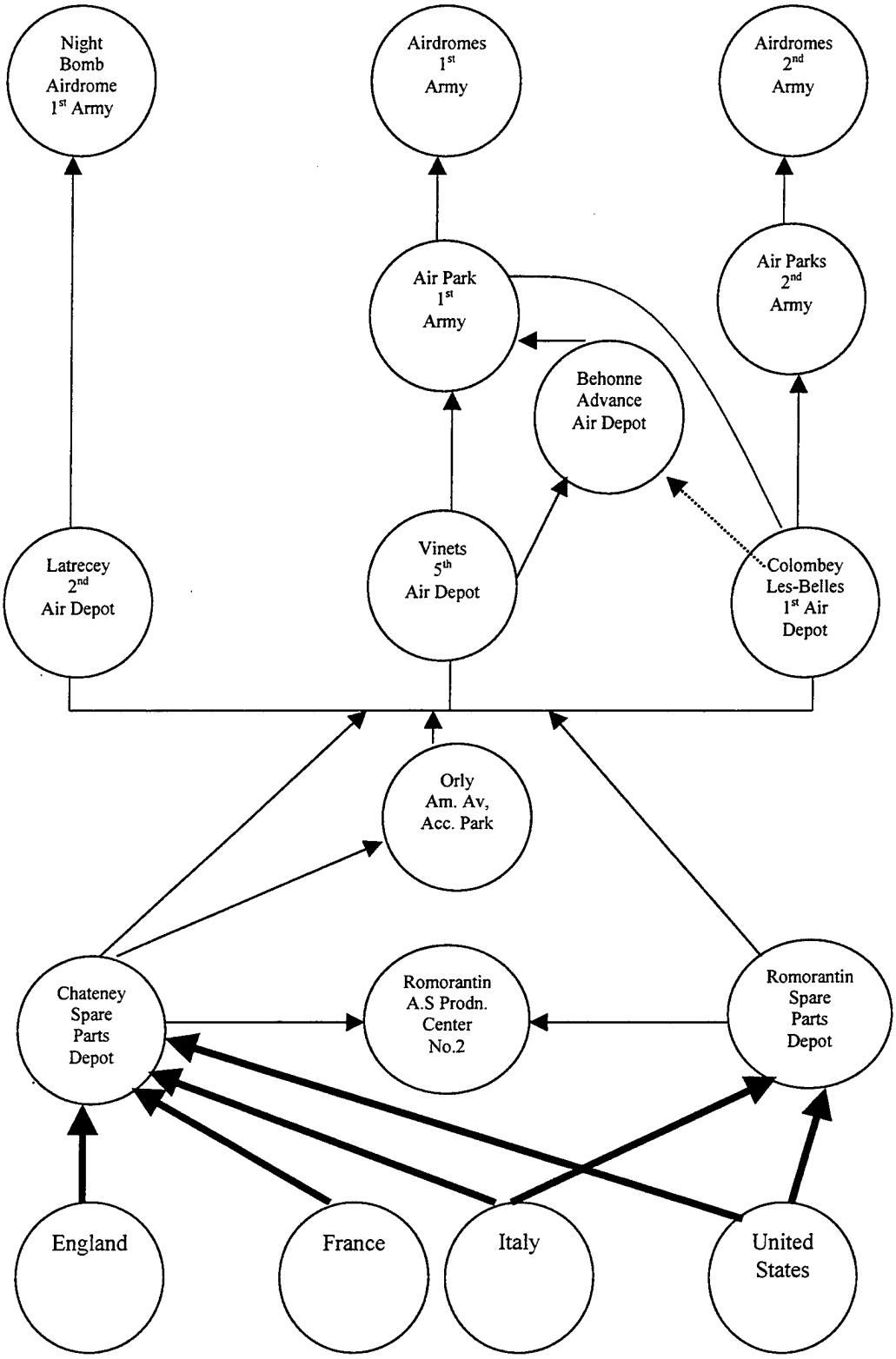

Figure 5. Spare Parts Flow Diagram
(Toulmin, 1919)

U.S. Reliance on Foreign Equipment

Due to the lack of airplane construction well into 1918, the Air Service was forced to rely on foreign countries to supply airplanes and engines, and other equipment (rail transportation) to support the flying squadrons on the front lines. The first Aero Squadrons activated in 1917 flew older versions of the SPAD (the SPAD VII) and the Nieuport (the Nieuport 28) (Hudson, 1968:3). It wasn't until the summer of 1918 that the Air Service received the more modern pursuit planes, the SPAD XIII and the Sopwith Camel (Hudson, 1968:94).

In mid-1917, the French government, confident in their own airplane manufacturing ability, offered to provide 6,500 airplanes to the Air Service (Knappen, 1919:52). The French were to produce these aircraft in an unofficial exchange for raw materials sent from the United States (there was a strict understanding that the delivery of French airplanes was not contingent upon the delivery of raw materials) (Knappen, 1919:55). Again, the United States had much greater availability of natural resources than did its allies, so this request was not out of reach. This proposal was consistent with Premier Ribot's request for rapid American air involvement, as there was little chance that the Air Service could enter the conflict in 1917 relying on its own production efforts. In all, 18 different types of airplanes were ordered from the French, totaling 14,378 planes (Sweetser, 1919:306). The actual number delivered by November 6 1918 was 2,676 combat aircraft (Sweetser, 1919:306) and 4,784 total planes (Toulmin, 1919:207). As promised, the French also furnished aircraft engines. For every four airplanes, the French supplied one engine to the Air Service (Toulmin, 1919:207).

The central reason that the French were unable to deliver in accordance with their own proposal was the unexpected increase in demands of their own air service (Knappen, 1919:54). Since most of the aircraft supplied were of the surplus variety, fewer airplanes than originally thought were available for deployment with American squadrons. The airplanes that the Air Service did receive were often already obsolete, or well on the way to obsolescence. Author, and pilot, Elliott Springs humorously illustrates this point in his story "9214". In the story, he details his flight on a suicidal balloon busting mission with the intent of bringing the aircraft back so badly damaged that the unit would receive a replacement. Springs remarks that the allied thought process was to get the most use out of a plane, and send it, like a hand-me-down, to the American units (Springs, 1928:175). Other factors, such as the failure on the part of the Americans to deliver the materials promised, may have also had some effect (Knappen, 1919:54).

The American reliance on the French for airplanes spawned related problems. Naturally, there was some difficulty in obtaining the necessary spares for the French airplanes. Since the French focused on supplying their own units first, and their industry was already being taxed heavily, American units flying French aircraft often had to resort to unconventional methods to keep the aircraft flying. When the 96th Aero Squadron began to fly the Breguet 14-B2 bomber, according to an officer in that squadron, it was nearly impossible to secure spare parts for the planes. As a result the mechanics in the squadron often used discarded pieces of farm machinery to keep the aircraft operational until the supplies from Colombey-les-Belles arrived (Hudson, 1968:85). The ammunition issue also proved contentious. Toulmin, an officer with munitions experience, reported that the only ammunition available in quantity was supplied by the allied governments.

This ammunition was of different caliber than the Air Service used. In short, to use their ammunition, the Air Service had to use their own guns. This difference in ammunition, Toulmin stated, meant that there would be certain squadrons using American ammunition and others using French ammunition causing difficulties in "replacement, repair and supply of not only ammunition but of the mechanisms" (53). Either the gun systems in airplanes were modified to fit the American shells, or French shells were secured for Air Service use. In essence, two separate ordinance systems were created by the reliance on foreign equipment (53).

Summary

As time passed, the logistics operations of the Air Service in France became increasingly refined. Like the methods employed domestically, the methods used by the Air Service to keep its units flying adhered to certain logical principles. Unfortunately for the Air Service, the transportation system in France did not always cooperate as well as the one in the United States. Poor road conditions, language barriers and other problems forced the Air Service to devise new ways to get things done. Since transportation is the lifeblood of logistics, the need for rail and road resources was not flexible. Like other aspects of the logistics arena overseas, the Air Service was able to adapt to and overcome some of the problems that arose. From bringing their own tracks to efficiently managing port operations, the Air Service was able to keep the flow of materials at an acceptable rate.

The Air Service's leaders also realized the importance of a well-managed supply system, and took the necessary precautions to ensure that the flow of material was preserved. By utilizing a multi-echelon depot system, the Air Service Supply Section

was able to provide flexible and timely support. Forward thinking was evident in the establishment of the mobile parks close to the airdromes. These mobile support centers negated the need for fixed depots close to the front. This enabled rapid redeployment with limited exposure of supplies to enemy fire (a point stressed by Heiser) but did not diminish the level of critical supply and maintenance support to the aero squadrons. The requisitioning process, salvage and repair operations and other supply practices were logical and imaginative, and worked extremely well. These practices are explored in greater detail in the following chapter.

While in France, the Air Service also learned that the heavy reliance on foreign equipment and machines can lead to a dangerous situation, as Magruder warned. The United States had few options, and the overall ability of the Air Service to conduct effective operations may have suffered as a result of the inability to secure the necessary spare parts to repair its foreign-built airplanes. Had the U.S. been more involved in airplane production prior to its involvement in the war, the need for French aircraft would naturally have been diminished. As a result of a decrease in reliance on the allies, the Air Service's capabilities, quite possibly, may have been enhanced.

VI. Impact on Military Logistics

In general, the workings of the entire Air Service logistics support structure improved dramatically in little more than two years, a remarkable feat for any organization in such an environment. This final section answers the investigative questions presented in the introduction. The discussion of these issues enables us to answer the overall question that asks if the successes and mistakes experienced in the formation of the first logistics structure designed to support a combat air arm provided guidance for the formulation of modern day military logistics principles. From the spring of 1918 until the of the cessation of hostilities in France, the logistics structure employed by the Air Service continued to improve, but had not yet reached anything resembling a steady state of peak performance. Had the war continued into 1919, however, it is quite probable that the system would have realized the full measure of its potential, and would have been capable of providing the best logistics support available.

Investigative Question #1

Eccles, Magruder, Huston and Heiser provide the established logistics principles used as a benchmark for assessing the Air Service's logistics operations. By no means do these authors represent the entire military logistics community, and there are most definitely other experts whose views are valid. These selected authors provide comprehensive, and generally accepted, viewpoints on all major facets of logistics operations: production, transportation, supply and logistics planning.

Investigative Question #2

The lack of early airplane and motor production forced the U.S. Air Service to delay initial entry into the war, and also required the Air Service to rely heavily on the allies for airplanes and spare parts. Even when the production rates were sufficient to send the first DH-4s to France in an operational capacity, the availability of repair parts was often limited. The lack of production in the U.S. meant that there were no appreciable reserves in the United States to be used until production had reached an appropriate level. However, the Production Center at Romorantin opened nearly simultaneously with the arrival of the first DH-4, so the effects of the lack in domestic production may have been somewhat mitigated, though not totally erased.

Many lessons were learned from the establishment of the airplane industry. First, proponents of military aviation had the foresight to realize that if possible, the production base must be kept warm to prevent future chaotic situations such as the ones that faced the aircraft production board in 1916-1917. Second, the government realized that it must utilize commercial production capabilities. By allowing aviation firms to compete for government contracts, the government encouraged the growth of the airplane industry. Competition between these firms would most likely lead to increased quality and would provide airplanes to the military at, possibly, lower prices. Putting the responsibility of airplane development on these companies ensured that there would be no repeat performance of 1916, where only nine contractors were involved in producing already obsolete airplanes. The government also decided (correctly according to Eccles' principles) to become involved in the procurement of raw materials in attempt to ensure

their availability. The government still maintained a presence in the industry, but remained removed from actual construction.

The principles outlined by Magruder, Heiser and Huston reflect the impact of these production lessons learned. Magruder and Heiser both stress the need for adequate reserves to sustain operations until the domestic production levels reach a satisfactory level. Magruder cites an example that the short notice of the Korean Conflict required the military to rely solely on materials already available (Magruder, 1991:42). Huston later adds that the production capacity of the United States soon surpassed that of the enemy, and eliminated any advantage the North Koreans had (Huston, 1966:617). It is likely that the production base after World War II did not go completely cold (though there was heavy demobilization), and allowed for a more rapid mobilization of raw materials and resources than was possible in 1917.

Investigative Question #3

Huston mentions that the ease of production of new weapons, more so than the actual battlefield performance, will determine the feasibility of employing them. Again, this seems to reflect, at least indirectly, the challenge facing airplane and engine builders in 1917. The Americans could have designed their own pursuit plane or their own bomber, but it didn't make sense to do this. Therefore, DH-4 was chosen as the American contribution to the allied air efforts for two reasons; first, it would be easy to obtain information on the construction of the plane and second, there was no knowledge in the organization of what a combat plane was, let alone design one. Presumably, the construction would not be as difficult, or as timely as it would have been, had the U.S. sought to design its own model.

Unlike aircraft production, the engine production efforts centered on a U.S. design, as it was determined (or rather, hoped?) that the automobile manufacturers in this country had the ability to produce a superior aerial engine. While it took longer to produce one engine than it did one plane, the Liberty Engine became a shining success. It is possible that the difficulties in generating the aircraft used in WWI subsequently influenced the government's decision-making process when determining the feasibility of new weapons platforms. This could be the reason that aerial platforms such as the C-47, C-130 and the F-4 have each had active service lives of over 30 years. The trials and tribulations of the C-17 and the F-22 lend credibility to the argument that often new weapons are too costly to build, and even stellar battlefield performance may not compensate for the immense generation efforts associated with the new platforms.

The production of the Liberty Engine, again, is an example of, and precursor to, Magruder's tenet that domestic production should reach a level that is capable of sustaining all requirements in the theater. The ability of the U.S. to support allied needs for a powerplant was remarkable given the state of the industry just two years earlier. While there was no appreciable resource base prior to U.S. involvement, it is possible that the production processes used to build the legendary Liberty Engine, from contract to completion, could most likely have served as a blueprint for future production efforts. While it is almost certain that Magruder was not referring solely to the Liberty Engine when he made his statements regarding production, it is likely that he did use the production efforts of the Aircraft Production Board as part of the justification for his observations.

Investigative Question #4

While production efforts shifted from a weakness to a strength, domestic transportation remained a strength of the logistics support structure in the U.S. Road conditions in the Pacific Northwest aside, the ability to transport raw materials and finished goods from point of production to the ports was satisfactory. This being the case, the APB and the National Committee on Aeronautics could focus their efforts on other problems. As Magruder states, the key to successful logistics operations is a capable transportation infrastructure; everything else should fall into place. The formation of the Inland Traffic System might be seen as the predecessor of the domestic component of the Movement Control Office used in WWII, to provide guidance and planning for the movement of men and material. Future efforts to make available transportation resources (for example, limiting unnecessary civilian travel) are well rooted in the lessons learned in WWI. Transportation in France was a different matter. The port operations at Le Havre and Brest were probably adequate to handle the massive workloads. However, the transportation infrastructure in the theater was severely lacking. Few resources were available for resupply efforts, and the road conditions often made such efforts infeasible. In order to lessen the effect of this problem, the Air Service relied on equipment shipped from the U.S. Vehicles and railroad equipment were sent to provide some transportation relief. While this did not completely erase the problems, it did afford the Air Service some increase in flexibility. Not only did the U.S. seek to increase the capacity of its transportation division with this deployment, but it also sought to lessen their reliance on the French by using domestic resources.

Investigative Question #5

Supplying the aero squadrons was something that the Air Service did extremely well. The multi-echelon system employed is remarkably similar to the system used well into the 1980s. The concept behind the supply system was extremely simple and efficient given the new nature of the mission. The establishment of the mobile parks to provide timely support to the front line supply, maintenance and transportation personnel is akin to Heiser's admonition that there be no fixed depots in the objective areas (Heiser, 1991:262). Additionally, the stockage policy of the supply system seems to have anticipated the principles stated by both Magruder and Eccles. Only items that were high demand items were stocked in the forward echelons of the depot system. Engines and airplanes, two of the highest demanded items, were located at the Intermediate Depot level, allowing for rapid transportation to the front. General supplies, such as clothing and other quartermaster items were kept further to the rear, as they could be stored in greater quantities. By limiting the stocks in the forward echelons to those that move fast (are requested often by the units), the supply system was able to maintain its resilience (Eccles, 1947: 187).

Even though the system proved flexible, the limited availability of spare parts still caused problems. As a result, the Air Service designed a system of queries to locate high demand items and ensure their delivery to the necessary squadrons. The practice of the Air Service to query every Depot in the Zone of Advance to fill a request corresponds to the theory that there should not be a due out (an unfilled requisition) at the forward Depots or mobile parks unless there is a due out for an item at the main Depot (Magruder, 1991:3). Again, there are parallels between this process and the methods used in the

modern Air Force. Today, the use of lateral resupply between bases (sending parts from one base to another to fill a high priority need) is common to fill requirements unmet at the depot level. Since the French theater was somewhat stabilized—little change in the front lines—this system of "due outs" should worked well (Magruder, 1991:3).

One necessity that the Air Service's supply system lacked was a clearly defined priorities and allocation system. While Eccles mentions that a system of dispatches must be used in depot operations, there is no mention of the system used to distribute spare parts, especially the ones that were in limited supply, to the flying units. Magruder states that the distribution should be based on theater requirements, which, in all likelihood is how parts were sent to the different Aero Squadrons. However, it is not clear as to how those requirements were determined, as there was no experience on which to base them. In WWII, the Army developed a formal priorities and allocation system to correct this problem.

Probably the principle that can derive its existence almost singularly from WWI is the notion that local (U.S.) resources should be used as much as possible to reduce the dependence on foreign countries for warfighting materials. At no time since WWI has the United States been so largely at the mercy of her allies when it comes to furnishing a fighting force. The Air Service relied totally on the French for pursuit planes, spare parts, munitions and other items. When the French could not meet the demands of their own Air Corps, the Air Service received little support. Even when the French were able to help, assistance usually came in the form of surplus or outdated supplies. Had the U.S. been better prepared for the war, this reliance on the French would have had much less of an impact. It is evident that the American military planners have taken this lesson

learned to heart. In every major conflict since WWI, the United States has been nearly self-reliant. While the U.S. military still counts on some host transportation resources, it has the ability to provide its own limited infrastructure if needed, something the Air Service may have inspired when it laid 9 miles of railroad track at Colombey-les-Belles.

Logistics Planning

An area of logistics not mentioned in the prior two chapters is one that deals with logistics planning, to include requirements derivation and logistics structure organization. Both areas presented major challenges to the Air Service. First, as with almost everything else, there was no prior knowledge that the planners could use to develop the requirements for the Air Service. Magruder notes that this requirements planning stage needs to be done early "to permit the organization and training of troops and the procurement of special equipment" (Magruder, 1991:45). Obviously, the Air Service was lacking in this regard.

Logistics planning, in general, is seen as the first step in conducting successful strategic and tactical operations. Much of the discussion found in modern logistics principles revolves around the way in which a military conducts logistics operations in peacetime as well as in wartime. Heiser suggests that a military should have the same processes and policies at all times. He states that this consistency will better prepare an army for operations in combat. It is probably ambiguous to say that this statement refers in any significant way to the Air Service, since there was no Air Service to speak of before the war. However, if one were to apply this to the shell of a military aviation section in 1916, one could only surmise that there was little thought of wartime processes, and as a result, the initial stages of logistics support may have suffered as a

result. Heiser also notes that planning should resolve to provide the soldier with a single source of supply. While the Air Service did have its own depot system, it did have separate sources of supply for items like ammunition. Eccles adds that modifications to the structure should not require a major shift in the command structure. Even as the supply system was modified to conduct operations in a more efficient way, the structure of the organization remained intact and provided flexibility in supply support. Eccles also notes that a single chief of staff will become bogged down, and unable to maintain the necessary flexibility required to lead effectively. The Air Service had one chief of staff, but also had a number of assistant chiefs that were, in actuality, functional or geographic managers. This organization appears to have afforded the system the flexibility to deal with the unforeseen problems of supporting the flying units. Like many other areas of logistics, the tactics employed by the Air Service can be seen in the way planning tasks have been conducted since the war.

Part of the logistics planning challenge the Air Service faced lay in the interaction of the Air Service commanders and their French counterparts. Eccles mentions that at the highest levels of command, there are "officers of great experience in exercising major area or global responsibilities" (Eccles, 1947:68). This is interesting since this conflict was not only the first one that was global in nature, but also the first one that involved aircraft. It is likely that the high level officers in the Air Service did not have the global experience that Eccles says is desirable in a theater commander. Undoubtedly, this war provided priceless experience to officers (such as Billy Mitchell and Hap Arnold) who would use it in WWII. Eccles states that both national and international situations and decisions must be continuously interrelated. It was imperative for U.S. commanders (as

well as the politicians in Washington) to communicate the needs and the plans of the Air Service their opposite numbers in France and Britain (Eccles, 1947:63). This communication was necessary, since there was no evidence of the presence of a unified command. American Generals controlled all American assets.

Research Question

When comparing the policies, processes and decisions made by the leaders of the Air Service with the principles extracted from modern day logistics, it is imperative to realize that all of these principles were documented at least **30** years after WWI. The Air Service did not have the benefit of prior knowledge when it came to the organization of its logistics structure. Nevertheless, the Air Service's system, on a whole, quickly adapted itself to supporting the first combat air units. If one looks past the initial apathy and subsequent near-catastrophic delays in production, it is apparent that the Air Service basically constructed a functioning logistics organization in only a year and a half. Given the nature of the mission and the distance from the United States, this is a remarkable feat. It is likely that this system would have become increasingly perfected had the war lasted into 1919 and 1920.

In terms of production, the Air Service and the aviation industry certainly did not operate in a desirable manner for a country on the verge of war. The lack of available industrial capacity, compounded with little knowledge of combat aircraft production, prohibited the United States from entering the war with the necessary reserves that Magruder and Heiser deem necessary for efficient initial logistics operations. Future Air Service leaders, such as General "Hap" Arnold used the troubles experienced in 1916-1917 as support for continued investment in the aviation industry. When the United

States entered WWII, the aircraft were still older models, but not nearly not as old as the American inventory in 1916. The U.S. was much better prepared, industrially, to support an Army Air Force, and it was, for the most part, due to the path cleared by the Air Service pioneers.

In many respects, the U.S. transportation infrastructure was the model for future mobilizations. There were initial problems in securing oceanic transport ships, but the port operations and the domestic roadways were sufficient to handle the burden of the mobilization efforts. The Air Service's supply operations were also well suited for its purpose, and many concepts were still applicable in the Air Force's supply system until very recently. The reliance on foreign equipment and all of the subsequent difficulties undoubtedly led planners to rethink the entire logistics pipeline to reduce this need. While the Air Service's behavior was not consistent with this principle, its actions most likely led to the implementation of the principle in later conflicts.

In terms of planning and organization, the Air Service provided a baseline from which future leaders could learn. Since this was the first time that the U.S. sent troops overseas in great numbers, the idea of theater command (with other forces commanding U.S. assets) was relatively new. It appears that, like the issue of reliance on foreign equipment, the arena of planning and organization led to the development of the principles outlined by Eccles and Heiser.

It appears that the Air Service's logistics support system showed future commanders how to conduct certain logistic operations, and at the same time, how not to conduct other logistic operations. The lessons learned by the Air Service provided valuable experience in the area of aviation logistics that has persevered. In all conflicts

since WWI, the aviation logistics structures have all carried some of the aspects of the Air Service's own. Even though it wasn't perfect, the Air Service's logistics support structure was very good, and its lessons are relevant today.

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Vita

Captain Andrew W. Hunt was born on [redacted] in [redacted]. He is a 1991 graduate of Council Rock High School, Newton, Pennsylvania. In 1995, he graduated from the Pennsylvania State University with a Bachelor's Degree in Political Science, and received his commissioning through the Reserve Officer's Training Corps, Detachment 720.

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13. ABSTRACT (*Maximum 200 Words*)

This historical study details the U.S. Air Service's logistics operations at home and abroad in an attempt to determine the relationship between the process and more recently established logistic principles. The information in the study was collected through an extensive review of both first hand accounts and historical compilations of the nature of World War I aviation logistics. Information regarding the production of the De Haviland DH-4 and Liberty Engine serve as the primary case examples of the operation of the logistics system. The established principles required for comparison were extracted from the writings of a number of expert military logisticians. After a careful review of the information, it seems that the production, transportation and supply aspects of the Air Service's logistics system are in accordance with established principles while he area of domestic production was not. The establishment of a transportation infrastructure and a depot system enabled flexible logistics support. The lack of viable production nearly grounded the air effort. The Air Service was able to design a fully functioning logistics system in less than two years, and the experiences in World War I provided U.S. military aviation leaders with the knowledge needed to prepare for future military engagements.

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