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Into a Wild New Yonder: the United States Air Force and the Origins of Its Information Age

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Abstract

The United States Air Force is an organization operationally focused on gathering, processing, and utilizing vast quantities of information, so much so that it added "cyberspace" to its core missions of air and space in 2005. Service leaders have argued that a USAF information revolution – its entrance into the "Information Age" – began as early as the first computers in the 1940s or as late as the proliferation of networks in the 1990s. Upon close inspection, however, it becomes clear that such assertions overlook decades of information operations and management, and overemphasize the concept of a single information age. This dissertation illustrates how the Air Force's information age has origins dating back to the Civil War-era, a half-century before the development of the first air service. Through reviewing methodological and technological changes in information operations, it becomes clear that the post-World War II "information age" grew from numerous early service efforts to improve the quality, quantity and delivery of its information.

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Introduction

By all accounts, the United States Air Force today is optimally organized for the gathering, processing, and utilizing of vast quantities of information. It runs its global, networked information environment through every installation – and every electronic device – in its possession and aims to develop the most information-dominant warfighting capability in existence.[1] Service leaders believe that "[w]ith today's technology, information and communications can be optimized like never before, and timely information alone can make or break a mission's success."[2] This emphasis on electronics, communications, and data processing – colloquially known as "The Information Age" – has brought a new technological and methodological dimension to a military service formerly preoccupied with the speed and capacity of its aircraft,

[1] "Air Force Space Command," U.S. Air Force Fact Sheet, accessed July 1, 2013, http://www.af.mil/information/factsheets/factsheet.asp?id=155.

[2] "Air Force Careers," Cyberspace Operation Officer, accessed July 03, 2013, http://www.airforce.com/careers/detail/cyberspace-operation-officer/.

not its data pipelines. Since the 1990s, "orchestrating the process of getting the right information, putting it into a usable form, and getting it where it needs to go in a timely manner" has become a major theme in Air Force thinking.[3]

The current "Information Age", however, has origins that stretch back many decades into the past. The purpose of this dissertation is to examine the evolution of information handling in the half-century leading up to the development of the air service and subsequently down through and beyond the establishment of the USAF. I review the methodological and technological changes that occurred as the organization out of which the air arm grew, and the air arm itself, sought to improve the quality, quantity and delivery of information.

The "Information Age" is a term many are familiar with yet few can precisely define. This lack of precision has not stopped those military and technology experts who attest that the United States Air Force's history goes hand-in-hand with the emergence of the "Information Age", especially in the context of the development of the first

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[3] Glenn C. Buchan, *Information War and the Air Force: Wave of the Future? Current Fad?* (Santa Monica, CA: RAND, 1996), 3.

organizationally-useful computers in the 1940s and the expansion of USAF computer operations in the following decades.[4] By 1970, after all, the air service was officially the largest computer user of all federal agencies in the U.S. government and its information requirements and developments made it a technological leader among its sister services.[5]

Asserting or implying that the "Information Age" began with the rise of the modern computer, however, is open to challenge. Some have argued that particular technological developments in the 19th Century or even the 18th Century heralded its coming, while others have claimed that such an age only occurred with the growth of the internet in the 1990s.[6] More helpful in the concept of multiple ages of

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[4] See Gordon T. Gould, Jr. "Computers and Communications in the Information Age." *Air University Review*, May-Jun 1970, accessed May 01, 2011, http://www.airpower.au.af.mil/airchronicles/aureview/1970/may-jun/gould.html (date accessed: 12 Dec 12); and Neufeld, et al., *Technology and the Air Force: A Retrospective*, 313.

[5] Gould, Jr. "Computers and Communications in the Information Age."

[6] See Nico Stehr, "Theories of the Information Age," in *Historical Developments and Theoretical Approaches in Sociology*, by C. Crothers, vol. II (Oxford: Eolss Publishers, 2010); James Essinger, *Jacquard's Web: How a Hand-loom Led to the Birth of the Information Age* (Oxford: Oxford University Press, 2004).

information, and the recognition that every "age" evolved – sometimes in complex ways – out of what came before.[7] This is certainly the case with respect to information and the U.S. Air Force. As for "information" itself, the meaning is also subject to debate.[8] In this dissertation, I treat it as a single piece, or a collection of pieces, of knowledge, intelligence, or fact, whether it be as small as a single data figure on a ledger or as vast as a multi-volume statistical report.

The dissertation unfolds as follows:

- <u>Chapter 1</u>: *The Dawn of an Information Age, 1859-1919.* In this first chapter, I demonstrate how numerous modifications in the Army's information environment in this period were not part of a centralized, coordinated strategy by the service's senior leaders but instead the product of independent decisions made at all echelons to support unit-level interests. By

[7] Richard J. Cox, "The Information Age and History: Looking Backward to See Us," The Information Age and History: Looking Backward to See Us," accessed March 03, 2013, http://d-scholarship.pitt.edu/2698/1/r_cox_1.html.

[8] See "Information Definitions," Merriam-Webster, accessed June 06, 2013, http://www.merriamwebster.com/dictionary/information; "Information," Oxford Dictionary - Online, accessed June 06, 2013, http://oxforddictionaries.com/us/definition/american_english/information; Nico Stehr, "Theories of the Information Age"; and Richard J. Cox, "The Information Age and History: Looking Backward to See Us."

exposing the origins and outcomes of these changes, I show how this information transformation was unsystematic and occasionally myopically-focused. Regardless of their origin, the results of these changes were often beneficial as the organization struggled through its reconstruction and reorganization. In doing so, the Army found it could standardize its processes, refine its decision-making, and justify its actions and relevance in the face of bureaucratic opposition.

- Chapter 2: *Information Standardization, Data Mechanization, and Statistical Control, 1907 - 1947*. This chapter demonstrates how information management and application played an essential role in the development and operation of a budding air service. I discuss the myriad devices, from aviation-specific forms to inventory and reporting systems, which developed the information capabilities of the Army's air units in order to help organize and employ forces both in-garrison and at war. As the air arm grew, these devices provided more timely and expansive information generation and processing for the service's logistical and administrative functions as well. Throughout this chapter, I explain why this information evolution occurred and demonstrate how information was pivotal to the growth of the Air Force and its technological development.

- Chapter 3: *Early Air Force Computing and Mechanized Data Management Programs, 1947-1955.* In this chapter, I focus on the origins of Air Force computing and mechanized data management and how important individual initiative was to the service's success. I explore how, through the dedication and tenacity of a number of key individuals, change across the service's information environment was produced in this period. All this is displayed by focusing specifically on the early years of the Air Force and the contributions and advances that helped shape the service's operational and organizational information landscape.
- Chapter 4: *The Origins of a Data Automation System, 1953-1968.* In Chapter 4, I address the development of the groundbreaking Standard Base Supply System (SBSS) program. This chapter covers the discussions and events that led to the SBSS becoming the Air Force's one-and-only supply system by the highpoint of the Vietnam War. I further explore the important aspects of the program's evolution that help illuminate the

critical programs that followed soon after the SBSS began.

This structure will illustrate the extent to which the computer-driven air force "information age" was part of an evolutionary process dating back to the years after the Civil War; decades during which one information system, or set of systems, succeeded and often overlapped with another. As will become clear, though use and integration of the computer in the mid-20th Century marked a major milestone for the Air Force, the roots of service information gathering and processing can be found in a post-Civil War "information age".

Chapter 1
The Dawn of an Information Age – 1859-1919

Long before the formation of a distinct aviation branch, its parent organization – the U.S. Army – spent decades developing the information processes and procedures that helped define its operating environment coming out of the Civil War. Through orders, manuals and regulations, elements of the Army made conscious efforts to uniformly apply these practices throughout their standard routines. At the same time, the interest in applying emerging information technologies and business machinery grew in importance, both at the unit level and at its headquarters. By the time the Aeronautical Division became a reality in August 1907, information was already a critical mission resource. Operationally and administratively, information application grew evermore intertwined into the organization's functions and training capability, especially given the increase in overall departmental paperwork.[9] As America entered World War I in 1917, the

[9] Direct quotations include: "[i]ncreasing the mere paper work has always overweighted (*sic*) our army and stood in the way of the comfortable supply of the soldiers," found in *Annual Reports of the War Department, 1899.*, vol. 1,

regulations directing the collection, recording, storage, exploitation, and transmission of information were not just a function of daily operations; instead, the information required often defined these operations as well.[10]

The necessity for information in Army operations began in earnest decades earlier. In 1881, the complete *Regulations of the Army of the United States* were codified and published into one document under the orders of the Secretary of War. This massive anthology, well over 1300 pages in length, contained every order, law and regulatory article required of America's land-based military organization fifteen years into its post-war reconstruction. With more than 300 pages of governing edicts and over a thousand pages of forms and corresponding

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series 3 (Washington: Government Printing Office, 1899), 481, and "[k]nowledge of paperwork is fair; efficiency in that direction is increasing. None of the medical officers had any experience in paperwork prior to the Spanish-American War," from *Annual Report of the Surgeon General, United States Army, to the Secretary of War* (Washington: Surgeon General's Office, 1899), 146.

[10] For example, in the 1916 version of Manual for the Quartermaster Corps, the fuel (coal) accounting procedures listed in the supplies and property regulations of the Quartermaster Corps dictate the use of Q.M.C. Forms 210 and 203 to account for total coal credits and debits [see *Manual for the Quartermaster Corps, United States Army, 1916.* (Washington: Government Printing Office, 1917), 336]. In short, these specific forms defined the process as they were specific to the requirement and not a general form applied as such.

direction, this compendium was the War Department's most comprehensive set of directive guidance in existence. From implementing military discipline to operating national cemeteries, *Regulations* is an exhaustive document in both its breadth and depth.[11]

Collections like *Regulations* provide readers with insight into the Army's operational and administrative control methodology for a given period. These collections are especially helpful when exploring more specific and detailed topics as they often provide the baseline information required for historical investigations. Therefore, when examining the information environment that predated the air arm, there may be no better documents for encapsulating all of the Army's important and oftentimes interconnected data management policies and procedures. In fact, with more than three-quarters of *Regulations* dedicated to Army-specific guidance for forms, reports, and registers, this particular document may look to some as much an information manual as it does a regulatory one.[12]

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[11] *Regulations of the Army of the United States and General Orders in Force on the 17th of February, 1881. Codified and Published by Order of the Secretary of War...*(Washington: Government Printing Office, 1881).

[12] *Regulations of the Army of the United States and General Orders in Force on the 17th of February, 1881*.

With such a strong emphasis on information collection and transmission in this one document, it is surmisable that such a systematic and thoughtful display of regulatory control is representative of an integrated and organized data management strategy developed by the service's senior leadership. Likewise, it is just as reasonable to conclude that these information interconnections were both planned for, coordinated and vetted through each Army branch's and staff department's chain of command. However, herein lies the crux: not only is *Regulations of the Army of the United States* not indicative of such conclusions, but these conclusions are in fact invalid themselves.

Regulations was not a display of the Army's organizational abilities and operational foresight, was not indicative of a service-wide coordination process, and certainly was not the end result of an efficiency study determining the best way to collect and distribute Army information. In reality, the War Department created this document in hindsight and under orders from Congress. On the direction of the Appropriations Act of June 23, 1879, and under the advisement of the Judge Advocate General, the Secretary of War ordered the Adjutant General of the Army to codify and publish all applicable regulations and orders in one complete volume.[13] A board of five senior officers convened shortly after the congressional mandate to examine the codification with orders to remove errors, inaccuracies, misinterpretations, repetitions, contradictions, or any relevant defects…but there were no orders or discussion regarding the design of the service's information process nor were any of these five officers experts in all the relevant elements covered in the volume.[14] Therefore, although it may appear that *Regulations* was a major step forward for information control, in reality it was only a nominal step in organizing a chaotic regulatory library and correcting the information mistakes of the past.

Regulations is a microcosm of the Army's information strategy during this period – a kluge of directives and processes established separately and unified without strategic forethought or vetting. Although there were significant changes to the information environment between the Civil War and World War I, many of these changes originated at either the branch- or unit-level and were not

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[13] *Ibid*, vii.

[14] William Winthrop and Charles McClure, *A Digest of Opinions of the Judge-Advocates General of the Army* (Washington: Government Printing Office, 1901), 744-746.

part of any master plan to manage the service's data. Unfortunately, efforts like *Regulations* help feed overgeneralizations and misinterpretations that exist regarding the coordination and responsibility associated with these changes.[15] It is only through a more thorough

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[15] There is no evidence to suggest that the Army ever cross-coordinated all of its information policies and procedures between each of its organizations. This misconception is typically inferred by those who read branch histories or historical summations that draw lines of distinction between specific information requirements when in reality these lines were often blurred. At times, these conclusions are drawn by authors who make broad generalizations about either the lines of responsibility or the coordinated approval of these processes. For example, in Keith E. Bonn's *Army Officer's Guide*, the author makes the statement that the Adjutant General Corps, which acts on behalf of the Commanding General of the Army, "historically [has] been given the responsibility for developing Army personnel and administrative policies and programs" [Keith E. Bonn, *Army Officer's Guide* (Mechanicsburg, PA: Stackpole, 2005), 156.]. However, given that a number of personnel and administrative information processes were also under the direction of both the Quartermaster and the Surgeon General, this statement is misleading. A thorough review of the Army and individual branch regulations, reports, manuals and publications published between 1865 and 1919 clearly shows examples where branches established reporting or data recording requirements without the authority of the Commanding General of the Army. In fact, there was such discord between line and staff organizations that the two were consistently at odds, especially considering that the line worked directly for the Commanding General and the staff for the Secretary of War. In one notable instance, Commanding General of the Army General William T. Sherman noted that he had "no authority, control or influence over anything but the (line organizations)" [See *American Military History.* (Washington: Center of Military History, United States Army, 1989), 263.]. Although there were moves to create staff organizations before the end of the

examination of the Army's information history in this period that the true origins of these changes can be uncovered.

Therefore, the purpose of this chapter is to demonstrate how the numerous modifications to the Army's information environment in the half-century following the Civil War were not part of a centralized, coordinated strategy by the service's most senior leadership. It will show that these changes were actually driven by a series of independent decisions made throughout the service at all echelons, often to support the finite interests of subordinate units. However, by exposing both the origins and outcomes of these changes, this chapter also shows that while this information transformation was unsystematic and occasionally myopically-focused, the results often proved beneficial to an Army struggling through reconstruction and reorganization so that it could standardize its processes, refine its decision-making, and justify its actions and relevance in the face of bureaucratic opposition.

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century, the integration of a formal General Staff – pushed by then Secretary of War Elihu Root in 1899 – helped add a more sophisticated layer of organization and control of the Army that helped alleviate several of these coordination issues prior to World War I.

The Army Environment

As the Civil War came to an end, a new chapter in the United States Army began. The military, whose purpose and size were debated in the years leading up to the war, faced similar uncertainty in the post-war landscape. With no central purpose to match its previous wartime mission, the Army continued to struggle with both its size and its mission. For decades following the war, the Army encountered a number of critical challenges including the occupation in the South, the French threat in Mexico, hostilities in Indian Territory, growing constabulary and civil engagement duties, and a number of small wars throughout the world. However, perhaps no challenge quite defined the changing Army as did post-war demobilization and reconstruction.[16]

The Army's challenge during demobilization and reconstruction was five-fold. First and foremost, the Army had to survive Congress. Following the Civil War, many congressional leaders sought to minimize the role of the military, which in extreme cases meant rendering the armed

[16] See Paul J. Scheips, *Darkness and Light, the Interwar Years, 1865-1898* (Washington: Government Printing Office, 1971), 281-282.

services altogether useless.[17] Congressmen from both parties questioned the validity of newer post-war Army roles, such as constabulary services, asset protection, and election security. By the mid-1870s, some went so far as to claim that less than half of the Army was engaging in legitimate purposes at all. This "spirit of unfriendliness" concerning the Army continued toward the end of the decade, even as the nation's military demands began to increase. In those years, some in Congress (along with their staff) saw the military as a resource drain whose expenditures had grave economic consequences, including driving up inflation. This period was marked by Army leaders and their congressional supporters struggling to find ways to defend the service's existence against its numerous critics, leaving the War Department in what one general officer called a "condition of constant panic."[18]

Second, this congressional backlash produced a force significantly reduced from its wartime strength. Although

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[17] Although many were Democrats from the southern states who held animosity against the Army following it post-war occupation, numerous Republican senators also voted for increased military cutbacks…oftentimes for economic reasons. See Charles A. Byler, *Civil-military Relations on the Frontier and Beyond, 1865-1917* (Westport, CT: Praeger Security International, 2006), 25-29.

[18] Byler, *Civil-military Relations on the Frontier and Beyond, 1865-1917*, 25.

the Army had been barely 18,000 strong prior to the Civil War, service leaders felt its missions in post-war America warranted a much more significant force. The result was quite the opposite. By the time the first Reconstruction Acts were passed in 1867, the volunteer army had nearly ceased to exist. In mid-1866, just over 11,000 of the one million-plus U.S. soldiers who ended the war were still in uniform, many of whom were either whites serving in occupation duties or colored troop regiments.[19] Despite the Army's reconstruction-era duties, Congress only authorized a maximum strength of 56,815 in 1867, which was cut to 27,442 by 1876.[20] This figure remained relatively constant until the end of the century. Congress hardly deviated thereafter despite numerous attempts to raise and lower troop strength and appropriate funding. It was not until the turn of the century and the reorganization of the Army that authorized numbers began improving.[21]

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[19] By November 1865, over 800,000 troops were already discharged and home. See Scheips, *Darkness and Light, the Interwar Years, 1865-1898*, 281-282.

[20] Many of the reconstruction duties had to do with the occupation of the South, but not all [see Scheips, 282, as well as Jerold E. Brown, *Historical Dictionary of the U.S. Army* (Westport, CT: Greenwood Press, 2001), 39].

[21] Scheips, *Darkness and Light, the Interwar Years, 1865-1898* and Byler, *Civil-military Relations on the Frontier and Beyond, 1865-1917*.

The third challenge was the professionalization of the military. The post-war era was an introspective period in which senior service leaders reviewed the Army's core missions and foundational requirements in order to best determine its future. From this came the perceived need for an Army professional development system for officers. This system involved the founding of numerous postgraduate technical and developmental schools that educated officers on both branch-specific and command skills. School development and a stronger officer corps in turn created a requirement for the mass publication of professional Army journals. Through reading occupation-centric titles such as *The Journal of the United States Artillery* and *The Military Surgeon*, and military-centric publications such as *United Service* and *Army and Navy Journal*, officers in the field kept themselves professionally up to data and followed their service's major proceedings. However, at the unit level, professionalization also meant the codification of unit processes and programs. Professional competence meant more at the unit level than mere schooling in the operational arts or keeping pace with the latest in military politics or programs. Instead, the military took its lessons from the Civil War by better-defining its operational requirements and processes to ensure unit activities remained consistent across the service.[22]

The fourth challenge was the disconnectedness between Army staff and line organizations. Even before the Civil War, Army line organizations (e.g. artillery, infantry, or cavalry) served the Commanding General of the Army whose role it was to organize, train and equip each unit with the single focus of combat efficiency. They were the "professional" Army, armed and ready to fight and win the nation's wars. Supporting the line organization were the staff departments (e.g. ordnance, signals, engineers) which were devoted to the more scientific and technical aspects of the service. While the Commanding General controlled and disciplined the Army's territorial line commands, the Army conducted its fiscal affairs through its staff departments via the Secretary of War. Naturally, the situation was rife with potential friction and animosity, something which did not improve during the war nor in the dramatic drawdown that followed. In 1874, as Congress yet again attempted to reduce the size of the Army, Commanding General William T. Sherman noted that he thought certain staff officers were "no more soldiers than the men at the

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[22] Matthew Motten, "Who Is a Member of the Military Profession?" *Joint Forces Quarterly*, no. 62 (2011), 14-17.

Smithsonian."[23] Although reconstruction did not solve the disconnection, its clarity in the post-war Army defined these issues for the senior leadership as well as the congressional leaders who oversaw their performance.[24]

Finally, demobilization and reconstruction significantly affected the technical development of the Army, both in positive and negative ways. On one hand, the period was replete with technological expansion and scientific applications. The use of railroads for logistical and communication purposes, the advancement of breech-loading rifles and artillery, the development of both field- and long-range telegraphy and telephony, and eventually the militarization of lighter-than-air aircraft are all examples of Army advances in the era. On the other hand, the period was also marked by staunch military conservatism, a lack of fiscal resources and personnel, and a national resistance to the technical developments of war. The military lagged behind both industry and its European counterparts on many technological and scientific fronts.

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[23] *American Military History.* (Washington: Center of Military History, United States Army, 1989), 263.

[24] For more information on issues between the line and staff, see Scheips, *Darkness and Light, the Interwar Years, 1865-1898*; and Joseph G. Dawson, *The Late 19th Century U.S. Army, 1865-1898: A Research Guide* (New York: Greenwood Press, 1990), 9-15.

These mixed results put the Army in a difficult situation leading into the twentieth century, showing that the Army would not and could not keep up with industrial or peer competitors so long as it lacked the proper resources and maintained its persistent isolationist state.[25]

These five demobilization and reconstruction challenges not only helped define the Army during this period, but also clearly influenced its actions and decisions. With service brass and even some congressmen clamoring for additional personnel and fiscal resources, often to no avail, leaders across the Army took it upon themselves to better their environment and their units any way they could. These improvements included changing the way they processed and distributed their information. Branch leaders often took it upon themselves to redesign their area's key processes and then formalize their application throughout the Army, even if that meant writing their own regulations.

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[25] Scheips, *Darkness and Light, the Interwar Years, 1865-1898*; Byron Farwell, *The Encyclopedia of Nineteenth-century Land Warfare: An Illustrated World View* (New York: W.W. Norton, 2001), 48-135; Rebecca Robbins Raines, *Getting the Message Through: A Branch History of the U.S. Army Signal Corps* (Washington: Center of Military History, U.S. Army, 1996).

Early Army Information Processes

While there were a number of military information advancements throughout the nineteenth century, few periods provide such a vivid picture of informational progress as did the period of the American Civil War. In many ways, the Civil War was an information war, prosecuted by both sides using both old and new methods of communication, reconnaissance, intelligence, data collection and reporting. In fact, several of the war's methodological and technological developments were groundbreaking in that their integration into unit operations permeated nearly all aspects of operational endeavor. These developments included the founding of two new military communications units, the addition of both tactical and strategic telegraph communication applications, the addition of new short-range visual signaling, an increased use of military and commercial messenger services, photographic communication and reporting, and lighter-than-air aerial reconnaissance and communications ventures.[26] Thanks to a

[26] The two new military communications units were the Signal Corps, founded in 1860, and the Military Telegraph Corps, founded in 1861. The tactical (or short line) telegraph was part of the Signal Corps attempt at using the Beardslee Magneto-Electric Telegraph while the strategic (long line) telegraphs were a greater function of the Telegraph Corps. The new short-range visual signaling system, called the "wig-wag," was developed by the first Army Signal Officer,

growing reliance on information in military operations, the Army's information environment following the war looked very different from the one in place just a few years earlier.

As part of the service's post-war reform process, leaders in the post-war Army sought to further develop how the organization would maintain and transfer its data. With indicators such as the *Annual Report of the Secretary of War* and its numerous sub-reports, the importance of information to senior leaders was unmistakable.[27] These reports overflowed with quantitative and qualitative information gleaned not only from headquarters units but also from the Army's remaining field units. Obtaining what was necessary for such documents required higher echelon units to dictate exactly what information they needed as

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Albert Myer, and was the rationale for the Signal Corps created in 1860. See Rebecca Raines, *Getting the Message Through*.

[27] Examples of these reports include the numerous *Annual Report of the Secretary of War* volumes, as well as the individual annual reports to the Secretary of War. For reference, see *Annual Report of the Secretary of War* (Washington: Government Printing Office, 1881), *Annual Report of the Chief of Engineers to the Secretary of War upon the Improvement of Cumberland River, Tennessee and Kentucky, and of Obion and Forked Deer Rivers, Tennessee.* (Washington: s.n., 1896); *Annual Report of the Chief Signal-Officer to the Secretary of War.* (Washington: Government Printing Office, 1873).

well as *how* units should document and transmit this information at each installation. By and large, these methods assumed several dominant standards that remained consistent until the World War I. They included the use of:

- Registers (ledgers, record books) to record operations at military installations and between units throughout the Army

- Standardized forms or documentation formats to annotate the transfer and documentation of information

- Either handwritten or mechanically-written documents and correspondence

The Army used orders and regulations to dictate the service's priorities for administrative processes. For a service fighting for clarity in a period of national and organizational transition, these standards represent but a portion of its attempt to regulate its operations during a period of change and conflict.

Among these standards, the best documented is official record bookkeeping. Formally maintaining official records grew out of the establishment of the War Department in 1789 and became an important organizational function. For decades before and after the Civil War, the Army's primary means of information documentation continued to be the compilation of operational and administrative data in record books, also referred to as ledgers or registers. Coming in numerous shapes and sizes, these records remained the primary method for documenting and filing information across the spectrum of Army processes ranging from personnel matters to logistics to combat maneuvers. Additionally, although the Government Printing Office maintained the capability to produce formalized, printed copies of Army data beginning in 1861, the original ledgers remained overwhelmingly handwritten. Even as new technologies allowed for recording improvements, the Army remained faithful to the ledger system well into World War I.[28]

Requirements for Army registers are strewn throughout War Department regulations of the age and derive from the requirements of the various service branches. By the late nineteenth century, these document books were an inescapable part of standard Army administration and record keeping procedures. For instance, in 1895, the Army required that all stations maintain a series of "books of record" at each location, to include an order book,

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[28] The Government Printing Office was created in June 1860 by Congressional Joint Resolution 25 but did not begin its operations until March 1861. See James L. Harrison, *100 GPO Years: 1861 - 1961; A History of United States Public Printing* (Washington: Government Printing Office, 2010).

letters-received and letters-sent books (both with corresponding index books), and a post council administration book.[29] Additionally, individual branches such as the Quartermaster and Adjutant General required ledgers that included a morning report book, guard report book, and a Post Exchange council book.[30] Meanwhile, at lower levels on post, divisions and companies also maintained their own records to preserve order and document administration. At the company level, for example, registers included a separate company order book, books of letters and sent, company council book, sick report book, clothing book, morning report book, a descriptive and deposit book, and a duty roster. In some cases, these ledgers became so extensive they even included descriptive books of all public animals on post. By the end of the nineteenth century, the Army appeared committed to using registers as its means of systematically documenting the major activities at each of its posts around the world.[31]

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[29] *Regulations for the Army of the United States, Appendixes No. 8.* (Washington: Government Printing Office, 1895), 29.

[30] *Regulations for the Army of the United States, Appendixes No. 8*, 29.

[31] *Ibid.*

Beyond documenting the standard logistical events at each location, each station was additionally responsible for maintaining a standardized and comprehensive store of directives and regulations. The War Department required that post record clerks diligently maintain all downward-directed orders and instructions to ensure each location operated alike. Army commanders, as required by regulations, insisted all existing orders, letters and correspondence affecting company personnel be likewise maintained to ensure information standardization.[32] Meanwhile, this uniformity across installations allowed for a level of information homogeneity that made station and unit data readily available to headquarters echelons. By either inquiry or up-channel reporting, this process permitted senior leaders access to subordinate data by way of rolls, reports, and returns on a regular basis. For branches such as the Quartermaster and Adjutant General, keeping operations uniform across the department became paramount, and Army leaders wrote additional regulations standardizing information recording to ensure correspondence between units remained consistent. Record book documentation and regulations, however, were not

[32] *Ibid*, 37.

enough. What often predicated this data recording, and other times stood on its own, was the application of standardized information forms.[33]

Official Army forms, typically numbered for simplicity of reference, were often pre-printed documents used by units or installations to provide or annotate information. Although the term *form* usually represented the paperwork itself, the terms form and format were often synonymous in that the specified verbiage on a document form could instead be written by hand on blank paper. Overall, the meaning and importance of forms over time were often the guiding principles of administrative processes throughout the Army. For example, one Army publication emphasized that:

> The ultimate end for which a company is created and maintained is to render perfect service on the field of battle. To attain this end many things are required and a realization of the correct proportion, each bear to the other is necessary….[efficiency in paperwork] is required by law and regulations and can not be slighted, nor done in a slip-shod manner. If it is done thoroughly and accurately at first, it ends there....The instructions on the blank forms have the same weight as regulations and should be followed explicitly.[34]

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[33] See *Regulations of the Army of the United States and General Orders in Force on the 17th of February, 1881* and *Regulations for the Army of the United States, Appendixes No. 8.*

Prescribed forms and formats in Army administrative operations were nothing new in the service, some dating back to the earliest years of the War Department. In fact, early departmental regulations at the turn of the nineteenth century make specific reference to blank forms designed to illicit specific information from field commanders.[35] As the military matured, the use of these forms grew even more prevalent and dynamic.

With improved reproduction devices and the formation of the Government Printing Office by the early 1860s, the department increased its capability to provide blank forms to the Army posts across the nation.[36] In addition, the mass printing of Army regulations amplified the use of standard forms as they became a more integral part of normal administrative operations. All this ensured a

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34 *Fifty Forms, Company and Regimental U.S. Army Paper Work, with Instructions and Sample Forms (to Date, July 1, 1918)* (Tacoma, WA: Pioneer Bindery & Print., 1918), 3.

35 *An Act Establishing Rules and Articles for the Government of the Armies of the United States: With the Regulations of the War Department Respecting the Same, to Which Are Added, the Several Laws Relative to the Army, the Militia When in Actual Service, Volunteers, Rangers, Ordnance Department, and the Quarter Master's and Commissary General's Department.* (Albany: Webster's & Skinners, 1812), 115.

36 James L. Harrison, *100 GPO Years: 1861 - 1961; A History of United States Public Printing*.

greater level of consistency in the department's information gathering efforts. For example, beyond the standard record keeping logs of the post Quartermaster, the Army required supply customers to complete specific requisition forms to ensure requests were officially transmitted, logged, and acted upon. Army Regulations from 1861, 1881, 1895, and 1916 all dictate similar paperwork requirements for managing logistical stocks regardless of station.[37] Despite the vast changes in the military over more than fifty years, form requirements prior to World War I closely mirrored those of the Civil War. Although the forms were subject to change based on the branch or division from which they derived, the requirement for their use hardly changed at all.

The importance of detailed record keeping and form management in this period cannot be understated. Depending

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[37] See *Theodore S. Case, Quartermaster's Guide Being a Summary of the Army Regulations of 1863, and General Orders from the War Dept. from May 1861 to April 10, 1865 Which Affect the Quartermaster's Dept., with All General Orders from the Quartermaster General's Office to April 10, 1865. (St. Louis: P.M. Pinckard, 1865); Regulations of the Army of the United States and General Orders in Force on the 17th of February, 1881* (Washington: Government Printing Office, 1882); *Regulations for the Army of the United States, Appendixes No. 8,* and *Manual for the Quartermaster Corps, United States Army, 1916.* (Washington: Government Printing Office, 1917).

on the specific Army branch, service directives frequently dictated that unit leaders account for their activities and resources to higher echelons on a regular basis. These accounts, filed either in periodic written reports or form-derived bookkeeping statements, were often later compiled into much larger volumes that were sent to either senior military agencies or congressional committees. The task was often arduous and time consuming, but was nevertheless a mandatory requirement for commanders across the War Department. Of all the branches and units requiring data for operations and reports, few organizations exemplify this requirement more than the Army's Quartermaster.

The Quartermaster's responsibilities in the 19th Century remained relatively true to its Continental Army origins in 1775.[38] As the sole provider of logistical support to the Army, its mission was naturally administratively intensive. Therefore, its reports and corresponding forms required a great deal of clerical work and administrative forbearance. For instance, general orders required each branch officer to file an end-of-year Quartermaster Report by the close of each fiscal period.

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[38] "Quartermaster History," US Army Quartermaster School, Fort Lee, Virginia, accessed April 5, 2013, http://www.quartermaster.army.mil/qm_history.html.

The report was demanding; by order, it required narrative summaries, resource compilations and calculations, and personal assessments of condition and readiness for nearly all logistical matters under the officer's purview. Moreover, regulations required the report include additional logistical data encapsulated in thirteen distinct branch forms.[39] These forms, labeled Forms A through M for simplicity, covered public funds, quartermaster property, clothing and equipage, transportation costs, lost or captured materiel, telegraph systems, and property sold at public auction. Upon completion, orders required the officers to file these reports in specific fashion without deviation – on half-sheets of "fools cap" paper, written only on one side and fastened uniformly at the top. With the vast amount of required data, standardization remained key in the post-war Army, even if only for convenience in filing.[40]

With forms providing so much data at each location, the final information challenge concerned recording. Whether the documentation medium was a record ledger, an

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[39] *General Orders, Quartermaster General's Office 1868* (Washington: Government Printing Office, 1869), 60-89.

[40] *General Orders, Quartermaster General's Office 1868*, 60-62.

official memorandum, or a blank personnel request form, the options regarding printing method changed dramatically in the mid-1870s with the invention and consumer production of an industry-ready typewriter.[41] Once these machines became commercially available and operationally viable, Army units had their choice of "writing," either by hand or machine. Without any regulatory requirement to use one or the other, it became incumbent upon each unit to either acquire these machines or continue documenting and corresponding in longhand. The absence of service-directed guidance for typewriter purchases (or other administrative machines, for that matter) meant funding for these devices was deficient. For commanders, the choice of documentation method was their decision to make. Therefore, despite the creation of standardization methods such as registers and forms, *how* information was recorded ensured that department-wide consistency remained elusive.

By and large, administrators continued to rely on handwriting as their primary means of data recording and correspondence going into the twentieth century. Since the War Department never mandated mechanically-produced writing, handwritten record books, personally scripted

[41] Charles Edward Weller, *The Early History of the Typewriter* (La Porte, IN: Chase & Shepard, Printers, 1918).

correspondence and hand-scribed orders remained a principal form of Army documentation for decades in the post-Reconstruction military. The compilation of data at each military station remained essential to its daily operations. Equally important was the delivery of the written word both on post and across locations. As it happened, Army regulations of the late nineteenth century stressed the importance of written reports, directives and correspondence. In fact, many regulations of the period stipulated that the appropriate transmission of information either be originated or finalized in handwriting, without exception.[42] Even as late as 1915, Army disbursing regulations required handwriting and prohibited the use of mechanized printing or stamping when filling out certain forms.[43] Additionally, most pre-bound ledgers could not accommodate machine-entered data given their construction and configuration. Handwriting may have been antiquated, but it remained an important method of communicating information well into the twentieth century.

[42] *Regulations for the Army of the United States, Appendixes No. 8, Manual for the Quartermaster Corps: United States Army : 1916* (Washington: Government Printing Office, 1917).

[43] *General, Property, and Disbursing Regulations, Signal Corps., United States Army.*

With the establishment of these critical documentation methods, the United States Army determined its own administrative, information processing future, though without any unified, central guidance from its commanding general. Meanwhile, the draw of administrative machines – most specifically, the typewriter – quickly became a factor in the information processes of both the military and the national government. As the 19th century drew to a close, machines that could "write" or "compute" were fast becoming part of the public conscience despite the challenge of injecting them into military operations. Whether or not the Army applied these devices in its information environment was no longer the military's concern alone. Its ability to adapt to the most modern administrative methods of the day became an issue both inside the War Department and out.

Early Army Information Machinery

At the same time leaders throughout the Army were shoring up information procedures, several additional variables came into play as the both staff and line branches examined the future of their administrative environment. These variables centered on the potential usefulness of machines, ones specifically designed to complement the growing information requirements found throughout the industrialized world.

Beginning in the 1870s, the pages of local and national publications were often strewn with advertisements praising workplace improvement products. Amidst the announcements for specialized office furniture, groundbreaking communication devices, and innovative writing utensils were some for the latest industrial consumables: mechanical office equipment. Office machine manufacturers used these ads to boast how their products possessed the capability to improve workplace efficiency, generate sales volume and increase output production. From the paper-roll and standard-type typewriters to damp-leaf and papyrograph copiers, the promise of these information instruments enticed administrators and bookkeepers from across the industrial landscape to seek business improvement through their use.[44]

Industrial corporation leaders found themselves debating the utility of these and other office improvement products. The possibility of enhancing accounting, statistical, and information management techniques proved

[44] For the best source of these advertisements, see *The Cosmopolitan, March-August 1886*, 1-415, with specific reference to pages 403-418.

alluring to many corporations, but especially to those with a large administrative overhead. Organizations administratively responsible for a multitude of resources could clearly benefit from automation and mechanization if all the advertisements were to be believed. The popularity of these products in this era underscores the imagination several of certain inventors, entrepreneurs, and companies, each seeking success in increasing the documentation, reproduction, and data calculation capabilities of office machines in the latter half of the nineteenth century. Likewise, instruments such as the mechanical typewriter, mimeograph printing machine, electrical data tabulator, and arithmometer and comptometer mechanical calculator all provided organizational leaders with the potential for achieving an increase in capability.

The question facing United States Army commanders, meanwhile, was choosing which innovations to apply, if any at all. In the decades following the Civil War, the nation's military attempted to settle into a more conventional rhythm. Branch organizations such as the Adjutant General, Surgeon General, and the Quartermaster spent a great deal of time and effort standardizing their administrative activities and practices to best control the information of the Army in garrison. Despite record books and standardized forms serving as a baseline for military administrative procedures, individual War Department units began looking to mechanical advances to improve their information processes, especially those in the areas of logistics, health management, administration and personnel. Innovative equipment capable of dramatically improving the quality of unit correspondence, interaction, and information maintenance proved especially intriguing to those units whose very livelihood depended on the accurate and reliable transfer of information. By the last decade of the century, much to the delight of magazine advertisers, the typewriter's relative absence in Army doctrine was fast being overshadowed by the willingness of soldiers to test these mechanical devices in their units.

The Army's use of the typewriter prior to 1890 was sporadic at best. In fact, mention of mechanical typewriters in service documents before that time is incredibly sparse, highlighting a general lack of interest amongst service leaders in promoting their use. In 1874, Quartermaster General of the Army Brigadier General Montgomery C. Meigs examined the first production model of Sholes and Glidden's typewriter and saw its utility for future army administration.[45] Thereafter, though, Army records of the era that specifically mention "typewriter" refer more often than not to a person holding a clerical position.[46] Other documents do, however, place increased emphasis on the printing of official documents as opposed to the reliance on those accomplished by hand, thereby signifying a shift toward preference for data recorded in typeset. This in turn led to individual unit purchases of typewriters. As the haphazard purchasing and utilization of typewriters increased throughout the service, it became incumbent upon War Department leaders to ensure future

[45] Erna Risch, *Quartermaster Support of the Army: A History of the Corps, 1775-1939* (Washington: Center of Military History, U.S. Army, 1989), 734-735., "General Montgomery Cunningham Meigs," *Scientific American* 66 (1892), 71.

[46] *Reports of Committees of the Senate of the United States for the First Session of the Fiftieth Congress, 1887-88* (Washington: Government Printing Office, 1888), 130; *Register of the War Department: January 1, 1889.* (Washington: [s.n.], 1889), 139, 154, 176. *Testimony before the Joint Commission to Consider the Present Organizations of the Signal Service, Geological Survey, Coast and Geodetic Survey, and the Hydrographic Office of the Navy Department, with a View to Secure Greater Efficiency and Econommy (sic) of Administration of the Public Service in Said Bureaus,* (Washington: Government Printing Office, 1886), 316; *Business Methods in the War Department: Report of the Board Appointed in Compliance with the Request of the Senate Select Committee to Investigate the Methods of Business in the Executive Departments.* (Washington: Government Printing Office, 1889).

equipment use fell within an Army operational standard. Therefore, the Army began issue regulations.[47]

The Army's initial attempt to regulate and record typewriter usage appears in various War Department directives published in the latter half of the 1880s.[48] Over the next several decades, thousands of typewriters from a myriad manufacturers were unsystematically acquired by headquarters and field units depending on their needs and resources at the time. Between 1892 and 1920, Army reports and directives show a steady increase in typewriter usage, especially in administratively heavy organizations such as the Quartermaster Department, Office of the Surgeon General, Adjutant General, Corps of Engineers, and Signal Corps. Moreover, throughout this period, calls for typewriters, typewriter stands, paper (both letterhead and

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[47] This information derives from *Annual Reports of the War Department* (Washington: Government Printing Office, 1885), 422; *Business Methods in the War Department: Report of the Board Appointed in Compliance with the Request of the Senate Select Committee to Investigate the Methods of Business in the Executive Departments.* (Washington: Government Printing Office, 1889), 19; Francis Marlon Cockrell, *Report [of] the Select Committee of the United States Senate: Appointed under Senate Resolution of March 3, 1887, to Inquire into and Examine the Methods of Business and Work in the Executive Departments, Etc., and the Causes of Delays in Transacting the Public Business, Etc.*(Washington: Government Printing Office, 1888), 31-92.

[48] *Ibid.*

plain), ribbons, machine oil, brushes, and cases are scattered throughout the requirements of field units.[49] Since administrative machine usage remained predominately unit-based, shifting from handwritten records to a more formal, typewritten form of documentation varied from unit to unit. When to change across the board, as well as how and why, would all become questions for a War Department consistently in transition.

Prior to World War I, perhaps the clearest indication of the typewriter's acceptance in the Army is found in the regulatory vernacular itself. Towards the end of the nineteenth century, administrative doctrine utilized the term "writing" in an all-encompassing fashion, implicitly refusing to a draw distinction between handwritten and mechanized print-based correspondence. While it was implied that Army clerks should have access to typewriters

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[49] For a sample of this guidance, see *Property and General Regulations of the Signal Corps, U.S. Army.* (Washington: Government Printing Office, 1898); *Manual for the Quartermaster Corps, United States Army, 1916.* (Washington: Government Printing Office, 1917); *General, Property, and Disbursing Regulations, Signal Corps, United States Army.* (Washington: Government Printing Office, 1915); *Manual for the Medical Department* (Washington: Government Printing Office, 1896); *Annual Report of the Chief of Engineers to the Secretary of War [upon the] Improvement of Cumberland River, Tennessee and Kentucky, and of Obion and Forked Deer Rivers, Tennessee.* (Washington: s.n., 1896).

by the early twentieth century, there was no standing requirement for most paperwork to be typed.[50] As late as 1916, the *Manual for the Quartermaster Corps* directs soldiers to complete supply forms and correspondence by dictating they "so state in writing," "write upon the discharge" and "write the words," with no mention of which writing method – handwritten or typewritten – to utilize.[51] Meanwhile, regulations further stated that blank forms contain spaces "of such size as to permit [information] being typewritten on an ordinary machine," yet said nothing explicitly about these spaces being filled with typed information.[52] Thus, although the Army grew more accustomed to machine-written documentation, typewriter use remained a matter of individual preference influenced by industrial standards and marketing campaigns.

On occasion, it did become necessary for operational Army regulations to mention the typewriter by name. Although infrequent in the context of the voluminous amount of directives issued during this period, these certain

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[50] James Alfred Moss, *Army Paperwork: A Practical Working Guide in Army Administration* (Menasha, WI: G. Banta, 1917), 214.

[51] *Manual for the Quartermaster Corps, United States Army, 1916,* 234, 311-324.

[52] *Ibid,* 58.

regulations aimed to provide guidance concerning typewriter use within Army organizations. For instance, Army courts martial instructions specify that if a typewriter is used that the court must utilize a "copyable ribbon" when practicable to save time and labor when making copies.[53] Other regulations, meanwhile, set strict limits on typewriter use. By direction of the Secretary of War, typewriter use was prohibited among payroll disbursing officers when filling out checks due to the belief that typewriter ink could be erased and/or changed more easily than ink on handwritten checks.[54] In another case, the Quartermaster General ruled in 1912 that certain expense accounts "must be made out in ink" and would not be accepted if typewritten.[55]

In fact, at the start of the twentieth century, the verb "type" had not yet entered the Army's administrative lexicon. Instead, the service still used the verb "to write" in its regulations to signify the act of typing as

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[53] *Ibid*, 1916.

[54] *Regulations for the Army of the United States, Appendixes No. 8*, 343.

[55] *General, Property, and Disbursing Regulations, Signal Corps., United States Army.* (Washington: Government Printing Office, 1915), 24.

well as handwriting, along with the more specific phrase "written on the typewriter."[56]

Before America's entry into World War I in 1917, the Army refrained from any service-wide programmatic acquisitions of typewriters.[57] Although thousands of typewriters were bought in bulk by various units inside the War Department as the Army prepared for war, there was no centralized buying program or single headquarters oversight. Thus, there was no unilateral allegiance to a specific machine or manufacturer. Nonetheless, individual unit bulk purchases became significant for the typewriter companies.[58] In fact, many manufacturers eagerly used their service contracts as marketing tools in their advertising campaigns. Periodicals from this period show contract flaunting was not only a matter of pride but also the result of extensive market competition. Oftentimes, it was

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[56] *Regulations for the Army of the United States, Appendixes No. 8,* 386, and *Army Circular No. 29, Headquarters of the Army, Adjutant-General's Office (August 22, 1900)* (Washington: Government Printing Office, 1900).

[57] Email correspondence with Paul Morando (Director of the Army Quartermaster Museum), Leo Hirrel (Historian of the Army's Quartermaster School), Luther Hanson (Curator for the Army's Quartermaster Museum), and Darcie Fouste (Director of the Adjutant General Museum), between 11/19/12 and 12/31/12.

[58] *Ibid.*

not enough to merely boast about contract possession; it was equally important to explain *why* a product was chosen over its competitors. As a result, typewriter contracts made both the news and the advertising pages of periodicals and magazines of the day.

Examples of such flaunting ranged from prideful expressions of technological superiority to outright bragging over the impact of one's product. As an example, a Smith Premier Typewriter Company's advertisement boasted in 1892 about receiving an order from the War Department for 150 machines. Claiming that "improvement is the order of the age," Smith Premier asserted that this order was the largest typewriter contract signed by any government or corporation to date and was based upon the company's "many improvements and superior mechanical excellence…over all other typewriters."[59] Just a year later, a Densmore Typewriter Company ad explained how War Department units had also adopted its product into daily operations, approving of their performance to the point that they renewed the contract two years later.[60] By World War I,

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[59] Darcie Fouste, *Smith Premiere Typewriter Advertisement*, Adjutant General Collection, United States Army Adjutant General Museum, Fort Jackson, SC.

industry leaders such as the Corona Typewriter Company had published advertisements boasting of their involvement in the nation's war effort. The company claimed that "countless Coronas are in daily use in many sectors of the great battle-fields…their ready portability, made possible by their light weight and compactness, appeals [to] the officer whose orders must be legible."[61] Although the Army left few details about typewriter use before the war, the typewriter classifieds of the day were rife with application examples. For those outside the service, these advertisements were perhaps the only written notice of the Army's adoption of the typewriter into daily information operations.

Congress, however, once World War I was over, grew increasingly concerned over how many typewriters the Army had actually purchased . . . and why. In an address to the Congressional House Subcommittee on Appropriations in February, 1920, Army Major Charles Arrighi of the Quartermaster Corps reported that as of June 30, 1919, the

60 Darcie Fouste, *Densmore Typewriter Advertisement*, Adjutant General Collection, United States Army Adjutant General Museum, Fort Jackson, SC.

61 Darcie Fouste, *Corona Typewriter Advertisement*, Adjutant General Collection, United States Army Adjutant General Museum, Fort Jackson, SC.

War Department maintained 47,748 typewriters in their administrative arsenal – 35,024 in use and another 12,724 in stock or storage.[62] With an Army projected as needing nearly 275,000 men following additional post-war reorganizations, the Major predicted the War Department would require approximately 28,588 typewriters for administrative utilization in the Army of the future, or roughly 1 for every 10 soldiers. Moreover, he estimated that a requirement also existed for another 20,000 typewriters for vocational training. With an average life span of only three years, typewriters had in fact become an essential commodity at each Army post around the world. It was Major Arrighi's job not only to account for the number of machines in the service but also to report on their condition, utilization, and potential reuse. Prior to the war, purchases of more than a hundred machines were considered major acquisitions by Army organizations. In the post-war Army, however, usage and replacement requirements meant that acquisitions now ranged in the thousands with little slowing in sight.[63]

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[62] Major Arrighi was from the Quartermaster Corps' Division of Storage.

[63] *Legislative, Executive, and Judicial Appropriation Bill, 1921: Hearing before Subcommittee of House Committee on Appropriations... in Charge of the Legislative, Executive,*

What brought Arrighi to Congress was not so much the number of typewriters in use but rather the number apparently going to waste. Representative William R. Wood (R, Indiana) led the congressional appropriations inquiry in which Arrighi, two additional Army officers and a senior civil servant carefully justified the number of typewriters required by the War Department in peacetime.[64] At issue was the element of machine waste with three major categories under contention: machines purchased during the war but unpacked and unused; machines used and operational but no longer in use; and machines broken and repairable but in storage while new machines were purchased. On February 12, 1920, Representative Wood challenged the United States Army

and Judicial Appropriation Bill for 1921. Sixty-sixth Congress, Second Session ... (Washington: Government Printing Office, 1920).

[64] Besides Major Charles T. Arrighi, the other three individuals summoned to the hearing were Lieutenant H. A. Clemetsen of the Division of Purchase, Lieutenant Colonel L. B. Gerow of the Requirements Division, and Mr. W. D. Koch from the Office of the Director of Sales. *Legislative, Executive, and Judicial Appropriation Bill, 1921: Hearing before Subcommittee of House Committee on Appropriations... in Charge of the Legislative, Executive, and Judicial Appropriation Bill for 1921. Sixty-sixth Congress, Second Session*. Information on Representative William Robert Wood found at "Wood, William Robert - Biographical Information," Wood, William Robert - Biographical Information, accessed April 1, 2013, http://bioguide.congress.gov/scripts/biodisplay.pl?index=W000706.

to articulate its official plans for the administrative use and care of its typewriters…but the Army simply did not have a coherent answer. According to Arrighi, War Department leaders initially surmised that perhaps a ratio of one typewriter per 75 soldiers was appropriate, but that figure was inaccurate as it failed to account for the civilian workforce requirement. Additionally, this ratio was devised for an operational Army, thus additional training and recruitment requirements would skew that number tremendously. Overall, it became clear to Wood and his committee that there existed no coherent plan for typewriters in the Army and that thousands of these machines were going to waste, either being bought without reason or purchased with appropriate intent but not utilized or reutilized properly. Despite his incredulous and unprofessional tone, Wood had uncovered a longstanding truth about the Army's strategic administrative plans for the typewriter – there were none.[65]

[65] This entire paragraph derives from the testimony given Arrighi, Clemetsen, Gerow, and Koch to the House Committee on Appropriations led by Congressman Wood. United States. *Legislative, Executive, and Judicial Appropriation Bill, 1921: Hearing before Subcommittee of House Committee on Appropriations... in Charge of the Legislative, Executive, and Judicial Appropriation Bill for 1921. Sixty-sixth Congress, Second Session*, 2536-2566.

For his part, Wood seemed bent on teaching the Major and his associates a hard lesson in fiscal responsibility and program management. With an Army preparing for a dramatic drawdown and serious economic constraints, the inquiry was certainly well-timed. After questioning individuals from the Quartermaster's Requirements Division, Purchase and Storage Divisions, and an agent of the Office of the Director of Sales, Wood was unable to extract a coherent answer concerning the Army's administrative strategies and requirements. Based on testimony, the Army possessed few valid calculations determining the clerical support required either per individual or per unit. It merely based its projections on previous organizational and administrative experience. Moreover, estimates submitted never determined if all clerks or administrators even required typewriters, or if there existed a more valid ratio or correlation between such men and machines. The Army also grappled with the issue of whether its non-clerical personnel required typewriters at their location, and if so, how many? All told, the notional data presented by the four War Department representatives never satisfied the appropriations committee. Instead, the testimony of Arrighi and three other officials only proved the Army's inability to discern between haphazard information processes and valid administrative principles.[66]

While the Army had no coherent strategy for typewriter use, the war did manage to become the impetus for one strategic decision regarding the service's office equipment. Of the information machinery improvements made in and around World War I, one of the most important was the centralization of Army purchasing. Beginning in August 1918, the service's Purchases Office in Washington, DC became the clearinghouse for all office machine-related acquisitions through the end of the war and beyond. In fact, between August 15 and November 11 of 1918 alone, the Army centrally approved the purchase of 23,378 machines of various kinds for use throughout the service.[67] For the first time since they appeared in the marketplace, typewriters and other administrative devices could no longer be purchased on the whim of an individual unit. Moreover, the Army required that requesting organizations provide appropriate justification to the Director's office for any administrative requirement they had. Although the War Department had no official service-wide procurement

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[66] *Legislative, Executive, and Judicial Appropriation Bill, 1921*, 2536-2566.

[67] *Ibid*, 1920, 2557.

program at the time, this purchasing centralization managed to at least unveil the Army's unit-level administrative necessities to its most senior echelons. Furthermore, it forced the financially strapped postwar service to investigate alternative methods for fulfilling these mission-essential requirements, most notably the use of unused and reusable equipment.[68]

While reusing equipment was not new in the military, the coordination of such a process was. In combination with the new centralized acquisition process, this new approach allowed the Army to capitalize on a centralized surplus accountability system that operated both inside the Army and out. Inside the Army, the Supply Section in the office of the Director of Purchase, Storage and Traffic became the arbiter of service-wide machine management, determining how best to redistribute excess typewriters and other equipment stored throughout the country. Originally, the Army installed the office in December 1918 under wartime authority to dispose of surplus property acquired during the "war emergency."[69] Following the war, rather

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[68] *Ibid*, 2536-2566.

[69] Lloyd M. Short, *The Development of National Administrative Organization in the United States,* (Baltimore, MD: Johns Hopkins Press, 1923), 264.

than contracting for new equipment straight away, the process tightened to ensure all new equipment requests were first reviewed by headquarters and then, after crosschecking the Army's surplus registers, filled with devices held in excess. If no machines were available, the Army looked outside the organization to the General Supply Committee of the Treasury. There, the department maintained its own ledger of government-wide surplus machines and redistributed them as applicable.[70] In both cases, in an effort to recover money spent in the frenzy of wartime preparation, any remaining excess machines were sold to other government agencies, or even to industry, in an effort to recover the costs of war.[71]

For the Army, the combination of equipment operations and maintenance, future requirements management, and service-wide distribution and redistribution of equipment resulted in a centralized office equipment management program designed to save money in a manner Congressman Wood and the appropriations committee had expected. Their concern, however, was that the process took place too late in the Army's purchasing scheme. Moreover, they were not

[70] *Legislative, Executive, and Judicial Appropriation Bill, 1921*, 1920, 2558.

[71] *Ibid, 1921*, 2536-2566.

convinced it worked as advertised in the first place. With such a high volume of typewriters purchased in such a short amount of time, it is quite possible Army managers lost sight of both the purchasing and destiny of this equipment, much as the committee surmised. Luckily, other administrative machines purchased during the same period were not nearly as abundant and could thus be better tracked. Therefore, the Army was able to more accurately account for and regulate these machines. Administrative records from the post-war Army depict an organization with a growing interest in information devices beyond the typewriter. As it happened, the War Department's complement of office equipment grew to include a plethora of devices designed to calculate, duplicate and record information, demonstrating a concerted effort to improve the information capability at the headquarters- and the unit-level alike.[72]

As mentioned, purchased quantities of these "other" administrative machines were much smaller than with typewriters of the era. In fact, they represented less than two percent of the total administrative machine

[72] *Legislative, Executive, and Judicial Appropriation Bill, 1921*, 2539-2544.

stockpile in the War Department as of January 1920.[73] Still, their impact on the Army's tactical and strategic information processes was invaluable at the time. Despite their small number, these machines exposed soldiers to an even broader range of mechanization. Instead of the usual power production or transportation machinery soldiers had grown accustomed to as part of the Machine Age, Army professionals were instead considering a relatively unique premise during this period: the automation of manual information processes and data tabulation. This information mechanization opened the aperture for a newer way of thinking about data recording and manipulation, in turn affecting administrative actions and organizational decisions.

Of the nearly 800 non-typewriting administrative devices in the Army at the end of 1919, the most prevalent by far was the mimeograph machine. With over 560 of these mechanical units in place throughout the Army, the device became a primary means of document reproduction outside of the Government Printing Office (GPO). Post-war mimeographs had evolved from their first marketable versions in the 1880s, but their replication method of ink transfer

[73] *Ibid, 1921*, 1920, 2539.

mechanisms and stencils remained similar in most latter models and proved to be an extremely compact and expeditious method of duplicating. Derivative of Thomas Edison's "Autographic Printing" patent in 1876, these devices grew in popularity due in part to their benefits over alternative methods, predominately tremendous cost savings and a lower skill requirement for users.[74] Besides bearing the burden of unit reproduction needs, use of the mimeograph was vital to the Army's rejuvenated periodical program. By 1920, alongside more than a hundred circulars and bulletins reproduced by either the GPO or other service methods, the Army produced publications founded after the war using mimeographs. Periodical reproduction by mimeograph spread well beyond typical users such as the Quartermaster and the Surgeon General. Instead, participating branches now included chemical warfare, infantry, recruiting, motor transport, and even a budding new organization called the Air Service.[75] Mimeographs made

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[74] "Mimeograph," RedOrbit - Inventions Reference Library, accessed February 20, 2013, http://www.redorbit.com/education/reference_library/technology_1/inventions/2583628/mimeograph/

[75] *US Congressional Serial Set, 66th Congress, 2nd Session, December 1, 1919-June 5, 1920, Senate Documents*, vol. 15 (Washington: Government Printing Office, 1920).

document reproduction viable and affordable for individual unit needs, once again highlighting the capabilities of innovative equipment.

The next largest category of these office devices after document production tools was what congressional leaders called "computing" equipment, most notably adding machines, calculating machines, and comptometers.[76] These early computational mechanisms made up nearly twenty percent of the War Department's non-typewriting administrative machine stockpile with adding machines being the most prevalent. With large volumes of calculable data in areas like finance, supply, personnel, and ordnance, units across the Army sought to purchase computational device to ease the numerous arithmetic duties required of soldiers who compiled statistical data or reported complicated statuses. Although adding machines were the most common device in the Army, calculating machines and comptometers had greater capability, often performing all four arithmetic functions and even more depending on sophistication and design. In all, by the end of 1919, the Army owned 130 of these computing machines in twelve of

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[76] *Legislative, Executive, and Judicial Appropriation Bill, 1921*, 1920, 2539-2544.

fourteen regional zones across the country.[77] For the two zones supposedly without them, the answer is simple: the Army only counted machines purchased by the service in their reporting figures. Units that leased this equipment were another matter entirely.

While a number of Army organizations believed they required some form of computing device, War Department headquarters was often not convinced. At costs ranging from $125 up to $1,000 depending on complexity, these were incredibly expensive items given their sometimes limited impact on the unit. Beyond the Army's own skepticism, members of Congress additionally questioned the validity of military unit requirements, even accusing the Army of wasting machines already purchased and creating irresponsible requirements through which to acquire them in the future. In fact, Congressman Wood moaned that "every fellow who has half a dozen figures to add up thinks he must have a computing machine to do it."[78] For their part, the Army's Office of the Assistant Chief of Staff, Director

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[77] *Legislative, Executive, and Judicial Appropriation Bill, 1921*, 1920, 2539.

[78] *Ibid*, 2540., *Compilation of Supply Circulars and Supply Bulletins of the Purchase, Storage and Traffic Division, General Staff, War Department.* (Washington: Government Printing Office, 1919), 9.

of Purchase, Storage and Traffic Division closely scrutinized these requirements following their takeover of the program in 1918. In fact, staff members took pride in disapproving a significant amount of these requisitions, with no more than a dozen machines actually being purchased between November 1918 and February 1920. However, this does not account for the machines leased by individual units. In those circumstances, the requirement did not require centralized approval and thus was not part of the Army's calculations at all.[79] The end result, as reported to Congressman Wood and his panel in 1920, is a data set skewed by the nuances of the Army requisition system. For years, the Army calculated their office equipment usage based on the purchase of such equipment. The leasing issue remained an unresolved War Department data point for years to come.

In the end, what is missing from post-war records and congressional testimony is the complete extent of the Army's mechanized office equipment following the World War I. Records from the Director of Purchase, Storage and

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[79] *Annual Report of the Chief of Engineers, United States Army, to the Secretary of War for the Year 1894, Part IV, 53d Congress, 3d Session. House of Representatives*, vol. II (Washington: Government Printing Office, 1894), Example Document 1, Part 2 of Volume II.

Traffic Division in 1919 and 1920 show that besides the typewriter, mimeograph, and computing machine totals, the War Department owned an additional 100 addressographs, Dictaphones, duplicating machines, Ediphones, billing machines, and mimeoscopes. Added together, this figure – approximately 49,000 individual devices in all – presumably accounted for all of the Army's purchased office equipment during this period. In fact, this was the data reported to Congress following the war. However, upon a more thorough review of Major Arrighi's figures, supplementary Army records confirm the Army used more mechanized devices than these initial figures indicate. Besides these machines, the Army also owned a separate suite of mechanical office devices designed to enhance record keeping and other office services. The number and range of these devices, which included bookkeeping machines, stamping machines, letter-opening machines, sealing machines, perforators, presses, multigraphs, electrotyping and etching machines, are further evidence that by the end of World War I, Army units had certainly embraced the mechanization of administrative functions throughout the service.[80]

[80] Marcel S. Keene et al., *War Department Correspondence File: A Subjective Decimal Classification with a Complete Alphabetical Index for Use of the War Department and the*

Representative Wood's assertion that soldiers were overeager to obtain mechanized administrative equipment may have been accurate, but nonetheless highlights the genesis of a new era in military information; that is, one of seeking more detailed information in larger quantities through mechanical and electrical data devices. Wood's accusation bears testimony to the fact that members of the Army sought out new and purportedly better methods for obtaining and exploiting information, whether it was necessary or not. This desire to harness modern technological advances in an effort to ease an administrative burden has its origins in the period between the Civil War and World War I. Very little of this was downward-directed by Army leadership at the time. Instead, it was bottom-up, driven by the desire and curiosity of the average user. It was that desire and curiosity that helped advance perhaps the most important innovation of the era and one that inevitably led to the more familiar beginning of the "information age" – the first computer. The device, originally named the electric enumerator, would eventually change forever the way the Army looked at data compilation and manipulation. More commonly known today as a punched

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United States Army (Washington: Government Printing Office, 1918), 148.

card tabulating machine, this groundbreaking device grew to become a catalyst for transformational information changes throughout the military and government over the next quarter century.

Data Mechanization Systems: the Electric Enumerator and Data Tabulation

While Arrighi and Wood argued about the equipment totals required for the Army of the future, one thing was certain: they only discussed the machines as individual office items and never considered a larger, more comprehensive data mechanization system. On one hand, ledger books and forms got soldiers thinking about how to better record information, while typewriters and mimeographs got them thinking about how to improve its quality and quantity. Even *computing* machines, to use the colloquial congressional term, looked to improve the speed and accuracy of data manipulation but always in a very singular, individualistic way. What escaped the congressional testimony in 1920 was any conversation about capturing large volumes of information, assembling and organizing it, and then presenting it in a meaningful fashion – all with one device. Such a device was well known in government circles as it had made headlines with its publicized use by the Bureau of the Census beginning in 1890. What had been missing from the appropriations conversation was what was missing from the Army's strategic vision for information – a data mechanization *system*. The fact that the Army was already a pioneer in the use of such a system apparently escaped the attention of all concerned, soldier and civilian alike.

This effort began in earnest in 1888. As the challenge of managing large amounts of quantifiable data grew in significance, industry leaders understood that incremental additions of mechanical calculators and enumerators were not an end solution. What was needed was a system capable of somehow capturing and manipulating substantial volumes of data while reducing the amount of human intervention involved in the process. In 1890, one such solution made the front cover of *Scientific American* magazine, the inside text boisterously detailing the success story of that year's American Census and the incredible time-saving device labeled as the world's first "electrical numerating system." This innovation was not news to the Army Surgeon General's office. Two years earlier, a senior member of the Vital Statistics Branch had recognized this system's capabilities and its potential applications for health and mortality records. The system's inventor was Herman Hollerith, and his primary product – the punched card tabulator – would lead to his co-founding of information behemoth International Business Machines (IBM) only a few decades later. This machine would almost singlehandedly set the foundation for information collection and exploitation for the next fifty years.[81]

Hollerith's journey began years before the Army called on his assistance. Long before his tabulator took on both the Surgeon General and the Census Bureau projects, the inventor shopped his innovation across several northeastern states shortly after applying for his first patent in 1884. He began his quest modestly, designing his first device to "simplify and thereby facilitate the compilation of…various kinds of statistics."[82] Originally a paper tape-driven system akin to the telegraph, it soon became obvious that any long-term utilization required a more durable documentation medium. Thus, he rejected his earlier tape-

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[81] See Joel N. Shurkin, *Engines of the Mind: A History of the Computer* (New York: Norton, 1984), 70-72, and Lars Heide, *Punched-card Systems and the Early Information Explosion, 1880-1945* (Baltimore: Johns Hopkins University Press, 2009).

[82] "Patent 395782," Patent 395782, accessed February 14, 2013, http://www.uspto.gov/patents/resources/methods/afmdpm/examples/395782.jsp.

based system in favor of a medium more closely resembling that used by French weaver and inventor Joseph Marie Jacquard and his famous loom – i.e., the punched card.[83] As the decade progressed, Hollerith looked for customers requiring large volume statistical computation, eventually finding several in the New York area railroad and health industries. Working with the health departments in Baltimore, the state of New Jersey and New York City proved fortuitous as the device clearly had other health-related applications.[84] Moreover, thanks to a preexisting relationship with one of the Army's senior officers in the Vital Statistics Branch, news of his successes did not have to travel far.[85] As unit leaders sought to prioritize the importance of preventive health statistics, they recognized the potential in Hollerith's system. By 1888, the decision was made to address the inventor formally.[86]

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[83] James Essinger, *Jacquard's Web: How a Hand-loom Led to the Birth of the Information Age* (Oxford: Oxford University Press, 2004).

[84] Love, Hamilton, and Hellman, *Tabulating Equipment and Army Medical Statistics*, 38-39.

[85] Shurkin, *Engines of the Mind: A History of the Computer*, 75.

[86] Heide, *Punched-Card Systems and the Early Information Explosion, 1880-1945*, 30-67.

Approaching Hollerith as the year drew to a close illuminated two primary concerns harbored by the Vital Statistics branch: capability and cost. First, the Army wanted to ensure the device not only worked as advertised, but also could handle the sizeable data fields their records and analyses required. To accomplish this, Hollerith had to change the design of his punched cards to allow aggregate combinations, thus permitting more detailed data in greater numbers. Then, in an effort to prove the solution's effectiveness, he would have to test the new system using historical data from his New York City application. As time would show, both the card redesign and testing platform worked to the Army's satisfaction. Still, there remained the issue of cost. Spending money on a relatively unproven technology was a risky proposition for such a small branch deep inside a resource-constrained Army. Accordingly, the inventor applied a different albeit common business model – an equipment lease – to allow the Surgeon General of the Army to keep costs down while keeping interest up.[87] The Army's total lease cost was only $1000 per unit, plus the cost of the punched cards themselves. In September 1888, the War Department agreed

[87] *Ibid,* 34.

to the lease and contracted with Hollerith for the compiling of medical and casualty statistics. Although this was only a small application almost completely out of the purview of most Army leaders, it was nevertheless incredibly significant; after all, regardless of its scope, it was the earliest known implementation of this technology in the military.[88]

For the next several months, Hollerith focused his efforts on installing and preparing the system in the Vital Statistics office. In January 1889, he wrote a letter informing the War Department that the tabulating equipment installation was complete and ready for application. Over the next several months, members of the unit worked with Hollerith to apply prior health department lessons to the challenges faced by the Surgeon General. By April, Captain Fred C. Ainsworth, the officer in charge of all medical records and statistics for the Surgeon General's office, appeared pleased with the capabilities of the punched card system. In fact, although he was hesitant to endorse the

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[88] The majority of data in this paragraph derives from a number of sources, specifically: Love, Hamilton, and Hellman, *Tabulating Equipment and Army Medical Statistics*, 36-51, Heide, *Punched-Card Systems and the Early Information Explosion, 1880-1945*, 33-63 (especially 33, footnote #73), Shurkin, *Engines of the Mind: A History of the Computer*, 66-92.

machine for Hollerith's entrance in 1889's Exposition Universelle in Paris, France, he did state the machines thus far were operating to his satisfaction. Despite the general acknowledgment of success, Ainsworth still held reservations about their overall usefulness. Matters worsened when a few months later, the War Department directed the Surgeon General to consolidate all Civil War volunteer medical records and muster rolls with all pre-existing medical records in the Vital Statistics office, a task that helped form a new and independent Record and Pension Division. By July, the Army had prepared over 50,000 cards for the project, although it understood that such a large amount of data would require additional tabulating equipment. As Hollerith's contract was up for renewal, the question arose whether or not the Army would continue with the inventor's system or go back to manual compilation. In July, he received his answer: Ainsworth endorsed his contract and the Army renewed the arrangement until June of 1890.[89]

Despite the apparent success of the early punched card system, the Army soon realized it no longer truly required such mechanization, especially given the small number of

[89] Love, Hamilton, and Hellman, *Tabulating Equipment and Army Medical Statistics*, 36-51.

troops remaining on active duty. In the early 1890s, the total number of military personnel on active duty dropped to a meager 27,000, thus abating the need for a complex tabulation system like Hollerith's.[90] Even with the apparent capabilities of a data compiling system, the Army felt transcribing each information incident from a report card to a statistical ledger remained a more realistic and cost-effective option than one requiring automation.[91] While the ledger system lingered well into the First World War, the advantages of card-based accounting continued to be an optional and functional component in Army information management. Moreover, although the Vital Statistics Branch discontinued its use at the time, the application of punched card systems was no longer confined to a single office. Even though the Surgeon General of the Army was Hollerith's only viable and paying contract in early 1889, his fortunes soon changed. By the time the Tenth Census began a year later, industry knew well of his system's capabilities and possibilities. Moreover, the exposure from the *Scientific American* article, not to mention the magazine's cover dedicated to Hollerith's innovation, gave

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[90] Heide, *Punched-card Systems and the Early Information Explosion, 1880-1945*, 63.

[91] *Ibid*, 33.

the inventor a running start into this new and budding industry.[92] The Army may have temporarily halted its punched card operations, but the world did not. It would take more than a quarter-century for the service to catch back up to the industrial standard.

The Army's history of punched card systems between the end of the Vital Statistics project and the beginning of the World War I is one of extraordinarily limited use and sparsely documented implementation. Without a directive from the War Department, individual attempts at applying this burgeoning technology proved relatively insignificant, which was ironic given the success of tabulators in industry during the same period. Army historians maintain that until 1917, the implementation of tabulating machines was minimal at best.[93] As war loomed on the horizon, applications in place remained nearly absent. Official histories recount only one small tabulator installation in

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[92] "The Census of the United States," *Scientific American* 63, no. 9 (August 30, 1890): 132.

[93] Love, Hamilton, and Hellman, *Tabulating Equipment and Army Medical Statistics*, 51. This Medical Department History is perhaps the most significant resource for understanding tabulation use in the Army. This book shows no military use between Hollerith's first application in 1889 and the next major application in 1917. Specifically, Love et al. state, "It appears that the Surgeon General's Office was the first in the War Department to use the Hollerith equipment in 1917" on page 51.

the Surgeon General's Personnel Division used for locating specially trained officers and another in the Ordnance Department used for data compilation at its depots.[94] Meanwhile, veterans of Hollerith's original implementation in 1889 were anything but pleased with the potential return of tabulators to the Army, even cautioning their superiors against further use. They warned about card preparation issues, insufficient and ineffective data calculations, and an overall sense of time wasted in integrating a system that more often worked better by hand.[95] Despite their reservations, the Division leaders understood something had to be done. With Congress declaring war against Germany on April 6, 1917, the requirements of mobilization necessitated a better way to manage the flood of information set to pour into the Army.[96]

This deluge of information, of course, was originally precipitated by the mass of individuals mobilized to support the war effort. When Congress enacted the Selective Service Act into law on May 17, 1917, the volume

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[94] Love, Hamilton, and Hellman. *Tabulating Equipment and Army Medical Statistics*, 33, 51.
[95] *Ibid*, 34.

[96] Charles Lynch, *The Medical Department of the United States Army in the World War* (Washington: Government Printing Office, 1921), 49-56.

of Army personnel data expanded like never before. Over the next four months, nearly 10 million males between the ages of 21 and 30 completed their registration for military service. Within the next year, another 14 million registered after the entry age widened to include men up to 45.[97] The job of tracking the medical condition of recruits fell, as expected, to the Army Surgeon General's office. Unbeknownst to many in the organization at the time, this mission was about to transform into a landmark endeavor that included "the largest studies of men done so far by data mechanization equipment."[98] Of all the data tabulator applications in this wartime era, few are more indicative of an information sea change than the systems put in place to handle the Army medical establishment's information crises at the start of the war.

In October 1917, the Medical Records section of the Surgeon General's Sanitation Division was charged with the mammoth responsibility of processing, maintaining and distributing all Army sick and injured records of both

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[97] Charles Benedict Davenport and Albert Gallatin Love, *Army Anthropology: Based on Observations Made on Draft Recruits, 1917-1918, and on Veterans at Demobilization, 1919* (Washington: Government Printing Office, 1921), 49-52.

[98] Cortada, *Before the Computer: IBM, NCR, Burroughs, and Remington Rand and the Industry They Created, 1865-1956*, 81-82.

current soldiers and new recruits.[99] The section bore the additional responsibility of preparing, compiling, and analyzing all Army medical statistical data for the numerous Surgeon General reports and analyses provided regularly to the War Department.[100] That year, Major General William Gorgas, the Army Surgeon General, recognized that not only was the current method of hand data compilation inadequate, but that future uses of the Medical Records section required a more robust and capable mechanically-based information apparatus.[101] With no time to waste, a "punch-card system" was installed with the requisite tabulating and sorting machines in tandem. The capabilities of the Hollerith devices completely opened the aperture for what statistical data the Medical Records Section could provide the Army. For the second time, the Surgeon General's office was attempting to utilize

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[99] Davenport and Love, *Army Anthropology: Based on Observations Made on Draft Recruits, 1917-1918, and on Veterans at Demobilization, 1919*, 49-52.

[99] Cortada, *Before the Computer: IBM, NCR, Burroughs, and Remington Rand and the Industry They Created, 1865-1956*, 49.

[100] Davenport and Love, *Army Anthropology: Based on Observations Made on Draft Recruits, 1917-1918, and on Veterans at Demobilization, 1919*, 49.

[101] Love, Hamilton, and Hellman, *Tabulating Equipment and Army Medical Statistics*, 33.

Hollerith's data tabulation system for medical record administration. This time, the volume of personnel data generated made this application a far more useful effort.[102]

With millions of recruits undergoing physical and psychological examination, the responsibility for compiling and analyzing this data fell to records personnel in the Surgeon General's office. Taking full advantage of the compiled data, the organization not only reviewed and evaluated the physical and mental limitations annotated in patient records, but also employed the information for manpower utilization and anthropological analysis.[103] In fact, in some cases, the analyses went so far as to include a measurements study of soldiers' physical characteristics as a precursor to standardizing and ordering uniforms.[104] At one time, the volume of material nearly reached two million records of those selective servicemen sent to military encampments. As anticipated, data tabulators could more efficiently break down demographic and

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[102] Davenport and Love, *Army Anthropology: Based on Observations Made on Draft Recruits, 1917-1918, and on Veterans at Demobilization, 1919*, 49-60.

[103] Cortada, *Before the Computer: IBM, NCR, Burroughs, and Remington Rand and the Industry They Created, 1865-1956*, 81-82.

[104] *Ibid.*

physiological information in a manner almost unthinkable without mechanization. In fact, such information became so detailed that the Army created reports that included "Defects Found in Drafted Men," which broke down military rejection statistics by state, urban and rural environments, and another 156 population sections grouped into series of occupational, physiographic, and racial statistics.[105] After thirty years, Army leaders had finally found an effective use for Hollerith's data tabulators.

Between America's entry into the war and the Armistice in November 1918, the availability and application of data tabulators increased significantly throughout the government, including the military. Demand was so great, in fact, that federal officials required tabulators be diverted from commercial customers to federal agencies throughout the war emergency period.[106] Behind this edict, of course, was the War Industries Board, the controlling agency for nearly all war supply activities. The Board presided over the country's purchases, industrial

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[105] Love, Hamilton, and Hellman, *Tabulating Equipment and Army Medical Statistics*, 49-52.

[106] Cortada, *Before the Computer: IBM, NCR, Burroughs, and Remington Rand and the Industry They Created, 1865-1956*, 81-82.

production, raw material allocation, transportation and communication during the war. To account for it all, they acquired and applied a host of data tabulators, the backbone of the organization's statistical support.[107] In fact, punched cards and tabulating equipment became so prevalent that, as Hollerith's biographer wrote, "the punched card [became] a daily fact of life for thousands of clerks marshalling the nation's food supply and other resources."[108] Authors Frederick Bohme and J. Paul Wyatt echoed this assertion in their book *100 Years of Data Processing: The Punchcard Century* by claiming that "the nation implemented hundreds of these machines throughout its military, federal departments and public bureaus."[109] Clearly, these devices were no longer a clerical oddity in American government organizations. Instead, they were an

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[107] Frederick G. Bohme and J. Paul. Wyatt, *100 Years of Data Processing: The Punchcard Century* (Washington: U.S. Dept. of Commerce, Bureau of the Census, Data User Services Division, 1991), 8; Cortada, *Before the Computer: IBM, NCR, Burroughs, and Remington Rand and the Industry They Created, 1865-1956*, 81-82; Robert D. Cuff, *The War Industries Board; Business-government Relations during World War I* (Baltimore: Johns Hopkins University Press, 1973); Heide, *Punched-Card Systems and the Early Information Explosion,* 63-65.

[108] Love, Hamilton, and Hellman, *Tabulating Equipment and Army Medical Statistics*, 81-82

[109] Bohme and Wyatt, *100 years of Data Processing: The Punchcard Century,* 8.

integral component of numerous information processes across the nation’s administrative landscape.

However, the statements above pertain to the government as a whole and not the military specifically. This distinction is important, for although the government’s data tabulator application rate did increase significantly, and that figure does include the military, the portion of that increase relative to the armed services is markedly small. Thus, it is critical that historians be cautious in referencing the punched card tabulator’s significance during this period. Despite a number of generalizations to the contrary, the military was not part of the industrial leading edge of this phenomenon, nor was it even a primary user during the Great War. That distinction belongs instead to the insurance and railroad industries which almost singlehandedly kept Hollerith in business during this period. Claims of ubiquitous data mechanization throughout the War Department’s information processes at this time are erroneous as well. While there are indeed several cornerstone cases, including those in the Surgeon General’s office, the Army did not fully appreciate the capability and potential of data tabulators in this period. The aforementioned uses of data tabulators are oftentimes referenced by authors attempting to closely correlate the military and punched card usage during World War I. Unfortunately, this small number of cases pales in comparison to the massive use of manual card-based data processes used throughout the Army leading into 1919. In short, while the military remained involved with data tabulators during this period, to claim the existence of any widespread usage or monumental program is to distort the historical facts of the period.

Although the War Department was obviously not the data mechanization catalyst prior to the end of the war, the Army and its government and industrial colleagues did manage to lay fertile ground for its future information processes. Thus, for Herman Hollerith and other tabulator companies, the time for widespread mechanized data compilation was clearly within sight. With organizations across the public and private sectors jumping at the chance to implement these information mechanization devices, tabulator earnings tripled by the height of the war.[110] Hollerith, who decades before was trying to solve a simple problem in the Census Bureau, had almost single-handedly launched arguably the greatest information improvement device of the era. Moreover, by the end of the war, the

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[110] Cortada, *Before the Computer*, 58.

seemingly insatiable appetite of government and industry leaders for more elaborate statistical analyses and more comprehensive data manipulation meant that the age of information had finally, and unequivocally, arrived.

Data Transfer and Communications Systems of the Period

Beyond the processes and machines that dictated what information the Army thought was important as well as how they compiled and exploited it, a final factor worth examining was how the Army transferred its information from one participant to another. As previously mentioned, the Civil War was a catalyst for numerous advances in battlefield communication, such as the wig-wag signaling system, field telegraph machines, and horse-drawn "flying" telegraph lines. Following the war, the federal government disbanded the Military Telegraph Corps and gave the reins of the War Department's communication system over to the Army Signal Corps. In doing so, the application of the telegraph and its operational uses became more than just a Signal Corps concern; it became an Army information problem. Now that the war was over, it was up to the Army to discern how to best utilize the telegraph, and why.[111]

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[111] See Raines, *Getting the Message Through,* 41-109; and George C. Mattoy, "The Flying Telegraph," *The Army Communicator*, Fall 1981, 30-36.

Prior to 1880, the military did not heavily regulate telegraph usage, regardless of whether it was through military or commercial channels. By and large, telegraph applications were often sporadic and became a function of necessity, proximity, and cost, especially for those units based in the West. In 1881, with the publishing of *Regulations of the Army of the United States*, the Army finally brought all telegraph procedures into one document and created strict guidelines for their application. For example, the Army officially announced in *Regulations* that the telegraph was not intended to be a primary means of communication; that was saved for mail or messenger service. Instead, under the charge of the Chief Signal Officer of the Army, soldiers were only to use the telegraph in "cases of urgent and imperative necessity, where the delay of the mail would be prejudicial to the public interest."[112] By these directives, the Army practically prohibited telegraph use, especially for non-emergency reporting and information requests from higher echelons. To the Army in peacetime, telegraph messaging remained reserved for official and immediate communication

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[112] See *Annual Report of the Chief Signal Officer to the Secretary of War for the Year 1872*, 158. For all other information, see *Regulations of the Army of the United States*, 68, 272.

purposes only. Over time, however, growing Army requirements necessitated more expedient information transfer. By the end of the decade, the rules and regulations put in place in 1881 were under scrutiny by both the Signal Corps and their telegraph clientele.

Over the next several years, the telegraph emerged from its emergency-only status to become an integral part of primary service communications. In both 1892 and 1899, the Chief Signal Officer confirmed this notion in the Corps' own set of regulations that controlled what was acceptable in modern Army telegraphy.[113] For example, in the 1899 version, the directives stated that the realm of legal telegraphic operations included "[a]ll business of the War Department, its officers and agents, and telegrams authorized by competent authority, and all 'official messages' of the several departments of the Government."[114] The Army tested this notion in their 1895 regulatory

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113 *Regulations for the Operation and Maintenance of United States Military Telegraph Lines: And General Regulations of the Signal Corps, United States Army. (Washington: Government Printing Office, 1899)*, 1-8; *Regulations for Operation and Maintenance of U.S. Military Telegraph Lines* (Washington: Government Printing Office, 1892).

114 *Regulations for the Operation and Maintenance of United States Military Telegraph Lines and General Regulations of the Signal Corps, United States Army*, 8.

anthology (printed in 1899) by directing that commanders notify the Adjutant General *by telegraph* of specific personnel actions ranging from positional appointments to escorting a legally insane soldier.[115] Further examples extended primarily to the post quartermasters, especially in cases where the speed of information delivery was time dependent. By the end of the century, the telegraph was no longer an administrative rarity for Army field units. Instead, as expounded upon in Signal Corps regulations, it was an integral part of the information landscape.[116]

Meanwhile, back in the 1880s, a new communications device – the telephone – began to interest soldiers on staff and in the field alike. With thousands of telephones in public service by 1887, Chief Signal Officer General Adolphus Greely recognized the importance of the device to future service operations. In doing so, he formally acknowledged the telephone's military possibilities in 1889 by including the technology in his annual report to the Secretary of War. There Greely reported that the telephone, along with the telegraph, heliograph, and the

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115 *Regulations for the Army of the United States, 1895, with Appendix Separately Indexed Showing Changes to January 1, 1899*, 34, 61.

116 *Ibid*.

electric flashlight, were all "potent factors in civilized warfare" and condemned the Army for not applying more money into the research, development, and practice of these various devices.[117] By 1893, years of politicking paid off as Congress issued General Order 20 approving and appropriating resources to the Signal Corps to purchase and maintain telephone equipment. Although its application was still not widespread in the service, the potential uses of the telephone were characteristically undeniable to those who witnessed its capabilities.[118]

Five years later, the Army's role in the Spanish-American War proved critical to granting field credibility to the telephone. In magazines dedicated to this new technology, telephone enthusiasts of the day bragged about a new service practice:

> [t]he often hinted at, frequently discussed, but never before realized field telephone in actual warfare has come and is come to say. For the first

[117] *Annual Report of the Chief Signal Officer of the Army to the Secretary of War for the Year 1889* (Washington: Government Printing Office, 1890), 5.

[118] General telephone information derived from "Telephone History," The Telephony Museum, accessed April 10, 2013, http://www.telephonymuseum.com/telephone history.htm. The remainder of the information can be found in *General Orders by the United States War Department, United States Adjutant-General's Office, United States. Military Secretary's Department* (Washington: Government Printing Office, 1894), 117-131.

> time in the history of the United States army, a long-distance telephone has been used for the purpose of handling troops in time of war.[119]

In garrison, peacetime telephone usage helped transfer information among geographically separated staff offices. In one example at Camp Black in New York, adjutants, chiefs of staff, and field hospital commanders all had access to a newly-installed telephone system. After testing its usefulness, the telephone proved extremely helpful in reporting operational and patient information, as well as providing “moral influence” over those not geographically stationed at the same location. According to one source, in almost every branch of government, telephone service increased between 1898 and 1899.[120] Even as telegraph usage continued to increase throughout the service, the telephone endured as an operational alternative throughout the era.

Finally, as the Aeronautical Division was coming into existence, another communications innovation became the talk of both the operational and administrative communities

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[119] Edward E. Clement, "This Years Progress in Telephony and Telegraphy: Electrical Engineering and Telephone Magazine, Vol XIII, No.89, February 1899, Chicago." *Telephone Magazine: An Illustrated Monthly Magazine, Volumes 12-13*, Aug-Dec 1898, 57-60.

[120] *Ibid.*

in the Army – the radio. Originally known as "wireless telegraphy," it appeared to service leaders that radio communication provided the answer to the myriad wire constraint issues suffered in telegraph and telephone operations. At least, that was the original leadership expectation. Although it would take years for wireless telegraphy and spark-gap technology to play an integral part in Army operations, the potential of radio technology kept departmental leaders interested and engaged in wireless telegraphy projects. With maritime communication and safety a major potential application for this technology, the Navy took the lead role in radio communication endeavors. As it was, despite initial interest, the Army was still developing current communications applications via telegraphs and telephones. Realistically, how interested servicemen were in radio was a factor completely dependent on unit leadership.[121]

As it turned out, that leadership – predominately in the Army's Signal Corps – remained engaged throughout the initial technology indoctrination process. For instance, at the first international wireless telegraphy conference in Berlin in 1903, Chief Signal Officer Greely was part of

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[121] Raines, *Getting the Message Through*, 136-138.

the select group that helped produce international protocols for future civilian and military applications. Three years later during a second conference in Berlin, Greely's successor and air arm-founder Chief Signal Officer James Allen attended. While new to the position, Allen impressively contributed to the conversation by helping create radio operations policy. Even further, Allen helped define the radio's military usefulness to the point that it found its way into Cuban operations in 1906 and Philippine operations in 1907. Although clearly in its infancy, the Army did not squander its opportunity to begin integrating radio into the operational elements of the service.[122]

Over the half-century that separated the Civil War and World War I, the means by which the Army transmitted its information changed dramatically. As the years passed, the ability to move data more rapidly grew at nearly the same speed as the requirements to do so. In the beginning, the Civil War proved that visual signaling and telegraph requirements could be more effective information transmission methods (at times) than mail, messenger, or carrier pigeon. By the end of the era, the Army possessed a wide variety of transmission methods that ran the

122 *Ibid.*

spectrum of technological capability. Operationally, as shown by its regulation in Army documents, the functionality and importance of each transmission method most often depended on the speed and cost of those methods that superseded them. Still, two things appeared abundantly clear to military leaders at the beginning of World War I: first, that technological advances in information transmission would continue into the future, and second, that they would be driven by the incessant desire to improve on the communications status quo.

Conclusion

In 1864, Captain August Kautz of the Sixth U.S. Calvary wrote an official compendium detailing the proper methods for managing the books, records, and accounts required of an Army unit administrator. Entitled *The Company Clerk: How and When To Make Out All The Returns, Reports, and Other Papers, and What To Do With Them*, Kautz's compendium stressed the importance of the administration business, noting that current regulations failed to properly guide clerks and other data keepers on the proper methods of recording and reporting the unit's vital information.[123] What the Army needed, the captain wrote, was a handbook that explained not only what data – or as he termed, "administrative matters" – was required, but also how to process it.[124]

Army Colonel James Moss' 1917 attempt at a similar compilation echoed several of the key themes Kautz had developed over a half-century earlier. In *Army Paperwork, A Practical Working Guide in Army Administration*, Moss emphasized the indispensable nature of paperwork in Army operations, signifying that without ensuring its accuracy and completeness, the information dispensed across the service would be all but useless, wasting time, resources, and energy. To the Colonel, the documentation, exploitation, and transfer of information was as essential to the military profession as any other function inside the Army. Thus, "the man behind the desk" who was denied the glamor of battle or popular favor of the war hero could live with the solace of knowing that without the information he maintained and provided, the "man behind the

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[123] August V. Kautz, *The Company Clerk: Showing How and When to Make out All the Returns, Reports, Rolls, and Other Papers, and What to Do with Them. How to Keep All the Books, Records, and Accounts Required in the Administration of a Company, Troop, or Battery in the Army of the United States.* (Philadelphia: J.B. Lippincott & Co., 1863).

[124] *Ibid*, 3.

gun" would fail.[125] As Moss concluded, Army paperwork and the information contained within it was "less spectacular though no less important" than any other detail in military operations.[126]

By themselves, these two documents illustrate a pair of important truths: one, information requirements remained a consistent and often disjointed Army issue in the 53 years that separated them; and two, the absence of direction from the Army's senior leadership that allowed two comparatively junior officers to act independently shows that information and administrative operations had not earned the former's full attention. Throughout this chapter, example after example of information environment modifications – from registers and typewriters to punched card tabulators and telegraphs – demonstrate how the Army's most senior leadership neglected to proactively centralize or coordinate a data management strategy for the service. Instead, branch leaders like those from the Quartermaster, the Signal Corps, the Surgeon General and the Adjutant General culled together processes and procedures as best

[125] James Alfred Moss, *Army Paperwork: A Practical Working Guide in Army Administration* (Menasha, WI: G. Banta, 1917), 1-2.

[126] Moss, *Army Paperwork, A Practical Working Guide in Army*, 1-32.

they could, often clamoring for additional resources to accomplish their mission. The Army during this period functioned, but certainly not cohesively.

These often independently driven changes and decisions at the branch- or unit-level became problematic for the service. For example, haphazard unit typewriter purchases throughout the late 1800s meant a lack of unit standardization. This difference in standards caused a number of concerns across the Army, most especially those resulting in administrative training issues where unit transfers potentially meant completely relearning information-related duties. Another example occurred in 1899, by which time telegraph usage standards varied by unit, branch, and staff. Not only had the Adjutant General and Signal Corps published competing regulations, but also inside regulatory anthologies like *Regulations of the Army of the United States* were various directives that contradicted one another.[127] In one final example, the Surgeon General's relative failure to fully incorporate Hollerith's card tabulating system into hospital information operations denoted a near failure of the data

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[127] As referenced in *Regulations for the Operation and Maintenance of United States Military Telegraph Lines and General Regulations of the Signal Corps, United States Army*, 169.

mechanization concept itself. This resulted in ill-will among the medical statistics community that permeated the mechanization discussion a quarter-century after this initial project. The Army had issues that needed solving, but attempting to resolve them at lower unit- and branch-levels only caused more challenges for the service later on.

Fortunately, however, some of the outcomes that derived from these uncoordinated and provincial activities still managed to benefit the service. First, during the many conflicts and campaigns that arose between the Spanish-American War and World War I, wartime operations were significantly benefited by the compilation of Army regulations and the standardization of information processes. Likewise, although the volume of data traversing the service was massive, especially given the reporting needs codified in the late 1800s, such information in the right hands allowed Army leaders to make more intelligent decisions than ever before…or at least, more informed ones. This was especially true for the Quartermaster, who between 1865 and 1898 managed to develop a staggering array of supply and clerical forms that captured a tremendous amount of data for the Corps. From that data, the operational, logistical, and administrative decisions made both by Quartermaster and other branch leaders were based on facts as far as possible. Last, such intensive data collection was helpful to officers and civilians who fought for resources and defended programs in front of an assortment of congressional committees. As noted earlier in the chapter, the case of Major Arrighi and post-war typewriter purchases highlights that data collection and exploitation measures proved quite helpful.

Looking back, there clearly was no Army information strategy during this period, even though there were clear attempts to act as if one existed. Army branch and staff organizations, each with its own purpose and directives, often followed their own path to gathering, exploiting, and transferring information within a set of relatively innocuous macro-level constraints. This lack of strategic forethought or regulatory vetting process on the part of the Army senior leadership speaks to the general lack of cohesiveness in the service following the Civil War, much as General Sherman pointed out. Given the amount of debate in Congress over what the Army did, its size, or its very existence, this disorganization is not surprising. Moreover, for those who have overgeneralized the Army's lines of responsibility or misinterpreted the connections between organizations, this chapter challenges this false sense of a singular, unified Army and replaces it with the notion that each unit – oftentimes by whatever means available – did what it could to improve its operational and administrative information status. Using their data as a critical resource, these organizations overcame disorder, inadequate leadership, and inept guidance to eventually become a deciding military factor during the World War I.[128]

[128] Edward M. Coffman, *The War to End All Wars: The American Military Experience in World War I* (Norwalk, CT.: Easton Press, 1986), 368.

Chapter 2
Information Standardization, Data Mechanization, and Statistical Control, 1907-1947

To properly understand the early history of the United States Air Force, it is important to explore the advances and decisions made using information management and technology as these were integral to the service's development and operation. In service narratives that tend to highlight successive aviation achievements, data management and mechanization often fail to emerge as significant themes. However, these fields underpinned a great deal of the operational and organizational change that supported military aviation in its early decades. Examining the history of service data management and mechanization is therefore important to a comprehensive understanding of how the organization used its information for its operational and administrative needs and how in turn this affected the organization's development as a service over these four critical decades.

The early U.S. military aviation component developed within a growing culture of information standardization that carried over from its Signal Corps origins. Like other Army components, the burgeoning air arm repeatedly sought to identify what information it required and then determined how best to generate it, albeit arguably not always in the most effective or efficient manner. A large part of the resulting information generation involved the application of business machines and data management systems we construe today as information technology. These advancements and improvements were pivotal factors in the development of new operational capabilities, organizations, and processes at both the unit and service level.

However, these were not the only factors affecting the air service's growing information requirements.[129] Although information technology did progress significantly during this period, some service processes remained married to manual systems and regulatory control in operational management. Throughout this period, airmen relied upon the application of paper-based information forms and procedures, manual accountability systems, and hand-calculated data/statistical analysis in order to meet their

[129] The term "requirements" is a frequently used military term signifying a perceived need or desire – real or imagined – on the part of the requester. It is not meant to signify an absolute need without question. In fact, far from it. However, a great deal of military programming and budget planning is based upon requirements-based decision making and such an item should not be left out of the conversation.

information needs. By the end of World War II, information management using both technological and manual systems was a fundamental component of Army aviation operations and administration.

This chapter demonstrates how, from 1907 to 1947, the management and application of information in the Army's air arm played an essential role in the service's development and operation. From aviation specific forms and procedures, to manual and punched-card inventory and reporting systems, to a service-wide statistical control and analysis system, the Army's aviation service developed its information capabilities to help train, equip, and employ its forces both in-garrison and at war. As the air arm grew from a three-man office to more than a two-million-airmen organization, more timely and expansive information generation and processing for logistical, administrative and other purposes evolved. Explaining how and suggesting possible reasons why this evolution occurred will demonstrate both the way information was pivotal the growth of the Air Force and the extent to which technological development in the arm was not simply a matter of progressively more powerful and complex aero engines and airframes as standard service histories imply.

Information and Mechanization in the Air Service

World War I afforded the War Department a tremendous opportunity. No longer manpower or fiscally constrained as in years past, the Army was able to use wartime authority to rebuild its organization, revamp its procedures and retool its operations and supporting equipment for the first time in decades. Administratively, several branches used the opportunity to assign and improve information gathering, dissemination, and archival methods, given that pre-war requirements were but a fraction of wartime responsibilities. As business machines and data mechanization became more prevalent in corporate and other circles, some branches already accustomed to organizing and manipulating large volumes of data did not hesitate in adopting these advancing technologies. Although the military was certainly not keeping pace with its industrial and government counterparts, the parity achieved both during and after the war proved it was not blind to opportunity.[130]

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[130] For more information on how different industries flourished with larger adaptations of business machine or data mechanization use, see Lars Heide, *Punched-card Systems and the Early Information Explosion, 1880-1945* (Baltimore: Johns Hopkins University Press, 2009), 31-45. Similarly, information on the typewriter's integration into the workplace and its corollary impact on gender roles, see James W. Cortada, *Before the Computer: IBM, NCR,*

Between 1907 and 1918, the history of early military aviation information processing is quite similar to that of the United States Army as a whole during the same period. From its origins in August 1907 until it reorganized as the Aviation Section of the Signal Corps in July 1914, few information processes of the air arm differed from standard War Department procedures.[131] This pattern changed only slightly in the years leading up to America's entry into World War I despite explicit efforts to single out aviation-specific issues.[132] At the time, there appeared little need to forsake most regular Army information procedures, especially given the seemingly ancillary nature of air applications in either a wartime or peacetime

Burroughs, and Remington Rand and the Industry They Created, 1865-1956 (Princeton, NJ: Princeton University Press, 1993), 11-14.

[131] Evidence in this paragraph is derived from conversations with members of the Adjutant General, Quartermaster and Signal Corps historians of the U.S. Army between November 2012 and February 2013. Specifically, until the Army Reorganization Act in 1912, few administrative processes like these were accomplished Army-wide.

[132] For example, in 1917 the Army published a completely separate equipment manual for the Aviation Section of the Signal Corps. See *Unit Equipment Manual for the Aviation Section, Signal Corps.* (Washington: Government Printing Office, 1917), 17, and *Annual Report of the Secretary of War 1913* (Washington: Government Printing Office, 1914), 808-809.

environment. After all, as the country entered the First World War in 1917, the American military ranked fourteenth among nations with an aerial military component and could boast little more than few dozen airmen fully capable of flying. Thus, improving information efficiency and data gathering was hardly a dominant goal in the air arm leading up to the war. In some respects, early airmen considered themselves fortunate just to have the equipment and procedures they had.[133]

This is not to say there was no effort on the part of airmen to establish their own information environment. All things considered, air officers appeared to understand from the start that there existed a need for certain levels of documentation and information control, mechanized office equipment, and effective administrative processes specific to military aviation. Chief Signal Officer John Allen's

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[133] There is no evidence to suggest the air arm dedicated any large-scale, extraneous effort trying to improve its data management procedures during this time, although steps were clearly taken to ensure aero-specific requirements were not neglected. The primary focus on the unit, especially during such austere years as between 1908 and 1913, was establishing the unit as a viable function of the Army. See Martha Byrd, *Chennault: Giving Wings to the Tiger* (Tuscaloosa: University of Alabama Press, 1987), 18-20; and Arthur Sweetser, *The American Air Service; a Record of Its Problems, Its Difficulties, Its Failures, and Its Final Achievements,* (New York: D. Appleton and, 1919), 15-17.

first memorandum creating the Aeronautical Division suggested as much in ordering that all "data on hand will be carefully classified and plans perfected for future tests and experiments…and no information will be given out by any party except through the Chief Signal Officer of the Army or his authorized representative."[134] As the service developed over the next decade, its information needs swelled even as the organization's future remained under consistent scrutiny from various War Department and Congressional committees. Flight and accident reports, maintenance schedules, aircraft data, stock tables, and other administrative records all became essential information sources as the air arm defended itself, its requirements, and its expenditures time and again. With so much at stake, the equipment, processes, and personnel responsible for recording and disseminating data tested the air arm's information capabilities.[135]

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[134] This quote comes from the "Memorandum #6" in Hennessy's book detailing the origins of an air arm in the Army. Juliette A. Hennessy, *The United States Army Air Arm April 1861 to April 1917* (Washington: Office of Air Force History, U.S. Air Force, 1985), Appendix 1.

[135] Specific information regarding flight records can be found in Hennessy, *The United States Army Air Arm April 1861 to April 1917*, 28-89. Although there is widespread discussion of these records throughout the manuscript, pages 28, 33, 34, 40, 54, 57-61, and 84 mention these records specifically. Additionally, evidence regarding

Beginning in 1912, Signal Corps reports and regulations contained sporadic hints of administrative measures adopted for aviation purposes specifically. In that year's *General, Property, and Disbursing Regulations of the Signal Corps*, mention of fixed-wing aeronautics and its materials is slight at best. Compared to balloons and dirigibles, the regulation barely mentions heavier-than-air flying machines and associated equipment despite four years of military operation. Nevertheless, the single reference to a new standard form – Army Form 277: *Record of Aeroplane Flights* – speaks volumes, clearly denoting a conscious effort on the division's part to create a unique data recording process codified by headquarters.[136] Meanwhile, aviation administration mirrored that of Signal Corps field companies with equipment allowances for such

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typewritten documents as well as use of the telephone and telegraph in incident reporting and service documentation are also a part of this document.

[136] Balloons and dirigibles receive far more mention in this regulation than do the aeroplane, which as mentioned is known as "machine, heavier-than-air." There is mention of handmade aeroplane tents, but otherwise little else is afforded the aircraft. Page 161 contains the entire list of blank forms available for the Signal Corps specifically, of which Form 277 is listed under "Miscellaneous." *Property and Disbursing Regulations, including Miscellaneous General Regulations,* (Washington: Government Printing Office, 1912), 102-103, 158-161.

items as typewriters, field books, letter boards, message envelopes, and pencils. Meanwhile, for data processing and accountability, Corps ledgers and standard bookkeeping began giving way to a new method of data recording: manual data card accountability systems.[137]

Intermittent use of card reporting and archiving was common across the Army before the war. A manual derivation of the punched card tabulating system developed by Hollerith in the late nineteenth century, card records grew incredibly popular in many military fields, especially in the personnel, medical, and logistics branches. The use of standard-sized cards with specific codes and recording standards allowed units to organize and manage their information, not to mention their associated resources, with considerably greater precision than the ledger-based accounting systems previously in operation. For example, following the abandonment of Hollerith's patient card

[137] The equipment listing for Signal Corps field companies is standard, only deviating with organizations specifically assigned telegraph duty. As for the manual data card accountability systems, a number of different uses are recorded in this document. Specifically, the use of descriptive and assignment cards for personnel use, the civilian employee cable accountability record, and the daily report cards used in reporting issues and receipts of Signal Corps property. See *Property and Disbursing Regulations, including Miscellaneous General Regulations,* 10, 30, 60-64, 76-82, 101-3, 31.

system in the 1890s, the Surgeon General of the Army began using manual 3½ x 8 inch "sick and wounded report cards" near the turn of the century to replace the decades-old *Report of Sick and Wounded*. By 1904, the unit had nearly eliminated ledgers altogether and instead reported a soldier's condition and treatment on cards maintained for hospital accounting. Moreover, as patients transferred to other medical facilities, hospitals created "transfer" cards to ensure the data passed to the receiving facility without losing the information at origin. Finally, on a monthly basis, the Surgeon General's office pulled the data from all hospital cards to report a complete picture of Army medical status and demographic information to its higher echelons. While not an automated system like Hollerith's, data systems like this set a benchmark for future information management processes throughout the War Department.[138]

For their part, between 1912 and 1914, the Signal Corps and its aviation units used card recording procedures

[138] This report encompassed data ranging from illness and wounded figures to a census of the military population by rank, race, and color. The bulk of the information in this paragraph derives from the following website: http://history.amedd.army.mil/booksdocs/misc/tabulatingequipandarmymedstats/ chapter2.htm

that generally revolved around either personnel data or the Quartermaster duties of supply requisition and inventory control. At the time, these systems were often a function of Army General Order 92, a 1909 regulation requiring units to use a card record system to document all military correspondence.[139] Although muster rolls and manpower registers remained personnel requirements at each post, this information still derived from *descriptive* and *assignment* cards originally maintained either on station or higher headquarters.[140] At the same time, Quartermaster requirements for property accountability and responsibility dictated that Signal Corps Depots and Posts use a card record system to maintain order and discipline throughout their supply system. By using daily report cards, depot stock cards, and storekeeper record cards, units maintained a record of all property available for issue. Additionally, by order of the Chief Signal Officer, depots used these cards to report the daily status of all property received and issued as well as the balance of items

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[139] James A. Moss, *Army Paperwork, a Practical Working Guide in Army Administration... (Printed March, 1917).* (Menasha, WI: George Banta Pub., 1917), 57.

[140] *General, Property, and Disbursing Regulations, Signal Corps, United States Army.* (Washington: Government Printing Office, 1912), 10; and Moss, *Army Paperwork, a Practical Working Guide in Army Administration*.

remaining on hand. So enthused was the Army's top signalman that he even bragged to the Secretary of War that the processes were "working with complete success and to the entire satisfaction of all concerned."[141] As a service to the units, this information additionally allowed the crosschecking of data between property records and daily reports while further ensuring stock accountability with detail as minute as the disbursing officer's order number and the item requisition number.[142]

With such stringent and task-intensive administrative requirements placed on Army units, the men of the Aeronautical Division and their Signal Corps superiors began to question the responsibilities of aviation officers and enlisted men. In standard Army units, the responsibility for administrative duties such as personnel, finance, and Quartermaster often became either an officer's additional duty or their full-time duty. However, a long aviation training timeline and intensive operational duties, coupled with the harrowing possibility of death in both peacetime and war, made the administrative duty

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141 *Report of the Chief Signal Officer, United States Army, to the Secretary of War* (Washington: Government Printing Office, 1914), 17.

142 *General, Property, and Disbursing Regulations, Signal Corps, United States Army,* 10, 60-62, 76-83, 99, 168.

requirement for pilots seem unacceptably burdensome. Army Chief Signal Officer Brigadier General George P. Scriven testified to this issue to the Secretary of War in 1913:

> In the assignment of officers to the companies it is assumed that [the aviators] are acting either as instructors or pupils, and it is highly desirable that they should not be included in any of the administrative or property work of the organization. In other words, the company should be regarded somewhat as a school organization. To each company, whether on a peace or war footing, it is most desirable to assign an officer as executive and property officer who will not be an aviator and not subjected to the unusual risk which such service involves.[143]

Administrative duties were not necessarily seen as being beneath Signal Corps aviators, although over time some would draw such a conclusion. Instead, to General Scriven and others in Army leadership positions, their job was far too intensive and perilous to burden further with unit clerical duties. Instead, the General suggested one officer be assigned as an adjutant in each aero company or squadron in order to handle the unit's requisite paperwork. Furthermore, a part-time clerk serving as a first sergeant, or perhaps even a supply or mess sergeant would also serve a similar purpose.[144] Despite its growing importance in

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143 *Annual Report of the Secretary of War 1913* (Washington: Government Printing Office, 1914), 809.

144 *Annual Report of the Secretary of War 1913*, 809.

aeronautical operations, information, data collection and the routine paperwork that accompanied it appeared to some as too bothersome to be handled by Corps aviators.

By 1914, the advance of military aeronautics had brought with it a corollary organizational milestone: Congress' passing of Public Law 143. The law, also known as the Act of July 18, 1914, effectively eliminated the Aeronautical Division in favor of an Aviation Section, a more discrete and autonomous organization complete with more manpower, resources, and its own special applications and necessities. Over the next four years, Section leaders attempted to operate more independently even as congressional overseers showed little interest in funding their progress. In fact, only months after PL-143's passing, General Scriven's request for an increased budget was met with so little interest that his original appropriation was instead reduced by more than fifteen percent. Despite capturing the public's interest and imagination, military aviation was stagnating. The Army, having only purchased two dozen aircraft in the five years since the Wrights' first delivery, operational aircraft were scarce as many became unserviceable due to accident and maintenance issues. As Army aviation author Arthur Sweetser detailed shortly after the war, these issues were the perfect indication of just "how purely experimental and negligible the service was considered at that time."[145] The challenge for aviation and Signal Corps officers was more than just survival; it was overcoming indifference in an effort to prove aviation's capabilities and worth once and for all.

This indifference by Congress was neither based on ignorance nor factual misrepresentation; congressional leaders had more than enough information on the status of American aviation to comprehend what these budget decisions meant to the service. Such facts were integral to the Army's case and had been previously submitted to Congress in the *Annual Book of Estimates* published that same year. These volumes contained facts and figures from a host of services and programs on both the federal and state level and were indicative of the amount of data collection and exploitation achieved at the time. The statistics were straightforward and abundantly clear: the aviation expenditures of several other countries far exceeded those of the United States including five that equaled or surpassed the one million dollars Scriven had originally

[145] Arthur Sweetser, *The American Air Service; a Record of Its Problems, Its Difficulties, Its Failures, and Its Final Achievements*, (New York: D. Appleton and, 1919), 17-19.

requested and three that exceeded his congressionally-approved budget by more than a factor of twenty. Additionally, the information clearly showed that the Army also lagged behind in combined appropriations (a five-year total), numbers of aircraft and numbers of pilots. Overall, the Army clearly had done its job collecting and assembling the requisite information to make its case. Unfortunately, despite such evidence, Congress still chose to reduce the budget. Although this effort did not deter the Army from compiling such data in the future, it was clear that even the best and seemingly most convincing information did not infallibly justify requirements in congressional eyes.[146]

Eighteen months after its creation, the Signal Corps took a major step in aiding its Aviation Section's bid for organizational legitimacy. This step involved the Chief Signal Officer's approval of *Equipment for Aero Units of the Aviation Section*, a new service publication formally recognizing the unique equipment requirements of aeronautical units, including administrative items. The notion was simple: detail the requirements of forward

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[146] See Sweetser, *The American Air Service*, 15-18, and *Congressional Serial Set, 64th Congress, 2d Session, December 4, 1916-March 4, 1917: House Documents*, vol. 117 (Washington: Government Printing Office, 1917), 55-56.

deploying aviation units by identifying an approved, standardized set of equipment items. What developed in this documentation, besides the obvious aero-centric necessities, were the distinct information needs of the unit. As expected, many requisite items fell directly in line with the standard Army forms, folders, filing cabinets, and office utensils found across the service. What differed, however, provides evidence that unit leaders understood the organization's advancing information needs and offers insight into the air arm's attempts to manage its organization and document its progress. These differences fall into two categories: equipment and processes.

Overall, the vast majority of information equipment required by the Aviation Section was hardly different from that of regular Army units and its parent Signal Corps. Through *Equipment for Aero Units*, the Chief Signal Officer set out to ensure the Aviation Section not only specified what different information equipment it needed, but also why. The publication dictated that aviation units acquire special filing cabinets with hundreds of cards in order to file and preserve aircraft records. Additionally, beyond a call for five miscellaneous-duty typewriters, it required $500 in blank forms, binders, and other assorted material earmarked for keeping additional aeroplane documentation. The sophistication of maintenance administration grew to the point that even the Engineering branch required its own typewriter, presumably for both aircraft data recording and supply requisitioning. While the aviation requirements as a whole did not massively differ from standard Army needs, the few equipment requirements that did diverge from the norm clearly established the exceptional nature of an organization determined to document essential data.[147]

The second area of difference came by way of information processes. The service had increased the use and number of aviation-specific forms significantly since their first iteration in 1912. Four years after the introduction of the *Record of Aeroplane Flight* form, the Army now had seven aeronautical-specific forms with four directly related to flight records and aircraft maintenance. Meanwhile, it was the increase in aviation information recording that required specific attention in the publication. Developed in aeronautical field units, these enhanced recording procedures ensured the Aviation Section documented the progress of flight at every turn.

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[147] *Equipment for Aero Units of the Aviation Section (Signal Corps), Tentative, 1916.* (Washington: Government Printing Office, 1916), 30-31, 49-51.

The procedures required every officer to keep an official diary to document each flight, designed to include comprehensive aeroplane and motor data for inclusion in section records. Additionally, aircraft-responsible sections kept daily records of their own aeroplane and motor data, including descriptive lists for up-channeling squadron information. Finally, unit expenditures and transportation vehicle data were also required, as were weekly and monthly reports that complemented those submitted on a daily basis. In the end, each unit section kept a small record chest to hold the voluminous amount of spare forms and records required. In this way, information recording became more than a necessity inside the Aviation Section; it was fast becoming a way of life. In fact, few Army branches appeared as committed to such high levels of pre-war data documentation as did those in the aeronautics field.[148]

In 1917, the significance of articulating distinct aeronautical requirements went a step further. This time, rather than directing a separate equipment publication from the Signal Corps, the Army's Adjutant General published the document under the ultimate approval of the Secretary of

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[148] *Equipment for Aero Units of the Aviation Section (Signal Corps), Tentative, 1916*, 30-31, 49-51.

War – a sizeable leap forward in administrative oversight. While there are significant similarities between the two documents, the more recent publication abandoned building itemized allowances for organizational subsections. Instead, the Adjutant General centralized the Aviation Section's administrative requirements under a special "Office Supplies" section, thus abating the need for individual units to account for their own exclusive requirements. Like the previous Signal Corps version, the justification for an extensive card recording system (and requisite materials) remained firmly in place. However, the Army tripled the requirement for mechanized writing instruments. In this iteration, the service approved a complement of 17 typewriters as part of the standard aviation contingent, of which a dozen were portable machines built specifically by the Corona Typewriter Company. This incremental improvement coupled with increased organizational oversight highlights the emerging importance of the organization inside the War Department and the persistent requirement to document its progress.[149]

[149] *Unit Equipment Manual for the Aviation Section, Signal Corps.* (Washington: Government Printing Office, 1917), 1-17.

As indicated by an ever-increasing amount of regulatory guidance, Army leaders clearly spent a great deal of time before the war codifying the purpose, materials and procedures associated with War Department information processing. As Army Colonel James A. Moss stresses in his administrative compendium *Army Paperwork, A Practical Working Guide in Army Administration*, paperwork was an essential albeit "irksome" requirement in the modern Army. It was its primary means of recording, exploiting, transferring and archiving its information and now had become an indispensable characteristic of life in the military.[150] Leaders understood that modern Army information processes were not only a factor in military and legislative requirements, but were also part of the "complexity of our present form of civilization."[151] As the ability to record data both increased and grew more efficient, so too did the requirement to exploit it. For the Aviation Section and those seeking a more prominent role for military aeronautics, there existed an understanding that aero-specific documentation and reporting would remain vital to their struggle for greater

150 Moss, *Army Paperwork, a Practical Working Guide in Army Administration…*, 29.

151 *Ibid.*

organizational legitimacy. With the War Department leading all government agencies in adding new clerical positions in the intrawar period (over 5,000 new administrators in Washington alone), the institutional desire for information skyrocketed alongside increases in personnel and materiel.[152] It became clear that the Army was becoming enamored with information and its corresponding technology and that information was becoming an integral part of its operations.

The scope and size of aviation's information requirements remained reasonably small as before America entered the war. As an organization insignificant in comparison to its great power counterparts, the Army's air arm had little reason to invest copious amounts of resources toward improving or expanding its data processes. With few pilots and aircraft, there was little need to track pilot training or aircraft maintenance statistics, or separately improve aircraft materiel requisitioning or personnel employment records. The meager budget allocations did not help matters either. Overall, the Aviation Section was in a survival mode, just another

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152 "The Growth of the Capital in War Time," *Air Service Journal, Vol I, November 29, 1917, 666.*

subordinate Army unit jockeying for scarce resources and operational respect. Until the war, however, they received little of either.[153]

By the summer of 1917, however, that paradigm had changed completely. America's entry into the war afforded the Army and its air component the opportunity to pursue new technologies and methodologies without the intense fiscal pressure of peacetime. In short order, the Aviation Section's pre-war budget constraints began to vanish, usurped by the influence of wartime authority and public opinion. Principal among these changes was President Wilson's approval of the July 1917 Aviation Act. Two months earlier, French Premier Alexandre-Félix-Joseph Ribot sent a cablegram to Washington briefly describing how aviation assistance from America "…would allow the Allies to win the supremacy of the air." To meet his challenge required unprecedented changes in both military and civilian aeronautics, with the Aviation Act providing the catalyst a mere fifteen weeks after America's declaration of war. For the first time since its inception, Army aviation leaders could finally begin building an air

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[153] Sweetser, *The American Air Service; a Record of Its Problems…,* 66-104.

service without the oppressive restrictions placed on them by an uncooperative Congress.[154]

The response to the Aviation Act's was massive. Ribot's 150-word cable requested aircraft and aviator acquisitions requiring over 640 million dollars in new funding, a seemingly absurd amount for an aviation program that had received less than a quarter of that sum over the past ten years combined. With less than 300 planes in the government's inventory at the time, the Act called for the production of more than 20,000 new aircraft, nearly half of types never before witnessed on American soil. It required placing a thousand qualified men in training a month, 24 new aviation training fields, as well as air parks, supply depots, and maintenance centers to keep the entire organization operational. American aircraft manufacturers were tasked to produce two thousand planes a month in order to maintain the rigorous demand schedule, not to mention producing twice that many engines for aircraft and spares. Within the first six months alone, France specified that victory for the Allies required a flying corps of approximately 4,500 aircraft, complete with 5,000 new American aviators and nearly ten times that amount in

[154] *Ibid*.

maintenance technicians. Ultimately, such sweeping changes challenged the organization and operation of the air arm in the war. It also challenged how airmen handled their corresponding information requirements.[155]

Aviation leaders such as Generals George Squier and Benjamin Foulois were seasoned officers with experience in difficult situations. However, the problem of handling the windfall of new aircraft, the selection and training of thousands of new aviators, and the operations of an organization ballooning to nearly ten times its former size was more than just a leadership issue. This mammoth escalation in personnel and equipment created a host of new challenges for the air arm, not the least of which was an escalating amount of organizational information. Until that point, the management of military aviation information was primarily an issue for higher Army echelon staff organizations.[156] As the air service grew, however, its expansion necessitated the development of distinct administrative procedures ranging from aero-centric forms,

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155 *Ibid.*

156 In these specific cases, I am referring to the Adjutant General staff for personnel documentation, the Quartermaster department for logistical and maintenance concerns, the Surgeon General for medical and psychological documentation.

files and reporting procedures to a card-based personnel system that dovetailed into the larger Army system. Following the Aviation Act, Army leaders looked to new information and administrative procedures that were not based on a previous Army construction.[157] For their part, air officers and their supporting cast began experimenting with data processes better suited to harness voluminous amounts of data, most often in the form of newer derivations of manual card-based data management systems.

Despite the continuing use of ledgers and registers, migrating to manual card systems became a universal tendency for major Army information processes during the war. For aviation personnel specialists specifically, managing the growing horde of pilots and supporting airmen

[157] See *The Personnel System of the United States Army.* (Washington: National Publication-U.S. Army Adjutant-General's Office, 1919). Throughout this document, the Army discusses how the onset of the war forced a number of administrative changes for the individual Army branches and makes a number of specific references to the Air Service. There is an entire section beginning on page 56 that details how Secretary Baker and General McCain oversaw "The Committee on Classification of Personnel in the Army," which had a great deal to do with the administrative details of recruiting, training, and administering to massive influx of incoming airmen. In addition, Chapter 47, page 604 is entitled "Cooperation with the Aviation Section, Signal Corps and Department of Military Aeronautics" and deals directly with the selection and classification of air officers. Also see Sweetser, *The American Air Service…*, 84-145.

was an alarming task. In the first year of America's war, the total air arm population grew from 65 officers and 1,100 enlisted men to more than 12,000 officers and over 130,000 enlisted men. By mid-1918, the newly created Air Service had expanded to a size almost equal to that of the entire pre-war Army.[158] With so many additional personnel, each with his own individual characteristics and background data, using a Hollerith tabulation system seemed a viable option for managing this information. However, after nearly three decades of sporadic military use, some felt punched card systems were suited for little else other than figure calculations and were not a fundamental or necessary capability for large-scale data management. Thus, instead of fielding its own data tabulation systems, the Aviation Section would instead borrow from the larger War Department effort of creating a single, manual personnel data system designed to handle the colossal amount of manpower pouring into the Army during the war.[159]

The rapid influx of troops put the Army and its aviation arm in a difficult position. Recognizing the

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[158] Sweetser, *The American Air Service…*, 225.

[159] *The Personnel System of the United States Army.* (Washington: National Publication-U.S. Army Adjutant-General's Office, 1919), 143-150.

issue early on, Secretary of War Newton Baker established a special committee to oversee the service's growing matriculation and assignment concerns. This group of highly-regarded civilians became known as the Committee on Classification of Personnel in the Army, responsible for tackling the Army's manpower expansion challenges throughout the war. Most notably, the committee recommended in September 1917 that the Army establish a manual card-based data management system built on identically-sized "Soldier Qualification Cards" to be universally applied across all branches. Replete with space for a soldier's background information, education, occupational experience, assignment desires, and other pertinent data, the service strove to get all qualification cards completed within hours of a soldier's arrival on station. Moreover, cards were specially marked with orange-, black- or green-colored celluloid tabs to denote a soldier's skill level in his given trade as well as his usefulness to the service. In June 1918, project managers refined the card system with simplicity and universality in mind. Instead of an overbearing and complicated program, the committee members sought out a system that was easily cross-indexed, sortable between skill levels and trade sets, and would inevitably fit into a standard Army filing cabinet.[160] With qualification cards in use throughout all Army branches, air units specifically used them to integrate new personnel into the organization as a means of ensuring aviation procedures aligned with its higher echelon counterparts.

One area where the Aviation Section did require deviation, however, was in the selection of many of its enlisted airmen, especially ones designated for aircraft maintenance positions. From its inception, members of the Classification Committee used their expertise to design tests for incoming soldiers that assessed mechanical capability and potential. Nevertheless, air officials believed these examinations only validated general mechanical aptitude and did not discern between these individuals and those more qualified (or with the potential) for more challenging positions in aeronautical maintenance. The Aviation Section convinced the committee in 1918 to design special tests to select soldiers for this specialized field. The results were immediate, and the quantity and quality of airmen entering the air arm

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[160] *The Personnel System of the United States Army*, 143-163; Mark R. Grandstaff*, Foundation of the Force: Air Force Enlisted Personnel Policy, 1907-1956* (Washington: Air Force History and Museums Program, 1997), 15-16*;* and Edwin Garrigues Boring, *Psychology for the Armed Services.* (Washington: Infantry Journal, 1945), 13-14*.*

profoundly improved. Moreover, the mechanical capacity of incoming soldiers coupled with the diversification of the profession allowed enlisted aviation positions to proliferate into numerous subspecialties. Whereas only the position of "Air Mechanician" existed before 1917, World War I saw aviation specializations develop in aircraft engines and wing fabric, in propeller making and testing, and in general aircraft maintenance.[161] For those in the aviation organization not directly involved in flight operations, careers expanded in similar fashion to those in the Signal Corps itself, with positions in communications, engineering, photography, and weather.[162]

A similar evaluation and selection overhaul awaited the Aviation Section's massively reinvigorated pilot selection program. In general, the selection of new aviators both before and during World War I presented some

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161 It is worth noting that the term used was not mechanic but mechanician, although reasons why are unknown.

162 Grandstaff, *Foundation of the Force: Air Force Enlisted Personnel Policy, 1907-1956,* 15-16; Walter Van Dyke Bingham, *Army Personnel Work, Vol II* (Washington: American Psychological Association, 1919), 1-12; Harry David Kroll, *Kelly Field in the Great World War* (San Antonio: Press of San Antonio Print., 1919), 53; and Robert Mearns Yerkes, *Report of the Psychology Committee of the National Research Council,* 2nd ed., vol. 26, The Psychological Review (Washington: National Research Council, 1919), 83-149.

of the most significant data compilation challenges the air arm had ever seen. Although exact figures vary, by the start of the war the total number of fully-qualified "flyers" in army aviation only amounted to approximately 50 officers, although some estimates project that even a third of those were not considered completely competent in the air.[163] From July 1914 to June 1918, the Army's aeronautical unit processed 38,770 men seeking admission as Air Service pilots. In some periods, as in December 1917, the application load grew incredibly intense with nearly 3,000 candidates volunteering for examination in one month alone. The administrative process became so selective that only 18,004 individuals made it past their initial screening, cutting the selection pool nearly in half. By the time the Armistice was signed in November 1918, the U.S. Army Air Service had examined and trained upwards of

[163] Records and accounts on the exact figure of "qualified" pilots vary considerably, although one could argue that numbers as miniscule as 26 to 54 are insignificant considering the figure rose to over 16,000 just a short time later. Data for these early numbers derive from Martha Byrd, *Chennault: Giving Wings to the Tiger* (Tuscaloosa: University of Alabama Press, 1987), 19; Diane L. Damos, *Foundations of Military Pilot Selection Systems: World War I* (Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences, 2007), 2; and V. A. C. Henmon, "Air Service Tests of Aptitude for Flying," *Journal of Applied Psychology* 3, no. 2 (1919): 103-109.

16,000 air cadets in their program. No administrative task of this magnitude had ever been attempted. Like the overall Army personnel system, the pilot selection process gave air leaders the opportunities to manage and exploit information in volumes the likes of which were foreign to the service's short history. And, once again, the method of data management became nearly as important a lesson as the information derived from the data.[164]

Although the air arm's data recording methods were similar for enlisted and officer enrollment, the recruiting and subsequent information gathering processes for aviator selection were altogether different. In the first place, the standards for aviation officers were incredibly high, calling for "men of the highest character" who were both "well-educated" and of "good physique."[165] Luckily, with aeronautical interest remaining strong throughout the country during the war, the number of applicants was staggering. Thus, Signal Corps leaders understood they could afford to be particular when selecting pilots, even

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[164] Along with the aforementioned records and accounts of Byrd, Damos, and Henmon, another valuable reference in this discussion is Sweetser, *The American Air Service…*, p. 96-102.

[165] "How Army Aviators Are Trained," *Air Service Journal*, September 28, 1917, 370.

in the face of the massive requirements levied by the Aviation Act. Ensuring a thorough vetting process meant more than choosing those applicants who survived a stereotypical military training scenario. Potential future aviators required a combination of qualification programs each designed to ensure only the most fit would eventually take to the air. In fact, even the Adjutant General of the Army warned that neither schools nor competency boards should be the overall arbiter for pilot qualification as neither could perfectly determine who was truly airworthy. The final result was to be not only a test of the potential pilot’s aptitude and attitude, but also an extensive assessment of the service’s ability to manage the millions of corresponding data points that defined the process. Pilot selection was to be the largest information management program in aviation history until the Second World War.[166]

The amount of information collected on candidates journeying through the pilot selection process was staggering. Each potential aviator provided substantial personal and professional information on his application forms in addition to the standardized data set required on

[166] *The Personnel System of the United States Army*, 612-614.

his Army qualification card. This allowed examination boards to review an abundance of information determining everything from a candidate's academic compatibility to his potential for courage and "zeal for risk."[167] The primary selection paperwork instrument during this process was known as a "Form 609," a document that originated as a pre-war medical evaluation form only to grow into a professional and mental examination document that included elements administered by Aviation Examining Boards. Through these forms, candidates provided answers to questions on family, education, business experience, athleticism, previous responsibility, and other forms of military or professional training. Included in the Form 609 package were no less than three letters of recommendation and the results of an oral examination conducted before yet another aviation board. For each pilot candidate, the total amount of information required and compiled became a very daunting and invasive process that matured considerably throughout the war.[168]

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[167] *Ibid.*

[168] Diane L. Damos, *Foundations of Military Pilot Selection Systems: World War I* (Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences, 2007). Additional information derived from several interviews with Damos via telephone and email between November 2012 and January 2013.

Aptitude data was continuously added and updated as prospective aviators navigated a gauntlet of intense educational and training experiences. Beginning with a rigorous ground school, trainers tested and documented everything from aeronautical talent, to ceremonial drill, to wireless telegraphy knowledge. By the time students made it through flying school, their cadet records reflected competency levels in flight theory, engine operation, aircraft rigging, navigational aids, reconnaissance and artillery theory, and a variety of other topics from bomb characteristics to general military paperwork. Ultimately, despite being dispersed across forms, cards, and other assorted paperwork, enough diverse and detailed information existed on each cadet to determine his airworthiness. Moreover, with so much concerted effort poured into each recruit's evaluation, final graduation authority was not left to low-ranking officers but instead rested with the school's commandant and the Chief Signal Officer himself.[169]

While air leaders designed the decision process to be both incredibly strenuous and selective, the task of

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[169] "How Army Aviators are Trained," 370; *The Personnel System of the United States Army*, 617; and Sweetser, *The American Air Service…,* 119-168.

organizing, accounting and distributing all this information was still a chore in and of itself. Therefore, to make this happen required managing this information throughout each process element. For those military and civilian administrators who participated in this endeavor, pilot selection grew to become an exceptionally arduous procedure to adjudicate and was made worse by the vast amounts of paperwork required for process completion. Moreover, without any form of data mechanization or unlimited clerical assistance, the scale and scope of this effort was at times overwhelming. After reviewing the pilot selection process in detail, one might question why the Aviation Section (and after 1918, the Army Air Service), the Signal Corps, or the Army did not introduce any form of data mechanization into this procedure to alleviate such a cumbersome administrative burden. The fact is that punched card tabulators were, in fact, used in this process but not in the procedures previously discussed. Instead, punched cards were used by another medical group in this process . . . one that was outside of the traditional military purview at the time.[170]

[170] *Ibid.*

As mentioned in the first chapter, the Surgeon General of the Army used the rapid escalation in the number of recruits as an opportunity to exploit the personnel data of soldiers. Encased in this effort was the Army's psychological testing, of which aviation became an integral part given the newness and inherent danger of aircraft. The day after the United States declared war on Germany, a group of psychologists eager to contribute to the war effort formed a committee to address potential psychological problems in Army recruits. At the request of the National Research Council, this "Psychology Committee" aligned with the Council of the American Psychological Association and examined ways to best utilize the expertise of the nation's top psychologists. Under the original direction of Dr. (and later, U.S. Army Major) R. M. Yerkes of Harvard, the group established a subcommittee specifically to examine the unique military problems related to aeronautical personnel. Formally designated "the Committee on Psychological Problems of Aviation," Yerkes selected this panel of experts as one of the twelve breakout groups to assist the war effort. Shortly thereafter, they began work on selecting specific testing methods and certifying the mental and psychological information captured on the Form 609.[171]

A year later, shortly after the Air Service came into existence, the aviation psychological committee continued to make substantial progress in its aero-centered investigations. By closely studying the examining board and intelligence test data, committee members were able to discern valuable information on progressing aviation cadets as well as devise additional assessments to further hone their findings. After a study of over two thousand records, committee chairman Dr. Edward L. Thorndike determined critical relationships existed between pilot success and a candidate's age, social status, intellect, professional achievement, and athleticism. From that data, the committee designed a testing and ratings plan for the

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[171] See Damos, *Foundations of Military Pilot Selection Systems World War I*, 1-23; Yerkes, *Report of the Psychology Committee of the National Research Council*, 83-99; Diane L. Damos, *A Summary of the Technical Pilot Selection Literature*(Randolph AFB, TX: Air Force Personnel Center Strategic Research and Assessment, 2011), 1-13. It should be noted that the psychological testing of recruits is one of the most misinterpreted Army processes of the war. This testing, which began only days after Congress' declaration of war, is often referenced in historical literature as the first large-scale use of data mechanization in the Army. It is often assumed that the air arm had some experience with these Hollerith systems and thus likewise participated in this form of information processing. However, evidence clearly shows that both the Army's and the Air Service's involvement are exaggerated.

Air Service's Personnel Procurement Branch to adopt in order to meet the Aviation Act's goal of one thousand aviation cadets per month. Still, even with such an advanced level of analysis, the processing methods remained a manual endeavor. Although numerous accounts of the Psychology Committee recall the use of Hollerith tabulators during the war period. Hundreds of clerks worked for days on end to compile, sort, and distribute the committee's data throughout the remainder of the war. It was not the finest hour for air arm information processing. Eventually, however, the toil spent during this period would become an exemplar for future systems generated during the next World War.

In the meantime, the larger Psychology Committee did manage to capitalize on its opportunity. After culling approximately 200,000 records from a pool of over 1.5 million, Major Yerkes and his committee of experts applied a Hollerith punched card system to statistically examine the progress of this subsection of Army troops. The board compiled as much data into one card as they could feasibly imagine: camp assignment, state drafted from, age, rank, military specialty, nativity, time in country (for foreign born soldiers), schooling, test scores, and most important of all – race, specifically White or Negro. While interesting and informative, the end result was a series of statistical studies that were not as groundbreaking or as helpful to the war effort as perhaps some committee members initially expected. While the compiled material certainly provided a host of surveys and reports useful to higher echelons, the data remained predominately useful for selection and training procedures.[172]

Thus, by war's end, data mechanization clearly existed as part of the Army's information processing programs, but only on a limited basis. Meanwhile, for the newly-minted Army Air Service, tabulation systems for inventory and personnel control were of even less importance in its overall information processes. The qualification card, the Form 609, and the abundant amount of aero-specific tests and evaluations performed on recruits (especially pilots) remained the most enduring information control lessons learned from the First World War. It would take several more decades, as well as a continuing fascination with statistics and data analysis, to entrench the use of punched card tabulators in the military's air organization

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[172] Robert Mearns Yerkes, *Psychological Examining in the United States Army.*(Washington: Government Printing Office, 1921), 565-570, 659-869; *Reprint and Circular Series of the National Research Council.* (Washington: National Research Council, 1919), 8-10.

as well as produce the need for information technologies more powerful than Hollerith ever imagined.

Supply, Statistics, and Data Tabulation

The newly christened Air Service came out of World War I with renewed focus. No longer driven by the operations, logistics, and support missions of the war, the service could now concentrate on standardizing and improving its processes and procedures in order to sustain itself as an independent Army branch. Part of this improvement process meant taking a close look at how the organization managed and exploited its information. In the post-war Air Service, few endeavors exemplified this effort as much as those undertaken by the service's Supply Division.

In the winter connecting 1919 and 1920, Supply Division Lieutenant Edwin R. Page engaged in what one historian described as "undoubtedly one of the most important steps taken by the Air Service after World War I."[173] His junior rank notwithstanding, Page developed a new property classification information system that would become the backbone for aviation logistics processing for

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[173] Lois E. Walker and Shelby E. Wickam, *From Huffman Prairie to the Moon: The History of Wright-Patterson Air Force Base* (Washington: Air Force Logistics Command, 1986), 349-350.

the next thirty years. By dividing all equipment and supplies into 29 different classes, this new program allowed logisticians to navigate a manual supply system that identified, stored, and issued supply items with relative ease. Given the intricacies and disconnectedness of the existing system developed both before and during the war, Page's methods were welcomed in the Air Service. Moreover, the fateful presence of then-Major Augustine Warner Robins in the same office truly brought the program to light. Robins, now known as the father of Air Force Logistics and the namesake of one of today's largest logistical bases in the world, helped take the system public, believing in it so strongly that some writers mistakenly give him credit for developing the program himself. Interestingly, when Robins transferred to take command of a transitional air depot in the plains of Ohio, Page went with him. It was there that the importance of information control was tested in the post-war Air Service through the service's first true operational applications of data tabulators.[174]

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[174] Lester Durand Gardner, *Who's Who in American Aeronautics* (Los Angeles: F. Clymer Publications, 1925), 1, 88; William P. Head, *Every Inch a Soldier: Augustine Warner Robins and the Building of U.S. Airpower* (College Station: Texas A & M University Press, 1995), 83-84; and Walker, *From Huffman Prairie to the Moon,* 349-352.

In 1919, small airfields, depots, and other service-related installations peppered the countryside of many American states, and western Ohio was no exception. Just outside of Dayton in Fairborn, Fairfield Air Depot served as the service's supply clearinghouse, especially for the trainloads of excess airplanes, engines, and various unsorted aeronautical equipment shipped there after the war. Only miles away, McCook Field was an up and coming experimental laboratory that housed, among a number of other organizations, the Airplane Engineering Division tasked with designing and redesigning aeronautical components ranging from engines to armament. In the two locations, the Air Service developed some of the basic logistical functions required of an air arm, specifically the acquisition, supply, and experimental research systems of the organization. To do so required the establishment and formalization of key information processes designed to ensure the most effective operation possible, especially given the financial constraints of the post-war Army. What information the organization tracked, and how, became a principle factor in the behavior of the post-war organization . . . a fact not lost on other service officers besides Robins and Page.[175]

In line with its wartime procedures, the Air Service put aside thoughts of mechanizing their data processes in favor of the tried-and-true manual card-based systems applied over the past decade. At McCook Field, known throughout the service as an "information clearinghouse" for producing aviation-specific reports and bulletins, this meant that the statistical analysis and information processing required for these publications would remain a manually-processed endeavor. For its airmen, this amounted to using tens of thousands of cards each month to operationally control information. In July 1919 alone, the Engineering Branch at McCook used over 33,000 three-by-five inch cards just to monitor the phases of aircraft development programs. Steeped in information documentation, a number of functional units under the much larger Engineering Division used this card system in coordination with other data "machines" and methods. Using recording processes that involved blueprints, blank forms,

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[175] Walker, *From Huffman Prairie to the Moon,* 349-352; Mary Ann. Johnson, *McCook Field, 1917-1927: The Force behind America's Golden Age of Flight* (Dayton, OH: Landfall Press, 2002), 296-299; "Engineering Branch of Shop Engineering Section," *Slipstream* I, no. 3 (September 15, 1919): 1, 32; Head, *Every Inch a Soldier*, 84.

stationary stock, mimeographs, multigraphs, photographs, and a plethora of other documentation and also office machines, McCook airmen were able to publish the reports, bulletins and special orders required by the unit's experimentation and engineering work.[176]

A few years later, Fairfield Air Depot contained more than 250 million dollars' worth of government property registered on 120,000 stock record cards, each requiring continuous updating to ensure accuracy. With Robins in command and Page on staff, the Fairfield depot became a supply repository for post-war aeronautical surplus, not only from inactivated airfields throughout the states, but also from the host of overseas depots established during the war. Because so many war surplus items (both serviceable and obsolete) made their way to the depot, the amount of excess supplies requiring sorting, classification, and storage created "serious record-keeping problems."[177] In fact, it took well over two years for the operation to become fully functional. The painstaking accountability process involved identifying, designating, cataloging, and indexing entries for hundreds of thousands

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[176] *Ibid*.

[177] Walker, *From Huffman Prairie to the Moon,* 349.

of technical supplies. In all, it took a team of 350 civilian employees nearly four years to annotate the entire system. If reviewing the programs at McCook and Fairfield reveals anything about the Air Service during this period, it is that these installations relied heavily on manual card information processes. Even more so, it highlights the importance of the information they generated and the service's persistence in obtaining it regardless of cost.[178]

The effective maintenance of supply information after World War I shows just how important accurate and timely information was to the air arm. However, methods employed also demonstrate a reluctance to make massive, wholesale changes to information systems. As time went on, the reliance on manual card-based systems stood in even greater contrast to the mechanized data machines in use across similar logistical and administrative networks outside the military. War Department personnel understood that eventually programs would include an either partial or completely mechanized information system. The only question was when. With companies adapting to modern

[178] Walker, *From Huffman Prairie to the Moon*, 349-352; Johnson, *McCook Field, 1917-1927*, 296-299; "Engineering Branch of Shop Engineering Section," 1, 32; Head, *Every Inch a Soldier*, 84.

administrative technologies at a faster pace, the gap between the military and industry grew more noticeable with each passing year.[179]

In the decade following World War I, the commercial market for data tabulators and business machines in general grew even larger as new and improved variants enticed a growing pool of potential users. Additionally, new market competitors pushed the prevailing technological boundaries as each sought their own niche in the fast growing office machine industry. The American public was swept up in the phenomenon, with more school aged children signing up for typewriting classes each year and an increase in office machine and furniture sales for industry and in the home. In these early business machine years, companies such as Remington Typewriter, Dalton Adding Machine, and Powers Accounting Machine all competed for market share against

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[179] Information of industrial advances in these areas is far better documented than those of the military. For example, *Technological Innovation in Retail Finance* includes the use of punched card machines in the banking industry [see Bernardo Batiz-Lazo, Carles Maixe-Altes, and Paul Thomes, eds.,*Technological Innovation in Retail Finance: International Historical* (New York: Routledge, 2012), 278.] following World War I, while *Punched-Card Systems and the Early Information Explosion* expounds upon tire producers like Michelin and Renault who used these machines to process operational statistics in the same post-war period [see Heide, *Punched-Card Systems and the Early Information Explosion: 1880-1945*, 158.]

original standouts like Herman Hollerith's Tabulating Machine Company. Even the Census Bureau, which only years earlier had relied on Hollerith's innovation for their all-important decennial event, turned inward and created its own machine shop to build the equipment for its data collection and statistical needs. In short, there were enough machines, with enough capability, with enough proven performance to satisfy many of the statistical and informational requirements of the military in the mid-1920s. The question of when the air arm would abandon manual systems and begin employing modern business machines was anyone's guess.[180]

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[180] The history of these business machines is found in numerous narratives written about the age. Heide does a worthwhile job of highlighting Herman Hollerith's journey from inventor to businessman, all the while identifying key market trends and users along the way [see Lars Heide, *Punched-card Systems and the Early Information Explosion, 1880-1945* (Baltimore: Johns Hopkins University Press, 2009)]. Another helpful resource was Essinger's *Jacquard's Web*, which also delves into the history of Hollerith from a slightly different angle [see James Essinger, *Jacquard's Web: How a Hand-loom Led to the Birth of the Information Age* (Oxford: Oxford University Press, 2004)]. An IBM pamphlet is also helpful in tracing the story of that company's involvement during this period [see *IBM Highlights: 1869-1969* (Washington: International Business Machines (IBM), 2011)]. Finally, Cortada discusses at length the role of data mechanization, information control, and business machines in the interwar years [see James W. Cortada, *Before the Computer: IBM, NCR, Burroughs, and Remington Rand and the Industry They Created, 1865-1956* (Princeton, NJ: Princeton University Press, 1993)].

Accounts vary as to the time and place of the first significant, aviation-specific data mechanization program in the air service. There are some writings that place mechanical business equipment at McCook Field as early as 1919; others suggest an operational application at Ohio's Wright Field in 1926. However, with documentation as the best arbiter of fact, perhaps the two earliest and most developed data mechanization accounts occurred even later in the post-war decade – in the Inspection Division's Development Section in 1927 and in the Materiel Division in 1929.[181]

Service historians note that beginning in April 1927, the Inspection Division's Development Section tracked aviation trends, especially those pertaining to improving pilot and aircraft performance, by performing statistical analyses using the latest mechanized data equipment. As aircraft enhancement programs progressed in the post-war military, the Development Section remained focused on studying aircraft accidents and forced landings by way of statistical investigation. Moreover, the unit used these investigations to pioneer new standards for recording

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[181] *Charles R. Landon, ed., United States Air Force - Review of Statistical Services, January 1950 - July 1954 (Washington: United States Air Force, 1954), 1.*

aircraft flying hours, individual flying hours, and aircraft engine time. The section took on the additional task of life insurance management, a task stemming from the unit's original accident documentation mission. Using data tabulation and calculations, these airmen were able to examine data quicker and with greater proficiency than ever before. The significance of these analyses clearly revolved around the quality and efficiency of its information. At the unit level, these data-focused units grew evermore significant as this information became essential to daily operations. At the higher headquarters echelons, the importance was magnified as this same information helped determine the major organizational decisions being made throughout the service.[182]

It was at these higher echelons that the Inspection Division's Development Section sought an even greater impact with its information. Given its access to mission-critical statistical and operational data, the Section aimed to serve as a research and planning agency for the Office of the Chief of the Air Corps (OCAC) in hopes its statistical methodologies and mechanized processes could

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[182] Frances Acomb, *Statistical Control in the Army Air Forces, Air Historical Studies: No. 57* (Washington: USAF Historical Division, Air University, 1952), 1-3.

formulate management control methods for Air Corps leadership. Even more, the unit looked at developing special statistical studies for OCAC offices to aid with pending Congressional legislation affecting the air service. Unfortunately, despite contributing numerous reports to headquarters organizations, the unit operated for over a decade without being credited with any major impact on either service decision making or management. In fact, with the exception of providing both personnel and products to support headquarters' statistical support, the Development Section's impact up to 1939 is regarded as nominal at best. As fate would have it, nearly a dozen years and countless mechanized data analyses failed to make a significant contribution to Air Corps decision making in the interwar years. Just as they had prior to World War I, senior leaders focused so heavily on service relevancy in a fiscally-constrained military that the importance of promoting data mechanization paled by comparison. The drive for statistical data did not cease in the interwar military, but its importance remained questionable until another world war was imminent.[183]

[183] Acomb, *Statistical Control in the Army Air Forces*, 1-3.

At the same time the Development Section was advancing data mechanization processes, a key statistical organization inside the Air Corps' Materiel Division began a three-year process of installing punched card tabulators. Beginning in 1929, the Materiel Division – the service's largest branch responsible for all aircraft and equipment research, development, procurement and maintenance – ordered the Statistics Unit of its Field Services Section to record and preserve the consolidated records of aviation's critical flight development programs. These programs maintained an abundant amount of vital information on all airplanes, airships, balloons, and engines in the Division's arsenal, including inventory totals, location, condition, status, and flying time of each part or aircraft. To effectively utilize this information, the Field Service Section installed "business machine equipment" at Wright Field to perform analyses on aircraft and equipment.[184] In fact, without tabulating equipment, reporting comprehensive airframe and engine statistical data was deemed too arduous to attempt. Although leaders originally purchased these machines for cost accounting purposes, their reports became a quintessential part of the

[184] *Ibid*, 2-4.

Section's operational effectiveness, not to mention a useful tool in the Air Corps operations and logistics management.[185]

By 1936, the Materiel Division's statistical mission officially migrated to the Air Corps Budget Office due in large part to a continued headquarters requirement for such reporting. To those at the OCAC-level, it was clear these reports and analyses represented only a fraction of the unit's potential, especially given its steadily increasing use of modern business equipment. Of course, as these statistical programs were visible to the rest of the War Department, the benefits of data mechanization extended beyond the offices of the Air Service. For example, in 1938, General George Marshall took inspiration from other service mechanization efforts and ordered the creation of Army electronic accounting units to handle administrative tasks ranging from manpower to finance to logistics. A year later, the War Department began hiring administrative

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[185] Acomb, *Statistical Control in the Army Air Forces*, 2-4; *Review of Statistical Services, January 1950 - July 1954*, 1; Arthur Tatnall, *History of Computing: Learning from the Past : IFIP WG 9.7 International Conference, HC 2010, Held as Part of WCC 2010, Brisbane, Australia, September 20-23, 2010 : Proceedings* (New York: Springer, 2010), 89-90; and "Air Force Materiel Command Fact Sheet," Air Force Materiel Command, accessed December 12, 2012, http://www.afmc.af.mil/main/welcome.asp.

specialists to coordinate with industrial experts to establish a new service-wide accountability program, known later as the U.S. Army Personnel Accounting System. This system used punched card tabulators capable of tracking every soldier with impressive accuracy, proving even more effective than the World War I mechanized card systems in the Surgeon General's office. Installing these tabulating units later became an integral part of the Army's broader plan to create mobile, truck-mounted "Machine Record Units," or MRUs, capable of handling the personnel management and record keeping for deployed units and designed with statistical control in mind. Near the end of the decade, it was clear that mechanization programs symbolized the coming of a new era in information management and control in the Army. Soon it became incumbent upon its Air Corps to follow suit.[186]

Between January 1939 and December 1941, the number of machine tabulators and calculating machines grew progressively throughout the Air Corps. After nearly two decades of meandering data mechanization programs that received little fanfare in the service as a whole, efforts

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[186] Acomb, *Statistical Control in the Army Air Forces*, 2-4; Norman A. Donges, "How the Army Knows Its Strength," *Army Information Digest* 3, no. 7 (July 1948): 65-69; Province, *General Patton's Punch Cards*, 8-10.

flourished as major organizations continued marrying their information processes to both the manual and machine-assisted statistical compilation programs of the day. In fact, elements of Air Corps data automation began permeating the highest levels inside the War Department. For example, after relocating a number of times, the Materiel Division's once meager Statistical Unit expanded to become the Air Staff-Statistics Office, responsible for liaising with the statistical sections of the Assistant Secretary of War, War Department General Staff, and the Office of Production Management. In another example, after several organizational moves of its own, the Development Section's statistical mission reappeared in early 1941 in the Inspection Division's newly organized Safety Section. This new element became responsible for all flight records, medical examination records, and emergency tabulations for the numerous divisions inside OCAC, taking on an entire Army machine tabulating unit assigned to assist with the additional workload. After years of changing priorities and requirements, the organization finally processed all Air Corps military personnel data and eventually, civilian personnel records as well. In the months before World War II, there was little doubt that the service's statistical control was a rapidly advancing capability. Its advancement was matched only by the organization's growing reliance on the data machines themselves.[187]

In June 1941, the combination of a dependence on statistical data and the various decentralized methods of obtaining it was too much for Air Corps leaders to ignore. At the time, the War Department was rewriting Army Regulation 95-5, a critical document that gave the aviation service the opportunity to reorganize. This allowed Corps leaders, anxious to make pivotal changes in departmental operations, to take advantage of the chance to rectify data process issues. At the time, thirteen distinct statistical activities operated independently throughout each major aviation organization of the service. A noticeable lack of control and information integration sometimes caused more problems than it solved. In fact, leading up to the reorganization, statistical reporting clearly suffered from an operational and organizational duplication of effort that rendered these endeavors ineffective to those who relied on them.[188] Using both data mechanization and manual

[187] Acomb, *Statistical Control in the Army Air Forces*, 1-4.

[188] The Air Force's *Review of Statistical Services* claims that the "result was duplication of effort" and an "overlapping of functions." *Charles R. Landon, ed., United States Air Force - Review of Statistical Services, January 1950 - July 1954 (Washington: United States Air Force, 1954), 1.*

reporting methods placed an undue paperwork and reporting burden on field units while failing to provide the necessary information to higher echelons who needed to "control the increasingly complex plans and operations of a defense organization."[189] What the Air Corps needed were organizational structures and processes that created a functioning relationship between these statistical units, not to mention one that removed the data errors or omissions caused by a lack of functional control. Regulation 95-5 provided a catalyst for change.[190]

Under the authority of this War Department regulation, the Army Air Corps reorganized as the Army Air Forces (AAF) on 20 June 1941. The event created an "overall administrative command" for Army aviation that finally oversaw all the organization's air-centric aspects.[191] At long last, this centralization of authority allowed AAF leaders to create headquarters-level information organizations to be the preeminent aviation statistical

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[189] Landon, *United States Air Force - Review of Statistical Services, January 1950 - July 1954*, 1-2.

[190] Acomb, *Statistical Control in the Army Air Forces*; and Landon, *United States Air Force - Review of Statistical Services, January 1950 - July 1954*, 1-2.

[191] Landon, *United States Air Force - Review of Statistical Services, January 1950 - July 1954*, 2.

control units, the most prominent of which became the Air Staff-Statistics organization. This entity initially focused its energy on generating studies focused on AAF personnel and materiel. However, within its first few months, requests from service leaders augmented its responsibilities considerably. The unit began producing analyses ranging from aircraft allocation and production reports to pilot and technician training rate studies. What occupied a good deal of time was the creation of tables, charts, plans, maps and general officer-purposed statistical handbooks for the AAF Commander's "War Room."[192] As service historians note, this was the first major step in creating an air service statistical control entity that not only centralized statistical reporting but also planned and directed "a strategic program upon the basis of statistical knowledge."[193] Overall, the leadership's information requirements were driving changes in service processes as well as creating new organizations and new strategic planning programs with data fidelity never before encountered in the department.

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[192] These were known as "General Arnold's Handbook" and "General Spaatz's Handbook" in the War Room, which was outside of General H. H. "Hap" Arnold's office.

[193] Acomb, *Statistical Control in the Army Air Forces*, 6.

Over the next several months, the importance of statistical information and the Air Staff-Statistics organization grew throughout the service. Another major information organization, the Research and Statistics Section, gave up its flight record machine tabulation program in August in order to concentrate its resources on developing and maintaining statistical, budgetary and other data analysis required for aviation programs and activities.[194] Soon key officers from across the Air Staff began studying the question of statistical controls and associated projects throughout the headquarters. Data collection and exploitation duties were split up between the statistical organizations with one organization solely responsible for the collection and compilation of primary and special operational data while another was responsible for regular and special studies based on such data. In a memorandum signed just five days before the Japanese attack on Pearl Harbor, future Air Force Chief of Staff and current Air Staff officer Brigadier General Carl A. Spaatz

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194 An investigation at the time found that the flight records program, while important, took all the personnel and machine tabulating equipment in the office. Leaders felt there was a better use for these resources at the time, especially given the reorganization and rise in hostilities in Europe. See Acomb, *Statistical Control in the Army Air Forces*, 6.

confirmed this relationship by formally codifying that, "[t]he Statistics Section of the Air Staff will furnish consultation service to all Divisions of the Air Staff and will conduct such specialized projects related to this study as may be required, with the assistance of the Statistics Sections, OCAC."[195] Spaatz's involvement proved that nearly a decade-and-a-half after the service founded its first true statistical units, headquarters echelons were finally solidifying the service's information and data mechanization processes. The AAF was now far better postured information-wise for war.

The three months that followed the bombing of Pearl Harbor saw two additional headquarters reorganizations in the air arm of the U.S. Army. As the War Department mobilized for this next global war, those responsible for the framework of statistical control in Army aviation sought to establish a more structured and standardized state for their mission. The crucible of war quickly proved to a rapidly expanding air service how it was suffering from an information management problem, one that posed a significant threat to pursuing any form of data

[195] Acomb, *Statistical Control in the Army Air Forces*, 5-8, with specific reference to General Spaatz's 2 Dec 1941 memorandum for the Chief of the Air Corps.

automation and statistical control in wartime. The issue was not a shortage of data or the lack of report generation. Rather, the air arm was generating too much information. In all, the newly designated Army Air Forces' produced over 2500 recurring official reports and statistical publications, making it nearly impossible for units to operate without them. Moreover, despite the preset responsibilities assigned by Spaatz and others at the headquarters level, the AAF had done little to control the statistical units and their data equipment in the field. Overall, it was clear to those at headquarters and throughout the air arm's reporting agencies that while tabulating equipment was indeed essential to the service's statistical activities, it required centralized control to operate effectively.[196]

In March 1942, the air service prepared for yet another reorganization. This wartime organizational change, combined with the growing data requirements across the major operational and support branches, led some AAF leaders to yet again jockey for control over the nature and missions for future statistical control organizations. Some envisioned statistical units producing enough reports

[196] Acomb, *Statistical Control in the Army Air Forces*, 5-10.

to cover all aspects and activities of the service. Others focused on creating a new officer position – the statistical officer – who would be so important to AAF operations that they were to be handpicked by the service, educated at a newly established and specialized school at Harvard University, trained by headquarters, and assigned to nearly every squadron and headquarters unit in the organization. With the Army focusing its efforts on Machine Record Units and the pre-war automated personnel accountability system, the air forces concentrated on creating an accountability system all their own. They sought more than the administrative data, personnel roster and troop strength reports, and casualty records that made up the mission of the MRUs. AAF leaders wanted a system that provided "continuous studies" of AAF requirements and maintained a reporting system that could keep headquarters echelons consistently updated on the status of all aviation and supporting units. On March 9, 1942, the War Department performed a major reorganization creating three autonomous Army Commands (Army Ground Forces, Services of Supply, and Army Air Forces), a result of which was the conglomeration of all headquarters' statistical functions. That outcome created a single unit responsible for controlling the preponderance of mission-essential information traffic across the AAF worldwide. This organization became simply known as the Directorate of Statistical Control.[197]

The mission of this new directorate spoke directly to the growing requirement for data automation in the service. The AAF Statement of Functions specifically detailed the organization to "provide machine tabulation and other statistical services for all subdivisions of the AAF located at Headquarters, and to coordinate the activities of all machine-tabulation installations in the AAF."[198] In charge of the directorate was Charles Bates "Tex" Thornton, a civilian at the time but a Colonel by war's end. With a mission statement rooted in machine tabulation and a growing stable of highly-educated and extremely competent statistical officers, Thornton's Directorate of Statistical Control set out to create an information environment predicated on detailed machine-based data reporting from field units, mechanized statistical analysis at the headquarters level, and decision-making based on a conglomeration of the two. Without question, after years

[197] "Air Force History Overview," Air Force History Fact Sheet, accessed March 1, 2013, http://www.af.mil/information/heritage/overview.asp.; and Acomb, *Statistical Control in the Army Air Forces*, 8-12.

[198] US Army Air Forces, *Statement of Functions: 6 Mar 42* (1942); and Acomb, *Statistical Control in the Army Air Forces*, 12.

of delays and setbacks, data mechanization was now an integral function of the Army's aviation organization.

Over the next three years of the war, statistical control and mechanized data processing permeated nearly every aspect of major information transfer inside the air service. In the field, to allow for the Army's machine record unit's oversight of War Department-specific personnel information, the AAF established "Statistical Control Units (SCU)" throughout the American theaters of operation and placed them in proximity to the MRUs for both control and equipment purposes. In many cases, the MRU functioned as an adjunct of the SCU when attached to the same headquarters, especially under the auspices of equipment sharing. Following the reorganization at headquarters in 1942, the AAF set out immediately to resource each statistical unit with IBM machinery. Although this effort took time, a standard control unit prior to D-Day in 1944 contained the following equipment:

- IBM 405 Alphabetic Accounting Machine
- IBM 513 Summary Punching Reproducer
- IBM 522 Alphabetic Interpreter
- IBM 080 Horizontal Sorter
- IBM 077 Collator
- IBM 031 Alphabetic Key Punches
- IBM 054 Alphabetic Verifier [199]

[199] "Memorandum to Lt Col Williams, 12 Feb 44," 65th MRU to Lieutenant Colonel Williams, US Strategic Air Forces in

Moreover, each unit was staffed with at least one officer experienced in statistical control work and machine operations, ten enlisted men with specific machine processing and form processing experience, and another five to ten enlisted men with key punching or typing/clerical experience. Overall, the establishment of a SCU at a designated location signified the Army Air Forces' requirement to establish a controlling authority over that location as well as an information hub responsible for reporting its personnel, equipment, and readiness status on a consistent basis. To the headquarters, this effort was clearly a matter of centralized control. To the field units, however, it sometimes seemed to be little more than headquarters-generated paperwork.[200]

One of the earliest issues confronting the field placement of SCUs was gaining the permission of the field commanders themselves. On one level, the control units represented a watchdog organization for headquarters and added little to the unit's mission as a whole. However, as

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Europe, February 12, 1944, in *U.S. Air Force Historical Research Agency, IRIS: 00214762*.

[200] "Memorandum to Lt Col Williams, 12 Feb 44"; Acomb, *Statistical Control in the Army Air Forces*, 42.

they also represented the potential to reduce the unit's administrative burden, most units were willing to yield. Furthermore, because the SCUs were designed to alleviate field unit paperwork, operational units could nearly rid themselves of the administration deemed as a "great plague" in combat arms.[201] The military had made little progress reducing the administrative burden on commanders, unit leaders, and clerical personnel since the previous World War. Throughout this new conflict, the Army and its subordinate air forces spent a great deal of effort delineating what information they wanted from field units, and how often, in hopes of rectifying the problem. In one particular example, the machine units concentrated on the Army's focus on personnel information by centering their energies on "mechanizing" the Officers and Soldiers Qualification cards (AGO Form 66-1 and AGO Form 20), as well as the standard "Morning Report," unit strength report, and a change report providing supplementary personnel information when required. The machine record units, oftentimes operating out of one or more heavy vehicles, took this burden from field organizations and

[201] Acomb, *Statistical Control in the Army Air Forces*, 42. As stated in this section, "Anything which promised a measure of relief from [paperwork] was welcomed."

transmitted the data to upper echelons via either teletype or telephone. With successes such as this, the AAF statistical unit responsibilities grew even larger, expanding in depth and breadth beyond anything imagined before the war.[202]

There were many data requirements for statistical control units in the field, most presented as official forms to be mechanically compiled and transmitted by each unit on a regular basis. These documents ranged from the standard AAF Form 120, which calculated the unit's daily aircraft inventory, to the more complex air mission AAF Form 34 containing individual sortie data that included aircraft totals, flight time, bomb tonnage, ammunition and fuel consumption, and even approximated losses on both sides of the equation. However, of all the information forms generated by the service, perhaps none were more important than the two primary, mechanically-prepared forms known universally as the Form 127 and the Form 110. In response to the data presented by the MRUs, the air arm developed the AAF Form 127, also identified as the Weekly Report of Personnel Status and the primary report for

[202] Acomb, *Statistical Control in the Army Air Forces*, 42, 66.

statistical manpower information. The Form 127 reported all aviation personnel by unit and military specialty, helping to ensure headquarters leaders and unit commanders fully understood their established personnel requirements, unit condition and pending disposition. The data also ensured that decision-makers across the service received the same information simultaneously, and that leaders based higher echelon decisions on the same data.[203]

Meanwhile, the AAF Form 110 dealt with the other critical resource for the air arm: service equipment. For aircraft, the Form 110 provided a daily inventory report that reported the type, model, and series by serial number for every aircraft on hand at each location. Additionally, the form recorded the aircraft's current status and its total number of flying hours, a vital statistical that also doubled as an accident and battle loss reporting mechanism for the service's high command. Overall, between these two primary forms and the additional data collected at each location, the volume of information traversing the SCUs on a recurring basis was staggering, not to mention complex.

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[203] Wesley Frank Craven and James Lea Cate, *The Army Air Forces in World War II, Chapter VI* (Washington: Office of Air Force History, 1983), 35-39; *Army Air Forces Statistical Digest World War II* (Washington: Office of Statistical Control, 1945), 111; Acomb, *Statistical Control in the Army Air Forces*, 66.

However, the large volumes of data crossing each unit gave field commanders an entirely new perspective on information operations, not to mention their impact on mission success.[204]

Commanders with assigned statistical control units quickly recognized that despite the volume of information required by each unit, the hard work and dedication of the men in statistical operations made their job easier. Despite the initial culture shock of seemingly endless amounts of required information, commanders recognized that SCUs could actually contribute to the unit's mission by shouldering the administrative reporting burden and freeing up valuable combat personnel resources. Requests for SCU assistance began to rise considerably throughout the war theaters as commanders credited SCUs with simplifying reporting procedures and handling their statistical reporting tasks. In addition, field leaders recognized that the benefits of large volume data reporting were not limited to headquarters elements. Knowledge of personnel and equipment shortages on a regular basis often translated into quicker replacement times from manpower and supply

[204] Craven, *The Army Air Forces in World War II, Chapter VI*, 35-39; *Army Air Forces Statistical Digest World War II*, 111; Acomb, *Statistical Control in the Army Air Forces*, 66.

chains, sometimes even without requiring formal requisitioning forms on the part of the unit. In fact, the system appeared so beneficial that the commanding general of Tenth Air Force went so far as to formally report that "[t]his statistical reporting system has worked wonders for the Army Air Forces."[205] With thousands of pieces of IBM equipment manned by highly-trained field personnel, the investment made in SCUs appeared to be paying off. These statistical units foreshadowed the ever-growing requirement for improved information capabilities in the service.[206]

During the war, data mechanization permeated a number of AAF organizations beyond the standard information reporting chain and the purview of its statistical organizations and data mechanization experts. For example, the Army Air Force climatology program used punch card tabulators to record more than 26,000 station-months' worth of records during the war, utilizing nearly 20 million cards in the process. Additionally, after German weather punched cards were captured, allied meteorologists deciphered two large card decks full of climatological data on the European and Asian theater, providing previously

[205] Acomb, *Statistical Control in the Army Air Forces*, 66.

[206] *Ibid*.

inaccessible weather information to Western forces.[207] In another instance, this time in direct support of the flying mission, the IBM 405 accounting machine was essential to producing Air Almanacs that delivered essential aeronautical data used for all American flying forces during the war, each more than 700 pages long and containing approximately 3,000 machine-verified figures.[208] In these cases and many others, it became clear that by war's end statistical units were not the only data automation organizations in existence in the Army Air Forces. These units nonetheless provided the legitimacy needed for other aviation organizations to procure their own data mechanization systems that produced results similar to those that preceded them. As requirements for faster calculations of larger data sets began to prevail across the service, scientists and researchers looked for ways to accommodate these service needs. From these operational requirements and efforts, the first computers were born.

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[207] Paul N. Edwards, *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming* (Cambridge, MA: MIT Press, 2010).

[208] "World War II American Air and Nautical Almanacs," World War II American Air and Nautical Almanacs, accessed February 04, 2013, http://www.columbia.edu/cu/computinghistory/almanac.html.

Conclusion

Between 1907 and 1947, the management and application of information played an essential role in the United States Army's evolving air service. Using information to help train, equip, and employ these growing forces supported the air arm's emergence from a single administrative office to a war-changing, million-plus airmen organization in a relatively short span of time. In highlighting this evolution, this chapter disproves the assumption that air service data processes and technologies mirrored those of its parent Army organization. Instead, the air arm's information services developed at the speed of its user requirements, which frequently outpaced advances in aeronautical technology as well as the organizational growth of the air service itself.

These user requirements developed early. Although the aviation organization did not set out to create an independent information system before World War I, the needs of its developing air operations necessitated unique applications and alterations of its current data methodologies. Deviations from standard Army procedures were small at first: the addition of the *Record of Aeroplane Flights* form, the reference to aeronautical equipment in higher-order regulations, and the requirement to keep records on flight data, engine motor statistics, transportation expenditures, and many data points in-between. Soon the information requirement grew large enough that airmen implemented special concessions to feed the growing aviation-centered data processes. From publishing aviation guidance such as 1916's *Equipment for Aero Units of the Aviation Section* to requiring an air arm-specific data card recording system, the information processes of this flying organization diverged from standard Army procedures a little more each day.

World War I sped up this divergence considerably. President Wilson's approval of the July 1917 Aviation Act rapidly increased the Army's requirements for both pilots, support crews and aircraft with the organization ill-equipped at meeting their overall needs. The Aviation Section attempted to mitigate these shortfalls by creating their own manual data systems to handle the influx of recruits and equipment. They developed information procedures using Hollerith systems and comprehensive data forms (i.e. Form 609) to alleviate information shortfalls and corral the vast amounts of data pouring into the air organization on a daily basis. These improvements and others were critical to aviation's pursuit of greater organizational legitimacy, especially as the service struggled for a more prominent War Department role by using statistical documentation and data reports to make their case. This pursuit pushed the air service's data requirements further than ever and helped bolster future data requirements.

The organization's interwar years were met with massive budget cuts and drastically reduced mission requirements. Some air service units, however, took these circumstances as an opportunity to utilize information technology and procedural applications as a means of increasing operational efficiency. For example, aviation units used data mechanization to produce statistical analyses for improving pilot and aircraft performance. They pioneered new standards for recording aircraft and individual flying hours, aircraft engine time, and post-event analysis for aircraft accidents and forced landings. Aviation units also used business machines to record and preserve the service's flight development programs and kept a voluminous amount of information on all its airframes. In the months before World War II, the statistical requirements internal to the air service had increased to the point that centralization and consolidation of information activities began to take shape. Soon the budgetary, personnel, and other supporting data analysis took a back seat to the operational information processes that ran in tandem with the mechanization processes of the Army.

World War II spawned two significant information entities in the air arm: the Statistical Control Units in the field and the Directorate of Statistical Control in Washington.   The SCUs changed the way units conveyed their information by utilizing data mechanization gear to collect and report critical information while simultaneously reducing the administrative burden of its collocated, battle ridden field units. Meanwhile, Statistical Services at AAF headquarters created a new and widespread mechanized information environment that took SCU data and developed statistical analysis and decision-making data sets that permeated nearly every aspect of major information transfers inside the air service. Decisions on bombing targets, personnel relocations, and armament procurement were all made thanks to the information sent by field units and exploited by its higher headquarters. By war's end, the Army Air Forces were no longer an organization operating with information . . . they were an organization run on information.

By 1947, the air service hardly resembled the organization commanded by General Scriven in 1913, and was certainly nothing like what General Allen signed into existence with "Office Memorandum No. 6" in 1907. After two world wars, unprecedented technological advancement, and a mission progression few saw coming at its inception, the aviation mission had grown so autonomous of the Army's role on land that creating an entirely independent service seemed almost anticlimactic. While there was certainly cause for celebration on September 18, 1947, the reality was that the United States Air Force had earned its independence gradually through decades of functional and organizational change and not with the stroke of President Truman's pen. The Air Force developed into a separate service as it adapted to its operational and organizational environment and adjusted the way it functioned. Part of that journey involved the way the service regulated itself, kept track of its operations, maintained personnel data, and sought a growing level of speed and accuracy through task professionalization and office mechanization. As explained throughout this chapter, inside the history of the air arm from 1907 to 1947 is a complex story of Air Force evolution partially driven by the management and application of information processes and technology.

Chapter 3

Early Air Force Computing and Mechanized Data Management Programs, 1947-1955

The formative years of Air Force computing and data automation were defined by those individuals who pursued the development of relevant technology before the service was organized or overly interested in doing so. Between 1947 and 1955, these advocates – civilians, military, and contractors alike – challenged existing technological and operational paradigms and put the service at the leading edge of computer technology. This period was characterized by a lack of oversight and direction from higher echelons. Innovations were introduced by futurists who evaluated and anticipated service requirements even when unit leadership was otherwise preoccupied. While there were some official service programs designed to harness this technology, in reality efforts were guided by one or more key individuals, some of whom were guided by personal aims in addition to those of the service. Computing and data automation arose following the ENIAC's (Eckert and Mauchley's Electronic Numerical Integrator and Computer) initial development in the mid-1940s and evoked enthusiasm from those with the expertise and foresight to understand their importance to the service's future.[209] In 1955, the Air Force assigned computing oversight to a single office at the Pentagon – the Directorate of Statistical Services – in an effort to centralize responsibility inside the organization. However, given the myriad unique computing systems cropping up throughout the service, such consolidated oversight was to prove virtually impossible.

In this chapter I focus on the origins of Air Force computing and mechanized data management, not only from a technological standpoint but also from a leadership and organizational perspective in order to demonstrate how important individual initiative in this sphere was to the service's success. I will detail how the dedication and tenacity of a number of key military, civilian, and contracted individuals produced change during this period. I will highlight how in these early years of the Air Force key contributions and advances helped shape the operational and organizational landscape of a service void of an

[209] The ENIAC, or Electronic Numerical Integrator And Computer, was the world's first electronic digital computer designed by John Mauchly and J. Presper Eckert at the University of Pennsylvania and was developed to compute World War II ballistic firing tables for the United States Army's Ballistic Research Laboratory. See Martin H. Weik, "The ENIAC Story," ENIAC - World Wide Web, accessed May 1, 2013, http://ftp.arl.mil/mike/comphist/eniac-story.html.

identity beyond that of manned flight. Additionally, this chapter explains how and why the service chose to organize and operate itself in the wake of these new processes, new systems, and new possibilities.

Following an Information-fueled War

By the end of World War II, the U.S. Army Air Forces was an organization run on information. The service's statistical control operations, known in the field as the "Stat System," permeated nearly all organizational units from its headquarters to its squadrons. For over three years, military leaders had used the information gathered and disseminated by control units to strategically plan and execute their war orders. The service used the data traversing these statistical control units to do more than inform; it used it to influence operations affecting millions of lives and billions of dollars. Information was no longer important . . . it was mission critical.[210]

[210] See Charles R. Landon, ed., *United States Air Force - Review of Statistical Services, January 1950 - July 1954* (Washington: United States Air Force, 1954), 1-3. Contextual information regarding the importance of this information derives from *The Fog of War: Eleven Lessons from the Life of Robert S. McNamara*, dir. Errol Morris, perf. Robert S. McNamara and Errol Morris (Hollywood: Sony Pictures Classics, 2003), DVD.

As the world's "largest centrally controlled installation of mechanical accounting equipment and private-wire teletype" during the war, this information monolith continued to produce new data requirements and forced massive resource investments throughout the AAF.[211] Upholding a high level of information efficiency required a cadre of three thousand officers, fifteen thousand enlisted personnel, and enough data machinery, support equipment, and operating facilities to support sixty-six major SCU locations worldwide. After the war, budget cuts forced the service to drastically reduce the size of the statistical control entity, especially as it could no longer afford such a large personnel reserve. The requirement for statistical information, however, did not dimish. The success of World War II information operations confirmed the necessity for a centralized data control system as well as the leadership's desire to access large volumes of information. Statistical control remained an integral part of air operations through its integration into the Office of the Comptroller in 1947 and the service's independence soon thereafter.[212]

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[211] Landon, *United States Air Force - Review of Statistical Services, January 1950 - July 1954*, 2.

[212] *Ibid*, 1-3.

Three years earlier in 1944, Statistical Control's Combat Analysis Branch was the exemplar for wartime information processing in the Army Air Forces. Operating from a single office on the fourth floor of the still-under-construction Pentagon building, the branch's nine staff members (seven of them AAF officers) spent their days and nights translating field data into meaningful statistical information bound for leaders across the military. Their director was George Dantzig, a mathematician and statistician by trade and education, and an expert in statistical analysis who had served in the branch since the war began. Over the next several years, it was his experience in statistics and logistical planning that placed him at the helm of Air Force information control as well as at the forefront of its newest information devices.[213]

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[213] The "Roster of Key Personnel for the Statistical Control Division, 1944" listed 9 members of the Combat Analysis Branch, with Dantzig as its head and 8 additional members – 1 Major, 2 Captains, 3 First Lieutenants and one Second Lieutenant. The final individual's status is unknown. All were listed under room 4C1037 at the Pentagon (4th Floor, C Ring, 10th Corridor, Room 37). Communication outside the office was apparently not a major priority as there were only two telephone numbers assigned to the branch (as opposed to others who had 6-10 numbers). Dantzig was the only individual in the branch to have access to both numbers. See *Roster of Key Personnel, Headquarters Army Air Forces Statistical Control Division, 1944*, USAF

Dantzig's experience after nearly four years of AAF statistical analysis proved few knew more about the power and benefits of aggregated information. Combat Analysis collected the predictable air combat information – sorties flown, bomb tonnage expended, attrition rates, etc. – but they also prepared detailed Air Staff plans covering the gamut of service requirements ranging from the accountability of hundreds of thousands of various material goods to validating more than fifty thousand personnel specialties. Dantzig's efforts as director proved he clearly understood the statistical analysis capabilities of punched card tabulators and arithmetic calculators but was also equally aware of their limitations. The director's vision of implementing supplementary and more complex calculations was originally shelved due to the technical constraints of existing machinery. Fortunately, his familiarity with parallel projects underway throughout the Pentagon gave him both unique insight into and optimism about new calculation possibilities for the directorate. These projects produced machines that became known as

Official Document (Washington: United States Air Force, 1944), 1-4.

computers and played a significant role in Dantzig's own logistics planning mathematical efforts.[214]

Before 1947, the term "computer" was multifaceted. Its simplest definition, "something that computes," fully entered the AAF lexicon during the Second World War although its use varied widely. In 1943, General E. L. Eubank recommended the AAF purchase a dozen Model AAF10-B bombing error computers for its bombardment headquarters and training units. While the device helped analyze bombing errors and bombsight problems caused by ground speed, drift, and altitude, it more closely resembled a complex calculating instrument. Meanwhile, nearly two hundred female workers who performed ballistic computations for the war effort were ironically called computers themselves. Only in January 1946 did analysts from the National Defense Research Committee use a more current interpretation of the term as they foresaw a War Department "Tactical-Strategic Computer" complete with dials and controls capable of forecasting the outcomes of battles and wars. In all, the first "computers" took many forms: electronic calculators, machine programmers, tabulating

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[214] Information on Dantzig's role at headquarters derives from the USAAF's "Roster of Key Personnel, Headquarters Army Air Forces Statistical Control Division, 1944," 1-4.

machines, and so on. Shortly thereafter, the term finally arrived at its current definition – that of an electronic device capable of receiving information, performing a sequence of operations, and producing a result – in both the Air Force and among the general public.[215]

The Army's most prominent computational project during the war was the ENIAC – the electronic calculating machine designed to solve artillery algorithms and not the combat statistics or logistics planning Dantzig was familiar with. However, scientists and military leaders alike understood this device and others that followed could become the beasts of burden for the seemingly endless, mind-numbing calculations required by U.S. military missions. Boasting computing speeds almost one thousand times faster than the electromechanical devices in use at that time, ENIAC put to

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215 Reference to the "Tactical-Strategic Computer" derives from Warren Weaver, *Comments on a General Theory of Air Warfare* (Washington: National Defense Research Committee, 1946), 1-24. Mr. Weaver was Chief of the Applied Mathematics Panel at the National Defense Research Committee. The comments directed towards the War Department's "research and development of computer mechanisms" are from the report *War Department Research and Development Program, Fiscal Year 1948* (Washington: War Department General Staff, 1947), 57. Also see Jennifer S. Light, "When Computers Were Women," *Technology and Culture* 40, no. 3 (July 1999). The definition of computer derives from "Computer - Definition," Oxford English Dictionary - Online, accessed June 21, 2013, http://oxforddictionaries.com/.

rest any John Henry-type allusions that a person could out-calculate a machine of this caliber. In fact, no innovation in computing since has witnessed a leap so statistically significant. In Dantzig's world of seemingly endless amounts of data and calculable statistics, such a device might be invaluable to future operations. Although early computing histories do not connect the ENIAC to Dantzig, the Office of the Comptroller, or the Combat Analysis Division, its very presence affected them considerably. If there is a bridge that connects the worlds of Air Force statistical control and its computing programs, it is George Dantzig.[216]

Over time, Air Force leaders sought to utilize the computer not just to assist airmen in their day-to-day jobs, but in many cases to replace them altogether. As computers grew ever more powerful, computer applications capable of exceeding the realm of human capability became even more prevalent in project consideration. The replacement of human beings by machines had been long the subject of speculation by cybernetics and automation theorists such as John von Neumann, Norbert Weiner and John

[216] The ENIAC was often referred to as an electronic calculator. See Ceruzzi, *A History of Modern Computing*, 15.

Diebold who all predicted (in their own way) how computers would one day perform many of the same tasks as humans of the previous era. To some, this was simply futuristic fantasy. However, over the decade following the appearance of ENIAC, the operational and administrative requirements of modern industry and the federal government helped create a growing role for such computers in society.[217]

The Origins of Air Force Computing

In 1949, the United States Navy began publishing the *Digital Computer Newsletter*, a semi-annual publication designed to provide a "medium for the interchange, among interested persons, of information concerning recent developments in various computer projects."[218] The Office of Naval Research's Mathematical Sciences Division published the first volume that April and included as much recent information on current military systems as members

[217] See Ray Kurzweil, *The Age of Spiritual Machines: When Computers Exceed Human Intelligence* (New York: Penguin Books, 1999); Peter Galison, "The Ontology of the Enemy: Norbert Wiener and the Cybernetic Vision," *Critical Inquiry* 21, no. 1 (Autumn 1994); and Henry Edward Lucas, *Automation: A Study of Basic Concepts and of Factors Influencing the Decision to Automate.*, thesis, University of Texas., 1955, 2.

[218] United States Navy Office of Naval Research Mathematical Sciences Division, *Digital Computer Newsletter* 1, no. 1 (April 1949), 1-6.

could locate. At the forefront of the newsletter were those projects under the direction of the United States Army's Ordnance Department, which included the ENIAC, EDVAC, ORDVAC and the Institute for Advanced Study Computer.[219] The same edition credited the newly-formed United States Air Force with two of its own computing projects after little more than a year-and-a-half as a separate service – the National Bureau of Standards Interim Computer and the Institute for Numerical Analysis Computer. However, absent from the newsletter was the full story of the Air Force's computing journey that had begun years prior to the *Newsletter* and exhibited a far broader scope than the numerical analysis requirements offered in the Navy's publication. That journey centered on Project SCOOP.[220]

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[219] The ENIAC and EDVAC (Electronic Discrete Variable Automatic Computer) were successive products of Eckert and Mauchley. The ORDVAC (Ordnance Discrete Variable Automatic Computer) and the IAS (Institute for Advanced Studies) Computer were both built using the Von Neumann architecture, with the former built for the Ballistics Research Laboratory at Aberdeen Proving Ground through the University of Illinois. See Ceruzzi, *History of Modern Computing;* and Thomas J. Bergin, *50 Years of Army Computing, from ENIAC to MSRC: A Record of a Symposium and Celebration, November 13 and 14, 1996, Aberdeen Proving Ground* (Aberdeen, MD: U.S. Army Research Laboratory, 2000).

[220] United States Navy Office of Naval Research Mathematical Sciences Division, *Digital Computer Newsletter* 1, no. 1 (April 1949), 1-6; Ralph J. Slutz, "Memories of the Bureau

Without question, Project SCOOP (Scientific Computation of Optimum Programs) became the most significant venture in early air service computing efforts and evolved as a result of staffing efforts directed at improving the service's program planning process. Program planning during World War II meant fundamentally understanding and planning for all the resource requirements of a specified program or project, including all associated costs. The planning process then translated that data into an expected financial figure representing the program's impact on both the military establishment as well as the civilian economy. In early 1942, the Office of Statistical Control first attempted to mechanize this process but met with poor results due to insufficient data (caused by system reporting deficiencies) and inadequate mechanical calculating equipment. Two years passed before service leaders devised a viable alternative to existing planning processes.[221]

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of Standards' SEAC," in *A History of Computing in the Twentieth Century: A Collection of Essays*, by N. Metropolis, J. Howlett, and Gian-Carlo Rota (New York: Academic Press, 1980), 471-477.

[221] Direct reference is made by Lieutenant General E. W. Rawlings and Mr. Marshall Wood in United States Air Force, "Scientific Planning Techniques." (Special Air Staff Briefing: 5 August 1948, Pentagon, Washington), 4-8; Edward

By 1944, data reliability and consistency allowed Pentagon planners in the Office of Program Control to develop a more systematic program scheduling procedure, due in large part to the success of the centralized statistical reporting system. The procedure was led by service programming leaders Dr. Edward Learned and Marshall Wood and involved coordination between a great many staff and command agencies across the service. Both Learned and Wood believed that if they could time when each agency entered its statistically-generated data, and then plot out when each agency required such data for their own inputs, they could schedule the inputs in order to optimize the process without bottlenecks. The entire system became a well-orchestrated symphony of data reporting, analysis, and computation synchronized for maximum efficiency over the course of many months of trial and error. In effect, what they developed was a "program for programming."[222]

Unfortunately, it simply was not good enough . . . not for Learned and Wood, and certainly not for service leaders both during and after the war. The crux of the issue was speed: the entire process still took a grueling seven

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Dunaway, "U.S. Air Force Oral History Interview: Interview of Edward Dunaway," interview by Dan Mortensen, 1-4.

[222] *Ibid.*

months to complete per program. Command decisions, planning factors, and on-the-ground situations changed so quickly that any major fluctuations within such a long time span could throw off the entire process and make the programming result worthless. Additionally, time-sensitive reliability in such a slow program made it nearly impossible to have alternative solutions by the end of the process. Program scheduling became incredibly difficult in peacetime as more limitations, especially on funding, were placed on the military establishment. Air Force Comptroller Lieutenant General E. W. Rawlings pointed out years later that perhaps the greatest limiting factor to the entire problem "was a matter of simple arithmetic," noting that the Air Staff probably had more people working on arithmetic than any other single work item in the Pentagon.[223] The viability of programming was in question throughout the Pentagon and the service required a new methodology if the Air Staff process were to continue. The onset of the military's first computers in the mid-1940s made that new methodology possible.[224]

[223] *Ibid.*

[224] *Ibid.*

In 1946, the Comptroller's Office began building a "mathematical model" of the entire planning process. The diligent workers of Statistical Services using Air Staff-provided data calculated how to generate enough information over the next year to analyze the incredibly difficult mathematical functions and the dependent variable data from other agencies. To make this work, to actually generate the information, required finding a vendor who could produce a large-scale digital electronic computational device that could not only make the necessary calculations but also systematically classify and store all the requisite data. At the time, the United States Bureau of the Census was under contract with ENIAC's J. Presper Eckert and John Mauchly in their attempt to create a computer capable of storing a program internally while running at "electronic speeds." Air Force programmers understood that if something akin to the ENIAC could assist their situation, the Census contract was the most viable option available to them.[225]

[225] *Ibid*; Slutz, "Memories of the Bureau of Standards' SEAC;" Russell A. Kirsch, "Computer Development at the National Bureau of Standards," in *A Century of Excellence in Measurements, Standards, and Technology a Chronicle of Selected NBS/NIST Publications, 1901-2000*, by David R. Lide (Gaithersburg: U.S. Dept. of Commerce, Technology Administration, National Institute of Standards and Technology, 2001), 86-89.

The air service needed a bureaucratic go-between in order to quickly latch on to the Eckert and Mauchly contract. In cooperation with the Departments of the Army and Air Force, the National Bureau of Standards acted as the contract's technical monitor in light of its established expertise with electronic component design. The Air Force Comptroller initiated this process by transferring to the Bureau $400,000 in June 1947 so that Eckert and Mauchly could produce an electronic computer built to military specifications. This first commercial computer would be known throughout the industry as Univac and was to be the result of a three-machine order that would send one unit to the Census Bureau and the other two to the military departments (the second going to the Air Force). The air service needed a mathematical expert to be a part of this monumental and groundbreaking effort. That expert turned out to be the former director of the Combat Analysis Branch, George Dantzig.[226]

Dantzig did not stay with the service long after World War II. After his term in Statistical Control, the mathematician departed Washington to complete his doctoral program at the University of California-Berkeley, which he

[226] *Ibid.*

did in a single semester. The newly-appointed Dr. Dantzig turned down the opportunity to stay on as a professor and returned to the Pentagon as the Office of the Comptroller's Mathematical Advisor, which included Project SCOOP. By 1948, this effort had progressed from a project investigating theoretical mathematical and electronic computer applications to a full-fledged acquisition program with a number of project publications already underway. SCOOP personnel ensured the purposes of the Air Force's first computer project were abundantly clear:

- Most importantly, develop an advanced design for an integrated and comprehensive system for the planning and control of all Air Force activities.

- Prepare the Air Force to take maximum advantage of the recent developments in high speed digital electronic computers, especially as extensions of mathematical/quantitative management problems.

- Simulate Air Force operations using large sets of equations, effectively designated as mathematical models of operations.

- Free up personnel and resources, especially those bogged down in day-to-day arithmetic and clerical calculation duties.[227]

On 13 October 1948, Air Force Chief of Staff Hoyt S. Vandenberg codified these elements in Air Force Letter 170-3, an official document formally identifying the Air

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[227] Vandenberg's Air Force Letter 170-3 is found in "Scientific Planning Techniques," 4-12.

Force's entrance into this new era of computing by demanding "all echelons…support Scoop to the fullest possible extent."[228] The letter modified the earlier statements of Chief Comptroller General Rawlings who stated, "…if we can work this out…it will be possible for the Staff to spend more of its time in developing proper factors, in doing some real planning."[229] All Dantzig and the Project SCOOP team had to do was make it work.

1948 was not a good year for the development-stage Univac system. After a series of technical difficulties and subordinate projects delayed its completion, the absence of a Univac delivery forced the Air Force to seek an immediate, near-term solution. The problem was that Dantzig was not happy with his current choices. He was familiar with the systems either already in industry or under contract and determined Project SCOOP required a computer solution as fast as possible. The mathematical advisor told a panel of Air Staff leaders in August that of the fourteen large scale "digital computer" projects in the United States at the time, the ENIAC at Aberdeen was the only system built that he actually considered an electronic

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[228] *Ibid.* Note that the Air Force Chief of Staff is the highest ranking military position in the service.

[229] *Ibid.*

computer. The other “computers” in operation (e.g. the Mark I, the Mark II, and the IBM Selective Sequence Electronic Calculator) were in his opinion little more than electromechanical relay machines. Calculation-processing speed was a major factor in Dantzig’s assertion as earlier relay-based computers were not comparable to the systems currently under construction by Eckert and Mauchly. Dantzig and the other team members were confident that the right machine could do in a few hours what it would take a large staff several months or years to accomplish, but it was clear that the Univac was not going to be that machine any time soon.[230]

In an effort to obtain a temporary machine, or what Marshall Wood called “a pilot model,” Dantzig advised the Air Force to contract with the National Bureau of Standards (NBS) to develop a machine that *in the interim* could fulfill a number of their growing computing requirements. The Standards Bureau was already hard at work developing its own computer for both scientific research and the upcoming American census. By 1950, years of computer

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[230] Dantzig’s comments come from his briefing portion in "Scientific Planning Techniques," 13-15. The remaining information regarding the condition of the Univac project is Kirsch, "Computer Development at the National Bureau of Standards,” 86-89.

development at the Washington Laboratory produced a machine that could service NBS organizational needs plus meet Army, Air Force, and Census Bureau requirements equally. Such a computer would allow the Air Force to perform a number of important mathematical- and programming-based functions, serve as an investigative tool for certain specialized problems, solve general mathematical problems, and conduct performance tests on various types of supplementary equipment. For project leaders like Dantzig and Wood, this machine's best attribute was that the Air Force would possess it more than a year before the delivery of the first Univac. Early publications called this machine the National Bureau of Standards Interim Computer or the Interim SCOOP Computer until it was formally renamed the Standard Eastern Automatic Computer (SEAC) after its operational debut. To most of those involved in the process, it remained known as *Interim* as those who understood its purpose thought the name a better and historically-accurate fit.[231]

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[231] See Kirsch, "Computer Development at the National Bureau of Standards." Information on the SEAC's abilities for the Office of the Comptroller come from Computer Branch, Mathematical Sciences Division, Physical Sciences Group, Office of Naval Research, *A Survey of Large-Scale Digital Computers and Computer Projects*, report (Washington: Office of Naval Research, Department of the Navy, 1950), 10.

SEAC was the first operational internally-programmed digital computer in the United States with capabilities so newsworthy it joined the ENIAC in sparking the imagination of the public.[232] The New York Times published a piece entitled "Air Force Unveils Fastest Computer" the day after its unveiling in June 1950, praising the system: "Bewildering in its scope, speed and accuracy, it multiplies or divides eleven-digit numbers in 250 one-millionths of a second" and for being the "first automatically-sequenced super-speed computer to be put into useful operation."[233] While NBS Director Edward Condon received high billing for this accomplishment, it was General Rawlings as Air Force Comptroller who sang its praises in the Times. Referencing its four main sections – input/output, memory, control and arithmetic units – Rawlings discussed its service-wide importance through Project SCOOP and the "mathematical model" of programming equations pivotal to Air Staff budgetary and planning elements. For Danztig and others who had programs that had been awaiting the arrival of a computer, SEAC – the

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232 Department of Commerce, *The Retirement of SEAC: Thursday, April 23, 1964* (Washington: Department of Commerce, 1964).

233 Austin Stevens, "Air Force Unveils Fastest Computer," *New York Times*, June 21, 1950, 5.

“Mechanical Brain” – was a colossal success from its first day forward. Even after the Univac’s arrival, this “pilot” computer remained operationally relevant for well over a decade.[234]

The Univac computer’s eventual entry into Air Force operation in 1952 was met with far less fanfare thanks to the success of SEAC. Given the long delay in the Univac’s delivery, the development and acquisition of the Interim/SEAC computer appeared as a stroke of genius on the Air Force’s part, especially George Dantzig.[235] SEAC

[234] Between June 20-21, 1950, both the Air Force and the National Bureau of Standards produced a number of documents to help accentuate the excitement of the SEACs unveiling. These include the SEAC Dedication Program documents (June 20, 1950), the NBS Press Release TRG 6099 (June 21, 1950), the official transcript of Lt Gen Rawlings’ address at the dedication (20 June 1950), and the official transcript of the Chief of the NBS’ Applied Mathematics Laboratories’, Dr. John H. Curtiss’, address at the dedication (20 June 1950). See these referenced articles in the collection: United States Air Force, Comptroller of the Air Force, *SEAC Dedication Program Documents*, comp. Air Force Historical Research Agency, IRIS 01016559 (Washington: SEAC (Standards Eastern Automatic Computer) Collection, 1950).

[235] Interestingly, opinions and memories vary as to why he wanted the Interim Computer so quickly, whether it was to solve the Air Force’s mechanization edict or to solve his own mathematical issues. In his article "Memories of the Bureau of Standards' SEAC," Slutz claims Dantzig became so impatient with the some of the pending mathematical models (to include the von Neumann constant) that he refused to wait for the Univac’s completion. Regardless, NBS scientists were able to make good on producing a computer that not only worked provisionally, but also stayed as a

designers ensured success by utilizing corollary successes from a number of contemporary projects in the automatic computer field. The machine employed the acoustic memory achievements of the EDVAC project, the effective germanium diode uses from the BINAC system, and pulse transformer applications from an ongoing MIT Servomechanisms Laboratory project for the Navy (Project Whirlwind). Its use eventually stretched well beyond the Office of the Comptroller by performing computations as operationally relevant as the first Hydrogen bomb's production in 1952. Although SEAC was clearly a monumental step in industry computing, its impact on the air service was even bigger. What the Navy's first *Digital Computer Newsletter* edition left out in 1949 was how the individual initiative of one man – George Dantzig – helped galvanize top-level service support, push the organization's computing success forward by two years, and automate programs and processes in time to assist with the war in Korea. The SEAC Interim Computer changed the scale and scope of Air Force operations through its very use and thus became a monumental factor in the evolution of computing in the Air Force.[236]

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useful computing system until April 1964. See Slutz, "Memories of the Bureau of Standards' SEAC."

Early Computer Development in the Air Force

The SEAC computer drew a great deal of attention in both the Pentagon and the media but was not the only air service computing program under development at the time. The early success of ENIAC spurred the development of a number of Federal Government computer programs with many assisted or guided by the National Bureau of Standards. The developmental momentum from Project SCOOP and the Interim/SEAC Computer aided the creation of a second major calculation computer known as the Institute for Numerical Analysis Computer. In October 1948, the National Bureau of Standards' Applied Mathematics Executive Council sought to develop its own electronic digital calculator. The project was sponsored by the Air Force's Office of Air Research to provide high-speed electronic computational ability and an electrostatic memory capacity to the National Bureau of Standards' Institute for Numerical Analysis – a field station at the University of California at Los Angeles. Leaders in this effort, which included George Dantzig,

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[236] Comments from the US Navy derive from the Computer Branch, *A Survey of Large-Scale Digital Computers and Computer Projects*. Information on other projects' influence on the development of SEAC, as well as the computer's use on the Hydrogen Bomb project can be found in Department of Commerce pamphlet, "The Retirement of SEAC: Thursday, April 23, 1964."

intended that the machine should engage in long-range mathematical research as well as calculations for present-day problems originating with the Air Force, its contractors, and other governmental agencies. The service deemed the computer system so important to the development process that it diverted nearly $200,000 in funding away from other projects.[237] Like its SEAC predecessor, this highly-anticipated computer carried many primary requirements and was to be built "as quickly as possible."[238]

Work on the Institute for Numerical Analysis Computer began in earnest in January 1949 under the direction of the National Bureau of Standards' Dr. Harry Huskey. This computer veteran was another member of the University of Pennsylvania's former faculty who worked on the ENIAC project in the mid-1940s. Huskey was fond of a strong technical ensemble and built his high-speed electronic

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[237] The funds were previously earmarked for the Air Force's Air Materiel Command's effort with NBS' National Applied Mathematics Laboratories before being diverted for the IAS computer.

[238] See United States Air Force, Comptroller of the Air Force, *SEAC Dedication Program Documents,* "SEAC Dedication Program" (20 June 1950); and Computer Branch, *A Survey of Large-Scale Digital Computers and Computer Projects*, 13. Additional information on the IAS computer came from the National Bureau of Standards, Transcript: "SWAC Dedication Ceremony," (August 1950).

digital computer construction team complete with nearly a dozen senior and junior engineers, technicians, and mathematicians.[239] Plans for the computer that April included an electrostatic memory of approximately 1000 words and cutting-edge storage capabilities developed under the direction of renowned data storage pioneer (and Chair of Electrotechnics at England's Manchester University) Dr. Frederic Calland Williams. Huskey attempted to speed up the development process by allowing his team to let industrial contracts for a number of items, including 80 chassis support units for the arithmetic unit and 45 units for the cathode ray tube memory systems.[240] Despite an attempt to complete the project by year's end, the December progress report regrettably conveyed the fact that only eighty percent of the project was complete. It was obvious to Huskey that the new machine would have to be scaled back in computational power.[241]

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[239] In actuality, there ended up being only one mathematician whose responsibility it was to perform the coding and programming for the equations destined for machine calculation.

[240] This was not an uncommon practice in industrial development. However, accounts of the SWAC's development seem to emphasize this point considerably, especially given the speed at which they were trying to build the computer and the specification concessions made during that process.

The development team began January 1950 by looking for ways to complete the project within requirements but even more expeditiously than before. For example, Huskey and his team reduced the once lofty goal of a 1024-word memory to 512 words as memory capacity became one of the principle bargaining points among system developers. The engineers then agreed the computer would begin operations with only 256 words of electrostatic memory instead of their most recent 512-word goal. This allowed the team to expedite completion under the provision that memory would at least double as soon as practicable following initial operation. Other early expectations soon followed suit and were downgraded in an effort to meet development timelines. Originally espoused expectations that included an electromatic typewriter, a standard teletype-tape unit, and magnetic-tape storage units were sadly reduced in 1950 to only typewriter and teletype-tape unit input/output mechanisms.[242] What could be attained in the short term

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[241] See Harry D. Huskey, *Harry D. Huskey: His Story* (Charleston, SC: BookSurge Pub., 2004); Computer Branch, *A Survey of Large-Scale Digital Computers and Computer Projects*, 13-14; and Office of Naval Research, *Digital Computer Newsletter Vol. 1. no. 1*, 1-6. Additionally, data on Dr. Frederic Williams originates from the webpage: http://www.todayinsci.com/W/Williams_Frederick/Williams_Frederick.htm (accessed 3 Apr 12).

prevailed over what might be attained in the longer term during this critical construction phase.[243]

On August 17, 1950, Huskey and his team officially completed their project just two months after the SEAC dedication. Rather than retain its original name, the Institute for Numerical Analysis Computer's designation formally changed to the National Bureau of Standards Western Automatic Computer (SWAC) in an effort to align it with its SEAC cousin on the East coast. The Bureau followed the formal dedication ceremony by holding a one-day symposium on digital computing machine applications (specifically focusing on scientific problem solving) and honed in on methods studied by West Coast laboratories and universities at the time. Huskey's team maintained big plans for SWAC which, despite a shoestring budget of $170,000 still included upgrading its auxiliary memory, upgrading the input-output unit, and an improved chassis for integrating new hardware systems. Meanwhile, the Air Force's plans for SWAC did not change over time – service

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[242] Huskey's expectations of attaching one or more magnetic-tape units were put on hold until the computer reached initial operational capability, and even then further conciliations were made.

[243] Specific information in this paragraph sourced from Computer Branch, *A Survey of Large-Scale Digital Computers and Computer Projects*, 1-26.

experts remained vigilant in wanting a computer system that could help solve mathematical and statistical problems. SWAC's ability to solve pressing service calculation problems – aeronautical engineering issues, biological and radiological experimentation calculations, and differential equations based on von Neumann's "Monte Carlo" method – proved its usefulness to Air Force leaders.[244]

While the SEAC and SWAC computers represent the first direct computing efforts of the Air Force, the air service itself was involved in a number of programs predating those mentioned in the Navy computer publication. While not necessarily specific to flight operations they provided greater capabilities to the Air Force mission at the unit level. These systems did not show up in the pages of the *Digital Computer Newsletter* until years later, and even

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[244] Historical information on SWAC derived from United States Navy Office of Naval Research Mathematical Sciences Division, "Digital Computer Newsletter," 2, no. 4 (December 1950), 3; and Harry D. Huskey, "Technical Developments: Characteristics of the Institute for Numerical Analysis Computer," in *Mathematical Tables and Other Aids to Computation* (April 1950), 103-108. For additional information on SWAC, including its costs relative to SEAC, see Kenneth Flamm, *Creating the Computer: Government, Industry, and High Technology* (Washington: Brookings Institution, 1988), 74. Finally, applications for SWAC were found in "SWAC: National Bureau of Standards Western Automatic Computer – Recent Developments and Operating Expertise," *National Bureau of Standards Technical News Bulletin* 37, No. 10 (October 1953), 146-150.

then the Navy did not necessarily attribute their use to the Air Force. These operational systems, clearly vital to the service's efforts in the modern computer era, are an integral part of the Air Force's computer history.

The first such computer system took form in 1946 when the Northrop Aircraft Corporation earned a government missile system contract for a "unique, automatic, extremely accurate guidance system for long-range missions."[245] This system was named Project MX-775 by Northrop but eventually known throughout the service as the "Snark" missile project. The endeavor was based on a contract so specific that it demanded all the innovative and engineering talents the company could muster. The contract required a delivery range greater than 5,000 miles, a flight path at altitudes between 30,000 and 50,000 feet, and a delivery accuracy of one-tenth of a nautical mile (a tremendous feat undoubtedly requiring some form of an electronic navigational computation system). Already immersed in early computer-

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[245] See D.E. Eckdahl, I.S. Reed, and H.H. Sarkissian, "West Coast Contributions to the Development of the General-purpose Computer. Building Maddida and the Founding of Computer Research Corporation," *IEEE Annals of the History of Computing* 25, no. 1 (2003), 4-33. Additionally, see "The Dawn of the Computer Age," *Engineering & Science*, 2006, 7-12; and "G. Floyd Steele: Computer Oral History Collection, 1969-1973," interview by Robina Mapstone, January 16, 1973, 1977.

related technology, Northrop engineers assumed their most recent innovation could fill the Service's requirement: a newly-developed digital differential analyzer, nicknamed DiDA, capable of evaluating and solving ordinary differential equations. Workers in the company's "computer group" assumed this system could solve MX-775's navigational issues. However, Northrop's Assistant Project Engineer for Guidance Robert Rawlins decided to outsource the Snark's computational issue instead of using the DiDA system, a wholly unpopular internal decision but one that inevitably had a major impact on early Air Force and industry computing.[246]

Rawlins' decision to contract the navigational computer system shocked those inside Northrop but was a nearly impossible option for company leaders to overlook. The airborne digital computer contract Rawlins let went once again to industry experts and ENIAC producers Eckert and Mauchly who were in the process of developing the Univac. Few doubted their Philadelphia-based computer corporation possessed the capability to deliver a workable system both on time and within specifications. To Rawlins' benefit, rumors surrounding the computer corporation pegged

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[246] *Ibid.*

the duo as being in dire need of cash, presumably to help fund Univac's development. This was all but confirmed when Eckert and Mauchly's submission of a ridiculously low $100,000 contract bid gave Northrop little option but to accept on the basis of low cost and proven expertise. For nearly a year-and-a-half, the Philadelphia team made extraordinary efforts designing and building a pair of systems capable of fulfilling the range, altitude, and accuracy specifications for the system. The only contract specification they could not meet was the original intention have it airborne as well, but systems development problems made this requirement ancillary in comparison to overall project completion. After tens of thousands of dollars in cost overruns, Eckert and Mauchly convinced project managers to drop the airborne condition in an effort to meet or exceed the remainder of the requirements.[247]

Eighteen months after Rawlins let the contract, the result was a computer system the corporation officially named BINAC, an obvious derivation of the machine's binary number system operation and a similar-sounding moniker to its ENIAC predecessor. BINAC was a sophisticated, high-

[247] *Ibid.*

speed calculation device that could produce up to 3500 additions or subtractions, or 1000 multiplications or divisions, per second. Moreover, it was a bit-serial binary computer that hosted two independent processing units, each with its own 512-word acoustic mercury delay line memory. BINAC was not groundbreaking but was rather an evolutionary step in the creation of the faster, more powerful computer systems that developed later. Perhaps its greatest achievement was that both contractor and customer achieved a satisfactory end-state by the time the contract ended. Eckert and Mauchly's computer corporation received enough funding and experience from BINAC to utilize the computer as a partial prototype for the longer-awaited Univac venture. As for the Northrop Corporation – and by default, the U.S. Air Force – immediate possession of one of the smallest and most powerful computational systems available further solidified their contributions to the rapidly developing computer industry.[248]

The second computer deriving from Rawlins' decision came directly from within Northrop itself – the aforementioned DiDA. Northrop engineers worked tirelessly to modify the system in order to make it compatible with

[248] *Ibid.*

the Snark's navigational requirements until such time as the project went to contract. That contractual change became the catalyst for Northrop executives to realign the computer group and reevaluate new uses for both the project and its previous personnel. One of the most significant changes was the addition of magnetic drum memory as DiDA's primary storage device, allowing Northrop's computer experts to repackage the machine and allow the company to seek to market the product in new and different ways. The end-result was called Maddida, short for Magnetic Drum Digital Differential Analyzer, and was significant enough to attract the attention of other military and industrial organizations.[249]

Northrop may have performed the work for this project but the system truly belonged to the Air Force given its development under the pre-existing Snark contract. Regardless of ownership, the company still had to prove the computer's worth to the air arm as an improved differential analyzer. Maddida was an impressive machine to those who studied these machines, employing sixty-eight vacuum tubes,

[249] *Ibid.* Additionally, information on Maddida's progress came from the numerous editions of the Navy's *Digital Computer Newsletter* – specifically, Vol. 2, No. 3 (Aug 1950), Vol. 3, No. 2 (Jul 1951), and Vol. 4, No. 1 (Jan 1952).

one magnetic drum, and the integrating capacity of twenty-two differential analyzers. Reports in the mid-1950 editions of the *Digital Computer Newsletter* portray Maddida as a developing system built to solve differential equations and thus making it a viable system for both the military's scientific and its operational communities. Northrop believed in the product to such an extent that they sent Maddida prototypes to educational and military institutions across the country to prove its capabilities. By July 1951, Maddida was in use in several Air Force locations while new and improved versions remained throughout the service until the middle of the decade. What was once thought to be a casualty of corporate competition turned out to be a viable machine in the military's growing computer arsenal.[250]

Scientists and developers throughout this period built on one another's successes as the interest and funding for computer programs continued to escalate. Air Force officers and senior civilians who engaged in these projects soon realized that program funding was often easier for systems that directly supported the service's primary

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[250] *Ibid.* Also see United States Navy Office of Naval Research, *A Survey of Large Digital Computers and Computer Projects*, report (Department of the Navy, 1950), 17.

operational mission of manned flight. While there were a number of systems in significant competition for funding and resources midway through the decade, few if any fit the mold of an Air Force operational system quite as well as did the illustrious Whirlwind Computer.

During World War II, the U.S. Navy contracted with the Massachusetts Institute of Technology (MIT) to develop a "computer-aided" system to support its pilot training program. The project began in 1944 through the Office of Naval Research at MIT's Servomechanisms Laboratory and was specifically developed as a crude computer-aided flight simulator (simulated aircraft telemetry connected to a cockpit mock-up) for the U.S. Navy. The post-war environment and changing military priorities completely changed the course of the program by 1949 and was transformed into Project Whirlwind, a high-speed electronic digital computer system capable of solving complex problems through the repeated use of fundamental arithmetic and logical operations. Its first demonstration on 20 April 1951 quickly earmarked this electronic high-speed digital computer as a landmark machine as it was not only a pioneer effort in real-time information processing but also the first digital computer capable of displaying real time text and graphics on a video terminal (at the time, a large oscilloscope screen). The possibilities for Whirlwind continued to grow following this demonstration, but so too did the requirement costs. With their stake in the program waning and expenditures more than twenty-five percent over budget, the Navy soon lost interest. By 1953, the Navy had abandoned Whirlwind and left the Air Force as the project's sole military user.[251]

The Whirlwind's impact on computing over the next decade extended well beyond the innovations displayed in 1951. One significant development involving Whirlwind was the Lincoln Laboratory, a joint venture between the military and MIT that bonded the educational institution with the research and development programs of the air service's Scientific Advisory Board. This innovative combination of organizations became the forerunner for other similar research and development agencies such as

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[251] Information on the progress of the Whirlwind computer can be found throughout multiple editions of the United States Navy's "Digital Computer Newsletter," specifically from January 1950 to April 1955 (see specifically United States Navy Office of Naval Research Mathematical Sciences Division, "Digital Computer Newsletter," 2, no. 1 (January 1950): 1; Thomas P. Hughes, *Rescuing Prometheus* (New York: Pantheon Books, 1998), 22-67, 118; "Computer History: CHM Revolution," Whirlwind: Preparing the Way for SAGE, accessed March 20, 2012, http://www.computerhistory.org/revolution/real-time-computing/6/123; "MIT Whirlwind Computer from 1951," CED in the History of Media Technology, accessed March 20, 2012, http://www.cedmagic.com/history/whirlwind-computer.html.

MITRE and the Advanced Research Projects Agency (ARPA). A second effort connected with Whirlwind was the invention of magnetic-core memory, which altered the course of computer storage technology that had seemed stuck utilizing less-reliable storage-tube memory systems. Companies such as IBM and RCA soon applied this core memory in their commercial computer projects and it became a fundamental stepping stone in their success. However, of all the groundbreaking aspects arising from the Air Force's Project Whirlwind, few compare to the computer's use in the AN/FSQ-7 combat direction computer and its connection to the service's other critical operational effort: Project SAGE.

SAGE (Semi-Automatic Ground Equipment) was a ground-based air defense system initially designed to help protect the United States against long-range bombing attacks. Historians credit the project as the first major real-time, computer-based command and control system, of which the AN/FSQ-7 was a central unit. SAGE weighed 250 tons and contained more than 60,000 vacuum tubes, making it the biggest and heaviest computer system ever built. At a cost of more than $8 Billion, it was also the most expensive computer system in history. The program also consumed some of the greatest computer experts and technical resources of the age, including over 800 programmers from the military, a number of the country's leading computer corporations, and field "pioneers" Jay Forrester, George Valley, and J.C.R. Licklider. The integration of Whirlwind technology and the constant innovations pushed by Lincoln Labs and SAGE vendors advanced the Air Force's computer technology baseline beyond comparison with standard industry systems.[252]

The Whirlwind/SAGE computer efforts in the early 1950s dramatically changed the Air Force's computer research and development efforts, even though SAGE did not achieve its initial operational capability until 1958. This was because beyond the advances in air defense and telemetry calculations, SAGE was first and foremost a calculation machine that was built on the algorithmic programming required of an air defense system. As Thomas Hughes clarifies in his book *Rescuing Prometheus*, "[t]hough SAGE is conventionally portrayed as an air defense system, it

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[252] For information on SAGE, see "IBM-SAGE-Computer," Computer Museum, accessed May 13, 2013, http://www.computermuseum.li/Testpage/IBM-SAGE-computer.htm. Also, the Air Force's movie *In Your Defense* also provides an effective background and mission utility demonstration of the SAGE system, albeit considerably over-complimentary of its capabilities. See *In Your Defense*, prod. Western Electric and United States Air Force, perf. United States Air Force - Defense Projects Division (New York: Audio Productions, Inc.), accessed May 2, 2013, http://www.youtube.com/watch?v=06drBN8nlWg.

can also be described as an information-processing and real-time control system."[253] SAGE may have been a programmatic disappointment by the late 1950s, but its involvement with Whirlwind throughout the early part of the decade ensured it became an essential part of some notably groundbreaking events.[254]

By the time SEAC, BINAC, Whirlwind, and many of the other aforementioned projects reached completion, the scope of the computing environment was still expanding. By the end of 1955, the list of distinct, major computer models in use throughout government, industry, and academia had grown to several dozen. The decisions made in response to potential evolutionary changes and innovative improvements produced calls for systems upgrades or component conversions with the United States Air Force at the forefront of expansion. The air service had clearly established itself as a leader in the fields of scientific and mathematical computing by the middle of the decade, most especially in the research and development segments of the organization. Programs like SAGE and the ATLAS missile project continued to push the envelope of Air Force

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253 Hughes, *Rescuing Prometheus*, 30.

254 *Ibid*.

scientific development for the next several years, and computers played a major role in such programs. Were it not for the proactive nature of Air Force scientists, systems developers, and leaders, the history of specific computer mission systems might look considerably different today.

Part III - Early Air Force Data Management and Mechanization

Statistical control and data mechanization pervaded most Army Air Force operations and administration during World War II. The AAF's Statistical Control Units in the field delivered essential information to upper echelons on a regular basis as part of the most comprehensive data collection and exploitation mechanism ever used in the United States military. This management of data and statistics was integral to the tactical and strategic decisions of AAF generals such as Hap Arnold, Carl Spaatz, and Curtis Lemay, and became a natural function of daily operations throughout the service.

These data processes endured long after World War II was over. The Army expended a great deal of post-war effort eliminating extraneous organizations and personnel, but the offices and operations of statistical services were not among them. Instead, branch requirements for comprehensive data and statistical information remained an important feature in military operations and planning, and enabled the service's use of punched card machines and data tabulators until the days of Project SCOOP and Univac. It became incumbent upon the division chiefs and project leaders in Statistical Services to find new ways to harness this information in forms that benefited all levels of the service. The AAF decision maker's growing reliance on information mechanization was no longer a wartime phenomenon; it was now an embedded reality in the very culture of the air arm.

Statistical Service's first comprehensive, mechanized data management effort began in the waning years of World War II. Departmental leaders sought to compile the vast amount of statistical information acquired annually through the punched card to teletype delivery system. So much information traversed air service units that the immediate solution seemed almost elementary – compile an annual, all-inclusive compendium, using the latest in data exploitation techniques, which could be distributed across service organizations and would promote the impressive statistical processing capabilities of the statistical services unit. In 1945, the Army published its first major data collection volume: the *Army Air Forces Statistical Digest (World War*

II).[255] The AAF's intention was to prove to service leaders the value of widespread statistical mechanization and display the breadth and depth of the information such automation could attain. Along with a large supplemental addendum, the digest contained a voluminous amount of mission and support information covering everything from combat and operational data to training and recruiting statistics. Even as the air arm transitioned out of the Army organization in 1947, the service's year-end statistical data requirement remained unchanged and continued to provide data and statistical continuity throughout its transition.[256]

By 1950, the officially renamed *United States Air Force Statistical Digest* was christened as "the official Air Force statistical yearbook for the presentation of summary statistics on all phases of Air Force activity, strength, and operations."[257] The fifth annual compilation

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[255] *Army Air Forces Statistical Digest World War II* (Washington: Office of Statistical Control, 1945), iii.

[256] Operations Statistics Division of the Directorate of Statistical Services, Deputy Chief of Staff/Comptroller, *United States Air Force Statistical Digest, Jan 1949-Jun 1950, Fifth Edition* (Ft. Belvoir: Defense Technical Information Center, 1950).

[257] Operations Statistics Division, *United States Air Force Statistical Digest, Jan 1949-Jun 1950*.

was more than just a large accumulation of data: it had grown into an enormous, multi-disciplinary anthology. This installment was a mammoth undertaking containing over four hundred pages of numerical tables and figures of a quantity rarely consolidated in one volume. Its sixteen major sections comprehensively represented each phase of Air Force activities and represented months of data collection and exploitation even with the assistance of card machines and tabulators. This inclusive and wide-ranging compendium was so vital to service reporting and statistical evaluation that Air Force officials refused to cut back on it despite pending budget reductions. The *United States Air Force Statistical Digest* in 1950 was not just an important document in the service's administrative arsenal; it had become common, essential, and expected regardless of cost.[258]

The digest was indicative of an information landscape where such publications – along with the daily, weekly, and monthly reports due to headquarters – were regarded as invaluable to service decision makers and the organization's operational tempo. These reports were part of a much larger service reporting system known as Reports

[258] *Ibid.*

Control and were a carry-over from Army information administration. Each report (noted by its Reports Control Symbol, or RCS) consisted of official data compilations that were each formally approved by the Comptroller's office and sanctioned by higher headquarters.[259] Facilitating these transactions were each base's own statistical personnel made up of primarily keypunch operators and machine accountants who spent their workdays gathering, consolidating, and processing data for virtually all major Air Force activities.[260] As the central controlling authority for this data, Statistical Services became *the* critical link for information management across the Air Force.[261]

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[259] Each RCS report carried a specific alphanumeric designation distinguishing it from the myriad of other documents passing through the headquarters at that time. RCS reports included daily maintenance activities, personnel status reports, supply levels and budgetary analyses.

[260] "Processing" included encoding data on cardboard punched cards and then electronically transmitting it to higher headquarters for utilization.

[261] Service histories of this period are replete with information on RCS reports and PCAM usage as these were a primary function of the operation. See United States Air Force, *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Periods of 1 January – 30 June 1950* (Washington: United States Air Force, 1950) and United States Air Force, *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Periods of 1*

In the early 1950s, the importance of these daily information activities were matched in significance by the strategic statistical information compiled and utilized by department planners and tacticians. At the hub of this activity was Marshall Wood, the civilian scientist who in 1947 became the division chief of Planning Research and the Assistant Director of Management Analysis. More importantly, Wood was at the forefront of the Univac acquisition and Project SCOOP along with George Dantzig and the Air Force's top military leaders. While the Air Force awaited computerized solutions to its pending problems and studies, Marshall Wood and his staff developed key manuals and data management directives that gave utility to the information analysis and exploitation already underway at the Pentagon. Of these publications, one of the most important was simply known as WPF-50.[262]

The Wartime Planning Factors Manual, or WPF-50, provided contemporary and realistic planning information to the Air Staff and became an essential data set for

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July – 31 December 1950 (Washington: United States Air Force, 1950) for the periods between 1950-1955.

[262] For more information on Marshall Wood, see "Pioneer in Government Computer Planning," Washington Post, February 09, 2009, accessed May 3, 2013, http://articles.washington post.com/2009-02-09/news/36782416_1_secret-service-government-service-pentagon.

commanding air generals during the Korean War. Wood's statisticians built the manual from World War II statistical records and applied the data to current war planning factors to illicit statistical data comparisons between like air-centric operations. Such analysis was the result of years of statistical compilations and reporting, and provided valuable information that allowed air leaders and planners to update and modernize their tactics, aircraft and equipment data. In one particular case, Wood's division used a statistical data set built in 1945 to compare the relationship between operational aircraft damage and loss rates (fighters and bombers) in World War II to help the Air Force's acquisition planners consider the newest suite of aircraft to come off the line for Korea. In turn, the Korean War provided a tremendous opportunity to review previous war planning calculations and data sets and improve upon them by giving statisticians the opportunity to hone operational reporting skills not utilized since the previous war.[263]

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[263] Information covering the application of WPF-50 manual in the Korean War is located in United States Air Force, *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 January – 30 June 1950* (Washington: United States Air Force, 1950), 15-18.

The end of the Korean War did not diminish the demand for statistical data across the service. The Air Force instead demanded statistical services keep "tight administrative control and disciplined planning" over the service's data, especially when examining logistics resources, detailing materiel resources and equipment, and accounting for air service readiness in any of its primary missions.[264] Moreover, in light of the computing progress made during the war, the Air Force could now employ its new calculation technology to enhance its information reporting. Data management leaders like Dantzig and Wood were instrumental in helping Air Force developers compile special programs for the Project SCOOP (SEAC) and Univac computers and thereby integrate the two worlds of data processing and computing. In fact, the Air Staff created an entire subsection of operations entitled "Special Program Computations" to handle the headquarters' requests requiring unique computational or methodological assistance that fell into this category. This integration between systems – between the Pentagon's data processing and reporting processes and its newest computing projects – helped formalize the field of Air Force data automation, to

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[264] *Ibid.*

include developing statistical services into its own automation organization.[265]

The post-war propagation of RCS reports and other data compilations contributed to the service's growing need for electric accounting machines and punched-card accounting machine (PCAM) equipment. By the end of 1953, Headquarters Air Force's requirement for field reports topped more than 450 individual compilations by year's end, which was in addition to nearly 300 additional reports for the Secretary of Defense and another 308 for internal use. Senior leaders relied so heavily on this information that they began including data reporting and mechanization objectives in their strategic guidance to their staff and field units. This tone was first set by Air Force Assistant Vice Chief of Staff Major General William F. McKee in 1952 when he informed the Directorates of Installations and Statistical Services that base-level reporting mechanization was now

[265] Data on post-war activities, see United States Air Force, *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 July – 31 December 1951*, 9. Finally, information on the integration of SCOOP (SEAC) and Univac computing for statistical reporting purposes can be found across service histories during the war, but specifically in Section II, Activities of Planning Research Division, in United States Air Force, *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 July – 31 December 1951* (Washington: United States Air Force, 1950), 16-22.

one of his top objectives. Air logistics leaders echoed this sentiment by publishing (under the Deputy Chief of Staff of Materiel) their own strategic guidance promoting the use of advanced electronic information-handling devices in order to increase materiel logistics efficiency.[266] Experienced logisticians understood how automation could replace time-consuming paperwork and increase the effectiveness of the service-wide system as a whole. General McKee's edict in 1952 only solidified their desire for data processing expansion and kept their interest in data mechanization high.[267]

Yet another example of this senior level guidance derived from the Air Force's Office of the Comptroller

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[266] This strategic plan was entitled "Logistics for 1956" and was published by the Office of the Assistant for Logistics Plans in 1953.

[267] Report data for the period comes from United States Air Force, *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 July – 31 December 1953* (Washington: United States Air Force, 1950), 9. Information on Air Materiel Command and mechanized supply comes from D. B. J. Bridges, *Elements of a Mechanized Supply Information Flow System*(Dayton, OH: Battelle Memorial Institute, Wright Development Center, 1953), 10-12; United States Air Force. *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 January - 30 June 1954*. (Arlington, VA: United States Air Force, 1954): 9, 10; and United States Air Force. *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 June - 31 December 1954*. (Arlington, VA: United States Air Force, 1954): 4-35.

itself. Air leaders gathered from across the department at the service's annual Worldwide Comptroller's Conference to speculate on the practicality of mechanizing the Air Force's budget system. The conference aimed to accomplish this by appointing the task to a joint committee made up of directorate representatives from Budget, Accounting, and Statistical Services. The committee took only a few months before they first submitted plans to use data mechanization equipment to improve the Directorate of Budget's processes . . . a plan that was immediately approved. With the program underway so quickly, the Comptroller wasted little time in seeking opportunities to "mechanize" or "automate" existing paperwork systems using the Univac and other proposed computers planned for acquisition. The Comptroller and other senior Pentagon offices looked to data mechanization as part of their directorate's future. Air Force leaders began publically praising the benefits of information automation in their correspondence.[268]

The primary focus of the statistical services at the end of 1953 remained data production and transfer. Air Force data integration efforts only confirmed the division between what the air service expected electric/punched card

268 *Ibid.*

accounting machines to accomplish and what the Univac computer could calculate and produce just a few floors down in the Pentagon's basement. The Univac's use for Programming and Budgeting projects highlighted the connection between the two processes, especially since the Univac's data most often derived directly from Statistical Services' PCAM-generated data and reports in the first place. Throughout the year, indeed, and at the Worldwide Comptroller's Conference, the idea that the Univac computer should take Statistical Services punched card output to perform further "immensely complicated calculations" involving personnel, training, and requirements issues was considered.[269] Statistics leaders even pondered the possibility of a new device that collected data like accounting machines, processed information like the Univac, but included more memory to store the entire inventory of Air Force items. Such a machine was to be known as a "data-processing" machine and was thought to have great strategic value for the organization and became a model for what mechanization might look like in the future.[270]

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[269] *Ibid*.

[270] United States Air Force, *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 January - 30 June 1954*; United States Air Force. *Historical Summary: Directorate of Statistical Services,*

As 1954 began, the Air Force's data management successes remained a direct reflection of its lead statistical office and the hard work of many personnel. It was additionally a direct reflection of the efforts of the organization's experienced leader, Director of Statistical Services Major General Charles Raeburne "C. R." Landon. Landon had led the data management unit since 1950 and was one of a select group of commanders who possessed a background in operations, supply, and personnel administration. One of his most significant contributions came early in his tenure when he established the unit's four primary mission areas: directive and report verification; data consolidation and recording; statistical and mathematical data application; and data interpretation and presentation. As a former enlisted Marine and longtime veteran of the Army's Adjutant General Corps, Landon was no stranger to administrative paperwork and fully understood the possibilities for data automation across the information-heavy directorates. His guidance and leadership during the migration of PCAM and computing equipment into statistical operations placed him on the

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DCS/Comptroller for the Period of 1 June - 31 December 1953, 1-8; and United States Air Force. *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 January – 30 June 1953*, 1-10.

leading edge of Air Force data automation. Moreover, his leadership through both the Air Force's early strategic changes as well as the tactical challenges of the Korean War became a testament to his information management vision for the service.[271]

1954 marked General Landon's fourth and final year as director. When he took over in February 1950 his responsibilities predominately surrounded the rapidly increasing use of electrical accounting techniques. Over the next four years, however, Landon served out his third "war" overcoming two well-engrained paradigms in Air Force field units: first, that base mechanization was primarily a unit accounting function; and second, that such activities were mostly confined to the Pentagon or Air Materiel Command. These patterns made sense at the time as pre-1950 unit involvement included only localized base-level processing that fed a headquarters-derived requirement. In order to ensure the entire air arm understood his current automation methodology, the general authored the Directorate's strategic "Planning for Calendar Year 1954" report, stating that "[t]he contributions of Statistical Services to Air Force management may be

[271] *Ibid.*

measured in terms of the continuing improvements in the accuracy and timeliness of basic data, and the continuing progress in the extension of sound, modern mechanized business techniques to Air Staff Operations."[272] His goals to "explore and develop further mechanization of new reporting systems in major management areas" and to "continue expansion of base mechanization as a means of increasing the efficiency of administrative or support activities" set the tone for the future of the statistical services.[273]

Landon retired in July 1954 after more than four years in Statistical Services. Brigadier General Llewellyn O. Ryan took over the unit whose rise in importance was reflected by its increases in personnel and machinery.

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[272] General Landon's specific quote is from the official historical record: United States Air Force, *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 January - 30 June 1954*, 4.

[273] For information on Major General Charles Raeburne "C. R." Landon, his official military biography can be found at "Major General Charles Raeburne "C. R." Landon," Air Force Senior Leader Biographies, accessed April 10, 2012, http://www.af.mil/information/bios/bio.asp?bioID=6135. For information on the Office of the Comptroller and Statistical Services, see United States Air Force, *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 January - 30 June 1954*, 4, 5; and United States Air Force, *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 June - 31 December 1954*, 4-35.

With a worldwide statistical organization of 11,000 military and civilian personnel structured in a network across all Air Force bases, Ryan's new unit used approximately one hundred million dollars' worth of electronic and electric accounting machines and amounted to the "largest application of modern business equipment ever developed in industry or government."[274] The general began his tenure by charging the directorate to seek new ways to manage the volume of statistical data requirements. One solution involved centralizing information responsibility into one headquarters unit, which Ryan accomplished by appointing the Materiel Statistics Division as the primary manager of all data reporting on Air Force installations. Another was assigning responsibility for technology integration across the service by delegating it to the Machine Accounting Division. This division became responsible for merging the air service's electronic data processing equipment with existing punched-card systems. Finally, the directorate spent a considerable amount of effort modifying and refining existing reporting systems to ensure its baseline programs remained reliable and

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[274] *Ibid*. Inside the organization, the Plans & Liaison (P&L) Group promoted this frequency by steering an official "Base Mechanization Program," of which P&L was formally charged with planning and implementing.

effective. The efforts of General Ryan and his staff prepared the organization for an unknown operational and administrative future in the wake of two wars and periods of great organizational and technological growth.[275]

The increasing quantity of service statistical requirements sent Air Force researchers looking for systems with greater capacity and speed than those currently in inventory. Program managers began looking to their sister services and industry to survey the latest data processing equipment the market had to offer. Experts directed project managers to companies such as Remington Rand, RCA, and IBM. Headquarters programmers tested the IBM 650 drum calculator as a solution for several existing data processing projects, culminating in an air service purchase of a dozen machines by year's end. Air Materiel Command already employed eight of its own IBM 650 units plus a newly acquired Remington Rand Univac. While the number of Statistical Services computers was significantly on the rise, these were still heavily outnumbered by the existing data processing machines remaining in the field. By comparison, the Air Force still had 4,946 electric

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[275] United States Air Force, *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 June - 31 December 1954*, 4-35.

accounting machines in use at 170 installations across the Service by the end of 1954, up from 4,417 machines and 122 installations the previous year. The service was therefore clearly approaching a data machinery decision point and its leaders had little choice but to begin deciding which equipment to pursue for its future.[276]

In 1955, the United States Air Force formally decided to pursue a data processing environment beyond its traditional World War II-era reporting system. To do so necessitated extending the scope of mechanized reporting and creating an integrated reporting system that encompassed the entire service. Moreover, it required improving the quality and speed of its current systems, installing newer high-speed computing equipment at both the headquarters and in the field, and ensuring base mechanization became the organization's principle management tool. To manage and lead the post-war Air Force meant abandoning older information management techniques and embracing a single, integrated program that could handle the service's mounting information requirements. 1955 was an important year in the branch's

[276] *Ibid.*

data processing history and heralded the beginning of a new Air Force data automation era.[277]

On January 20, 1955, the Air Force officially recognized data automation as a legitimate departmental mission by establishing the first centralized office assigned to integrate it into service operations. This Office of the Special Assistant to the Directorate for Base Mechanization commandeered the data processing function out of its home in the Plans and Liaison (P&L) Group and created a separate office within the headquarters where it no longer shared the data mission responsibility. The decision to create such an office was not an easy one for Air Staff leaders. However, the growth of data processing throughout the air service – generation, transmission, exploitation, and distribution – simply grew too large and too important to leave in either a bifurcated or subordinate position. The Air Force charged former World

[277] The service history of this period covers all the individual branches and divisions of the larger Statistical Services organizations, each from their own perspective. However, as a whole, this period history is replete with details of a new era of base mechanization with an excitement missing in the year's previous histories. Thus, between this period and the next six-month installment, it becomes clear that 1955 was a unique and exciting period in Air Force data mechanization history. See United States Air Force, *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 January - 30 June 1955*, 1-4.

War II B-24 Liberator pilot Colonel Thomas E. Peddy and a senior staff consisting of a pair of former P&L majors, Wesley Saville and Seymour Colman, to run the unit. All three understood this was not a permanent assignment, but each also understood the importance of making this new mission work.[278]

The base mechanization environment Peddy and his staff faced in 1955 was incredibly convoluted, especially after years without central direction. The majority of service equipment originated from the IBM inventory but its acquisition and distribution had been haphazard across the major commands. Leaders outside the Statistical Services were not surprised by the lack of service-wide standardization, but they certainly were alarmed. The staff of the Special Assistant’s office attempted to rectify the situation by taking a number of immediate actions. First, they developed an Air Force policy directive that covered the application of data machine

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[278] Specific data on Colonel Peddy found in several locations. *11th Bomb Group (H): The Grey Geese. (Paducah, KY: Turner Pub., 1996);* "Colonel Peddy Heads ROTC Unit," *The Gettysburg Times*, September 1, 1949, 1-6; and "Lt Col Peddy, ROTC Officer, Is Transferred," *The Gettysburg Times*, July 24, 1951, 1. Outline of history covered in United States Air Force, *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 January - 30 June 1954*.

procedures, including base-level operations, record keeping and reporting. Second, the staff built an implementation schedule for the entire service base mechanization effort. With 144 bases contemplating mechanizing, as well as 74 of them already mechanized in one or more subject matter areas, such a schedule provided a baseline for implementation that had been non-existent in years past. Third, a Base Mechanization manual was developed to ensure the existence of standardized automation implementation procedures. Finally, the office sponsored and formed a Base Mechanization Coordinating Committee to assist and advise the Air Staff on all relevant automation matters. These initial actions played a significant part in providing the much needed structure absent in previous program management activities. Unfortunately, it was not enough to counteract them all.[279]

One of the biggest issues facing a service-wide base mechanization effort was enlisted training. At the end of 1954, an Air Proving Ground Command evaluation of the Machine Accountant training course highlighted the same issues many Major Command leaders found in previous program

[279] See United States Air Force. *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 January - 30 June 1955*, 3-4, 17-47.

efforts. The training course was located at Sheppard Air Force Base in Texas and trained all new career field entrants in preparation for any Air Force statistical machine operator position. Commanders concerned about the lack of continuity between base mechanization programs found the training courses ineffective at preparing trainees for their positions in the field. The issue became so pronounced that the de facto trainee solution was for them to learn what they could at Sheppard but be prepared to receive their meaningful, full-qualification training "on-the-job" at their duty location. The Command's own evaluation not only highlighted the problems inherent in service training, but also illuminated the standardization problems across the service itself. Its findings were but one of the challenges Colonel Peddy and his office would face all year.[280]

The training course staff had several objectives in mind for each trainee. First, course instructors educated

[280] Information on the Machine Accountants Course is found in United States Air Force Air Proving Ground Command, *Final Report on Evaluation of Graduates of Machine Accountants Course, Project Number APG/CSC/388-A* (Dayton, OH: Armed Services Technical Information Agency, 1954). Additionally, the number of equipment items per month is derived from United States Air Force, *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 January - 30 June 1955*, 6.

new Machine Accountants in the wiring and operation of the IBM 402 Accounting Machine, along with its corresponding sorter, interpreter, and collator. Additionally, they familiarized the students with the IBM 407 Accounting Machine, a successor to the 402, and its associated sorter and collator. Both of these accounting machines (and their peripherals) were late 1940s-era machines and were in widespread use across the service. However, instructors understood these two systems only covered a portion of the machines that future machine accountants would face on active duty. For example, those students returning to a base with an IBM 063 Card Controlled Tape Punch Machine had no training opportunities at Sheppard, and those who learned to operate the IBM 514 Automatic Reproducing Punch Control Machine could only do so on the older models as the newer models were not covered at all. Moreover, evaluators at Air Proving Command noted that trainers spent an entire week familiarizing students with the IBM 101 Electronic Statistical Machine, which leaders deemed wasteful due to the 101's limited service use across the Air Force. Coping with this cornucopia of accounting machines, along with the discontinuity issues, was naturally relegated to Colonel Peddy's organization. With more than fifty new pieces of electronic accounting equipment entering the air service each month, equipment standardization remained an issue for Peddy for the remainder of his tenure.[281]

The remainder of the year witnessed the continued progress of programs established in January, including the consolidation of the Air Force's integrated RCS reporting system. Progress also involved the continued increase in the number of Air Force bases with punched card equipment, a corresponding increase in the utilization of each machine (indicated by the number of reports processed each period), a sustained emphasis on machine processing procedure standardization (to counteract the formal and OJT training issues), and the modification and refinement of existing reports. Additionally, Peddy's office made a concerted effort to recruit more military and civilian personnel into the career field to deal with a shortage of trained machine operators caused by widening the program. Finally, headquarters began preparations for a service-wide project that included installing high-speed electronic computing equipment at each base location, presumably to take over the data management task of personnel report processing.[282]

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[281] *Ibid.*

[282] Information comes directly from the directorate and branch histories listed in United States Air Force, *Historical Summary: Directorate of Statistical Services,*

Colonel Peddy and his staff decided in September that the program was finally stable enough to update commanders on the office's progress, which they did the Air Force's first-ever Base Mechanization Conference.[283]

On December 31, 1955, after a full year dedicated to little but base mechanization, the Air Force formally disbanded Colonel Peddy's Office of the Special Assistant to the Directorate for Base Mechanization. Managing all punched card tabulating machines and electronic data processing equipment over the previous year amounted to successfully attaining a statistical reporting process at nearly all Air Force base-level organizations. This milestone meant a special program office was no longer needed. A more formal and long-lasting office to oversee the program's future was now required. The Air Force seemed pleased with the role of the Special Assistant's office, but especially with the work of Major Saville who earned an Air Force Commendation Medal for his work during

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DCS/Comptroller for the Period of 1 July – 31 December 1955.

[283] Air Training Command played host to the first official Base Mechanization Coordinating Committee Conference held at Scott Air Force Base. See United States Air Force, *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 July – 31 December 1955*, 11-12.

the program's test period. Peddy left the Special Program Office in phenomenal shape, having truly become a catalyst for service-wide data automation in the Air Force.[284]

To replace the Special Assistant's office, the Air Force formally appointed the Comptroller's Directorate of Statistical Services as the program manager for all punched card and electronic data processing equipment in the air arm at the end of 1955. This meant that any piece of electronic equipment designed to record, communicate, and process data now came under the purview of the directorate. Operational and scientific computers like those in the SAGE and ATLAS programs maintained their own separate program management. For those focusing on data management and exploitation elsewhere, however, responsibility fell to the directorate. The service was on track to implement base mechanization systems for 158 programs across the Air Force by year's end, including the maintenance, personnel, and supply programs that made up the bulk of the air service's data reporting. With so many base mechanization programs in place, it finally appeared as if the Department of the

[284] *Ibid,* 5-14.

Air Force – all of it – had officially embraced the computer as the newest phase of its information journey.[285]

Conclusion

Unlike other programs and procedures that ended with World War II, August 1945 did not mark the termination of air service data and statistical control. Quite the contrary: such procedures became more entrenched and organized, with the greatest surge coming after independence a few years later. The statistical services worked through the war using the information technology available, primarily punched card tabulators and electromechanical calculators. AAF leaders meanwhile received their information through this "stat system" with little need for major process improvements during the war. With the development of the ENIAC and its posited capabilities, however, the Army computer's reputation opened the aperture to a future that immediately included high-speed data proliferation. It still took someone, however, not just something, to make such a capability available to the air arm in the late 1940s.

[285] United States Air Force, *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 July – 31 December 1955*, 12-14.

The Air Force computing programs that succeeded the ENIAC were not isolated efforts but rather part of a growing crescendo of interest originally billed as Project SCOOP. Although SCOOP had the support of the Air Force Chief of Staff and the Comptroller General, it was civilian mathematician George Dantzig's insistence and perseverance that made the venture such a meaningful endeavor. The documents surrounding the project's early implementation do not read as a downward-directed edict but rather as the musings of leaders impressed by capabilities they hardly understood. In essence, while the enthusiasm for new technology belonged to these Air Force general officers, the actual understanding of the potential Air Force applications of computers belonged to Dantzig, Harry Huskey, and others. Without Project SCOOP, Air Force efforts like the SEAC/Interim Computer, the Numerical Analysis/SWAC Computer, and the UNIVAC computer might not have come to pass in the manner that they did.

The operational computer systems under development were likewise influenced by their project managers rather than just the expectations of those at the top. The development of BINAC for Northrop's Snark missile project, the spin-off development of the Maddida differential analyzer, and the rescue and reapplication of the Whirlwind computer were all the product of service advocates who challenged traditional practices and risked their careers to advance computer applications. Additionally, information projects such as SAGE and ATLAS continued testing computer potential driven by the scientists, systems developers, and leaders who supported them. In the years between its independence and the centralization of computer applications in Statistical Control, the number and capabilities of service computers grew exponentially through these often bottom-up efforts. By 1955, the service was firmly established as a leader in the fields of scientific and mathematical computing.

Intertwined with all this computer system development was the issue of data management. Although it was important to determine what computer system would manipulate the service's data, and how, it became even more important to determine what data would be exploited, and from where. Data compendiums like *United States Air Force Statistical Digest* and the *Wartime Planning Factors Manual* (WPF-50) were as well-known and influential as the computers (i.e. SEAC, Univac, Maddida) that manipulated data. While many of the statistical processes were born in World War II, it was the Korean War that solidified the prominence of the statistical services and led to it becoming the service's computer focal point. Through all the top-down authorized changes, however, it was always the individuals in the fray who made data automation a service reality. Civilians like Dantzig and Wood were institutions in service computing and remained dominant voices behind the data mechanization projects of the 1950s. The public face, meanwhile, belonged to military officers such as Landon, Ryan, Peddy and Saville, whose diligence and tenacity helped data automation become the success it was by mid-decade.

The period September 1947 to December 1955 witnessed the bulk of the service's transition into the era of computing, both in computer application and data automation. However, I argue this was a part of, but should not be confused with, its longer and more established "information age" that began almost a century earlier. Data mechanization and the service's information applications began long before 1955, but the centralization of these activities and the application of computing mark this as a new stage of the Air Force's evolving information environment. Whether this period is lumped in with other historical periodizations such as a "computer age," an "electronic age," or a "digital age" is a matter of conjecture and preference. The fact is that these new innovations saw information continuing to grow as a valuable Air Force commodity, with the principle difference being how it could be harnessed and exploited. By officially creating a Special Assistant for Base Mechanization in 1955, as well as formally assigning the Directorate as the central authority for data processing equipment, the Air Force was preparing itself to enter this new era without abandoning older premises. The need to collect, manage, and exploit the service's large data resources remained a vital part of the organization's methodology. The difference after 1955 would be how such method's would be achieved.[286]

In the early days of computing, the Air Force had the benefit of being a new and extraordinarily technical military department, thus granting it the latitude to explore and contribute to the greater technological efforts underway in industry and academia. Early data mechanization had everyone from the most senior Air Force leaders to the lowest airmen looking to advances in electronic tabulators and accounting machines to connect geographically separated units with information and alleviate the growing stacks of paperwork in a massive

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286 *Ibid.*

bureaucracy. Luckily, by the end of this period, these two endeavors began to unite. By 1955, the same companies that were bidding on computer contracts for aviation projects were often the same ones that sought to create the next, better data processing machine. As the lines between an electronic data processor and a general purpose computer began to blur, these devices became more and more commonplace in the military and in general. For the Air Force, the impact on the Department was clearly substantial. While the mission of the Air Force may have been to fly and fight, no one was doing much of either without the assistance of either a computer or data processor, or both. In time, the two machines would become one and the same.

This chapter focuses on the origins of Air Force computing and mechanized data management through a leadership as well as a technological lens. By highlighting some of the service's overarching organizational and operational issues, as well as the computer and data processing solutions designed to solve them, this chapter hones in on not just how they were solved, but also by whom. Computer and data automation history is often a narrative tightly focused on the technology that purportedly "enabled" relevant changes in the industry. However, it becomes apparent that it was the individual leaders rather than the technology itself that enabled change to occur.

Chapter 4

The Origins of a Data Automation System, 1953-1968

In 1962, the United States Air Force officially embarked on the largest and most expensive computer project in its fifteen-year history. Years of smaller, base- and command-independent ventures with electronic tabulators, punched card machines and even early computers prepared the Air Force for a service-wide, cutting-edge upgrade that promised to eliminate hundreds of manpower positions, save tens of thousands of hours of work, and change the organization's operations by the next decade. This system featured the new UNIVAC 1050-II computer and was the first data automation project in the Department of Defense to provide "direct and immediate customer access to the computer by remote input/output devices."[287] The Air Force called this program the Standard Base Supply System, or SBSS, and approved a development plan charging supply

[287] Brigadier General A. A. Riemondy, "Supply and Service—The Nucleus of Logistics," *Air University Review*, July/August 1970, accessed January 12, 2012, http://www.airpower.au.af.mil/airchronicles/aureview/1970/jul-aug/riemondy.html.

logisticians with taking the lead role in air service data automation.

The history of the Air Force's first data automation system is not a common narrative in service history. Moreover, that such a massive investment began first in a support operation is almost counterintuitive to those familiar with the major investments and expenditures of the military during this period. It is more logical to assume that a service devoted to aviation and aeronautical support would aim its first major computer system directly towards manned flight. Such experimental and costly technological advances are most bureaucratically palatable when falling within the bounds of an organization's key mission – in this case to fly and fight. Rather than forging their future with flight management automation systems or electronic air traffic control data systems, the Air Force chose a very different route. Service leaders instead looked to one of the most administratively-intensive organizations within its ranks to find the most useful and wide-reaching applications of data automation available: Base Supply.

In *Logistics of War*, a quintessential service history published by the Air Force Logistics Management Agency in 2000, authors Scott, Rainey and Hunt give their brief assessment for the rationale behind the SBSS' design and fielding. They suggest that with the initial elements of the Vietnam War underway, "an enormous inflow of supplies and equipment" going into theater was a primary requirement for a new, Air Force computer-based supply system. Additionally, the authors refer to a number of preexisting and compounding problems in the service's previous supply system, including multiple and incongruent computer and manual systems that often ignored the standardized supply procedures set forth in Air Force Regulation 67-1, the *USAF Supply Manual*. Using both rationales, *Logistics of War* helps detail how Air Force leaders developed the SBSS as a reaction to both the demands of war and existing service constraints.

Up to a point, the authors of *Logistics of War* are correct; the Air Force did use the system during the Vietnam War and did suffer from a tremendous service-wide supply system incompatibility issue. For example, in the latter case specifically, Air Force Director of Supply and Service's Brigadier General A. A. Riemondy stated in his *Air University Review* article, "Supply and Service—The Nucleus of Logistics:"

> In 1962 most Air Force base supply accounts were managed by a mix of manual, punch-card, or computerized

> inventory control systems. Eleven different systems were in use, each designed autonomously by the major commands to fit the peculiarities of their accounting equipment. Proliferation of nonstandard base supply systems, designed with minimal Hq USAF control, restricted the Air Staff in establishing meaningful supply policy.[288]

However, Scott, Rainey and Hunt's argument that these two period-specific issues were somehow the genesis for this program grossly underplays the history of the Supply Corps and most especially its pioneering legacy. Discussions about such a system predate the program's actual establishment by almost a decade and a tradition of integrating new logistical procedures and technologies was part of a long heritage of organizational and operational improvement that preceded both the first service-purchased punched card systems of 1926 and even the card- and form-based inventory systems of World War I. In fact, the legacy of American supply data improvement dates as far back to the first true form- and regulatory-based supply methods established a full generation before the Civil War. The airmen of Supply and the legions of Army quartermasters that preceded them offer a long history of proactivity and innovation. To claim that the SBSS was an isolated and

[288] Riemondy, "Supply and Service—The Nucleus of Logistics."

reactive measure to the events of the early 1960s is a misrepresentation of the facts.

The purpose of this chapter is to place the Standard Base Supply System in its proper historical context – as a groundbreaking Air Force program built on years of discussion and debate and the result of a long legacy of logistics innovation. To do this, I briefly explore several key areas in the service's long history of supply accountability and inventory control. Next, I review the debates and events that led to the SBSS as the Air Force's singular and groundbreaking supply system. Finally, I review the evolution of the SBSS program itself, as well as illuminate the critical programs that resulted both during and after the system's development.

Humble Beginnings

Service logisticians in the early 1950s were accustomed to the manual, data-intensive supply inventory system that had been initiated long before the Air Force's founding. Through a series of stock card and supply form procedures, airmen accounted for each item in meticulous detail and produced composite tallies accordingly. This data was forwarded to senior echelons for reporting and evaluation purposes, placed alongside other unit data, and managed with painstaking effort. However, on the heels of Project SCOOP and the UNIVAC's acceptance, Air Force members could finally visualize a "mechanized" or "computerized" logistics future that included data processing and information data control across the entire service. The fact that the technology did not exist did not stop service leaders from developing a requirement for such a system, which became more and more elaborate as technological capabilities progressed. Years of technical theorizing, the continued operational process, and information improvement helped the Standard Base Supply System come into existence.

Until the 1950's, the origins of supply accountability and control in the air corps could be traced back to two founding fathers. The first was quartermaster pioneer Brigadier General Thomas Sydney Jesup who served as the Army Quartermaster for an unprecedented 42 years from 1818 to 1860. Jesup built the foundation of modern Army supply accountability after significantly revising the War Department's preexisting supply methods and techniques. By installing a series of regulations and procedures in the years leading up to the Civil War, the general literally rewrote the book covering stock item purchases and supply requisitioning. Regarded as the "Father of the

[Quartermaster] Corps," the general set out to improve the supply accountability process by creating a form-based information process designed to facilitate supply purchases through a voucher and receipt system, thus accounting for all activity published in the Army's monthly summary reports. The longtime Army Quartermaster was convinced that for a large military, a supply accountability system could be effective and efficient so long as individuals held themselves accountable and played by the rules. These "rules" remained an effective model not only for the Army Quartermaster, but soon also for its Signal Corps whose own supply requisitions were a vital operational element. As the air arm began its evolution in 1907, it was these supply regulations, forms, and procedures that guided its processes through World War I.[289]

While General Jesup built the foundation for supply processes and accountability, Colonel (eventually, Brigadier General) Augustine Warner Robins led the Army Air Corps through its interwar logistics transitions between 1919 and 1937 by establishing the procedural baseline for

[289] Steven E. Anders, "The Quest for Supply Accountability, Part I – Wholesale Logistics and the Beginnings of Automation." *Quartermaster Professional Bulletin*, Winter 2007. 12-17.

the SBSS program. Airmen at McCook Field (and ultimately at Fairfield Air Depot) initially utilized the manual, card-based accountability systems operated by the air service before and during the war. With tens of thousands of stock cards in cycle each month, the job of inventory management was both tedious and time-consuming. After Supply Division Lieutenant Edwin Page engineered a new organizational scheme for the manual system, it was Robins who advocated the design and set about revamping the inventory system altogether. As Air Force historians readily point out, it was Robins who used Page's organizational system in tandem with the preexisting card-based accountability system in use across the Ohio airfields to create a supply accountability system that remained in effect until the advent of computers thirty years later.[290]

Through these early developments, the importance of supply accountability and the necessity for an effective base supply system was established in the air arm. The Standard Base Supply System was the service's first departmental automated data system. The program was a

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[290] See Phillip S. Meilinger, *American Airpower Biography a Survey of the Field* (Maxwell AFB, AL: Air University Press, 1997).

mammoth and costly project that diverted precious manpower, equipment and fiscal resources away from other service projects and was built on foresight, sacrifice, and the inherent notion that data management of a military's materiel stockpile was essential to effective service operations. The SBSS' success was based on the idea of information management as a force multiplier capable of increasing operational efficiency while saving resources. Thus, this pioneering system, which some logistics airmen affectionately nicknamed "the grand-daddy of them all," opened the door to possibilities of data automation and consequently became the linchpin to a series of data projects in the 1960s, 70s and 80s that completely transformed Air Force operations and information management.[291]

The Inventory Data Processing Discussion

Data reporting and exploitation during and after World War II, along with the computer advances of the early 1950s, contributed to an organizational environment receptive to the service-wide application of computing.

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[291] Frank Spruce, *Evolution of the Supply Computer System from Univac 1050 to the GCSS/ILS-S*, Unpublished Report (Personal Collection of Mr. Robert C. Neibling, USAF Civilian (Ret)).

This reception was further aided by government agencies' excitement over receiving their first UNIVAC at the same time these Remington Rand systems were correctly predicting the 1952 election.[292] Contracts for UNIVACs increased shortly thereafter, including deliveries for such prestigious companies as General Electric, Metropolitan Life, U.S. Steel, DuPont, and Westinghouse. Meanwhile, industrial competitor International Business Machines (IBM) simultaneously ventured out from its staple product line of typewriters and calculating devices to start contributing to this new age of computing. The IBM 701 "electronic data processing machine" was UNIVAC's primary competitor in the early 1950s and boasted its own major contracts with Boeing Aircraft, General Motors, the University of California and the Atomic Energy Commission. The popularity of computers and their applications continued to grow through the early part of the decade, and the military remained a pioneering

[292] Chronologically, the systems went to the U.S. Census Bureau, the U.S. Air Force, and the U.S. Army Mapping Service respectively. When the Univac correctly projected Dwight D. Eisenhower's victory over Adlai Stevenson after only receiving a small amount of early vote totals, the electronically-induced prognostication introduced both industry and the public to the power of modern computing capabilities.

organization. It was, after all, become a growing part of its operational culture.[293]

By 1953, computing and data mechanization had become popular themes for discussion in numerous service communities of the United States Air Force, but perhaps none more so than the community of logisticians. These early years saw both technology experts and service leaders alike waxing philosophic over the future of service computing and the possibility of harnessing these machines to control and process the immense information resources of Base Supply. Over the next several years, ideas and proposals for new inventory control systems or new supply procedures dominated logistical conferences and publications. A number of RAND Corporation research memoranda were dedicated solely to such topics. The question for service members was no longer if Air Force materiel information would be mechanized, but when.

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[293] Information relating to the 1952 president election was among the following sources: Thomas Haigh, "Computing the American Way: Contextualizing the Early US Computer Industry," *IEEE Annals of the History of Computing* 32, no. 2 (2010): 8-20; Paul Ceruzzi, *A History of Modern Computing* (Boston: MIT Press, 1998); and Martin H. Weik, Jr. "A Third Survey of Domestic Electronic Digital Computing Systems" (Aberdeen Proving Grounds, Maryland: Department of the Army, Ballistic Research Laboratories, 1963), 390-394.

The conversation began in earnest in 1953, just a few years after the service received its first computer system. At Wright-Patterson Air Force Base in Ohio, officers of the Wright Development Center were hard at work postulating the future of a logistics function that would utilize some form of computer automation. Charged with evaluating the strategies in the service's forward-thinking "Logistics in 1956" planning document, these officers recognized they required assistance evaluating one specific task in the plan: the flow of information between the materiel user and Base Supply at a future prototypical Air Force location. To accomplish this, the Development Center contracted Ohio-based Battelle Memorial Institute – known primarily in industry for its work with fuels, metallurgy, and dry photographic reproduction – to help the Air Force solve its pending technical challenges. The first paragraph of Battelle's report echoed the thoughts of many computer proponents at the time:

> A keystone of this plan is the application, where feasible, of advanced electronic information-handling devices as substitutes for time-consuming paper work. Within their proper fields of application, such electronic devices may replace manual handling of data, and might (1) eliminate paper work on certain functions, (2) cut information flow time, (3) remove

> human inaccuracies from present records [and] (4) make data readily accessible.[294]

Since Air Force logisticians were no strangers to mountains of paperwork, the prospect of the automation of their information processes was welcomed. Within the scope of all logistics functions in the Air Force, no task seemed more appropriate for data automation than the paperwork of Base Supply.[295]

Across all American military departments, "supply" organizations in the 1950s were the embodiment of administratively inundated organizations. Following World War II and the Korean War, little if any equipment, materials, or goods arrived at a military installation without first going through these extraordinarily busy units. Base Supply was a service-wide function in the Air Force, which meant airmen managed inventory control of everything from aircraft parts to desk staplers not only at the base—level, but also at headquarters. The purpose of the supply pipeline was to ensure a steady flow of parts

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[294] The specific quote is from the report is from D. B. J. Bridges et al., *Elements of a Mechanized Supply Information Flow System* (Dayton: Battelle Memorial Institute, Wright Development Center, 1953), 1.
[295] Details on the Battelle Memorial Institute come from *Battelle: 75 Years of Innovation.* (Columbus, OH: Battelle, 2004).

for immediate availability when required. A shortage of equipment or parts in the pipeline system meant the potential failure of operational missions. Of course, managing supply levels of thousands of tons of parts, equipment, and supplies required outstanding clerical bookkeeping to ensure adequate stocks were always available. The officers at the Wright Development Center and their contracted experts at Battelle already realized there were fewer functions better suited for electronic data assistance than those of Supply, and soon the conversation extended well past these Ohio-based organizations.[296]

Over the next several years, the conversation about supply applications for computers began permeating strategic discussions across the military and industry. Between 1954 and 1956, reports by the National Bureau of Standards, the University of California, RAND, and the Massachusetts Institute of Technology theorized on the future of electronic data processing equipment and its application in inventory and production control.

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[296] Information on Base Supply from *James C. Rainey, Andrew W. Hunt, and Beth F. Scott, USAF Supply: Pride, Dedication, Professionalism* (Maxwell AFB, Gunter Annex: Logistics Management Agency, 2001).

Encapsulating a number of these discussions was a student paper published at Washington D.C.'s Industrial College of the Armed Forces (ICAF) in May 1956. Entitled "the Application of Electronic Data Processing Machines to Military Supply Systems," this paper written by United States Navy Commander Frank J. Roberts demonstrated how electronic data processing machines already performed numerous clerical-type functions with impressive speed and accuracy. He surmised that since military supply systems leaned heavily on clerical work, the use of computerized data processing would prove incredibly useful. Roberts concluded that although local supply offices had displayed impressive individual initiative in starting the automation of data, the major logistics line commands had not fully investigated the benefits of electronic data processing (EDP) in comparison to their minions at the station level. In fact, he believed those minions actually were proving the adaptability of military supply data processing through their daily experiences. In his summation, Commander Roberts recommended senior level officials of all military branches review the mass of data involved in logistics planning, both in peacetime and war, and recognize the “significant” potential of electronic data processing in the world of military supply.[297]

Commander Roberts’ study, however, was not the first to discuss the automation of logistics. Three years prior, and just months after cybernetics pioneer Norbert Wiener lectured at the college on “Automatic Control Techniques in Industry,” a committee of senior-ranking military students had developed their own study on the service-wide applications of cyber-oriented control. The committee documented how a “future in the centralized handling of military inventory control...seem[ed] almost limitless,” adding that supply calculations necessary for efficient operations “create a genuine demand for the utilization of electronic computers.”[298] By the mid-1950s there were in fact several studies of potential computer applications being conducted.

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[297] United States of America, Industrial College of the Armed Forces, *The Application of Electronic Data Processing Machines to Military Supply Systems*, by Frank J. Roberts (Washington: Industrial College of the Armed Forces, 1956).
[298] Industrial College of the Armed Forces, *Military Applications of Cybernetics*, by Frederic H. Miller (Washington: Industrial College of the Armed Forces, 1953), 5-12. Information regarding the U.S. Army’s automation conference is from the unpublished conference proceedings found at “Proceedings of U.S. Army’s Automatic Data Processing System (ADPS) Conference, 31 October - 1 November 1956,” 7-10.

The U.S. Army's automation conference in 1956 promoted the "adoption of an integrated Automatic Data Processing System" of which "logistical inventory control" and automated supply stockpiles would be key components.[299] In 1957, a Department of Defense logistics system study identified the need "to attain a maximum of automation in the processing of routine supply actions and attendant record-keeping at accountable or subordinate levels."[300] Even in industry, the call for EDP in logistics was growing too loud to ignore. In a 1957 "Automation in the Office" survey of nearly 4000 U.S. and Canadian companies, researchers showed inventory control systems were either present or planned in 98 percent of the companies staking their future in computers. Although scientific and engineering computing had existed for over a decade, the field of data automation was only now beginning to take hold – not least in relation to the supply functions of the U.S. military.[301]

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[299] "Proceedings of U.S. Army's Automatic Data Processing System (ADPS) Conference, 31 October - 1 November 1956," 7-10.

[300] *The Evaluation of Concepts for the Integration of the Military Supply Systems.* (Washington: Team 4, DOD Logistics Systems Study Project, 12 Dec 1957), 27.

[301] See Thomas Haigh, "The Chromium-Plated Tabulator: Institutionalizing an Electronic Revolution, 1954-

Supply was the first major Air Force organization to attempt full-scale data automation due, in part, to its previous automation efforts at base- and major command-level undertaken years earlier. Bases during the 1950s often operated using disparate computerized, manual and punched-card procedures that often varied between major commands, even stations. Such diverse electronic data processing efforts resulted in a disjointed Air Force supply environment – one that contained eleven different systems independently designed to meet the needs of their specific commands. Included in these distinct and disjointed environments were the training regimens of each major organization. With so many different systems in existence, supply airmen transferring to a new base often found their automation knowledge and skills virtually useless at their next assignment. Moreover, the proliferation of such nonstandard base supply systems, constructed with little or no oversight from the Pentagon, restricted higher headquarters' ability to establish any meaningful supply policy. It became obvious to Air Force leaders by the end of the decade that they had outgrown

1958," *IEEE Annals of The History of Computing* 23, no. 4 (2001), 75-104.

this system of outdated equipment and training incompatibility and that it required an immediate upgrade.[302]

The Air Force was not the only organization in need of systems enhancements by the early 1960s. Since both hardware and software capabilities had rapidly improved during the previous decade, the demand to upgrade entire systems had increased as well. In hardware, two major improvements marked the differences in systems design by the end of the 1950s: the transformation in circuit technology as transistors replaced vacuum tubes as the preferred computer processor; and the revolution in storage capabilities as memory progressed from large (and sometimes volatile) tube, mercury delay line, or rotating drum storage to a much smaller and expandable core memory system. In software, improvements in assemblers and compilers, data sorting algorithms, and programming languages such as FORTRAN and COBOL turned these boxes of circuits, tubes and wires into powerful data manipulation and storage devices. By 1961, researchers for the U.S. Army had documented these design system upgrades by categorizing over 220 unique systems at work throughout

[302] Riemondy, "Supply and Service—The Nucleus of Logistics."

industry, academia and the military/government complex. From major insurance and banking firms, to car and aircraft manufacturers, to science and technology laboratories across private and public institutions, leaders began integrating computer systems and their data automation capabilities into their operational landscape.[303]

Through the mid- to late-1950s, the size of the data processing industry continued to escalate. Companies that had made their fortunes earlier in the century producing cash registers, tabulating machines, and other electronic equipment invested in this latest trend with great enthusiasm. A review of the vendor list supporting Air Force systems is a glimpse of the industry's American computer leaders of the time. Corporations such as International Business Machines (IBM), Burroughs, UNIVAC-Remington Rand, National Cash Register (NCR), Radio Corporation of America (RCA), Elecom, and Bendix all supported more than one system in operation in the service. Much like those in industry and academia, a number of Air Force systems in the early 1960s required either retirement, replacement, or upgrade as older variants gave

[303] Paul E. Ceruzzi, *A History of Modern Computing* (London, England: MIT Press, 2003); Martin H. Weik, *A Third Survey of Domestic Electronic Digital Computing Systems.* (Aberdeen Proving Ground, MD: United States Army, 1961).

way to newer "second generation" technology. Service leaders understood this oversized legion of vendors and their myriad disparate and aging data processing systems posed a threat to a coordinated and integrated Air Force data processing future. Additionally, the methods the Air Force used to contact, review, and contract these vendors were themselves problematic as few commands possessed the same contracting standards and implementation guidelines. Controlling these problems quickly became a chief concern of senior service officers.[304]

The lack of computer system standardization and a systematic acquisition policy in the early 1960s became an Air Force-wide problem extending far beyond the sterile computing environments of the base data processing rooms. Operating independently of higher headquarters guidance, many of the unique major command and unit systems disregarded standardized Air Force operational procedures and policies. This caused significant conflicts in training, compatibility, and policy implementation issues at all levels across the service. The Air Force clearly required a much larger effort to rectify these issues

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[304] Much of this information derives from Weik's entire survey. However, see introduction and overview from Martin H. Weik, *A Third Survey of Domestic Electronic Digital Computing Systems*, 3-12.

across its organizations worldwide and understood that solving service-level automatic data processing (ADP) standardization and obsolescence issues required a significantly expensive and manpower intensive approach. Leaders in the Pentagon's Directorate of Data Automation and the Logistics Directorate began simultaneously advocating for an identical solution – a new era of service-wide automation and a large organizational user to lead the way. Both directorates looked to Base Supply to handle this task.[305]

The Birth of SBSS

The Air Force was similar to other services in that it did not launch headlong into a service-wide logistics automation program. In the years prior to this effort, the organization maintained a more ad-hoc version, the Electronic Inventory Control System, in order to increase responsiveness and inventory accuracy in the supply systems throughout the Commands. The air arm intended this

[305] Information from this paragraph is aided by Beth F. Scott et al., *The Logistics of War: A Historical Perspective* in 2000 (Maxwell-Gunter AFB: Air Force Logistics Management Agency, 2000). Organizational historians Scott, Rainey, and Hunt chronicle the logistics community through the past 50-plus years of service. The book, especially page 133, is especially helpful in discussing the conflicts in training, compatibility, and policy implementation.

program, under the authorization of Air Force Manual 67-1, to utilize EDP equipment systems for base inventory control, especially where they could accelerate responsiveness and improve the accuracy and timeliness of supply data. Such a system aimed to take data entries from base supply functions and transmit them to local management and to command/support channels. Program managers across the Air Force in turn maintained data link compatibility between other electronic base supply systems and transmission systems throughout the organization. The Air Force designed this initial inventory system to deliver important data such as consumption rates, supply requirements, transaction analysis, item location and expense distribution. The designers were also careful to ensure it tied in with other systems, such as the Comptroller's Financial Inventory Accounting System, in an attempt to integrate technological gains wherever possible. While not a final solution, the Electronic Inventory Control System provided a valuable springboard from which the Logistics community could broaden their data processing horizons.[306]

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[306] United States Air Force, Directorate of Data Automation, *United States Air Force Data Systems Automation Program, Sections I and II* (Washington: United States Air Force, 1963, 2-60 – 2-61.

Between 1962 and 1963, after years of studying, discussing, and prototyping supply control systems, the Air Force took a series of steps to establishing an official service-wide, stand-alone logistics automation program. The process began in 1962 when the yet unnamed program earned its official authorization from the Air Force Chief of Staff, General Curtis E. LeMay. It was October when the General, better known for his role in building Strategic Air Command (SAC), approved the concept of a standard supply system and authorized the base-level execution of automatic data processing management. LeMay was familiar with the benefits of data management having worked closely with future "Whiz Kid" and Secretary of Defense Robert S. McNamara during World War II, and appeared eager to incorporate its efficiencies in his organization. The data automation decision profoundly affected the service's organizational and operational future and eventually outlived even the once-mighty SAC.

Eight months after disseminating the General's decision, the Air Force published Special Order G-58 approving the formation of the Supply Systems Design Office, or SSDO, at Bolling Air Force Base in Washington, D.C. This new organization was comprised of personnel hailing from both headquarters and command units, and was formally charged to "develop and control a standard USAF base supply electronic data processing system."[307] The Directorate of Data Automation published their comprehensive Plan for Installation of EDPE in Selected Air Force Base Supply Activities in August that called for the installation of electronic data processing systems at selected Air Force Base Supply activities. These and other measures built enough momentum across the headquarters that the air arm created an official program to harness all the supply-oriented, data mechanization endeavors. This program was originally designated as the Standard Base Level Automated Inventory Control System, but as the systems' mission grew, the Air Force renamed it to better represent its larger purpose: the Standard Base Supply System.[308]

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[307] James E. Hogue, *Automated Logistics Information Systems: A Case Study* (Dayton, OH: Air Force Institute of Technology, 1992), 13.
[308] See Hogue, "Automated Logistics Information Systems: A Case Study;" and K. E. Codlin et al., *Implementation of the USAF Standard Base Supply System: A Quantitative Study.* (Ft. Belvoir: Defense Technical Information Center, 1968).

The Standard Base Supply System was a formal extension and standardization of various command systems falling within Supply's Electronic Inventory Control System with the eventual intention being to replace the latter entirely. The program's success relied on the purported "many proven benefits of automated inventory control" and the second- and third-order effects such automated inventory control created.[309] To homogenize the entire service supply system, program managers prepared to replace all individual Command computers, programs and external procedures with standardized versions to enforce a first-ever automated system at every Air Force location. To accomplish this required computers with a multitude of complex new capabilities: inputs receivable either at the computer or remotely; inputs processed through detailed edits and decisions for file/output determination; files maintained in storage for immediate access; and outputs that were distributed by on-line card punch or printers and generated for a wide variety of management products. Moreover, the task required the installation and operation of this complex system at more than 140 bases worldwide over the next three years. By May 1963, the deliberation

[309] United States of America, *United States Air Force Data Systems Automation Program, Sections I and II*, 1-22.

as to what this new system was supposed to do was over. It was time for the Air Force to find a vendor who could support these new SBSS ideals.[310]

The task of finding a vendor to handle such a program proved monumental for the Directorate of Data Automation. The Data Systems Coordination Division only finalized the method for evaluating such competitive computer proposals a few months prior in January 1963. Led by Colonel Kent Prim, the division published "Analytical Technique for Automatic Data Processing Equipment Acquisition" in order to facilitate competitive selection of EDPE regardless of the equipment's purpose. Following Colonel Prim's guidance, the division reported that twenty-three interested equipment vendors had received detailed systems specifications on the Air Force's future supply system in April 1963. Shortly thereafter, in mid-May, Air Force Systems Command's Electronic Systems Division hosted a vendors conference allowing interested contractors the opportunity for an in-depth review of SBSS specifications prior to the service's 19 July 1963 submission deadline.

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[310] See Codlin, *Implementation of the USAF Standard Base Supply System: A Quantitative Study*, v-vi, 1-10; and for an overview of previous systems, see Weik, *A Third Survey of Domestic Electronic Digital Computing Systems.*

The Directorate held the conference at Hanscom Field in Massachusetts and ensured vendors understood the magnitude of the system's set-up and operational requirements. Specifically, planners took care to ensure they paid special attention to the requirement for worldwide installation of approximately 152 computers at the rate of ten per month. Between July and September, the Air Force's System Source Selection Board arduously evaluated the submissions from a number of potential vendors. When Secretary of the Air Force Eugene M. Zuckert approved the Selection Board's recommendation on 4 November 1963, the announcement signified the organization's automation system choice to take Supply, and its hundreds of thousands of customers, into the next technological era. Zuckert, perhaps best known in military history as the initiator of the Air Force-wide "Project Forecast" future technology study series, appeared to be the perfect person to announce which system would lead the department into an automation future. That system was the Sperry Rand UNIVAC 1050-II.[311]

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[311] See United States Air Force, *Historical Summary, Directorate of Data Automation, 1 Jan - 30 June 1963* (Washington: United States Air Force, 1963), 32-33; and United States Air Force, *Historical Summary, Directorate of Data Automation, 1 Jul – 31 Dec 1963* (Washington: United States Air Force, 1964), 12. Also see Codlin, *Implementation of the USAF Standard Base Supply System: A Quantitative Study*, 1; Robert C. Neibling, *A*

The Air Force's order for the UNIVAC 1050 Model II was unprecedented in Defense Department computer system acquisition. According to a 1964 *New York Times* article on Sperry Rand, the Supply System's Design Office's order of more than 150 complete computer systems represented "the largest military order ever signed."[312] The Model II was an Air Force-specific, augmented version of the standard UNIVAC 1050 sent into industry. This UNIVAC was a second-generation computer system containing extra peripherals and real-time memory storage/access units in an effort to provide Air Force bases and their smaller supply satellite installations with the latest in data processing capability. The computer provided "real-time processing" according to the *Times*, meaning instant system updating with each stored supply transaction to ensure information stayed current. Its modular, or "building-block," design allowed capacity expansion or reduction dependent on the required workload and was the first in the Department of

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Narrative History of the USAF Standard Base Level Supply ADP Program, Unpublished Historical Report (1963), 1-20; Jacob Neufeld*, Bernard A. Schriever: Challenging the Unknown* (Washington: Office of Air Force History, 2005), 20-25.

[312] Gene Smith, "Past and Present Officials Deny Wall St. Rumor of Univac Woes," *The New York Times*, August 27, 1964, 45.

Defense to offer "direct and immediate customer access to the computer" by way of remote input/output devices.[313] To those involved, the 1050-II appeared as a true revolutionary device in the burgeoning automation age.

However, a glaring programmatic issue with the UNIVAC was its labor requirements. Sperry Rand estimated the system required a crew of 27 individuals to operate the computer around–the–clock in jobs ranging from supervisor to librarian. Therefore, while the Air Force looked to SBSS as a means of saving money through technology, the service faced the reality of adding and justifying nearly 4000 more computer personnel to its roster. The original plans called for reutilizing many personnel from previous EDP-related positions but it still remained the SSDO's responsibility to prove that the benefits of higher-level automation far outweighed any additional personnel costs. These were not unusual for computer transitions during this period but such Air Force costs were growing given the size of the program and its personnel load.[314]

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[313] *Ibid.*

[314] See "Univac 1050," Computer History Archives Project, accessed March 3, 2012, http://sites.google.com/site/computerhistoryarchivesproject/1/univac-1050; Quotes and statistics from The quote regarding "direct and immediate customer access to the

Like nearly all Air Force acquisition projects, funding such an epic venture was possible only if the return on investment appeared both reasonable and tangible. Making a case for such a massive allocation of resources required a considerable return on the government's investment, especially one renowned for its size and scope. To emphasize the system's benefits, the program management office established project goals that were straightforward and covered everything from fiscal, operational, and training objectives:

- Reduce overall costs, including manpower requirements, and eliminate duplicate programming efforts in the various commands.
- Decrease response time and increase asset control in base level supply operations.
- Facilitate implementation of Air Force base level supply policies.
- Eliminate the need for each command to design, justify, select, program, implement and control its own base level supply EDPS.
- Permit Air Training Command to train supply personnel, thus establishing a uniform training program allowing inter-command transfers without retraining (ensuring personnel were immediately useful at any base).

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computer" comes directly from Riemondy, *Supply and Service—The Nucleus of Logistics.* For additional information on Univac 1050-II progress, see Martin H. Weik, *A Fourth Survey of Domestic Electronic Digital Computing Systems* (Aberdeen Proving Ground, MD: Ballistic Research Laboratories, 1964), 280-284.

- Permit the compilation of standard management data regarding base level supply operations.[315]

Additionally, the Air Force also believed the system could promote better interaction among Air Force Logistics Command depots and the Major Commands, which was a much-needed improvement over the individualistic operations of the past. By eliminating duplicate operational and programming efforts across various commands and units, the service planned to use Supply as a test bed for a number of other mission activities. If the Air Force could save the Defense Department time, money, and effort using service-wide EDP equipment, the Standard Base Supply System developers had to prove it.[316]

That job fell primarily to Brigadier General Louis Grossmith. Grossmith was the Director of the Data Automation Directorate and oversaw both vendor selection and base installation preparation. The general was neither a supply guru nor a computer expert. He was instead a pilot-turned-comptroller who had earned his first star only

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[315] See United States of America, United States Air Force, Directorate of Data Automation, *United States Air Force Data Systems Automation Program, Sections I and II* (Washington: United States Air Force, 1963).

[316] United States of America, *United States Air Force Data Systems Automation Program, Sections I and II*.

months prior to entering his position in 1962. He was, however, the Directorate's inaugural leader and spearheaded the organization's transition after the Air Force moved data automation responsibilities into the unit. An experienced pilot and staff officer, he was ultimately responsible for translating the benefits of the SBSS to those in the service – especially aviators – who knew or understood little about the benefits of data automation. Producing guidance for his fellow commanders on upcoming computer-project implementation and training schedules was not the glamorous role many senior pilots saw themselves in late in their careers, but such was the life of a senior staff officer in the Pentagon.[317]

General Grossmith's guidance, including the unit's "Plan for Installation of EDPE in Selected Air Force Base Supply Activities," reached far beyond the Washington beltway and was distributed to all participating service Commands. The general and his staff acted quickly after Zuckert's system selection, especially as the contract programmed computer system installations to begin as early as September 1964. Headquarters personnel quickly warned

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[317] United States Air Force, *Historical Summary, Directorate of Data Automation, 1 Jan - 30 June 1963* (Washington: United States Air Force, 1963), 1-32.

units of the preparation time and parameter requirements as they simultaneously took major steps to ensure the Pentagon met all of its own responsibilities. For example, in addition to the SSDO, the Air Force formed a "Central Development Group" at Bolling AFB responsible for the systems design, programming, testing and debugging of the new supply system in the latter months of 1963. Moreover, to ensure the test base was close to the Directorate's Pentagon location, the Air Force chose Maryland's Andrews AFB as its initial site for the first operational SBSS computer. Finally, just days before Christmas of 1963, the Directorate completed all initial training of programmers and systems personnel. By year's end and after a tremendous amount of program actions on the part of Grossmith and his staff, the Air Force was officially ready to embark on its first service-wide, base-level EDPE system.[318]

The Implementation of the SBSS

As the Air Force ushered in the New Year, it subsequently kicked off its newest era of data automation – that of a standardized, service-wide system built on new

[318] *Ibid.*

technology and the backing of service leadership. In February 1964, the Air Force and Sperry Rand installed the first 1050-II computers at two locations, Bolling AFB in Washington, D.C. for program testing and at Sheppard AFB in Texas for a training center. By May, they had installed two additional systems, the first at Texas' Amarillo AFB in its own training center and at Maryland's Andrews AFB as an operational test location. Early on, leadership remained positive about the aggressive implementation schedule following "no significant problems" during installations at Bolling and Amarillo.[319] However, by the time Major General Elbert Helton took over as the Director of Data Automation in July 1964, a more guarded attitude prevailed across the program. Managers began cautiously holding in abeyance all additional base installations remaining for that year pending the completion of program development and operational evaluations at the Andrews site. Adding to the caution were configuration changes, such as the addition of magnetic tape recovery units, which forced planners to alter pre-established system structures and personnel training as test sites simultaneously underwent their

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[319] United States Air Force, *Historical Summary, Directorate of Data Automation, 1 Jan - 30 June 1964* (Washington: United States Air Force, 1964), 42.

evaluations. Making matters worse were site survey visits like one at Holloman AFB in Nevada that revealed not all sites were ready for an immediate computer install. In short, there was still much to do in preparing Air Force bases and their personnel for this system. For Sperry Rand, matters went from bad to worse as the Air Force reduced its order quantity from 154 systems to 141 due to service-wide base realignments and closures. As 1964 came to a close, the program management of SBSS was more important than ever, and the weight of such importance fell squarely on the shoulders of General Helton and his staff.[320]

Although the operational tests at Andrews eventually worked to the Department's satisfaction, the need for program improvement was everywhere. Halfway through 1965, the Air Force and UNIVAC officials remained well behind previous installation projections laid out by the SSDO and implementation staff. Only sixteen of the originally estimated 100 1050-IIs had made it onto their sites by mid-year. Worse yet, while these sixteen units stayed busy facilitating conversions and operator training, only two were actually fully operational, putting the Air Force

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320 *Ibid*, 42, 92.

nearly a year behind its original schedule. All of this occurred as the Data Automation Directorate underwent yet another leadership change that spring. After just a single year at the helm of Air Force data automation, General Helton left to be the logistics (J-4) director at Headquarters U.S. European Command in Paris, France. While Helton's brief tenure was not unusual for well-regarded aviators, it was an extremely unfortunate move given the state of the SBSS project. Moreover, the Air Force's choice of replacement – a Colonel – gives some insight into the decreasing prestige such a position had in the service at the time.[321]

Although changing leadership was a frequent occurrence at Headquarters, doing so with a significant rank reduction in the middle of programmatic issues was certainly problematic in the competitive halls of the Pentagon. Undaunted, Colonel William Pratt and his new staff went to work immediately to correct the "numerous difficulties" faced throughout the Directorate's multiple divisions and branches. Pratt and the Data Automation Directorate fought

321 United States Air Force, *Historical Summary, Directorate of Data Automation, 1 Jan – 30 Jun 1965* (Washington: United States Air Force, 1965), 52; United States Air Force, *Historical Summary, Directorate of Data Automation, 1 Jul – 31 Dec 1963*, 12.

hard to stay focused as Air Force organizations continued to inundate the unit with even more grandiose automation plans that called for replacing all Air Force punched card machines, standardizing all non-Supply data systems, and upgrading existing major command systems. In addition, a joint headquarters and major command evaluation team was about to complete a milestone assessment of the program as a whole. If SBSS was to remain a beacon of hope for Air Force automation, the Director understood that making significant progress over the next several quarters was vital.[322]

That spring, the joint evaluation team completed their assessment of the SBSS and recommended the system was finally ready for implementation . . . once the Air Force and the UNIVAC team agreed to specific improvements. Pratt and his unit ensured that more than 50 bases received their UNIVAC configurations with 31 of them reaching full implementation status by the end of December. During the Colonel's tenure, the system underwent considerable optimization with more deliveries projected for the upcoming year. Significant workload increases at a number of bases additionally raised the amount of system equipment

[322] United States Air Force, *Historical Summary, Directorate of Data Automation, 1 Jan – 30 Jun 1965*, 12.

configurations to five (up from three in the original equipment approval) to better facilitate site requirements. The rebirth of the program over the last half of 1965 impressed Pratt's Equipment Review Branch enough for it to theorize that all bases could complete their SBSS conversion before the end of 1966. This was made even more realistic by the Air Force once again reducing the number of required installations to 132 due to additional base closures and mission changes.[323] The Air Force, of course, had bigger and faster-growing concerns. The escalating war in Vietnam and an increase in even loftier data programs had Directorate planners readjusting their SBSS expectations, especially since they knew it was responsible for only a portion of the service's mounting automation issues.[324]

The Vietnam War added a new priority level as logistics requirements picked up overseas. The escalation in Vietnam in the mid-1960s required the Air Force to build up additional bases overseas, both in-theater and at

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[323] There were 154 originally allocated in the Univac contract.

[324] United States Air Force, *Historical Summary, Directorate of Data Automation*, *1 Jan - 30 June 1965;* United States Air Force, *Historical Summary, Directorate of Data Automation, 1 Jul – 31 Dec 1965* (Washington: United States Air Force, 1966).

supporting locations. Therefore, by the end of 1966, planners began adding additional systems to the contract and thereby returning installation figures to near-original projections of 148 systems. The major issue with Sperry's UNIVAC and the SBSS was nonetheless the excessive downtime involved in both installation and (computer) operation that was causing unsatisfactory systems performance and a significant modification of the remaining installation schedule. Only 126 systems actually met the end-of-year deadline. To rectify the slowdown, the Air Force scheduled the installation of the remaining 19 systems for 1967, but at half the originally projected monthly installation rate in light of ongoing issues. There was still much work to be done by the Directorate in order to put the program back on track. Doing so required a substantial effort from not only the Pentagon staff, but also the UNIVAC program office, the SSBO, and SSBS sites around the world.[325]

The extra work began immediately and continued throughout 1967. First, additional challenges with computer maintenance procedures, especially the 1050-II

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[325] United States Air Force, *Historical Summary, Directorate of Data Automation, 1 Jan - 30 June 1966* (Washington: United States Air Force, 1966); United States Air Force, *Historical Summary, Directorate of Data Automation, 1 Jul - 30 Dec 1966* (Washington: United States Air Force, 1967), 47, 66.

systems installed in Southeast Asia, forced the Directorate's Plans, Policy, and Technology Division and Sperry Rand to hold monthly meetings throughout the year to work on improvements. These maintenance issues necessitated the creation of traveling military computer maintenance personnel teams to service SBSS systems worldwide, especially in Southeast Asia. Next, when a fire in the UNIVAC installation at Westover AFB caused severe damage to the central processor, installation experts used the experience to highlight the need to review requirements for proper housing facilities and personnel training. Finally, as dictated in the acquisition specifications, the UNIVAC configurations accommodated the many smaller supply accounts not connected to a base system by connecting these accounts to a host 1050-II using a separate communications link. Between 1966 and 1968, the Air Force and Sperry Rand spent a tremendous amount of effort trying to improve the SBSS systems instead of merely trying to fix individual issues. Given the frequency of technological changes, implementation sites, and the war in Vietnam, nearly everything the Air Force could do to stay ahead was a positive step in the future of SBSS.[326]

[326] Primary source information derives from United States Air Force, *Historical Summary, Directorate of Data*

Between October 1967 and February 1968, two major incidents highlighted both the significance of the SBSS and the unity of the teams operating and maintaining it. First, as previously mentioned, a fire in the central processor at Westover AFB that October destroyed the base's UNIVAC 1050-II. The base, located just outside of Springfield, Massachusetts, was the center of numerous missions critical to both the Cold War and the war in Vietnam. One of Westover's major missions was to operate and support the 99th Bombardment Wing (Heavy), home to the B-52D Stratofortress bomber, the KC-135 Stratotanker air refueler, and the EC-135 Looking Glass Post-Attack Command Control System aircraft. With flying squadrons, maintenance squadrons, and a whole host of support units (civil engineering, communications, security forces, etc.), the need for rapid and ever-present control over the supply system was crucial. Hence, when the fire erupted in the data processing building on 25 October, individuals from

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Automation, 1 Jan - 30 June 1967 (Washington: United States Air Force, 1967), 55; and United States Air Force, *Historical Summary, Directorate of Data Automation, 1 Jan - 30 June 1968* (Washington: United States Air Force, 1968), 51-53. Additionally, clarification on the remote linking of supply accounts is from an email interview on 1 May 12 with Robert C. Neibling to clarify Neibling, *A Narrative History of the USAF Standard Base Level Supply ADP Program*, 1-12.

the Pentagon's Directorate of Data Automation (Program Management Division) and the Sperry Rand UNIVAC Division got to work within hours to replace the damaged components. Miraculously, in just over two weeks' time, Air Force and contracted professionals received, readied, and made operational a replacement UNIVAC system at the base. An investigation into the fire's causes reported there were no indications of any faulty environmental conditions, misuse, inexperienced personnel, accidental discharge, or neglect. Therefore, both the rapid operational return of the UNIVAC system and an error-free accident report proved all the training and effort at Westover was extraordinarily effective. To the Air Force, Westover became an example of what could go right even when something went horribly wrong.[327]

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[327] See United States Air Force, *Historical Summary, Directorate of Data Automation, 1 July – 31 December 1967* (Washington: United States Air Force, 1968), 50-56; and United States Air Force, *Historical Summary, Directorate of Data Automation, 1 Jan - 30 June 1968* (Washington: United States Air Force, 1968), 24. The Westover Air Force Base History website was also helpful (see "Westover Air Force Base History," Westover Air Force Base History, accessed April 16, 2012, http://www.westoverafbhistory.com/). Finally, oral history interviews with Bill Stevenson and Robert Neibling in February and March, 2012 were especially helpful in filling in data points, especially given their experience with SBSS in the 1950s and 60s.

The second incident occurred thousands of miles in South Vietnam on a Saturday morning in early February 1968. With the Tet Offensive well underway, base personnel at Da Nang Air Base, South Vietnam watched in horror as their former safe haven far from the front lines became a battleground for North Vietnamese insurgents. Personnel and equipment casualties, uncommon for a base so far south, instantly spiked as 27 Viet Cong mortar shells exploded across the base. Moments later, the warehouse housing approximately 16,000 items of armament and electronics supplies for F-4 Phantom aircraft was gone and with it, the base's SBSS UNIVAC computer system and the capability of supporting Da Nang's strike aircraft. Of all the training scenarios developed by the Data Automation Directorate, this was among the most catastrophic imaginable. Pentagon leaders had only hours to prove that all the system training and redundancy was worth the effort.[328]

Just a few hours after the attack, the Directorate got its opportunity. By midday, thanks to a pre-attack transmission by the 1050-II in Da Nang, another SBSS system began a selective readout of every equipment item lost to

[328] John C. Ford and Howard E. Wilson, "UNIVAC's Role in the Pacific: Autodin and Base Level Supply Systems," *Signal Magazine*, 1970, 25-26.

mortar fire. Simultaneously, Supply officials at Headquarters 7th Air Force in Saigon, Headquarters Pacific Air Forces in Hawaii and Headquarters Air Force Logistics Command at Wright-Patterson Air Force Base in Ohio laid the foundation to establish replacement materiel to support the base at Da Nang. Just five days later, 78 percent of all stock requisitions were entering the supply receiving line in South Vietnam, which would have been an absolute impossibility had it not been for the up-channeled supply information sent from base–to–base by the SBSS UNIVACs. After the case in Westover displayed the level of Air Force disaster preparation, the case in Vietnam confirmed that the rapid recovery had been no fluke. The Air Force showed it had implemented a system with both operational and contingency conditions in mind. Moreover, it proved that the SBSS worked as advertised as a central repository for supply data.[329]

By the end of 1968, the implementation of the Standard Base Supply System had essentially reached its initial completion point. The Air Force and the UNIVAC team completed their 167th 1050 Model II installation that December and had installed machines at a total of 144 bases

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[329] Ford and Wilson, "UNIVAC's Role in the Pacific: Autodin and Base Level Supply Systems," 25-26.

across the air arm, including 20 in the Southeast Asia region – overall, an unprecedented feat in data automation to date. Despite delays, computer downtime, and larger-than-expected account sizes, more than four years of base implementation experience helped reduce the average installation time by approximately 60% compared to original estimates. In addition to the 167 computer installs, the Directorate brought on 45 additional "satellite" sites where supply accounts were too small to earn a full-scale installation. Seven years after General LeMay approved the standard supply system concept, SBSS had finally reached fruition. The Air Force quickly reaped the benefits of data automation and its applicability to nearly all Service operations.[330]

Aftermath

In his 1970 article "The Logistics Challenge of the Seventies" for the *Air University Review*, former bomber pilot and sitting Deputy Chief of Staff for Systems and

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[330] Final tallies of total systems and bases derives from United States Air Force, *Historical Summary, Directorate of Data Automation, 1 Jul – 31 Dec 1968* (Washington: United States Air Force, 1969), 74-76. Average installation time quote is Codlin et al., *Implementation of the USAF Standard Base Supply System: A Quantitative Study*, 31. Satellite base information derives from Riemondy, "Supply and Service—The Nucleus of Logistics."

Logistics Lieutenant General Harry E. Goldsworthy touted the impact of the computer on Air Force operations as well as the "revolution in automatic data processing." Goldsworthy praised the "marked improvement in resource accounting and control, in accuracy and speed of reporting, and in improved logistics reaction time" thanks to the SBSS and the UNIVAC 1050-II computer.[331] The General gave credit to the system for delivering on its promise: giving the Air Force its first real-time requisitioning and inventory status capabilities. However, he went much further by elaborating on how the Directorate's insistence of standardizing computer hardware, data systems, and supply procedures resulted in significant improvements in inventory reduction, customer support, and manpower reduction efforts. In fact, he strongly emphasized the improvement to the logistics system in general. These second- and third-order effects made the SBSS not only successful in achieving officially projected intentions, but also in achieving the outcomes promised by the data automation community as a whole. Fortunately, General

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[331] Harry E. Goldsworthy, Lieutenant General, "The Logistics Challenge of the Seventies," *Air University Review*, July/August 1970, accessed January 12, 2012, http://www.airpower.au.af.mil/airchronicles/aureview/1970/jul-aug/goldsworthy.html

Goldsworthy was not alone in comprehending the benefits of the system and the precedent it created.[332]

In 1970, after the full integration of all satellite bases and several years of operation at the main bases, the Air Force began to review the post-implementation effects of the Standard Base Supply System. After all, feedback from the SBSS experience would prove critical if the Air Force wanted to further standardize data automation systems throughout the service. In summarizing his experience with SBSS, Brigadier General A. A. Riemondy highlighted the major advantages earned by the system's implementation:

- *The power of centralized development:* Having the ability to make a single program modification and having it immediately impact every location in the system. The Air Force, and the Logistics community especially, benefited greatly from their control over system design, implementation, and operation.

- *The benefit of having a single, standardized supply organization:* In the early 1960s, the supply data systems were as diverse as the major commands they served. With SBSS, there was now an Air Force standard for operations, system products, forms, and training at all bases.

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[332] In the July-August 1970 edition of the *Air University Review*, several Air Force logistics leaders came online to publish their thoughts on the advances in their field and, in many cases, to praise the impact of data automation. In this instance, Lieutenant General Harry E. Goldsworthy's article "The Logistics Challenge of the Seventies" covers the senior officer's perspective on the future of logistics systems and, specifically for this article, the impact of the SBSS. See Goldsworthy, "The Logistics Challenge of the Seventies."

- *The profits of efficiency:* From Supply's first conversion from manual to "interim" computers in 1957, the automation of data systems consistently paid manpower dividends. That first conversion allowed Supply to alter their own unit manning documents and eliminate nearly 2500 manpower spaces. When the SBSS program began acquiring the UNIVAC 1050-II system, Headquarters cut another 862 base supply personnel. After another cut of 290 billets thanks to system improvement, the benefits of having a standardized supply organization blossomed once again. This time, such an organizational move allowed the reengineering of manning standards for 39 base work centers and resulted in an Air Force-wide elimination of another 3020 positions.

- *The effectiveness of unified training:* As SBSS came online, the need for separate and distinct training courses quickly vanished. This allowed Air Training Command (ATC) to develop a more effective instruction model for the Service. SBSS allowed ATC to completely assume total system training responsibility. As such, by 1970, 38,000 of the Air Force's 49,000 supply personnel received formal training in the Standard Base Level System…a feat unheard of just seven years prior. [333]

General Riemondy's comments added significant depth to those of Goldsworthy, leaving the Air Force tremendously optimistic about data automation's future in the air arm. While the SBSS was not the perfect system and significant issues were omitted from Air Force leader evaluations, the impact of this first service-wide automation system was undeniable across the organization.

[333] Riemondy, "Supply and Service—The Nucleus of logistics."

In retrospect, General Lemay's original 1962 decision to update and standardize Air Force data automation proved even more monumental than anticipated. The general's edict acted as the catalyst for SBSS and spawned dozens of major and minor data automation programs that completely changed service operations. In fact, managing the addition of data processing systems (including several in logistics automation) became one of the primary concerns of the Directorate of Data Automation in the latter half of the 1960s. Much of this was a function of two additional major data automation programs pursued in the Air Force at that time, Phase II and Phase III. Phase II was the Air Force program to automate as many non-Supply functions as possible while Phase III focused on automating systems above base-level (i.e. major air command, higher headquarters). The intent was to use SBSS, now also known as Phase I, as a springboard for further data automation efforts. As an element of these programs, the Air Force automated specific components of base maintenance, transportation, and procurement in an effort to eliminate the routine and tedious functions performed by thousands of clerical and technical personnel. However, the continuous rise in data automation requests ensured Air Force leaders understood this was not a permanent, long-term solution.

From 1968 until 1975, the service grappled with new ideas and directions in an effort to solve the data automation issue once and for all.[334]

After numerous programmatic iterations, the final answer came in April 1976 when the Air Force officially eliminated all individual automation efforts and christened one single program to govern all data processing in the Air Force. It was known to some as the Base-Level Computer Modernization Program. Program managers simply knew it as Phase IV.[335] Phase IV established a single data processing center at each major Air Force location and would eventually lead the way for both "regionalized" processing (data centered at a regional, or command-centered, location), followed by centralized processing (data centered at a single Air Force location) in the age of the Internet. Francis Hughes, Assistant Secretary of the Air Force for Financial Management, summarized the direction

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334 See United States Air Force, STALOG Study Group, *A Study of the Automation of the Logistics System at Base Level (STALOG), Volume I*, 1-2. The critical line in this paragraph is in understanding that the "evolution of all logistics automation did not wait until [SBSS] completion before moving forward."

335 Data derived from official Air Force historical summaries of the Directorate of Data Automation from 1968-1973 and Goldsworthy, "The Logistics Challenge of the Seventies."

for Phase IV by saying, "[t]he most appropriate solution to these problems (equipment age, increasing cost of existing systems, and the forecasted growth of the standard base supply system)--and the policy of this office--is replacement of base level computers with equipment from a single vendor."[336] With Phase IV, the Air Force achieved yet another milestone in their "information age," all made possible through the efforts of the data automators and logistician pioneers who had helped develop the SBSS decades earlier.[337]

Reviewing the history of logistics-centered data automation helps illuminate how United States Air Force leaders thought about the future performance of their organizational functions, especially given the success of Base Supply automation in the 1960s. Nearly two decades after the Supply automation conversation began in earnest, the addition of automatic data processing functions to base-level logistics operations was universal. This soon became the catalyst for even larger programs and projects

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336 The quote itself is from the official memorandum: "Base Level ADP Program," ASECAF/FM to AF/CVA, July 30, 1976.

337 Hughes' intentions are referenced in United States Air Force, *Historical Summary, Directorate of Data Automation, 1 Jul – 31 Dec 1976* (Washington: United States Air Force, 1977), 14.

that led to the Phase IV initiative and the automation phases that preceded it. Were it not for the dialogue and experimentation of the 1950s and the early automation programs in the 1960s it is quite likely the history of Air Force data automation would look considerably different today. Thanks to the achievements of dozens of logistician visionaries, paired with their partners in the Air Force Comptroller's Directorate of Data Automation (and its organizational predecessors), it is difficult to conceive an Air Force data automation environment in the 1980s and 1990s without the innovations of the Standard Base Supply System.

In the end, the deceptively obvious decision to choose Supply as the test bed for service-wide automation turned out to be an incredibly intelligent selection. As a system, it delivered data automation for requirements computation, inventory control, fund control, requisitioning, issuing, receiving, and records maintenance for an entire Air Force. The SBSS proved once and for all that data automation, despite its large initial expenditure of money, manpower, and time, could save the Air Force valuable resources in the long run. The Air Force, as General Goldsworthy claimed, definitely took advantage of the automatic data processing revolution…and it was the Standard Base Supply System that led the way.[338]

[338] Many sources list the total billets saved by SBSS. Although the number often varies between 4,000 and 4,200, the variation does not change the overall impact whatsoever. See Kenneth B. Heitkamp, *Air Force Base-Level Information Systems* (Maxwell AFB, AL: Air University, 1987); and Goldsworthy, "The Logistics Challenge of the Seventies."

Conclusion

This dissertation has examined service information operations dating back to the Civil War and continuing well into the 1960s and Vietnam. It reveals that while the USAF did not exist independently until 1947, it inherited an emerging culture of information dependence formed through a series of methodological and technological advances. These advances grew out of initiatives most often generated from the ground-up – at the individual and unit level – and helped develop the service's information environment for what became the most information-dominant organization in the federal government. This dissertation also illustrates the extent to which Air Force information developed in the context of particular periods rather than as part of a monolithic "Information Age".[339]

It thereby challenges service perceptions that have prevailed for decades. At the same time it makes clear the

[339] This theory derives from Hobart and Schiffman's work regarding multiple information ages. However, the theory and its relationship to this argument is better found in Cox's analysis of Hobart and Schiffman's theory and its application. See Richard J. Cox, "The Information Age and History: Looking Backward to See Us," accessed March 03, 2013, http://d-scholarship.pitt.edu/2698/1/ r_cox_1.html.

extent to which the service and its predecessors grew increasingly reliant on access to statistical information.

Such dependence began building in earnest as far back as the Civil War. By the time the war ended, the average Union Army field commander had grown accustomed to an operating environment that included more access to, and requirements for, operational and intelligence information than ever before. Thanks to the creation of the Signal Corps, the Military Telegraph Corps, and the Government Printing Office (all organizations founded on growing information requirements), information transmission and reproduction capabilities became greater than in any previous conflict. The next half-century witnessed further service developments shaped by three factors: a reluctance to appear retrograde in information capability, a drive to improve on existing information standards, and a budding interest in the information technology of the private sector. The regulatory and technological improvements in this fifty-year period suggest an Army coming to understand its information needs and exploring new solutions to improve the service information environment. Therefore, by the time the Army established the Aeronautical Division in 1907, information was already a critical aspect of unit operations.

The four decades that preceded Air Force independence in 1947 witnessed the emergence of air-specific information needs. While the Army sought to improve its data management methods and technologies, airmen separately looked for ways to modify such tools to best suit the aeronautical environment. The period prior to and during World War I became a catalyst for such modifications, especially as the air arm came into its own as a formidable military entity. Information became an important commodity as personnel, equipment, and maintenance needs ballooned in the context of the service's sudden exponential growth. The later interwar manual- and punched-card accountability systems were indicative of the increasing demand for data and the unique purposes for which it was used. By the time World War II began, the Army and its air forces became so reliant on information for operational sustainment and decision-making that internal units (MRUs and SCUs) were created which were specially designed to collect, exploit, and transmit data throughout the entire service. Information was now not only an aspect of mission capability; it was essential to it. The formation and proliferation of statistical control in the Army Air Service is indicative of a service wholly dependent on information to accomplish its mission.

By the time the Air Force gained its independence following the war, it was an organization with decades of experience with aeronautical and logistical information requirements that had themselves emerged from the Army's general operational and administrative data environment. The subsequent rise of computers became the focus of a number of projects and programs designed to improve service decision-making and administrative statistical control. Finally, as the air arm launched its first service-wide data processing system in the 1960s, the organization became inextricably tied to the systemic electronic collection, exploitation, and distribution of huge quantities of information for its everyday activities. This was a significant achievement: but this new "information age" was in key respects the latest iteration of a process, or series of "information ages", that had been underway for a hundred years.

This process, however, is not a simple matter of technological determinism; of one clearly delineated age – that of the bound ledger, mechanical device, and automated system – succeeding another. As the preceding chapters have shown, there was rarely an instance where one way of doing things was suddenly and universally replaced by another via command fiat. Change occurred more commonly as the result of limited and often localized initiatives, some of which were deemed failures and not pursued further by those in overall charge. In the latter part of the nineteenth century unit- or base-specific initiatives produced local variations on standard practice. In the first half of the twentieth century, to be sure, overall and urgent necessity in the form massive wartime service expansion forced more widespread and top-down change in the way information was gathered, processed, and used. Even then, however, a new age did not dawn at the single stroke of a pen in Washington in either 1917 or 1941. As for the decades after World War II, it was the actions of certain key individuals that determined how the Air Force would react and adapt its information environment to the computer. Even SBSS, as the final chapter shows, had a far from straightforward, top-down development history.

The tendency in certain circles to imply that Air Force information operations arrived along with the term "cyberspace" in the early twenty-first century, or perhaps with the flowering of the internet in the 1990s, or – for those with a sense of history – the adoption of computers after World War II, is misleading.[340] The amassing,

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[340] See "Letter to Airmen", Secretary of the Air Force Michael Wynne and Chief of Staff General T. Michael

processing, interpretation, and utilization of large quantities of data by the military have a background in relation to the air service in its various early guises that predates both the computer and the formation of the US Air Force. Moreover, though intertwined with the emergence and development of new technologies, that history was not simply driven by an unspoken and universally accepted assumption by those in uniform that "new" automatically denoted "better" and therefore required universal adoption by the service. The actions and initiative of groups and individuals – not always those close to the seats of power – in combination with external events, were what defined perceived needs and the means of meeting them that were (or were not) adopted at least until the 1960s. The informational "Wild New Yonder" of today, therefore, has a long and often far from simple history behind it.

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Moseley, 7 December 2005; Cox, "The Information Age and History: Looking Backward to See Us"; Gordon T. Gould, Jr., Computers and Communications in the Information Age", *Air University Review* (1970).

Works Cited

Acomb, Frances. *Statistical Control in the Army Air Forces, Air Historical Studies: No. 57*. Washington: USAF Historical Division, Air University, 1952.

An Act Establishing Rules and Articles for the Government of the Armies of the United States: With the Regulations of the War Department Respecting the Same, to Which Are Added, the Several Laws Relative to the Army, the Militia When in Actual Service, Volunteers, Rangers, Ordnance Department, and the Quarter Master's and Commissary General's Department. Albany: Websters & Skinners, 1812.

"Air Force Careers." Cyberspace Operation Officer. Accessed July 03, 2013. http://www.airforce.com/careers/detail/cyberspace-operation-officer/.

"Air Force History Overview." Air Force History Fact Sheet. Accessed March 1, 2013. http://www.af.mil/information/heritage/ overview.asp.

"Air Force Materiel Command Fact Sheet." Air Force Materiel Command. Accessed December 12, 2012. http://www.afmc.af.mil/main/welcome.asp.

"Air Force Space Command." U.S. Air Force Fact Sheet. Accessed July 1, 2013. http://www.af.mil/information/factsheets/factsheet.asp?id=155.

Air Force Systems Command. *Data Systems Automation Program: Sections 1 and 2*. Andrews AFB, MD: Air Force Systems Command, 1963.

American Military History. Washington: Center of Military History, United States Army, 1989.

Annual Report of the Chief of Engineers to the Secretary of War upon the Improvement of Cumberland River, *Tennessee and Kentucky, and of Obion and Forked Deer Rivers, Tennessee.* Washington, D.C.: S.n., 1896.

Annual Report of the Chief of Engineers, United States Army, to the Secretary of War for the Year 1894, Part IV, 53d Congress, 3d Session. House of Representatives. Vol. II. Washington: Government Printing Office, 1894.

Annual Report of the Chief Signal Officer of the Army to the Secretary of War for the Year 1889. Washington: Government Printing Office, 1890.

Annual Report of the Chief Signal-Officer to the Secretary of War. Washington: Government Printing Office, 1873.

Annual Report of the Secretary of War 1913. Washington: Government Printing Office, 1914.

Annual Report of the Secretary of War. Washington: Government Printing Office, 1881.

Annual Report of the Surgeon General, United States Army, to the Secretary of War. Washington: Surgeon General's Office, 1899.

Annual Reports of the War Department, 1899. Vol. 1. Series 3. Washington: Government Printing Office, 1899.

Annual Reports of the War Department. Washington: Government Printing Office, 1885.

Armstrong, Lancelot W. Proceedings of UNIVAC Conference, May 17-18, 1990, Smithsonian Institution, Washington. Washington: Smithsonian Institution Archives, 1990.

Army Air Forces Statistical Digest World War II. Washington: Office of Statistical Control, 1945.

Army Circular No. 29, Headquarters of the Army, Adjutant-General's Office (August 22, 1900). Washington: Government Printing Office, 1900.

"Augustine Warner Robins." American Airpower Biography. Accessed March 20, 2013. http://www.airpower.maxwell.af.mil/airchronicles/cc/robins.html.

"Base Level ADP Program." ASECAF/FM to AF/CVA. July 30, 1976.

Batiz-Lazo, Bernardo, Carles Maixe-Altes, and Paul Thomes, eds. *Technological Innovation in Retail Finance: International Historical*. New York: Routledge, 2012.

Battelle: 75 Years of Innovation. Columbus, OH: Battelle, 2004.

Beeton, Samuel Orchart. *Beeton's Dictionary of Universal Information; Comprising Geography, History, Biography, Mythology, Bible Knowledge, Chronology, with the Pronunciation of Every Proper Name.* London: S.O. Beeton, 1859.

Bergin, Thomas J. *50 Years of Army Computing, from ENIAC to MSRC: A Record of a Symposium and Celebration, November 13 and 14, 1996, Aberdeen Proving Ground*. Aberdeen, MD: U.S. Army Research Laboratory, 2000.

Bingham, Walter Van Dyke. *Army Personnel Work, Vol II*. Washington: American Psychological Association, 1919.

Bohme, Frederick G., and J. Paul. Wyatt. *100 Years of Data Processing: The Punchcard Century*. Washington: U.S. Dept. of Commerce, Bureau of the Census, Data User Services Division, 1991.

Bonn, Keith E. *Army Officer's Guide*. Mechanicsburg, PA: Stackpole, 2005.

Boring, Edwin Garrigues. *Psychology for the Armed Services.* Washington: Infantry Journal, 1945.

Bridges, D. B. J. *Elements of a Mechanized Supply Information Flow System*. Dayton, OH: Battelle Memorial Institute, Wright Development Center, 1953.

Brown, Jerold E. *Historical Dictionary of the U.S. Army*. Westport, CT: Greenwood Press, 2001.

Buchan, Glenn C. *Information War and the Air Force: Wave of the Future? Current Fad?* Santa Monica, CA: RAND, 1996.

Business Methods in the War Department: Report of the Board

Appointed in Compliance with the Request of the Senate Select Committee to Investigate the Methods of Business in the Executive Departments. Washington, D.C.: Government Printing Office, 1889.

Business Methods in the War Department: Report of the Board Appointed in Compliance with the Request of the Senate Select Committee to Investigate the Methods of Business in the Executive Departments. Washington: Government Printing Office, 1889.

Byler, Charles A. *Civil-military Relations on the Frontier and Beyond, 1865-1917*. Westport, CT: Praeger Security International, 2006.

Byrd, Martha. *Chennault: Giving Wings to the Tiger*. Tuscaloosa: University of Alabama Press, 1987.

Case, Theodore S. *Quartermaster's Guide Being a Summary of the Army Regulations of 1863, and General Orders from the War Dept. from May 1861 to April 10, 1865 Which Affect the Quartermaster's Dept., with All General Orders from the Quartermaster General's Office to April 10, 1865.* St. Louis: P.M. Pinckard, 1865.

"The Census of the United States." *Scientific American* 63, no. 9 (August 30, 1890): 132.

Ceruzzi, Paul E. *A History of Modern Computing*. London, England: MIT Press, 2003.

Chambers, William, and Robert Chambers. *Chambers's Information for the People: Being a Series of Treatises on Those Branches of Human Knowledge in Which the Greater Part of the Community Are Most Interested, and Designed to Serve the Chief Uses of an Encyclopedia, at a Price beyond Example Moderate*. Edinburgh: W. and R. Chambers, 1835.

Clement, Edward E. "This Years Progress in Telephony and Telegraphy: Electrical Engineering and Telephone Magazine, Vol XIII, No.89, February 1899, Chicago." *Telephone Magazine: An Illustrated Monthly Magazine, Volumes 12-13*, Aug-Dec 1898, 57-60.

Cockrell, Francis Marlon. *Report [of] the Select Committee of the United States Senate: Appointed under Senate*

Resolution of March 3, 1887, to Inquire into and Examine the Methods of Business and Work in the Executive Departments, Etc., and the Causes of Delays in Transacting the Public Business, Etc. Washington: Government Printing Office, 1888.

Codlin, K. E., W. H. McGlothlin, A. H. Schainblatt, and R. L. Van. Horn. *Implementation of the Usaf Standard Base Supply System: A Quantitative Study.* Ft. Belvoir: Defense Technical Information Center, 1968.

Coffman, Edward M. *The War to End All Wars: The American Military Experience in World War I*. Norwalk, CT.: Easton Press, 1986.

Command and Control (Marine Corps Doctrinal Publication 6). Washington: Department of the Navy, 1996.

Committee on Civilian Industrial Technology, comp. *Technology in the National Interest.* Washington: Executive Office of the President, National Science and Technology Council, 1996.

Compilation of Supply Circulars and Supply Bulletins of the Purchase, Storage and Traffic Division, General Staff, War Department. Washington: Government Printing Office, 1919.

"Computer - Definition." Oxford English Dictionary - Online. Accessed June 21, 2013. http://oxforddictionaries.com/.

Computer Branch, Mathematical Sciences Division, Physical Sciences Group, Office of Naval Research. *A Survey of Large-Scale Digital Computers and Computer Projects*. Report. Washington: Office of Naval Research, Department of the Navy, 1950.

"Computer History: CHM Revolution." Whirlwind: Preparing the Way for SAGE. Accessed March 20, 2012. http://www.computerhistory.org/revolution/ real-time-computing/6/123.

Congressional Seriel Set, 64th Congress, 2d Session, December 4, 1916-March 4, 1917: House Documents. Vol. 117. Washington: Government Printing Office, 1917.

Cortada, James W. *Before the Computer: IBM, NCR, Burroughs, and Remington Rand and the Industry They Created, 1865-1956*. Princeton, NJ: Princeton University Press, 1993.

Cortada, James W. *Making the Information Society: Experience, Consequences, and Possibilities*. Upper Saddle River, NJ: Prentice Hall, 2002.

The Cosmopolitan, March-August 1886, 1-415.

Cox, Richard J. "The Information Age and History: Looking Backward to See Us." The Information Age and History: Looking Backward to See Us. Accessed March 03, 2013. http://d-scholarship.pitt.edu/2698/1/r_cox_1.html.

Craven, Wesley Frank, and James Lea Cate. *The Army Air Forces in World War II, Chapter VI*. Washington: Office of Air Force History, 1983.

Cuff, Robert D. *The War Industries Board; Business-government Relations during World War I*. Baltimore: Johns Hopkins University Press, 1973.

Damos, Diane L. *Foundations of Military Pilot Selection Systems: World War I*. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences, 2007.

Damos, Diane L. *A Summary of the Technical Pilot Selection Literature*. Randolph AFB, TX: Air Force Personnel Center Strategic Research and Assessment, 2011.

Davenport, Charles Benedict, and Albert Gallatin Love. *Army Anthropology: Based on Observations Made on Draft Recruits, 1917-1918, and on Veterans at Demobilization, 1919*. Washington: Government Printing Office, 1921.

Dawson, Joseph G. *The Late 19th Century U.S. Army, 1865-1898: A Research Guide*. New York: Greenwood Press, 1990.

Department of Commerce. *The Retirement of SEAC: Thursday, April 23, 1964*. Washington: Department of Commerce, 1964.

Donges, Norman A. "How the Army Knows Its Strength." *Army Information Digest* 3, no. 7 (July 1948): 65-69.

Dunaway, Edward. "U.S. Air Force Oral History Interview: Interview of Edward Dunaway." Interview by Dan Mortensen.

Eckdahl, D.E., I.S. Reed, and H.H. Sarkissian. "West Coast Contributions to the Development of the General-purpose Computer. Building Maddida and the Founding of Computer Research Corporation." *IEEE Annals of the History of Computing* 25, no. 1 (2003): 4-33.

Edwards, Paul N. *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming*. Cambridge, MA: MIT Press, 2010.

11th Bomb Group (H): The Grey Geese. Paducah, KY: Turner Pub., 1996.

"Engineering Branch of Shop Engineering Section." *Slipstream* I, no. 3 (September 15, 1919).

Equipment for Aero Units of the Aviation Section (Signal Corps), Tentative, 1916. Washington: Government Printing Office, 1916.

Essinger, James. *Jacquard's Web: How a Hand-loom Led to the Birth of the Information Age*. Oxford: Oxford University Press, 2004.

The Evaluation of Concepts for the Integration of the Military Supply Systems. Washington: Team 4, DOD Logistics Systems Study Project, 12 Dec 1957.

Farwell, Byron. *The Encyclopedia of Nineteenth-century Land Warfare: An Illustrated World View*. New York: W.W. Norton, 2001.

Fifty Forms, Company and Regimental U.S. Army Paper Work, with Instructions and Sample Forms (to Date, July 1, 1918). Tacoma, WA: Pioneer Bindery & Print., 1918.

Flamm, Kenneth. *Creating the Computer: Government, Industry, and High Technology*. Washington: Brookings Institution, 1988.

The Fog of War: Eleven Lessons from the Life of Robert S. McNamara. Directed by Errol Morris. Performed by Robert S. McNamara and Errol Morris. Hollywood: Sony Pictures Classics, 2003. DVD.

Ford, John C., and Howard E. Wilson. "UNIVAC's Role in the Pacific: Autodin and Base Level Supply Systems." *Signal Magazine*, 1970.

Fouste, Darcie. *Smith Premiere Typewriter Advertisement*. Adjutant General Collection, United States Army Adjutant General Museum, Fort Jackson, SC.

"G. Floyd Steele: Computer Oral History Collection, 1969-1973." Interview by Robina Mapstone. January 16, 1973.

Galison, Peter. "The Ontology of the Enemy: Norbert Wiener and the Cybernetic Vision." *Critical Inquiry* 21, no. 1 (Autumn 1994): 228-66.

Gardner, Lester Durand. *Who's Who in American Aeronautics*. Los Angeles: F. Clymer Publications, 1925.

"General Montgomery Cunningham Meigs." *Scientific American* 66 (1892): 71.

General Orders by the United States War Department, United States Adjutant-General's Office, United States.Military Secretary's Department. Washington: Government Printing Office, 1894.

General Orders, Quartermaster General's Office 1868. Washington: Government Printing Office, 1869.

General, Property, and Disbursing Regulations, Signal Corps, United States Army. Washington: Government Printing Office, 1912.

General, Property, and Disbursing Regulations, Signal Corps., United States Army. Washington: Government Printing Office, 1915.

The Gettysburg Times. "Colonel Peddy Heads ROTC Unit." September 1, 1949.

The Gettysburg Times. "Lt Col Peddy, ROTC Officer, Is Transferred." July 24, 1951.

Goldsworthy, Harry E., Lieutenant General. "The Logistics Challenge of the Seventies." *Air University Review*, July/August 1970. Accessed January 12, 2012. http://www.airpower.au.af.mil/airchronicles/aureview/1970/jul-aug/goldsworthy.html

Gould, Gordon T., Jr. "Computers and Communications in the Information Age." *Air University Review*. Accessed March 1, 2012. May-Jun 1970. http://www.airpower.au.af.mil/airchronicles/aureview/1970/may-jun/gould.html.

Grandstaff, Mark R. *Foundation of the Force: Air Force Enlisted Personnel Policy, 1907-1956*. Washington: Air Force History and Museums Program, 1997.

"The Growth of the Capital in War Time." *Air Service Journal, Vol I*, November 29, 1917, 666.

Haigh, Thomas. "The Chromium-Plated Tabulator: Institutionalizing an Electronic Revolution, 1954-1958." *IEEE Annals of the History of Computing* 23, no. 4 (2001): 75-104.

Haigh, Thomas. "Computing the American Way: Contextualizing the Early US Computer Industry." *IEEE Annals of the History of Computing* 32, no. 2 (2010): 8-20.

Harrison, James L. *100 GPO Years: 1861 - 1961; a History of United States Public Printing*. Washington: Government Printing Office, 2010.

Head, William P. *Every Inch a Soldier: Augustine Warner Robins and the Building of U.S. Airpower*. College Station: Texas A & M University Press, 1995.

Heater, Bonnie. "Historic Semaphore Flags to Signal Commands." Fort Gordon Signal. July 20, 2012. Accessed April 13, 2013. Http://www.fortgordonsignal.com/news/2012-07-20/News_Update/Historic_semaphore_flags_to_signal_commands.html.

Heide, Lars. *Punched-card Systems and the Early Information Explosion, 1880-1945*. Baltimore: Johns Hopkins University Press, 2009.

Heitkamp, Kenneth B. *Air Force Base-Level Information Systems*. Maxwell AFB, AL: Air University, 1987.

Henmon, V. A. C. "Air Service Tests of Aptitude for Flying." *Journal of Applied Psychology* 3, no. 2 (1919): 103-09.

Hennessy, Juliette A. *The United States Army Air Arm April 1861 to April 1917*. Washington: Office of Air Force History, U.S. Air Force, 1985.

Hogue, James E. *Automated Logistics Information Systems: A Case Study*. Dayton, OH: Air Force Institute of Technology, 1992.

"How Army Aviators Are Trained." *Air Service Journal*, September 28, 1917, 370.

Hughes, Thomas P. *Rescuing Prometheus*. New York: Pantheon Books, 1998.

Huskey, Harry D. *Harry D. Huskey: His Story*. Charleston, SC: BookSurge Pub., 2004.

Huskey, Harry D. "Technical Developments: Characteristics of the Institute for Numerical Analysis Computer." In *Mathematical Tables and Other Aids to Computation*. April 1950.

IBM Highlights: 1869-1969. Washington: International Business Machines (IBM), 2011.

"IBM-SAGE-Computer." Computer Museum. Accessed May 13, 2013. http://www.computermuseum.li/Testpage/IBM-SAGE-computer.htm.

In Your Defense. Produced by Western Electric and United States Air Force. Performed by United States Air Force - Defense Projects Division. New York: Audio Productions, Inc. Accessed May 2, 2013. http://www.youtube.com/watch?v=06drBN8nlWg.

"Information Definitions." Merriam-Webster. Accessed June 06, 2013. http://www.merriam-webster.com/dictionary/information.

"Information." Oxford Dictionary - Online. Accessed June 06, 2013. http://oxforddictionaries.com/us/definition/american_english/information.

"Interview with Darcie Fouste, United States Army Adjutant General Historian and Curator, Adjutant General Museum, Fort Jackson, SC." E-mail and personal interviews by author. November 11, 2012 – January 15, 2013.

"Interview with Diane L. Damos, PhD, President, Damos Aviation Services, Inc." E-mail and personal interviews by author. December 10, 2012 – January 5, 2013.

"Interview with Kenneth B. Heitkamp, United States Air Force Civilian (Retired)." E-mail and personal interviews by author. February 11, 2011 – January 9, 2013.

"Interview with Leo P. Hirrel, United States Army Quartermaster Historian, Fort Lee, VA." E-mail and personal interviews by author. December 10, 2012 – January 9, 2013.

"Interview with Luther D. Hanson, United States Army Quartermaster Historian and Curator, Adjutant General Museum, Fort Lee, VA." E-mail and personal interviews by author. December 10, 2012 – January 9, 2013.

"Interview with Paul Morando, United States Army Quartermaster Historian and Museum Director at the Army Quartermaster Museum, Fort Lee, VA." E-mail and personal interviews by author. November 19, 2012 – January 15, 2013.

"Interview with Robert C. Neibling, USAF (Ret)." Personal interview by author. May 2, 2012.

"Interview with William R. Stevenson, Stevenson Consulting, LLC." E-mail and personal interviews by author. May 2, 2011 – December 29, 2012.

Johnson, Mary Ann. *McCook Field, 1917-1927: The Force behind America's Golden Age of Flight*. Dayton, OH: Landfall Press, 2002.

Kane, Thomas M. *Military Logistics and Strategic Performance*. London: F. Cass, 2001.

Kautz, August V. *The Company Clerk: Showing How and When to Make out All the Returns, Reports, Rolls, and Other Papers, and What to Do with Them. How to Keep All the Books, Records, and Accounts Required in the Administration of a Company, Troop, or Battery in the Army of the United States.* Philadelphia: J.B. Lippincott &, 1863.

Keene, Marcel S., Clay S. Worick, Ralph G. Hersey, and H. M. McLarin. *War Department Correspondence File: A Subjective Decimal Classification with a Complete Alphabetical Index for Use of the War Department and the United States Army*. Washington: Government Printing Office, 1918.

Kerns, Patricia A. *The First 50 Years: U.S. Air Force Judge Advocate General's Department*. Washington: U.S. Air Force Judge Advocate General's Dept., 2003.

Kirsch, Russell A. "Computer Development at the National Bureau of Standards." In *A Century of Excellence in Measurements, Standards, and Technology a Chronicle of Selected NBS/NIST Publications, 1901-2000*, by David R. Lide. Gaithersburg: U.S. Dept. of Commerce, Technology Administration, National Institute of Standards and Technology, 2001.

Kroll, Harry David. *Kelly Field in the Great World War*. San Antonio: Press of San Antonio Print., 1919.

Kurzweil, Ray. *The Age of Spiritual Machines: When Computers Exceed Human Intelligence*. New York: Viking, 1999.

Landon, Charles R., Major General, ed. *United States Air Force - Review of Statistical Services, January 1950 - July 1954*. Report no. K134.01-00468883. Washington: United States Air Force, 1954.

Legislative, Executive, and Judicial Appropriation Bill, 1921: Hearing before Subcommittee of House Committee on Appropriations ... in Charge of the Legislative, Executive, and Judicial Appropriation Bill for 1921.

Sixty-sixth Congress, Second Session ... Washington: Government Printing Office, 1920.

Leib, Charles. *Nine Months in the Quartermaster's Department; Or, the Chances for Making a Million.* Cincinnati: Moore, Wilstach, Keys &, Printers, 1862.

Light, Jennifer S. "When Computers Were Women." *Technology and Culture* 40, no. 3 (July 1999): 455-83.

Losee, Robert M. "A Discipline Independent Definition of Information." *Journal of the American Society for Information Science* 48, no. 3 (1997): 254-69.

Love, Albert Gallatin, Eugene L. Hamilton, and Ida Levin Hellman. *Tabulating Equipment and Army Medical Statistics*. Washington: Office of the Surgeon General, Dept. of the Army, 1958.

Lubar, Steven. ""Do Not Fold, Spindle or Mutilate": A Cultural History of the Punch Card." *The Journal of American Culture* 15, no. 4 (1992): 43-55.

Lucas, Henry Edward. *Automation: A Study of Basic Concepts and of Factors Influencing the Decision to Automate.* Thesis, University of Texas., 1955.

Lynch, Charles. *The Medical Department of the United States Army in the World War*. Washington: Government Printing Office, 1921.

"Major General Charles Raeburne “C. R.” Landon." Air Force Senior Leader Biographies. Accessed April 10, 2012. http://www.af.mil/information/bios/bio.asp?bioID=6135.

Manual for the Medical Department. Washington: Government Printing Office, 1896.

Manual for the Quartermaster Corps, United States Army, 1916. Washington: Government Printing Office, 1917.

Mattoy, George C. "The Flying Telegraph." *The Army Communicator*, Fall 1981, 30-36.

Meilinger, Phillip S. *American Airpower Biography a Survey of the Field*. Maxwell AFB, AL: Air University Press, 1997.

"Memorandum to Lt Col Williams, 12 Feb 44." 65th MRU to Lieutenant Colonel Williams, US Strategic Air Forces in Europe. February 12, 1944. In *U.S. Air Force Historical Research Agency, IRIS: 00214762*.

"Mimeograph." RedOrbit - Inventions Reference Library. Accessed February 20, 2013. http://www.redorbit.com/education/reference_library/technology_1/inventions/2583628/mimeograph/.

"MIT Whirlwind Computer from 1951." CED in the History of Media Technology. Accessed March 20, 2012. http://www.cedmagic.com/history/whirlwind-computer.html.

Moss, James A. *Army Paperwork, a Practical Working Guide in Army Administration ... (Printed March, 1917).* Menasha, WI: George Banta Pub., 1917.

Motten, Matthew. "Who Is a Member of the Military Profession?" *Joint Forces Quarterly*, no. 62 (2011): 14-17.

Neibling, Robert C. *A Narrative History of the USAF Standard Base Level Supply ADP Program*. Unpublished Historical Report. 1963.

Neufeld, Jacob. *Bernard A. Schriever: Challenging the Unknown*. Washington: Office of Air Force History, 2005.

Neufeld, Jacob, George M. Watson, and David Chenoweth. *Technology and the Air Force: A Retrospective Assessment*. Washington: Air Force History and Museums Program, U.S. Air Force, 1997.

Operations Statistics Division of the Directorate of Statistical Services, Deputy Chief of Staff/Comptroller. *United States Air Force Statistical Digest, Jan 1949-Jun 1950, Fifth Edition*. Ft. Belvoir: Defense Technical Information Center, 1950.

"Patent 395782." Patent 395782. Accessed February 14, 2013. http://www.uspto.gov/patents/resources/methods/afmdpm/examples/395782.jsp.

The Personnel System of the United States Army. Washington: National Publication-U.S. Army Adjutant-General's Office, 1919.

"Pioneer in Government Computer Planning." Washington Post. February 09, 2009. Accessed May 3, 2013. http://articles.washingtonpost.com/2009-02-09/news/36782416_1_secret-service-government-service-pentagon.

Plum, William Rattle. *The Military Telegraph during the Civil War in the United States with an Exposition of Ancient and Modern Means of Communication, and of the Federal and Confederate Cipher Systems ; Also a Running Account of the War between the States.* Chicago: Jansen, McClurg &, 1882.

Pratt, Jerome J. *Courageous Couriers: Memoirs of a Pigeon Soldier*. Warrenton, MO: American Pigeon Journal, 1977.

Proceedings of U.S. Army's Automatic Data Processing System (ADPS) Conference, 31 October - 1 November 1956.

Property and Disbursing Regulations, including Miscellaneous General Regulations. Washington: Government Printing Office, 1912.

Property and General Regulations of the Signal Corps, U.S. Army. Washington: Government Printing Office, 1898.

Province, Charles M. *General Patton's Punch Cards: A Short History of Mobile Machine Records Units and IBM Punch Card Machines in World War II*. [S.l.]: CMP Productions, 2009.

"Quartermaster History." US Army Quartermaster School, Fort Lee, Virginia. Accessed April 5, 2013. http://www.quartermaster.army.mil/qm_history.html.

Raines, Rebecca Robbins. *Getting the Message Through: A Branch History of the U.S. Army Signal Corps*. Washington: Center of Military History, U.S. Army, 1996.

Rainey, James C., Andrew W. Hunt, and Beth F. Scott. *USAF Supply: Pride, Dedication, Professionalism*. Maxwell AFB, Gunter Annex: Logistics Management Agency, 2001.

Rainey, James C. *Logistics and Warfighting: Thinking about Agile Combat Support*. Maxwell AFB, Gunter Annex, Ala.: Air Force Logistics Management Agency, 2003.

Reed, Irving S. "The Dawn of the Computer Age." *Engineering & Science*, 2006, 7-12.

Register of the War Department:January 1, 1889. Washington: [s.n.], 1889.

Regulations for Operation and Maintenance of U.S. Military Telegraph Lines. Washington: Government Printing Office, 1892.

Regulations for the Army of the United States, 1895, with Appendix Separately Indexed Showing Changes to January 1, 1899. Washington: Government Printing Office, 1899.

Regulations for the Army of the United States, Appendixes No. 8. Washington: Government Printing Office, 1895.

Regulations for the Operation and Maintenance of United States Military Telegraph Lines: And General Regulations of the Signal Corps, United States Army. Washington: Government Printing Office, 1899.

Regulations of the Army of the United States and General Orders in Force on the 17th of February, 1881. Codified and Published by Order of the Secretary of War ... With an Appendix Containing All Military Laws in Force February 17, 1881, Not Contained in This Code. Washington: Government Printing Office, 1881.

Report of the Chief Signal Officer, United States Army, to the Secretary of War. Washington: Government Printing Office, 1914.

Reports of Committees of the Senate of the United States for the First Session of the Fiftieth Congress, 1887-88. Washington: Government Printing Office, 1888.

Reprint and Circular Series of the National Research Council. Washington: National Research Council, 1919.

Riemondy, Brigadier General A. A. "Supply and Service—The Nucleus of Logistics." *Air University Review*, July/August 1970. Accessed January 12, 2012. http://www.airpower.au.af.mil/airchronicles/aureview/1970/jul-aug/riemondy.html.

Risch, Erna. *Quartermaster Support of the Army: A History of the Corps, 1775-1939*. Washington: Center of Military History, U.S. Army, 1989.

Roster of Key Personnel, Headquarters Army Air Forces Statistical Control Division, 1944. USAF Official Document. Washington: United States Air Force, 1944.

Scheips, Paul J. *Darkness and Light, the Interwar Years, 1865-1898*. Washington: Government Printing Office, 1971.

"Scientific Planning Techniques." Special Air Staff Briefing: 5 August 1948, Pentagon, Washington.

Scott, Beth F., James C. Rainey, and Andrew W. Hunt. *The Logistics of War*. Maxwell AFB, Gunter Annex, Ala: AF Logistics Management Agency, 2000.

Short, Lloyd M. *The Development of National Administrative Organization in the United States,*. Baltimore, MD: Johns Hopkins Press, 1923.

Shrader, Charles R. *U.S. Military Logistics, 1607-1991: A Research Guide*. New York: Greenwood, 1992.

Shurkin, Joel N. *Engines of the Mind: A History of the Computer*. New York: Norton, 1984.

Slutz, Ralph J. "Memories of the Bureau of Standards' SEAC." In *A History of Computing in the Twentieth Century: A Collection of Essays*, by N. Metropolis, J. Howlett, and Gian-Carlo Rota. New York: Academic Press, 1980.

Smith, Gene. "Past and Present Officials Deny Wall St. Rumor of Univac Woes." *The New York Times*, August 27, 1964. 45.

Spruce, Frank. *Evolution of the Supply Computer System from Univac 1050 to the GCSS/ILS-S*. Unpublished Report. Personal Collection of Mr. Robert C. Neibling, USAF Civilian (Ret).

Stehr, Nico. "Theories of the Information Age." In *Historical Developments and Theoretical Approaches in Sociology*, by C. Crothers. Vol. II. Oxford: Eolss Publishers, 2010.

Sterling, Christopher H. *Military Communications: From Ancient times to the 21st Century*. Santa Barbara, CA: ABC-CLIO, 2008.

Stevens, Austin. "Air Force Unveils Fastest Computer." *New York Times*, June 21, 1950. 5.

"SWAC: National Bureau of Standards Western Automatic Computer – Recent Developments and Operating Expertise." *National Bureau of Standards Technical News Bulletin* 37, No. 10 (October 1953).

Sweetser, Arthur. *The American Air Service; a Record of Its Problems, Its Difficulties, Its Failures, and Its Final Achievements,* New York: D. Appleton and, 1919.

Tatnall, Arthur. *History of Computing: Learning from the Past : IFIP WG 9.7 International Conference, HC 2010, Held as Part of WCC 2010, Brisbane, Australia, September 20-23, 2010 : Proceedings*. New York: Springer, 2010.

"Telephone History." The Telephony Museum. Accessed April 10, 2013. http://www.telephonymuseum.com/telephone history.htm.

Testimony before the Joint Commission to Consider the Present Organizations of the Signal Service, Geological Survey, Coast and Geodetic Survey, and the Hydrographic Office of the Navy Department, with a View to Secure Greater Efficiency and Econommy (sic) of Administration of the Public Service in Said Bureaus,. Washington: Government Printing Office, 1886.

Unit Equipment Manual for the Aviation Section, Signal Corps. Washington: Government Printing Office, 1917.

United States Air Force Air Proving Ground Command. *Final Report on Evaluation of Graduates of Machine Accountants Course, Project Number APG/CSC/388-A*.

Dayton, OH: Armed Services Technical Information Agency, 1954.

United States Air Force. Comptroller of the Air Force. "NBS Press Release TRG 6099" (June 21, 1950. Compiled by Air Force Historical Research Agency. IRIS 01016559. Washington: SEAC (Standards Eastern Automatic Computer) Collection, 1950.

United States Air Force. Comptroller of the Air Force. "SEAC Dedication Program" (June 20, 1950). Compiled by Air Force Historical Research Agency. IRIS 01016559. Washington: SEAC (Standards Eastern Automatic Computer) Collection, 1950.

United States Air Force. Comptroller of the Air Force. "Transcript of Dr. John H. Curtiss, Chief of the National Bureau of Standards' Applied Mathematics Laboratories, Dedication Address" (20 June 1950). Compiled by Air Force Historical Research Agency. IRIS 01016559. Washington: SEAC (Standards Eastern Automatic Computer) Collection, 1950.

United States Air Force. Comptroller of the Air Force. "Transcript of Lt Gen Rawlings' Dedication Address" (20 June 1950). Compiled by Air Force Historical Research Agency. IRIS 01016559. Washington: SEAC (Standards Eastern Automatic Computer) Collection, 1950.

United States Air Force. *Historical Summary, Directorate of Data Automation, 1 Jan - 30 June 1963*. Washington: United States Air Force, 1963.

United States Air Force. *Historical Summary, Directorate of Data Automation, 1 Jan - 30 June 1964*. Washington: United States Air Force, 1964.

United States Air Force. *Historical Summary, Directorate of Data Automation, 1 Jan – 30 Jun 1965*. Washington: United States Air Force, 1965.

United States Air Force. *Historical Summary, Directorate of Data Automation, 1 Jan - 30 June 1966*. Washington: United States Air Force, 1966.

United States Air Force. *Historical Summary, Directorate of*

Data Automation, 1 Jan - 30 June 1967. Washington: United States Air Force, 1967.

United States Air Force. *Historical Summary, Directorate of Data Automation, 1 Jan - 30 June 1968*. Washington: United States Air Force, 1968.

United States Air Force. *Historical Summary, Directorate of Data Automation, 1 Jul – 31 Dec 1963*. Washington: United States Air Force, 1964.

United States Air Force. *Historical Summary, Directorate of Data Automation, 1 Jul – 31 Dec 1964*. Washington: United States Air Force, 1965.

United States Air Force. *Historical Summary, Directorate of Data Automation, 1 Jul – 31 Dec 1965*. Washington: United States Air Force, 1966.

United States Air Force. *Historical Summary, Directorate of Data Automation, 1 Jul - 30 Dec 1966*. Washington: United States Air Force, 1967.

United States Air Force. *Historical Summary, Directorate of Data Automation, 1 Jul - 30 Dec 1967*. Washington: United States Air Force, 1968.

United States Air Force. *Historical Summary, Directorate of Data Automation, 1 Jul – 31 Dec 1968*. Washington: United States Air Force, 1969.

United States Air Force. *Historical Summary, Directorate of Data Automation, 1 Jul – 31 Dec 1976*. Washington: United States Air Force, 1977.

United States Air Force. *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 January – 30 June 1950*. Washington: United States Air Force, 1950.

United States Air Force. *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 January – 30 June 1951*. Washington: United States Air Force, 1951.

United States Air Force. *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period* *of 1 January – 30 June 1952*. Washington: United States Air Force, 1952.

United States Air Force. *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 January – 30 June 1953*. Washington: United States Air Force, 1953.

United States Air Force. *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 January – 30 June 1954*. Washington: United States Air Force, 1954.

United States Air Force. *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 January – 30 June 1955*. Washington: United States Air Force, 1955.

United States Air Force. *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 July – 31 December 1950*. Washington: United States Air Force, 1951.

United States Air Force. *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 July – 31 December 1951*. Washington: United States Air Force, 1952.

United States Air Force. *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 July – 31 December 1952*. Washington: United States Air Force, 1953.

United States Air Force. *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 July – 31 December 1953*. Washington: United States Air Force, 1954.

United States Air Force. *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 July – 31 December 1954*. Washington: United States Air Force, 1955.

United States Air Force. *Historical Summary: Directorate of Statistical Services, DCS/Comptroller for the Period of 1 July – 31 December 1955*. Washington: United States Air Force, 1956.

United States Air Force. STALOG Study Group. *A Study of the Automation of the Logistics System at Base Level (STALOG), Volume I*. Washington: Headquarters USAF, Deputy Chief of Staff, Systems and Logistics, 1973.

United States Air Force. "Study of the Role, Organization and Management of Automatic Data Systems in the Air Force." *Headquarters, USAF Management Engineering Project 56-3*, 1956.

United States Navy Office of Naval Research Mathematical Sciences Division. "Digital Computer Newsletter." 1, no. 1 (April 1949).

United States Navy Office of Naval Research Mathematical Sciences Division. "Digital Computer Newsletter." 2, no. 3 (August 1950).

United States Navy Office of Naval Research Mathematical Sciences Division. "Digital Computer Newsletter." 2, no. 4 (December 1950).

United States Navy Office of Naval Research Mathematical Sciences Division. "Digital Computer Newsletter." 3, no. 2 (July 1951).

United States Navy Office of Naval Research Mathematical Sciences Division. "Digital Computer Newsletter." 4, no. 1 (January 1952).

United States Navy Office of Naval Research. *A Survey of Large Digital Computers and Computer Projects*. Report. Department of the Navy, 1950.

United States of America. Industrial College of the Armed Forces. *The Application of Electronic Data Processing Machines to Military Supply Systems*. By Frank J. Roberts. Washington: Industrial College of the Armed Forces, 1956.

United States of America. Industrial College of the Armed Forces. *Military Applications of Cybernetics*. By Frederic H. Miller. Washington: Industrial College of the Armed Forces, 1953.

United States of America. United States Air Force.

Directorate of Data Automation. *United States Air Force Data Systems Automation Program, Sections I and II*. Washington: United States Air Force, 1963.

"Univac 1050." Computer History Archives Project. Accessed March 3, 2012. http://sites.google.com/site/computerhistoryarchivesproject/1/univac-1050.

US Army Air Forces. *Statement of Functions: 6 Mar 42*. 1942.

US Congressional Serial Set, 66th Congress, 2nd Session, December 1, 1919-June 5, 1920, Senate Documents. Vol. 15. Washington: Government Printing Office, 1920.

Van Creveld, Martin. *Supplying War: Logistics from Wallenstein to Patton*. Cambridge: Cambridge University Press, 1977.

Walker, Lois E., and Shelby E. Wickam. *From Huffman Prairie to the Moon: The History of Wright-Patterson Air Force Base*. Washington: Air Force Logistics Command, 1986.

War Department Research and Development Program, Fiscal Year 1948. Washington: War Department General Staff, 1947.

Weaver, Warren. *Comments on a General Theory of Air Warfare*. Washington: National Defense Research Committee, 1946.

Weik, Martin H. "The ENIAC Story." ENIAC - World Wide Web. Accessed May 15, 2013. http://ftp.arl.mil/mike/comphist/eniac-story.html.

Weik, Martin H. *A Fourth Survey of Domestic Electronic Digital Computing Systems*. Aberdeen Proving Ground, MD: Ballistic Research Laboratories, 1964.

Weik, Martin H. *A Third Survey of Domestic Electronic Digital Computing Systems.* Aberdeen Proving Ground, MD: United States Army, 1961.

Weller, Charles Edward. *The Early History of the Typewriter*. La Porte, IN: Chase & Shepard, Printers, 1918.

"Westover Air Force Base History." Westover Air Force Base History. Accessed April 16, 2012. http://www.westoverafbhistory.com/.

Winthrop, William, and Charles McClure. *A Digest of Opinions of the Judge-Advocates General of the Army*. Washington: Government Printing Office, 1901.

"Wood, William Robert - Biographical Information." Wood, William Robert - Biographical Information. Accessed April 1, 2013. http://bioguide.congress.gov/scripts/biodisplay.pl?index=W000706.

"World of Wings: Military Pigeons." World of Wings: Military Pigeons. Accessed April 13, 2013. http://www.pigeoncenter.org/militarypigeons.html.

"World War II American Air and Nautical Almanacs." World War II American Air and Nautical Almanacs. Accessed February 04, 2013. http://www.columbia.edu/cu/computinghistory/almanac.html.

Yerkes, Robert Mearns. *Psychological Examining in the United States Army.* Washington: Government Printing Office, 1921.

Yerkes, Robert Mearns. *Report of the Psychology Committee of the National Research Council,* 2nd ed. Vol. 26. The Psychological Review. Washington: National Research Council, 1919.