AU/AWC/RWP061/96-04

AIR WAR COLLEGE

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HOW DID THE EVOLUTION OF COMMUNICATIONS AFFECT COMMAND AND CONTROL OF AIRPOWER: 1900–1945?

by

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A Research Report Submitted To the Faculty

In Fulfillment of the Curriculum Requirement

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Maxwell Air Force Base, Alabama

1 April 1996

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Contents

Abstract

Communications became an airpower combat multiplier through the evolution of communications equipment, procedures, and understanding. Once commanders understood the importance of reliable, flexible, and survivable communications systems they demanded more. Much of the improvements are attributed to the industrial base, extraordinary efforts, initiative, determination and innovations by key people. Commanders had the capability to communicate worldwide and to higher and lower headquarters. Communications advancements, particularly FM radio and radar greatly enhanced the coordination of airpower. Orders and missions were more easily disseminated throughout the theater. Overall information flow greatly assisted the commander's decision making process. In spite of a myriad of problems, communications, by the end of World War II was a significant airpower combat multiplier. As communications became more technologically advanced, more reliable, responsive, and effective, commanders realized an even greater combat multiplying effect on airpower.

Chapter 1

Introduction

> *Since wars began, commanders have sought effective two-way communication directly on the battlefield. The enemy must be located, his strength must be determined, and the field commander must receive this information promptly. Then, based on this information, the commander's instructions must reach his men.*[1]
>
> —David L. Woods
> *A History of Tactical Communication Techniques*

In the paragraphs below I will explain how communications became a combat multiplier for airpower. This paper will explore the affect of the evolution of communications on the command and control of airpower. To keep the subject manageable only major developments will be treated. The paper is limited to the period 1900-1945, further divided as; before World War I, during World War I, the interwar years, and during World War II. I will address in each period the means available to communicate; among ground forces, from aircraft to aircraft, from ground forces to aircraft, and from aircraft to ground forces. Next, I will discuss how the evolution of communications affected command and control. Finally, I will conclude with the effect of the evolution of communications on the command and control of airpower.

In this paper I define communication as "one man sending a message to another man, by any means."[2] Communications is a means to provide the commander with information and a means for the commander to provide direction to the forces commanded. As battle is modernized the communications are required to be more rapid and responsive. The speed that the commander can react to the opposing commander's moves can often decide the outcome of the battle. I also include radar as a communications means. Radar, radio detecting and ranging, is defined as a radio device or system for locating an object by means of ultrahigh-frequency radio waves reflected from the object and received, observed, and analyzed by the receiving part of the device in such a way that characteristics like distance and direction of the object may be determined.

"Command and control in the military context is concerned with the control of events and processes through the transmission and receipt of messages. . . . A commander on the battlefield exercises command and control through feedback loops."[3] The commander is subject to the "limitations of the apparatus for command and control available to him which is in effect a communications network."[4] A typical command and control system consists of four elements; command element, command structure, communications apparatus, and the language of command. The command structure for ground forces generally follows the same structure as the chain of command. Most communications command structures controlling airpower, however, allow for direct links to operational units without intermediate filtering.[5] The advantage to the commander controlling airpower is that the unfiltered communications has the potential to provide more timely information because of fewer interruptions in the flow of information.

Radio is the key element to these communications. Commanders sought simple methods to convey their orders on the battlefield. Simplicity is still the goal, but communications methods in order to keep pace with the complexity of modern warfare resulted in complex methods.[6] The goal for all tactical communication systems is simplicity. It is difficult to meet the requirements to operate throughout the combat zone, be faster, adaptable, lighter, capable of longer ranges, include the best of present systems, result from advance planning, employ man within the system, and still be simple. Future tactical communications systems will be complex.[7]

Below, I will discuss communications improvements and their affect on command and control structures.

Notes

[1] David L. Woods. *A History of Tactical Communication Techniques.* Orlando, Florida: 1965. p. viii.

[2] Ibid.

[3] For a good explanation of the elements of Command, Control, and Communications and the importance of communications to command see A.M. Wilcox, M.G. Slade, and P.A. Ramsdale. *Command Control Communications (C3).* Brassey's Battlefield Weapons Systems & Technology, Volume IV. 1983. pp. 1-3.

[4] Shelford Bidwell. *Modern Warfare.* London. 1973. p. 78.

[5] Ibid., pp.79-89.

[6] Woods, David L. *A History of Tactical Communication Techniques..* p. 238.

[7] Ibid., pp. 256-258.

Chapter 2

Before World War I

Commanders have always had the need to communicate with their forces wherever the forces might be located. When new platforms like balloons and airplanes were introduced a new and different challenge was added to the requirement to communicate with the forces. Before air platforms were added to the military arsenal, communications were required only across land. Air platforms changed that and added yet another challenge to command and control communications.

Before World War I the balloon and airplane were the new platforms introduced. They were observation platforms before they were weapon platforms. From the beginning ways to make these new tools more effective were explored. Commanders required communications to fully exploit the capabilities of these new platforms. The airplane was a new communications medium. Early aeroplanes had a shorter life as a technique of signaling than any other important method, even balloons were used longer. When the modern airplane replaced the aeroplane, aviation moved into a completely new realm.[1] This new means of communications took on a different role and required its on command and control systems. They required a communication means to receive feedback from the aerial observers and a communication means to give direction to the pilot of the new air asset.

In 1898, US Army observation balloons in Cuba participated in the battle of San Juan Hill. The commander on the ground was limited to visual communications to the balloons. Flags and lights were the dominant method of signaling. Sometimes messages were dropped overboard by the observers, and telephones were used when the balloons were tethered and a wire connection existed to the ground and another telephone.[2] The telephone provided a more responsive method of command and control, but the tether was a limiting factor. Accounts of the US Army's balloon experience during the Spanish American War give more weight to the dropping of notes from the balloon basket than the use of the telephone. Other militaries were using the observation balloon and similar communications means. Captain William Mitchell reported on the German Army's balloon activity as early as 1905. "Photography was an important adjunct of ballooning, and communication from balloons to the ground was by flags, lights, and long telephone cable. Mitchell praised the recent addition of wireless antennas to free balloons, which until that time had used only carrier pigeons."[3]

Elsewhere ground communications capabilities were being researched. In 1899, Brigadier General Adolphus W. Greely, US Army Chief Signal Officer from 1887-1906, assigned two of his officers to follow the experiments of Marconi. In April 1899, the Signal Corps was operating the first wireless telegraph system ever placed in service in the United States.[4]

Ground to air wireless signals were sent and received for the first time from the Navy's wireless stations in Washington and Annapolis to the basket of a US Army Signal Corps free balloon in 1908. In 1909, the Army Signal Corps acquired the first US military airplane. Command and control took a large step when in 1911 a group of US

Army airplanes were directed from ground wireless telegraph signals. In 1912, naval aircraft transmitted the first messages to ships and the ground from an aircraft. Although the distance covered was only about 3 nautical miles and from a height of 300 feet it was the beginning of a new phase that gave the commander another tool. In the same year the submarine *Skipjack* transmitted and received radio messages four miles off shore from Newport, Rhode Island. The US Navy ordered all battleships, destroyer flotilla leaders, and flagships of cruiser and gunboat divisions to appoint radio officers.[5] At this point the importance of communications was emphasized to the entire Navy.

The Pophan panel system of visual aircraft signaling was used as a means to communicate from the ground to the air before airplane radiotelephone and when radiotelephone was not available. This was a common method to signal the pilot. The pilot sent messages back to the ground by using colored lights and a pre-established code. As radios were fielded the Pophan panel system became a standby technique.[6]

The first use of airplanes for observation and adjustment of field artillery was in 1912. The Field Artillery Board requested two aircraft be sent to Fort Riley, Kansas for a series of experiments. Portions of a letter from 2d Lt. H.H. Arnold to the Commanding Officer, Signal Corps Aviation School, Washington, D.C., tell the story. It was written at Fort Riley, Kansas, and dated November 6, 1912:

"The first test in connection with artillery took place on the fourth of November; both machines took part in the test. There was no firing by the battery; the flying was done for the purpose of testing out different kinds of signals. There was a wireless station put up in the immediate vicinity of the battery and No. 10, (one of the aircraft) with Lieutenant Arnold, pilot, Lieutenant Bradley, operator, sent messages down to the battery. No. 11, with Lieutenant Milling, pilot, Lieutenant Sands, observer, was equipped with a smoke signal device made at this place. No. 11 sent signals from this device and also dropped cards. The smoke signal device, although improvised, showed that such a device could be used to signal from the aeroplane to the battery. However, on account of the manner in which it was constructed, the dot and dash system of signals could not be used. A system of dots alone had to be used.

> On the fifth of November, the aeroplane was used for the first time with the battery actually firing at a target. The target was about 3200 yards from the battery. It was a dark day, a dark target and a dark background for the target. In spite of this, the target was picked up by the aeroplane easily. . . ."[7]

The success of the Field Artillery test gave the commander yet another tool to effectively control artillery fires and another way to use airpower. The wireless increased the responsiveness of airpower in its observation role.

In summary, thus far communications available to the commander were rudimentary. On the ground, commanders used much the same communications methods they used in the Civil War, visual signaling and messenger. The wireless improved the commander's ability to control ground and air elements. The telephone, the wireless (radio), the military switchboard, and the tele-typewriter were all fielded, but in varying states of availability and reliability. Radio messages were exchanged between airplanes in flight for the first time. This gave pilots a better way to communicate, but the radio sets were too large and too heavy, and they robbed the plane of its maneuverability.[8]

The introduction of air to ground communications was a major development to improve future command and control. The two most significant communications advancements leading to the enhancement of airpower were the ability to adjust artillery fire from an air platform and the ability for commanders to control airplanes from the ground using a wireless. Commanders were gaining experience with the new methods of communicating with forces on the ground and in the air. Communications was beginning to become a combat multiplier for airpower, but it was still very limited.

Notes

[1] Ibid., p. 253.

[2] R.K. Tierney. "Offspring of the Signal Corps—The Balloon, Dirigible, and Airplane" in *The Story of the U.S. Army Signal Corps*. ed. Marshall, Max L. LTC, USA(Ret), The Watts Landpower Library. 1965. pp. 127-129.

[3] David L. Woods. *A History of Tactical Communication Techniques.* Orlando, Florida: 1965. pp. 180-182.

[4] David J. Marshall. "General Greely turns to Telephone, Aviation, and Radio" in *The Story of the U.S. Army Signal Corps*. ed. Marshall, Max L. LTC, USA(Ret), The Watts Landpower Library. 1965. p. 110.

[5] David L. Woods. *A History of Tactical Communication Techniques.* Orlando, Florida: 1965. pp. 219-220.

[6] Ibid., p. 251.

[7] R.K. Tierney. "Offspring of the Signal Corps. p. 134.

[8] David J. Marshall. "The Signal Corps in World War I" in *The Story of the U.S. Army Signal Corps*. ed. Marshall, Max L. LTC, USA (Ret.), The Watts Landpower Library. 1965. p. 143.

Chapter 3

During World War I

When the US entered World War I in April 1917, the Signal Corps was miserably unprepared to meet the challenge and needed practically everything.[1] Although improvements in communications equipment were made in earlier years, only limited supplies of the new equipment were available to the units in the field. This presented another obstacle to further improve the command and control of airpower. The concepts of communications and command and control were growing, but due to the limited availability of communications equipment mastering command and control of airpower would be delayed.

Although at the beginning of World War I the US Army had only three serviceable free balloons and two captive balloons on hand, aerial observation provided invaluable support to the ground commander, both as a source of intelligence and as a means of directing artillery fire.[2] The balloon companies and the airplane operations of World War I convinced many Army officers that aerial observation in support of the ground commanders was essential. Germany also used her military balloons. A portable telephone was used to link the observer in the balloon to the artillery battery whose fire was being observed.[3]

The state of ground communications in 1917 was lacking also. The American field wireless sets failed in Mexico and were thought not good enough to use in France. "The experience in radio had centered round an open spark gap and a crystal detector. . . . The open-gap transmitter sprayed its output over a wide range of frequencies, and the crystal-type receiver could pick up anything that happened to be in the air."[4] The potential for interference or enemy interception was great. "Under America's wide-open skies, there was no particular need of close tuning. But in the tightly concentrated combat zone of France, the air was nearly always packed with scores of transmissions, and the one thing necessary was fine-tuning. That was not possible with any of our radio sets."[5]

The close tuning problem needed solving, but it was not the only problem. Military radiotelephone needed a better vacuum tube in order for the electron stream between electrodes to move more freely. Voice modulated signals could then be amplified without significant distortion.[6] US Army Signal Corps leaders recognized that in the vacuum tube lay the key to a better military radio. There was great cooperation between the Signal Corps and civilian industry. Some of the best technicians from General Electric and Western Electric were commissioned directly into the Signal Corps. These officers took on the vacuum tube project and within six months vacuum tubes for Army radios came rolling off the assembly lines. The vacuum tubes were standardized, interchangeable, and more rugged than any tubes built before. The tubes had a more nearly perfect vacuum and could better amplify voice as well as continuous wave (CW) code signals.[7] This advance would lead to better communications capabilities and more interactive command and control possibilities for airpower.

The wartime progress of radio communications capabilities was made possible by two labs; one at Camp Alfred Vail (Ft. Monmouth), New Jersey, and the other in a mansion near Paris. These labs led the probe into all communications. Major Edwin H. Armstrong was the forerunner of such advancements as the superheterodyne circuit, grid detection and regeneration. He also developed the antecedent of frequency modulation.[8]

Air to ground communications remained limited to dots and dashes, until the US Army Signal Corps developed small aircraft radiotelephones. The first radio sets to remove the CW transmissions only limitation and give aircraft radio the flexibility of voice communications was the SCR-68, an airborne radio telephone and the SCR-67, a ground version of the same radio telephone. These radios were to be installed in De Haviland two-seater planes. Initial tests of the radiotelephone proved it would transmit and receive voice signals up to three miles between aircraft in flight and between aircraft and the ground.[9] The effort began in 1917 and by mid 1918 the new SCR-67 and SCR-68 began to arrive in France. The Chief Signal Officer during World War I, Maj. Gen. George O. Squire, believed the new radio sets constituted a revolutionary advance in radio and said they "will undoubtedly materially change the system of Army communication." He also noted that this innovation would permit the "voice commanded air squadron" and would enormously increase the military value of aircraft formations.[10] By November 1918, at war's end, sufficient SRC-67's and SCR-68's were received and used in France to demonstrate the potential superiority of voice radio. Development of the airborne radio telephone was considered the most spectacular accomplishment of the Signal Corps to that date.[11] The command and control potential for airpower progressed considerably with this accomplishment. This communications device would also multiply the effectiveness of airpower.

The new American voice radios were far from perfect. They did, however, provide hope for better communications. The Navy tried them in seaplanes and subchaser vessels, altering and improving them for their different needs. The commanders of subchasers were pleased they could keep in touch with each other more readily than before, increasing the effectiveness of the operation of the vessels in the groups. Obviously, the hope outweighed the fact that the first sets were not entirely dependable. No surprise since their development began with design and building in 1917 and delivery in 1918. The ingeniousness of this concept and effort in voice radio would lead to many future radio developments.[12]

Strategic communications efforts were led by Col. Edgar Russell, Chief Signal Officer of the American Expeditionary Forces in France. In 1917 he had the job to establish communications between the War Department in Washington and France. He found, "he would have to rely upon the transatlantic cables, the mails, and a system of messengers and couriers carrying the same communications by different routes and different ships in order to elude the German submarine packs."[13] A strategic radio system was badly needed. In 1918 a telephone repeater was developed, which with the triode thermionic valve developed in 1910 allowed telephone conversation over longer distances. This accomplishment increased the general military use of the telephone. The possible range of communications now exceeded 3000 kilometers.[14] The strategic communications solution was finished "in the spring of 1918. Radio Lafayette was then the most powerful HF radio station ever built and it placed the AEF in instant touch with Washington."[15]

By the end of World War I communications was becoming a combat multiplier for airpower. There were major improvements in range for command and control communications. Dependability and availability were still an issue. The introduction of air to ground voice radio was the most significant steps to improve command and control of airpower to date. This would allow the mobility and flexibility of aircraft to be more effective. This new apparatus gave commanders an increased ability to control events and processes through interactive voice communications feedback loops. Radio Lafayette allowed commanders rapid strategic communications.

Notes

[1] Army Times. *A History of the U.S. Signal Corps*. New York: G.P. Putnam's Sons. 1961. p. 98.

[2] R.K. Tierney. "Offspring of the Signal Corps. p. 129 .

[3] David L. Woods. *A History of Tactical Communication Techniques*. Orlando, Florida: 1965. p. 183.

[4] David J. Marshall. "The Signal Corps in World War I" in *The Story of the U.S. Army Signal Corps*. ed. Marshall, Max L. LTC, USA(Ret), The Watts Landpower Library. 1965. pp. 149-150.

[5] Ibid.

[6] Dr. George R. Thompson. "Radio Comes of Age in World War I" in *The Story of the U.S. Army Signal Corps*. ed. Marshall, Max L. LTC, USA (Ret.), The Watts Landpower Library. 1965. pp. 157-158.

[7] Ibid., p. 158.

[8] Army Times. *A History of the U.S. Signal Corps*. New York: G.P. Putnam's Sons. 1961. pp. 117-118.

[9] Dr. George R. Thompson. "Radio Comes of Age in World War I" in *The Story of the U.S. Army Signal Corps*. ed. Marshall, Max L. LTC, USA(Ret), The Watts Landpower Library. 1965. p. 161.

[10] Ibid., p. 160.

[11] Ibid., p. 165.

[12] Ibid., p. 163.

[13] David J. Marshall. "The Signal Corps in World War I" p. 147.

[14] David L. Woods, *A History of Tactical Communication Techniques*. p. 197.

Notes

[15] David J. Marshall. "The Signal Corps in World War I," p. 147.

Chapter 4

The Interwar Period

Seventeen radio projects and seventeen non-radio projects were listed on the US Army's Chief Signal Officer's Annual Report 1927 and by 1928, thirteen new communications sets were produced and nine of them dealt with improvements to aircraft communications.[1] In 1928, termed astonishing progress by MG George S. Gibbs, Chief Signal Officer of the Army, a new radio receiver for use with the aircraft radio sets was fielded. The new receiver was lighter, smaller and more rugged. It received CW signals, tone modulation and radiotelephone. This was a great technological leap that would potentially contribute much to the success of aircraft communications. Another important contribution to aircraft radio operations was the development of a double voltage direct engine driven generator for use in the aircraft. This reduced weight and cost by eliminating the need for a dynamotor for each radio set.[2]

The interwar years can be described as a time of great progress, but also a time when our communications technology failed to keep pace with combat equipment and command and control requirements. There were new requirements for mobility, range, and reliability. The early US Air-Service depended on commercial telephone and telegraph for communications between out stations and their headquarters. Airplanes had control stations, but had no radios. Cross-country flights required radio communications between airplanes and landing fields and from each landing field to adjacent landing fields. Powerful stations at frequent intervals to relay messages to all parts of the country were needed.[3]

The Air Service acknowledged early the requirement for a national network of airways and landing fields, permitting rapid movement of military aviation units throughout the country. It also saw the need for facilities for civil aviation. Development of airways and landing fields was a cooperative effort of federal agencies and state and municipal governments, business and industry, and civic groups. The Air Service was a major contributor to establishing and operating a model airway. "As part of that project, or in work closely related to it, the Air Service pursued development and improvement of navigational instruments, night-flying equipment, air-to-air and air-ground communications, weather service, and safety devices."[4]

In 1919, the Air Service founded the border patrol and announced a two-way, air-to-ground radiotelephony requirement for operations. The Service would also need air-to-ground radiotelegraphy for planes operating beyond the range of radiotelephone communications, and in certain instances want radiotelephony for plane-to-plane communications. Extended range capabilities became a command and control requirement.[5]

A handwritten note dropped in a tube, pouch with parachute, or a streamer proved during World War I, to be more reliable than radios for sending a message from airplanes to the ground. Airmen working with ground forces used prearranged signals using flares or aerial maneuvers. Ground forces used panels in various patterns or devised flares, rockets, smoke, or lights to communicate prearranged messages to airplanes. These methods were used throughout the first half of the 1920s because technology had not kept pace with command and control communications requirements.[6]

With help from the Signal Corps, Air Service radio communications were improved for the forest patrol in the early 1920s. Bombing tests in 1921 used radio for command and control of aircraft within formations. Bombing planes carried voice radio sets to talk between planes. Each formation's control plane had a radiotelegraph set for longer range to communications. Radio became standard equipment and progressively observation units adopted two-way radio to adjust artillery fire. "Experience with radios, together with modifications of apparatus and procedures, steadily enhanced communications" and "the Signal corps worked on a new radios with superheterodyne receivers for pursuit, observation, and bombardment."[7]

Many problems remained with radios. Reception problems caused by electrical interference and poor shielding of ignition systems. Some aircraft required complete rewiring. Wooden planes presented still greater challenges. They required wire and metal strips to be added to wings and fuselage for grounding. Any metal required bonding to prevent radiated energy from being absorbed and to eliminate sparks between metal parts. Reduction of receiver noise was a primary problem. This new technology and adaptation required extensive experimentation. Success was slow and often disappointing.[8]

Pursuit and bombardment units continued to train using radio for command and control. During the last half of the 1920s, the Air Corps held many shows using radio communications between ground stations and airplanes. In Chicago in June 1927 at a military tournament, Station WLS broadcast conversations between students of the Air

Corps Communication School, flying in O-2Cs, and controllers on the ground. The audience at Soldier Field heard the conversations over a public address system as they watched the aviators acknowledge and executed orders to ascend or descend, go in one direction or another, or fly in a certain formation. Technology posed a problem past the air show demonstrations. Tactical units had no equipment suitable for "radio control" of operations as the low frequency radio sets of the day proved deficient. "To communicate his orders to other pilots in his formation, a pursuit squadron or flight commander generally preferred older methods, like rocking the wings of his plane, waving his arms, or making other visual signals."[9]

The Air Corps worked with the Material Division, the Signal Corps, and industry to find better radio equipment. The requirement continued to be for equipment that was lighter, more reliable, and easier to operate. Longer range and higher quality communications were needed. Many obstacles got in the way particularly noise in voice transmissions. Despite static and interference pilots normally could read telegraphic signals, but microphones picked up excessive amounts of noise from the engine and the rush of wind in open cockpits. Pilots ordinarily could not understand voice transmissions. Other technical problems included adequate aircraft antennas. Masts and other fixed antennas provided only short-range communications. The antenna usually consisted of a wire one to two hundred feet in length with a weight at the end trailing the plane behind. Trailing antennae had a greater range than mast antennae, but were a hazard to other planes and prevented flying in close formation. When pilots maneuvered suddenly, the antenna could snap off. Flying too close to the ground, the wire would catch on trees or other objects and pull off.[10]

In 1928, Maj. Horace M. Hickam lead a board of Air Corps and Signal Corps officers that concluded two types of radio communications were required: "command" within a pursuit, bombardment, or attack unit in the air, or between units in combined operations; and "liaison" between aircraft in the air and Air Corps or other units on the ground. The equipment available at that time did not meet the requirements. The board recommended modification of current radios and use of a new receiver recently developed by the Signal Corps whose attributes were more compact, lighter, easier to install in the aircraft, and less complicated to use. This enhanced radio communications for bombardment, observation, and transport planes, and marked the first real efforts to use radio in pursuit operations.

> The 95th Pursuit Squadron, under Captain Elmendorf, pioneered in radio control of pursuit. The squadron exhibited its methods during a flight of eighteen planes from Santa Monica, California, to San Diego in March 1930. Elmendorf's plane carried a radio receiver and transmitter with a trailing antenna; the three flight commanders had receivers with mast antennas. General Fechet, in California on an inspection tour, directed the pursuit ships by voice radio from a transport plane piloted by Capt. Ira C. Eaker. Receiving Fechet's orders. Elmerdorf relayed them by radio-telegraphy to flight commanders, who passed them on to the other pilots by arm signals . . . throughout the operation the "use of radio exceeded anything . . . ever attempted heretofore in the history of the Air Corps.[11]

Command and control of airpower saw improvement. Bombing operations assisted by attack aviation had bomber commanders direct attack planes against unexpected targets. Command in the air now had greater flexibility as efforts to modify and train with existing radios paid off. The benefit to command and control would be possible elimination of predetermined itineraries, rendezvous points, and times of attack. This innovation might also keep missions from failing due to unforeseen antiaircraft resistance or inclement weather.

Another example of innovations that improved command and control of airpower was in 1930 by then Maj. Carl Spaatz, 7th Bombardment Group Commander. He modified a new Fokker C-7a at Rockwell Field by taking out some of the seats and installing two transmitters and two receivers. This allowed him without changing frequency to communicate with pursuit and bombardment aircraft in voice and code. Later that year, Spaatz explained radio control to the public through Fox Movietone News. And in training at Burbank, California, he parked his command aircraft at United Airport, fastened his trailing antenna to the flagpole, and using radio directed pursuit planes as they simulated defense of the airport. Early in 1931, Spaatz's 7th group obtained additional receivers to use with old transmitters and included voice radio in nearly every phase of training. The unit trained on radio-controlled interception using a bomber acting as a target to report location altitude, and course with voice radio to the ground station. Using this information, the ground station guided pursuit to the objective. Again because of determination and initiative of the Air leaders of the time command and control of airpower was improved.[12]

In early 1930s, radio figured prominently, showed great improvement in communications but much more was needed. Technology and availability of communications equipment continued to present problems. Only through determination and initiative of the airmen of the time was tactical training able to deal with the control of aerial operations through radio communications. Development in this area suffered an much of the radio equipment was less than adequate. As improvements occurred, the Air Corps experienced long delays in obtaining adequate equipment to operate. But doing the best with what equipment they had, tactical units trained using techniques that combined radio and visual communications to direct aerial operations.[13]

In 1933, the US Mail played in improvements of command and control of airpower. Commercial airlines owned modern hangars, shops, and offices and had good, well-equipped airplanes. Many of their pilots were graduates of the Air Corps' cadet program. They had training and experience using radios and instruments. They used two-way radios to communicate with ground stations at all points on their route. Airlines operated their own communications networks, and their pilots also used the communications radio beams, marker beacons, weather broadcasts, and facilities available along the federal airways.[14]

Voice radios for air-to-air ground communications were not the only improvements that had an impact on airpower effectiveness and its command and control. Aircraft combat capabilities were improved with directional gyroscopes, artificial horizons, and lighted instrument panels. There were also landing lights, Norden bombsights, automatic pilots, and electrically controlled bomb releases. Better aircrew comfort and safety were attained through free-fall parachutes, enclosed cockpits, inflatable life rafts, and survival kits. Improved communications and practiced operational techniques, together with training in flying, navigating, bombing, and shooting, raised the efficiency of the airpower as an instrument of national defense.[15]

Undoubtedly, the most advanced research being done in the second half of the 1930s was done by Colonel Blair, meteorologist of the AEF. Under the enthusiastic prompting of the new Army Chief Signal Officer, Major General J. O. Mauborgne, Colonel Blair dedicated his full attention to a detection device that would become radar. "On May 18, 1937, such an apparatus—designated as SCR-268—was successfully demonstrated at Fort Monmouth. It was proven, under the cloak of deepest security, that the ultrahigh-frequency beams could locate aircraft as well as direct searchlights for antiaircraft batteries. Three years later, the first operational sets went to duty at Fort Sherman in the Canal Zone."[16]

The payoff of the technological leap provided by radar would be enormous dividends in the command and control of airpower. The new radar could spot aircraft nearly 150 miles at sea. Future demands of the Signal Corps for communications were of a particularly scientific nature. When somewhat rudimentary instruments would do even in 1917, the Army in 1942 demanded the most advanced communications which included new radar models, walkie-talkie radios, teletypewriters, photoelectric radio transmitters, and telephone centers as fast and as automatic as any in the civilian sector.[17]

By the end of the 1930s the piston-engined monoplane was nearing the end of its technical development. All the advanced economic and technical powers approached this end at differing rates. At this point the only foreseen improvements to be made were in engine capacity, metallurgy, radio equipment, navigation aids and armament. "The British and American air forces had concentrated research efforts at what were seen to be critical points: engine power, armament, radio and radar equipment."[18]

The most significant communications improvement that would become a combat multiplier was FM (frequency modulation) radio. Its contribution is described in the World War II section below.

Notes

[1] Woods, David L. *A History of Tactical Communication Techniques.* pp. 230-231.

Notes

[2] Army Times. *A History of the U.S. Signal Corps*. pp. 126-128.

[3] Maurer, *Aviation in the U.S. Army, 1919-1939,* Office of Air Force History, U.S. Air Force, Washington, D.C., 1987. p. 36 .

[4] Ibid., p. 149.

[5] Ibid., p. 157.

[6] Ibid., pp. 157-158.

[7] Ibid., pp. 158-159.

[8] Ibid., p. 159.

[9] Ibid., p. 231.

[10] Ibid.

[11] Ibid., pp. 232-233.

[12] Ibid., p. 233.

[13] Ibid., p. 237.

[14] Ibid., p. 301.

[15] Ibid., p. 445.

[16] Army Times. *A History of the U.S. Signal Corps*. New York: G.P. Putnam's Sons. 1961.p. 132.

[17] Ibid., pp. 134-138.

[18] Overy, R.J., *The Air War, 1939-1945,* Scarborough House Publishers, 1991. p. 194.16

Chapter 5

During World War II

Liddell Hart credits Hitler going into World War II with giving "the strategy of indirect approach a new extension, logically and psychologically" but later Hitler "gave his opponents ample opportunity to exploit the indirect approach against him."[1] Hitler was more prepared at the beginning of the war than Allied Forces. As the Allied Forces improved their capabilities and processes Hitler did not always change his strategy, nor did he know he should change. Intelligence reports detailing military capability gave Germany status as the only force capable of organization, preparation, and leadership of an offensive and defensive air war.[2]

The effort and challenge of modernization for communications for command and control would again fall to the Signal Corps. The Signal Corps entered WWII with "relatively few officers and men, with utterly inadequate stores of equipment, with a skeletal training organization, and with insufficient industrial backing (the nation's electronic producers had little experience in mass production of intricate military radio, almost none in radar). Yet the Corps succeeded in the course of the war in creating a vast organization of skilled men, mountains of equipment, and worldwide communications systems."[3]

The Battle for France and the Battle of Britain illustrate communications as a combat multiplier. Communication was a combat multiplier for German command and control in the Battle for France and communication was a combat multiplier for Britain in the Battle for Britain.

In the Battle for France the German Blitzkrieg strategy had the principle of coordination between airpower and ground forces. It stressed speed and flexibility. Communication was a combat multiplier for Germany's command and control and gave them the ability to win in the early part of the War. German commanders were prepared to exploit the fight to their advantage because they had better command and control and understood the importance of communications. "In the beginning of World War II in Europe the Germans taught the British Army an important tactical lesson in the coordinated use of armor and close air support backed by motorized artillery and infantry. The secret of this mobility was effective signal communication, primarily radio."[4] The Germans had an extremely reliable radio system. They had voice radio connectivity for command and control. In 1918, the British felt that wireless was regarded as a standby method for wire line communication, but early in World War II wireless assumed its place as a "genuine alternate for use at all levels over considerable periods."[5]

In the Battle of Britain, Germany did not have the communications force multiplier advantage. The German air commanders were not aware of the significant communications and electronic advances Britain possessed, specifically radar. The British command and control systems and their integrated air defense system gave the RAF the advantage.[6] Against the British system, the lacking German command and control communications rendered German airpower more inflexible than flexible. When the Germans began a battle their communications were not capable of allowing them to consider options other than those predetermined; hit the target, hit an alternative target, or return.

At the beginning of the war radar direction finding, RDF, was reliable enough to allow operators of cathode ray tubes to estimate the distance of the incoming aircraft raid and to make a fairly knowledgeable calculation of the elevation and size of the incoming force. As operators gained experience their estimates became more accurate and experience made up for the technological inadequacies of the new equipment. Command and control of airpower was positively improved as the controllers continuously enhanced their ability to employ the radar system's information to control the airborne fighters. In Great Britain the RAF enjoy a distinct technological advantage over the Luftwaffe through their use of their backbone of chain home radar stations.[7]

At the strategic planning core of Britain's Integrated Air Defense system radar plots were correlated to provide range and direction of raids from radar by triangulation. Airpower, fighter forces were controlled by radar plots, IFF signals from the squadrons which in the air, and by HF, later clear VHF, radio transmissions. Aircraft remained under sector controllers until enemy aircraft were visual contact was made then squadron commanders assumed control to fight the air battle. The unbroken backbone of chain home radar stations cost the Luftwaffe surprise in the battle of Britain and proved to be a significant affect on the command and control of airpower.[8]

In 1943 the Luftwaffe was forced back onto the defensive. Their research and development was bound to be geared to the initiatives of the Allies. Their defensive response improved their command and control of airpower with improvements in radar and radio aids for night-fighters as well as technological advances like better armament to attack the heavy bombers and greater ceilings for fighters.

The greatest contrast between the intelligence efforts of Allied and Axis powers was in the degree that science was put to use for intelligence purposes. This was not always the case, as Russian radar remained below the standards of German radar. Low-level tactical radio intelligence was easily available on the eastern front to both sides. But in the west and in the far eastern war, greater emphasis was placed on radar and radio both for intelligence and for air operations. The difference in emphasis can be attributed to strategic needs. The crucial area for scientific intelligence in Britain's preparation for war and early conduct of the war was aerial defense that had an early warning system for short-term intelligence purposes. Later during the bombing offensives, it was necessary to use radar and radio communications as means to confuse the intelligence efforts of the enemy in addition to improving navigation and bombing accuracy.[9]

In 1940, the gap in research was not as broad as British intelligence at initially held. The difference was in the use of radar. German strategy accentuated a flexible radar use for tactical intelligence and the applicable technology was created for accurate prediction of range and speed, but not altitude, of attacking aircraft. There was a small chain of radar stations on the north coast of Germany to warn against British attack. "Had the situation been reversed in 1940 and the battle been bought over Germany instead of Britain, radar would have provided ample advance warning for the Luftwaffe as it did for the RAF."[10] The principal weight of German radar research was for use by the army on the battlefield and secondarily as defense.

World War II was a war of materials and machines, of tanks and vehicles of all sorts, and of the equipment that goes with motorized land operations, with aircraft and their specialized needs, and with all the communications equipment required to command and control.[11] There was a great demand for advanced communications whereas in 1917 elementary communications instruments would suffice. Size reduction, speed, reliability, flexibility were all requirements.[12] "Communications—that is reliable heavy-duty message and voice traffic—had previously meant telegraph, teletype, and telephone transmission over wire or cable circuits. But now mobile warfare, requiring communications links to every moving tank, command car and airplane, meant that radio circuits must also be heavily relied on."[13]

Communications equipment shortages were as common as they were in World War I. They were not unusual in any theater of the war. Through 1943 the entire South Pacific Theater had communications equipment shortages. "Practically everything was needed."[14] In the European Theater, it was no better. Normal wear, battle losses and climatic conditions were large consumers of communication parts. Colonel Grant A. Williams, Fifth Armored Division Signal Officer summed up the parts problem when he wrote: "We had an awful time, every place this division has been we left requisitions covering our requirements for supply parts and expendable supplies, for 60 days. . . . We have to go to the depots and yell and scream and steal to get even the few spare parts we have. . . . The worst part is to get tanks and other vehicles with no radio equipment at all."[15] Command and control communications improvements were often to no advantage because of the short supply of communications equipment.

The state of ground communications was positively improved with the introduction of Frequency Modulation radio. Major Edwin H. Armstrong invented FM radio. FM solved the reliability and distortion problems associated with radio communications. The tactical FM radio of American armies was the envy of all nations in World War II. "FM radio relay alone kept communications operating all the forward during General Patton's Third Army dash deep into France in 1944 after the Saint-Lo breakout." Patton's headquarters, Lucky Forward, was in complete communications because of FM radio relay.[16]

Command and control through worldwide strategic communications saw tremendous equipment innovations and expansions also. Before World War II a few radio and wire circuits for military command and administrative communications were extended over the continental United States, and beyond, to a few outlying headquarters locations. Most of the radio circuits were CW. "These facilities and methods were totally inadequate for worldwide nets that the Army and Army air forces required at once after Pearl Harbor—long-range, transoceanic, multi-channel circuits, channeling massive flows of communications traffic around the clock, day after day."[17]

Command and control at the strategic level was greatly improved in 1942 when the "Army Communications Service rapidly built up a huge semiautomatic global system called ACAN—Army Command and Administrative Net—which centered in station WAR in the Pentagon. The Service simultaneously built up a second global net servicing solely the Army Air Forces. This was called the AACS, or Army Airways Communications System."[18]

ACAN grew and became a worldwide communications net with stations established in London, Algiers, Cairo, Caserta, Italy, Paris, and by mid-1945 in Frankfurt, Germany.

Other stations in the Pacific theater included Hawaii, New Caledonia, Australia, India, New Guinea and by 1945 to Manila, Okinawa, and finally to Tokyo at the war's end.[19]

In June 1943 Dr. Edward Bowles, in the office of the Secretary of War made a study of the communications situation and reported: "At present despite the vital importance of communications, the Army Air Force has neither the organizational framework nor the integrated group of qualified military and technical minds which is necessary to derive the most from these important fields. . . . There is no strong consciousness of communications, radar and electronics within the Army as a whole. . . . High staff planning agencies lack the essential concept of communications as systems which are fundamental in tactical planning, and I successful combat operations."[20]

One answer came, in part, in the form of the joint Communications Board, representing Army, Navy and Army Air Forces. The organization went far toward effecting co-ordination, eliminating duplication and, in general, bringing communications as closely together "as is possible without a unified command."[21]

In 1943, FM 100-20 declared in all capital letters that land power and airpower were co-equal and interdependent forces. In regard to command of airpower, the manual said that it would be vested in the superior commander charged with the actual conduct of the operation and that Army Air Forces would not be attached to ground forces except when the ground force was operating independently or was isolated by either distance or communications. Control of available airpower must be centralized and command must be exercised through the Air Force Commander is mentioned numerous times in the manual.[22] "In order to obtain flexibility, the operations of the constituent units of a large air force must be closely coordinated. Flexibility enables airpower to be switched quickly from one objective to another in the theater of operations. Control of available airpower in the theater must be centralized and command must be exercised through the air force commander."[23]

As forces were coming ashore on Omaha Beach, General Pete Quesada and other commanders grew concerned. Off shore on the cruiser Augusta, Omar Bradley's "worries deepened over the alarming and fragmentary reports we picked up...we could piece together only an incoherent account of sinkings, swampings, heavy enemy fire, and chaos on the beaches."[24]

Back in the Combined Control Center at Uxbridge, radar operators, flight controllers and commanders frustrated by the chaotic messages because of inadequate communications to the distant shore grappled to make an sense of the situation, but their only certainty was that the operation at Omaha Beach was in imminent danger of failure. The complicated signals plan to direct air support had collapsed. Over half the American air liaison parties on Omaha Beach were now inoperable. There was very little radio contact between the support parties ashore and their forces afloat. Communications nets which required a series of relays spanning from the beach to fighter direction tenders offshore, to headquarters ships, and ultimately to Uxbridge were not responsive enough the tempo of the battle. The enormous operational undertaking that was D-Day had been planned to the last detail. Communications was the key to pull the complex campaign together. Without communications the operation would fail. The first lesson learned was that the cumbersome command channels were inadequately suited for close air support of a fluid ground battle. These systems were satisfactory for planned long-range bomber missions deep into the heart of Germany, the very kind of operations that had occurred the air war up to D-Day. The close air support war now beginning in Normandy would require new communications arrangements to successfully command and control airpower.[25]

In addition to voice communications, Quesada worked to connect his MEW radar to blind-bombing efforts. MEW was one of the campaign's early disappointments. After D-Day, Problems with radar included logistical problems of lost or damaged equipment as well as training problems. The 555th Signal Air Warning Battalion, in charge of the radar for the operational area, lost most of its original equipment on the transit across the English Channel, and when they received replacement equipment personnel were not fully informed of their mission. By 15 July 1944, a grand total of five aircraft were guided to targets with this equipment. The vision of a revolutionary offensive weapon remained only a prophecy. A different part of the problem was with the attitudes of pilots. These pilots grew up with stories of seat of the pants flights. They were young and eager, but reluctant to use the new technology despite its immense potential. "Flights controlled by science simply did not fit the heroic parameters set by an earlier generation of airmen. No radar technician on the ground had ever told Eddie Rickenbacker when to drop his bombs or fire his guns. Technology, however grand, must fit the disposition of the people who are to use it, and Quesada spend the rest of the war building his pilot's confidence in a variety of newfangled gadgets."[26]

MEW also had inherent deficiencies when used in blind bombing. Although it could locate fighter aircraft with accuracy, it alone could not correlate each aircraft's location relevant to the ground with enough precision for bombing. Medium and heavy bombers overcame this problem with airborne radar and the Norden bombsight, but fighters had not enough space or the payload capacity for such solutions. The smaller ordinance that fighters carried also demanded greater accuracy than offered by the radar systems in the bigger planes. Tactical air required something new and different to use radar to advantage. The SCR-584 was a special radar designed to direct antiaircraft fire. It was America's most accurate close-range radar and it held the key and possible solution to many of the obstacles associated command and control of airpower using radar.[27]

The tactics, techniques, and procedures used with the new radar helped overcome previous problems. The way the lash up of equipment, experimentation, and training worked was "a pilot flying a route prescribed by the radar would radio his wind, air-speed, and altitude to the radar center, where a "bombardier" would feed the information into the Norden computer. Moving the bombsight over the map as the plane flew over the terrain, the radar operator would release the bombs by radio once the aircraft was over the target. The pilot did nothing but fly the plane. The ground controllers did the rest."[28] Greater acceptance of this technology was fostered by greater successes.

In Africa, Sicily, and Italy, the Army-style command and control communications proved too unwieldy for the air war because of the speed and flexibility of airpower. The speed of aviation in World War II demanded an almost automatic ability to change plans. Flexibility and command and control of airpower improved with the unique radar setup. "With the adoption of SCR-584 equipped missions, Quesada now had the technical ability to shift planes already in the air. That capability would pay large dividends in the future."[29]

The evolution of command and control communications was responsible for many successes airpower enjoyed in August 1944. Although Quesada's command was much smaller, only half as big, it flew more sorties, dropped more bombs, destroyed more

German vehicles, and downed more Luftwaffe planes than in any other month in its history. "The IX TAC's August box score was...8,712 sorties, 21,237 tons of bombs dropped, 634 enemy tanks destroyed, and twenty-six aerial victories. Radar-controlled flights, . . . so hard to perfect, at last were playing the role scripted for them."[30] The combined MEW/SCR-584 radar center directed over 500 missions in August, verses 38 in July. The weather in August was no better, but clouds grounded fighters only 3 days verses the 11 in July. Again in IX TAC was at a high sortie count in October 1944. The command had the most sorties per plane, the highest rate of Luftwaffe kills, and the highest number of SCR-584 blind-bombing mission successes than any month in the war.[31]

Even with the recent, huge successes there were technical problems requiring technical solutions. Operational tests suggested better coordination between radar centers and directing posts would improve radar control and thus improve command and control of airpower. New guidelines to streamline the flow of information through the various cogs in the control system were issued giving procedural solutions to operational and technical deficiencies.[32]

Notes

[1] Hart, B.H. Liddell. Strategy. 1954; reprint, Faber and Faber Ltd., London, 1967. p. 207.

[2] Murray, Williamson. *Strategy for Defeat, The Luftwaffe, 1933-1945*, Maxwell AFB, Al., Air University Press., December 1983. pp. 27-56.

[3] Dr. George R. Thompson. "The Signal Corps in World War II" p. 181.

[4] Woods, David L. *A History of Tactical Communication Techniques*. pp. 226-232.

[5] Ibid.

[6] Mowbray, James A.. Ph.D., "The Battle of Britain Air Strategy and Operations, 1940" Department of Military Strategy and Force Employment, Maxwell AFB, Al.: Air War College, June 1989. pp. 24-26.

[7] Ibid., p. 5.

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[8] Ibid., pp. 6-12 & 24.

[9] Overy, R.J., *The Air War, 1939-1945,* Scarborough House Publishers, 1991. p. 200.

[10] Ibid.

[11] Dr. George R. Thompson. "The Signal Corps in World War II" in *The Story of the U.S. Army Signal Corps.* ed. Marshall, Max L. LTC, USA(Ret), The Watts Landpower Library. 1965. p. 174.

[12] Army Times. A History of the U.S. Signal Corps. p. 138.

[13] Dr. George R. Thompson. "The Signal Corps in World War II" p. 174-176.

[14] Woods, David L. *A History of Tactical Communication Techniques.* p. 201.

[15] Army Times. *A History of the U.S. Signal Corps.* p. 150.

[16] Dr. George R. Thompson. "The Signal Corps in World War II" p. 177.

[17] Ibid.,. p. 178.

[18] Ibid.

[19] Ibid.

[20] Army Times. A History of the U.S. Signal Corps. p. 147.

[21] Ibid.

[22] FM 100-20, Command and Employment of Air Power, 21 July 1943.

[23] Ibid., p. 7.

[24] Thomas Alexander Hughes, *Overlord: General Pete Quesada and the Triumph of Tactical Air Power in World War II,* New York: The Free Press, 1995. p. 7.

[25] Ibid., pp. 8-9.

[26] Ibid., p. 185.

[27] Ibid., pp. 185-186.

[28] Ibid., p .186.

[29] Ibid., p. 188.

[30] Ibid., p. 247.

[31] Ibid., p. 265.

[32] Ibid., p. 294.

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Chapter 6

Conclusion

In this paper, I explained how communications became an airpower combat multiplier and looked at the evolution of communications equipment, procedures, and understanding. This paper explored the affect of the evolution of communications on the command and control of airpower. It looked at the means available to communicate; among ground forces, from aircraft to aircraft, from ground forces to aircraft, and from aircraft to ground forces. Once commanders understood the importance of reliable, flexible, and survivable communications systems they demanded more. Significant logistical problems slowed the effect of communications as a combat multiplier. Command and control communications progressed to the point by war's end to be more reliable and responsive. Much of the improvements are attributed to the industrial base, extraordinary efforts, initiative, determination and innovations of a number of key people. The concepts were in place and practiced in varying degrees throughout the theaters. Commanders had the capability to communicate world wide and to higher and lower headquarters. Communications advancements, particularly FM radio and radar greatly enhanced the coordination of airpower. Orders and missions were more easily disseminated throughout the theater. Overall information flow greatly assisted the commander's decision making process. In spite of the problems mentioned communications, by war's end was a significant airpower combat multiplier. As communications became more technologically advanced, more reliable, responsive, and effective, commanders realized an even greater combat multiplying effect on airpower.

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