AIR COMMAND AND STAFF COLLEGE

STUDENT REPORT

ANALYSIS OF CHANGING TECHNOLOGY DURING THE BATTLE OF BRITAIN AND ITS APPLICABILITY TO FUTURE COMMAND AND CONTROL SYSTEMS ISSUES

MAJOR JEFFREY W. ACKERSON 88-0015

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Technology was a key element in determining the outcome of the Battle of Britain. The British developed and deployed new technology in areas such as radar and command and control that provided them with a significant edge in battle. The study evaluates the impact technology had on this battle and assesses the applicability of lessons learned in this area to the development of today's air command and control system in the NATO theater. The concepts of foresight and planning used during the Battle of Britain are compared to the steps currently being taken in the development of the NATO Air Command and Control System (ACCS). The study concludes that these concepts are still valid today and are being thoughtfully applied in the NATO ACCS.

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PREFACE

The Battle of Britain was one of the key air battles of the Second World War. The defeat of the German Luftwaffe by the British Royal Air Force (RAF) prevented an invasion of the British Isles and helped alter the course of the war. British success was not only due to the gallantry and skill of her fighter pilots, but also to their timely and judicious use of available technology to control RAF assets and enhance their capabilities. The inability of the Germans to grasp the significance of these technological advances directly contributed to their defeat. The decades that followed World War II produced significant technological changes in air defense capabilities, particularly in the North Atlantic Treaty Organization (NATO). Deployment of new technology, particularly in the air command and control area, must be carefully considered. It is possible that many of the concepts used by the British in the Battle of Britain concerning this area may still be valid today. A study of these ideas could prove useful for NATO commanders as they establish and deploy the air defense systems based on current and future technology.

ABOUT THE AUTHOR

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

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AUTHOR(S) MAJOR JEFFREY W. ACKERSON, USAF

TITLE ANALYSIS OF CHANGING TECHNOLOGY DURING THE BATTLE OF BRITAIN AND ITS APPLICABILITY TO FUTURE COMMAND AND CONTROL SYSTEMS ISSUES

I. Problem: Can an analysis of changing technology and related tactics during the Battle of Britain provide insight for developing future air command and control systems for the North Atlantic Treaty Organization (NATO)?

II. Objectives: Review the Battle of Britain and analyze how the British integrated new technology involving such systems as radar and command and control to their defenses. Evaluate the impact technology had on German and British tactics. Describe current NATO Air Command and Control System (ACCS). Determine what lessons learned in foresight and planning from the Battle of Britain can be employed in today's air defense environment.

III. Discussion of Analysis: Early planning and deployment of an integrated air defense system by the British prior to the outbreak of World War II enabled them to have significant advantages over the Germans in the Battle of Britain. Coordinated use of radar with an air command and control system enabled the British to successfully attack German formations and make the best use of their limited resources.

Poor German leadership, planning, and an inability to grasp air defense led to their defeat. Similar circumstances in the air defense arena may exist today with NATO's Air Command and Control System. The current NATO ACCS is an integrated air defense system with a plan for expanded development. Technological advances have been recognized and implemented as evidenced by the deployment of such systems as the Airborne Warning and Control System (AWACS). Lessons of the past have been recognized and a future-oriented system that incorporates and fields the latest technology is in place with the ACCS.

IV. Conclusions: The British recognized the importance of foresight, planning and fielding capable air defenses using the latest technology. The Germans failed to grasp the significance technology had on influencing the conflict, particularly in the command and control areas which led to their defeat in the Battle of Britain. Lessons learned from these concepts on the effective use of technology in these areas are evident in the NATO efforts to develop and deploy the ACCS.

V. Recommendations: Foresight and planning are timeless keys to success in battle. Every effort should be made to ensure that present leadership remains aware of these concepts that were proven in the past so they can effectively deal with today's complex technological environment in air defense.

Introduction

"The first great, decisive air battle in history" took place in the skies over England in the summer of 1940 (10: 51). The course of the Second World War was changed by this battle and the circumstances of the war's ultimate outcome were profoundly influenced. This conflict was known as the Battle of Britain and is unique as it was fought entirely in the air. While the actual combatants in the Royal Air Force (RAF) and Luftwaffe fighters and bombers displayed great courage, determination and skill, the battle was characterized by several distinct advances in technology. These advances significantly contributed to the final results of the battle. People played the decisive role in this battle. However, the role of innovative planning and judicious use of technology must not be overlooked in their impact and deserve further investigation. Foresight and planning were vitally important to the British in 1940. They recognized the importance technology could play in devising their air defenses. Today, while weapons and tactics have changed, these thought processes on the use of technology remain important.

The purpose of this research paper is to determine if an analysis of changing technology in the areas of radar, command and control, and related tactics during the Battle of Britain can provide insight for developing future air command and control systems for the North Atlantic Treaty Organization (NATO). This study consists of five chapters: Chapter One provides a brief overview of the Battle of Britain to include key events, components and players; Chapter Two describes the development and integration of radar with a command and control system by the British; Chapter Three explores the impact this system had on British and German tactics as the battle developed; Chapter Four reviews and describes the current NATO Air Command and Control System (ACCS) for key components and concepts; and Chapter Five determines if lessons learned from the Battle of Britain are applicable to today's scenario in the NATO theater.

Technology was not the ultimate determinant of who won this battle, but it did provide a tremendous advantage to the British who realized the important contributions it could make. Hopefully, a review of this crucial battle from a different perspective, mainly from the role played by

technology and its application, will enable the reader to determine its true impact then and its potential impact now. The process of analyzing and applying new technology was successfully accomplished by the RAF in the late 1930s. It provided them with significant tools to help carry out the vital defense of their homeland from the air in the Battle of Britain.

Chapter One

OVERVIEW OF THE BATTLE OF BRITAIN

BACKGROUND

Following the fall of France in June of 1940, only Great Britain was left to face the formidable German war machine. Hitler's forces had swept to easy victories against a Europe that was unprepared for the new blitzkrieg tactics. German forces were poised on the English Channel awaiting orders to turn on their next victim--England. The ease with which the Germans conquered continental Europe left them with a dilemma as to what they wanted to do next. Neither Hitler, nor the German High Command had any clear plans on the further conduct of the war (8:18).

German Perspective

Hitler hoped he could convince the British to give in without mounting an invasion (5:74). When this did not occur, the following order was issued on July 2, 1940, by the German High Command: "The Fueher...had decided...that a landing in England is possible, provided that air superiority can be attained and certain other necessary conditions are fulfilled" (5:76). The Germans needed to mass their troops and prepare for an invasion for which they were not trained or equipped. The key fact was their realization that they would have to destroy England's air defenses before they could successfully invade (7:477). Thus, the job of creating the right circumstances for an invasion went to Reichsmarschall Hermann Goering and his Luftwaffe.

While Goering enthusiastically went about planning for the destruction of the RAF, it must be pointed out that the ensuing battle was "never one of Hitler's original war aims. It was merely a stone which had rolled in his way; it either had to be removed or to be by-passed" (8:51). Once planning began in earnest, Goering's insistence on Luftwaffe capabilities to quickly defeat the British and his influence with Hitler went a long way in determining when and where the battle would be fought.

Initially, the Luftwaffe prepared for three objectives:

1. Blockade the British Isles in cooperation with the Navy--this included attacks on ports, shipping, and mining sea lanes and harbors.

2. Achievement of air superiority as a preliminary to the invasion (Operation Sea Lion).

3. Annihilation of England by total air warfare (8:12).

This was an ambitious plan, but it appeared that the Germans did have the resources to accomplish it. Goering had over 2600 serviceable aircraft at his disposal at the start of the battle. These forces were divided into three Luftflotten (air fleets). There were skilled subordinate commanders including Field Marshals Kesselring (Luftflotten 2, Holland and Belgium); Sperrle (Luftflotten 3, northern France); and Stumpff (Luftflotten 5, Norway and Denmark). These men employed their forces with as much flexibility as they were allowed, but as the battle progressed their commander took increasing interest. Goering "refused to relinquish his ultimate authority and the right to shape air force strategy ...and he hesitated to appoint officers of distinction who would expose his shortcomings" (13:165). This was unfortunate for the Germans as Goering "never made any attempt to understand the nature and limitations of air power" (5:91). This shortcoming, coupled with a concept of command by Goering that was rather crude, helped seal the German's fate in this battle despite the determined efforts of their airmen. A consolidated effort was essential as the Luftwaffe faced a country and a fighter force that had been preparing for the battle for several years.

British Perspective

The defense of England from the air was placed in the hands of Sir Hugh Caswall Dowding, Air Chief Marshal of the RAF Fighter Command. This choice of men was extremely fortunate for the British as Dowding was in command since July 14, 1936, and was the man responsible for completely remodeling Britain's air defenses (4:49). His ability to foresee future requirements and integrate changes in technology into a new system helped prepare the foundations for the success of the RAF in the battle. He understood aerial warfare and showed a deft ability to conserve his limited resources in planes and pilots. Dowding also helped devise an air defense system using the new technology embodied in radar that proved to be a key to his success in battle. "Among material factors which contributed to Fighter Command's success was a system of early warning and control that was unparalled outside Britain" (4:25). The important contribution of this system was that it "enabled the RAF to

avoid costly standing patrols and concentrate in real-time against the threat" (2:143).

Dowding's objective was simple. He planned to disrupt and repel the Germans by intercepting raiders whenever and wherever they appeared (9:261). He was able to do this for several reasons. First, he actively controlled and dispersed his forces which consisted of roughly 600 fighters (mostly Hurricanes and Spitfires) (15:50). Second, Dowding picked extremely capable subordinate commanders to whom he gave great freedom in directing their own operations. Fighter Command was divided into four groups. They were commanded by Air Marshals Park (Group 11, southeast); Leigh-Mallory (Group 12, midlands); and Air Vice Marshals Saul (Group 13, north) and Brand (Group 10, southwest) (4:52). The flexibility these men had under Dowding allowed them to effectively take the battle to the enemy on terms more to their choosing than their German counterparts under Goering. Finally, the command and control system coupled with radar enabled the RAF to position its squadrons with "at least a rough-and-ready knowledge of the scale and direction of the enemy's attack" (4:27). These factors weighed heavily on the battle. Leadership and the use of technology were crucial. "So far as skill and courage in combat were concerned, the two sides were evenly matched...the side which won was much more intelligently handled by its leaders than the side which lost" (4:28).

Phases of Battle

There is general agreement among historians and participants that the Battle of Britain had five distinct phases. While some dates overlap, the time frames are roughly the same. General Adolf Galland, a key participant as a German fighter pilot and commander, divided the battle as follows:

PHASE I -- 1 June--24 July 1940
(positioning and light attacks)

PHASE II -- 24 July--8 Aug
(fighter battle and Channel convoy bombing)

PHASE III --8 Aug--7 Sep
(air supremacy attacks--bombers attack fighter bases, radar installations and aircraft/engine factories)

PHASE IV --7 Sep--20 Oct
(London bombing--38 large-scale raids)

PHASE V --20 Oct--April 1941
(night bombing) (8:19,21,30,41,51)

These phases show how the battle evolved. There are some historians who view this battle as a series of skirmishes leading up to two decisive battles on September 15 (4:24). Although these battles were the last large-scale attempt by the Luftwaffe to draw out Fighter Command, one must include the concentrated attacks during phase III from Aug 7-15 (which includes the attack known as "Eagle Day") as the other decisive engagement in the battle (6:271).

The fighting varied in intensity throughout the summer. Goering initially tried to draw out the RAF over the English Channel. Dowding quickly saw through this tactic and refused to cooperate. Next, the Luftwaffe attempted to smash the RAF through ground attacks and fighter battles. This did not work as targets were often ill-conceived and bombers were squandered on targets of minimal significance. As losses mounted, German fighters became close escorts for the bombers. The Germans did not find the solution here either as bomber losses continued and their fighters lost effectiveness. Throughout the battle, the British concentrated on downing the bombers and avoiding the fighters. It wasn't until Sept 15 when two all-out fighter and bomber attacks on London occurred that the Germans got the fighter battle they wanted. The result was a decision for the British (4:26).

Several mistakes were made on both sides throughout the battle. Neither one made an accurate assessment of enemy losses, or determined their actual strength or intent. The British were better prepared overall, particularly through their use of technology to strengthen their abilities to intercept an attacker on favorable terms. They were fighting a battle that they prepared for years earlier (2:119). The essence of the battle was aptly stated by General Hap Arnold, Commander of the United States Army Air Forces, who observed the action. He wrote:

> In many ways, in all history there was never such a battle fought. It was not only the first all air battle in the world, it was perhaps the most epic. Suddenly, the inept, the pursued, became the foxy killers; not merely the defenders, but the hunters. Air Marshall Dowding's long...preparations, the great warning system, the movements of fighters back from base to base as the South England dromes were bombed out, the air-ground control system, the tireless morale of the British pilots, their skill and courage, and the Spits and Hurricanes paid off. At the peak of its triumph, Goering's Luftwaffe was

suddenly demoralized--not merely out-fought, but out-thought (7:472).

Dowding did out-think his adversaries. A key aspect in this area was his use of technology. He foresaw the importance of radar and developed from scratch a system for controlling air defense forces. The assets he used were not only fighters, but radar, barrage balloons, antiaircraft guns, observers on the ground, and a command and control network by radio-telephone. He "established the system of interlocking groups and sectors which received, interpreted and served as a conduit for all available sources of intelligence on enemy raids (9:322) While there are many factors that contributed to the ultimate outcome of this battle, Dowding's use of technology was highly important. Further study of his system and its impact on the battle should clarify how the Battle of Britain was won.

Chapter Two

DEVELOPMENT OF BRITISH COMMAND AND CONTROL SYSTEM

SYSTEM CONSTRUCTION

Radar Integration

One of the key elements of the British air defense system was radar. This system was developed several years before the battle. Following a series of RAF exercises in 1934, it was determined that British air defenses were inadequate to meet an attack across the English Channel (2:459). A committee was formed in 1935 to deliberate this problem. It was placed under the control of Henry Tizard, a renowned scientist. The committee explored several possibilities, but the most promising work was being done by Robert Watson-Watt, a scientist at the National Physical Laboratory. He was getting some promising results in his experiments involving the re-radiation of radio waves to detect aircraft (5:63). Sir Hugh Dowding, the future leader of RAF Fighter Command, was a ground floor observer of this process in his capacity as Air Member for Supply and Research. During the time period of 1935-1939, it was Dowding's realization of this system's promise, along with the support of the Tizard Committee, that allowed British scientists to "create the radar network that made victory possible in 1940" (5:62).

Once the radar concept was proven to work, planning for the construction of transmitting and receiving antennas began in 1937. Construction went well and resulted in a system that was in commission and fully operational prior to the start of the war (7:367). Dowding was instrumental in furthering work on this system. He promoted the work to link the system by radio telephone communications with his fighters and ground controllers. He encouraged the development of a simple identification (friend-or-foe [IFF] system) that meshed with the radar. All of these initiatives played a big part in the future battle. When the "Chain Home" radars came on line in 1937, the British had the bulwark around which a formidable air defense system could be built. "The creation of radar totally transformed the

ability of the defense to anticipate and then defeat a bomber attack" (5:62). The key step the British took was to integrate this system with other parts under the watchful eyes of Marshal Dowding. He devised a system to link his fighters with ground controllers, command and control operations rooms, searchlights, antiaircraft guns, barrage balloons, and a network of observers on the ground. Dowding called it "science thoughtfully applied to operational requirements" (14:173).

System Components and Operation

The air defense system was simple but effective. Attacking aircraft were picked up on radar prior to crossing the English coast. This enabled the RAF to roughly determine the attacking forces' strength and direction, a factor in the battle that the British understood well but the Germans did not.

> Although the Germans could not have failed to notice the towering pylon-like masts of the Radio Direction Finding (RDF) stations, and did in fact partially guess their purpose, they did not imagine radar would be able to differentiate between main air assaults and small decoy raids (12:42).

Dowding used this advantage over and over again to deploy his fighters against the greatest threat. He also proved quite adept at getting the most from the other components of the air defense network.

Once an aircraft crossed the English Coast it was no longer seen on radar as all the stations faced toward the sea. Further tracking of the raiders and passing this information to Fighter Command fell to the Royal Observer Corps. This group was founded in the 1920s and consisted of about 30,000 trained personnel (2:146). They proved to be quite competent in helping guide fighters to the proper intercept locations by sight and sound during the day. The Corps reported aircraft movements across the whole of England and played a key role in the battle with their simple but effective methods. This group meshed well with other ground defense components.

The central part of Dowding's ground defenses was comprised of seven antiaircraft divisions. These forces were placed under the command of General Sir Frederick Pike and were loosely controlled by Dowding. They consisted of 1,200 heavy and 587 light guns supported by 3,932 searchlights which were deployed around important targets (5:180). These guns were in most cases ineffective as they were not very accurate and mostly obsolete (5:180). They were able to

disrupt some attacking formations by making them attack from higher altitudes. These guns were tied into a network of barrage balloons.

The barrage balloons were tethered around what were considered vital targets and by July 31, 1940, consisted of 1,466 balloons with steel cables suspended from them. Their main impact was to discourage dive bombing and low-level attacks which they achieved with moderate success (2:55). Some of these components on their own did not amount to much. The key was in Dowding's work to integrate them into a smooth functioning system governed by a highly efficient control network.

Communicating attack information as fast as possible was crucial. This important link in the air defense system was maintained by the Post Office War Group. These people had the vital job of maintaining communications via telephone and radio telephone between radar stations, observer positions, RAF fighter airfields, and control rooms at all levels of command (2:148). They proved to be highly successful in carrying out this important task.

Marshal Dowding used all these parts to orchestrate his defense and kept important information flowing when and where it was needed. Radar picked up the enemy first and passed this information to the filter room at RAF Fighter Command Headquarters at Bentley Priory. It was then channeled to the appropriate sector controller. Command and operations rooms plotted raid progress with updates from the Observer Corps and airborne fighters. Dowding initially had control centralized but wisely changed this policy early in the battle. His decentralization efforts enabled the appropriate group and sector operations people to deploy their forces as they saw fit to meet an attack. Dowding was therefore able to take full advantage of the individual skills and initiative that his subordinate commanders possessed.

Dowding's foresight and planning to establish a cohesive air defense of England enabled the RAF to specifically design a system to defend against enemy air attack. It was tested and in place prior to the battle. The components were interlocking and supported the efforts of the RAF fighter pilots. This system forced the Luftwaffe for the first time to face an enemy who had well organized air defenses and a clear view of strategy (13:170). It produced circumstances that the Luftwaffe was unable to overcome. Time and time again RAF Hurricanes and Spitfires appeared from advantageous attacking positions and waded into German formations shooting down many fighters and bombers. Technology played a key role in creating these circumstances and caused both sides to modify their tactics.

Chapter Three

IMPACT OF TECHNOLOGY ON TACTICS

GERMAN TACTICS

The Germans entered the Battle of Britain with a key advantage "of better combat training and experience and better fighter tactics" (13:171). The two-ship and four-ship fighter formations they flew gave them open air, opportunity for the initiative, reduced vulnerability, and better vision. These tactics were flown and perfected by the Luftwaffe since their involvement in Spain in the late 1930s. Additional refinements came in the early days of World War Two. As a result of this advantage, the Germans won most of the early fighter skirmishes with the RAF. The British, however, caught on quickly and soon adopted tactics for their fighters that were similar to the Germans (8:25). The Germans understood why the RAF changed its tactics. What they failed to grasp was the significance these tactics had when tied to the latest changes in technology.

General Adolf Galland felt the technological advantage the British had was one of the crucial factors in the battle. "From the beginning the English had an extraordinary advantage which we could never overcome throughout the entire war: radar and fighter control" (8:26). Since little was known about these two facets of RAF air defenses, the Germans never understood how to effectively combat them (13:171). This deficiency, coupled with the lack of a heavy bomber, limited fighter cover due to lack of range, and poor operational planning and communications weighed heavily against the Luftwaffe.

The RAF depended on radio-telephone traffic to direct their fighters. German intelligence monitored these transmissions without grasping their significance. The advantage this gave the British in command and control enabled the RAF to meet the Luftwaffe raids with considerable flexibility. The Germans were not able to defeat or duplicate such a system and usually lost the advantages of surprise and flexibility to alter their tactics. Despite these large shortcomings, the Germans still came extremely close to defeating the RAF.

The Germans failed to draw the RAF out into large formation fighter battles early in the conflict. Their switch in tactics to

bombing radar stations, airfields, and aircraft production facilities was the correct way to proceed. Gaps were briefly created in radar defenses and many aircraft were destroyed. Unfortunately for the Germans, these losses and gaps were cleverly masked by the British and the Luftwaffe never was able to determine how effective these types of raids were. They had the British down, but never followed up by sustained attacks on these key targets. As it was, these tactics strained the RAF to its limits in planes and especially in pilots. Had these attacks continued instead of the switch to bombing London, the outcome of the battle may have been different.

As Luftwaffe losses mounted in the bomber force, Goering blamed the fighters. He demanded that they provide close and rigid protection for the bombers (8:37). What Goering failed to understand was that the RAF monitored his raids on radar as they formed. They usually were then able to determine which raids were feints and which raids they had to contend with. This order also further constrained the Me-109, one of the Luftwaffe's best fighters, which was operating at the limit of its endurance due to its fuel capacity. This lack of endurance cost the Luftwaffe the initiative on many occasions, a key element in air combat. The RAF capitalized on these circumstances time and time again with their command and control flexibility and radar direction. It was in this way that the Germans were prevented from fighting the battle on terms favorable to them.

German tactics in the air were initially excellent, as was their choice of targets during the early bombing raids. Poor intelligence and a failure to grasp the significance of the RAF advantages in radar and fighter control prevented the Luftwaffe from exploiting any advantages they created. The change in the role of the fighter to close escort for the bombers and the targeting of London instead of continuously pounding RAF bases and radar installations allowed the British to regroup and parry the next blow even when their resources in aircraft and pilots were down to absolute minimum levels. Coordinated attacks by the Luftwaffe on these critical areas using their original tactics could have swayed the battle in their favor. Ultimately, the Germans had neither the planning, the equipment, nor the leadership to produce the strategy and tactics required to overcome the RAF.

RAF TACTICS

Early in the battle during air-to-air engagements, it was apparent that Fighter Command's area defense and set piece strategy were not working due to faulty fighter tactics (4:110). The standard RAF tactic of three aircraft sections in line astern proved to be terribly vulnerable. They quickly adopted the German system of flying in pairs or fours which proved to be much more

effective, and tied these new tactics in with their comprehensive system of fighter control. Circumstances evolved to have RAF pilots completely controlled from takeoff to intercept which usually resulted in the fighter being placed in an advantageous attack position on the Luftwaffe raiding formation. Since the German raids were continuously tracked, the RAF was able to concentrate its fighters at key points to break up an attack. The Germans were forced into conducting repeated attacks against a concentrated defense (8:26). This type of intercept activity was due in large part to the information provided by radar and the close work of RAF sector controllers, observers, and the fighters themselves.

Air Marshal Dowding knew his limitations and carefully planned his actions with his critically small amounts of planes and pilots. The RAF could not fight a battle of attrition with the German fighters. Therefore, Fighter Command sent out orders that bombers were to become the key targets. This was done not only to limit damage on the ground but to conserve fighter resources. "Only when their Me-109 escorts intervened did it become a fleeting battle between fighter and fighter" (14:273). These tactics continued to frustrate the Luftwaffe as they could never get the decisive fighter engagement that they wanted.

There were some members of Fighter Command who wanted such a battle and advocated attacking in large formations known as "Big Wings" (7:419). The foremost supporter of this tactic was the commander of Group 12, Air Vice Marshal Leigh-Mallory. He felt that battles involving three to six fighter squadrons would inflict decisive losses on enemy formations (7:419). Air Vice Marshal Keith Park, commander of Group 11, argued against it as his sector bore the brunt of the attacks and did not have the time to form up into big formations. This argument came to be known as the "Big Wing" controversy (7:419). Air Marshal Dowding supported Park and continued his strategy to avoid a battle of attrition and to concentrate on breaking up attacks as early as possible to prevent or limit damage to critical ground targets (12:64). Other advantages of continuing these tactics were noted in decreased bombing accuracy by the Germans and limited engagement time for escorting fighters who were forced to fight at the extreme limits of their range. In many cases the bombers were not stopped from hitting their targets, but they paid a high price in losses. Creation of these circumstances was heavily dependent on the British command and control system and radar.

Technology created the advantages for the British and enabled them to exploit German weaknesses. Without these advantages, discussions involving the use of tactics like the "Big Wing" probably would not have occurred due to the lack of information crucial to the successful interception of the raiding aircraft. In addition, large formations would have been difficult to form. Technology in the hands of the RAF forced the Germans to change

their tactics several times during the battle which put them at a disadvantage. In essence, Air Marshal Dowding's integrated system of air defense allowed him to stretch his resources to the limit to prevent the Germans from gaining air superiority. He could place his fighter forces where they would do the most good and concentrated them at key intervals to harass and break up enemy raids to sway the battle in his favor.

Technology played an extremely important role in the Battle of Britain. Air Marshal Dowding's foresight and planning for technological changes aided immeasurably in denying the Germans the air superiority they needed to invade England. Without its influence, the outcome may have been very different.

The ability of NATO to deny the enemy air superiority today depends largely on how it deals with current changes in technology. An examination of the NATO effort in its work with the Air Command and Control System (ACCS) may help reveal if there were any lessons learned in this critical area.

Chapter Four

THE NATO AIR COMMAND AND CONTROL SYSTEM

PURPOSE AND DEFINITION

The NATO allies know the importance of gaining and maintaining air superiority for the defense of Western Europe. One of the best ways they can achieve this goal is not only to have the best air and ground defense forces, but to employ them in an integrated fashion through an effective command and control system. The purpose of "command and control of military forces is to create the ability to apply available military power at the time and place and in the quantity the commander requires" (23:27). In order to achieve their goal of an effective air defense in the NATO region, the alliance developed the Air Command and Control System (ACCS) program. This cohesive and long-term program is intended to provide an all-encompassing command and control system to cover the entire airspace above the NATO region and its maritime approaches (20:77). "ACCS is not a system in itself but a continuous update program...and is a combination of national and NATO common funded systems" (17:35). The system is envisioned to tie together the independent subsystems of NATO members and infuse the latest technology to their capabilities.

SYSTEM COMPONENTS AND FUNCTIONS

The ACCS is constructed around existing air defense systems to enhance their basic functions. It is an attempt to clarify air defense system capabilities by providing the following functions:

1. Reliable and timely detection and tracking of targets.

2. A clear display of the air threat situation with updated data.

3. Immediate transmission capability to operations controllers (21:17).

Since defensive measures against air attack rely heavily on early warning radar and adequate command, control, and communications,

the system concentrates on rapidly coordinating and reporting this type of information to prevent gaps in NATO defenses. The system uses the latest technology available including high speed computers to tie together NATO interceptors, ground-to-air missile batteries, ground-based and airborne radars, and command centers.

Radar and communication components of the ACCS have changed rapidly due to advances in computer technology--specifically through improvements in digital processors. Vital radar components now have computerized displays that greatly increase the capability of the new long-range, high-resolution radars (21:18). Communications have been hardened against attack and work is progressing "for secure transmission of voice and data over redundant land lines and radio links" (10:63). The effective use of these systems and subsystems serves to enhance NATO's capabilities and assists in their survivability. The other key component of the NATO ACCS is the airborne element contained in the Airborne Warning and Control System (AWACS) aircraft.

An AWACS aircraft is in essence a complete radar station in the sky. In addition to its radar, it has the capability of rapid movement and contains communications gear, IFF capabilities, data processing equipment, and digital display systems (24:27). Operating at 30,000 feet, this flexible weapon system can keep 120,000 square miles under surveillance and deny the enemy the use of various low-level air corridors that are not covered by ground based radar stations (24:27). The AWACS aircraft will also provide a key link, once the Joint Tactical Information Data System (JTIDS) comes on line, between tactical aircraft and ground based air controllers. The capabilities of ACCS both in the air and on the ground are the result of diligent effort by the NATO allies to meet the air defense challenge during the last two decades.

SYSTEM EVOLUTION

The NATO ACCS grew from several diverse systems that were developed independently by the member nations. Ground defenses and radar systems such as the NATO Air Defense Ground Environment (NADGE), and the NATO Early Warning System (NAEWS) were developed "more of less independently and...rely upon separate, dedicated sensors" (20:76). This system proved to be unbalanced and needed extensive revisions.

NATO recognized that the air war over central Europe with available electronic countermeasures would be barely manageable without substantial system improvements (10:63). Interceptor aircraft, surface-to-air missiles, radar, IFF equipment, and command and control facilities all required attention in light of an ever-changing threat due to technological advances. NATO worked this problem hard. A key turning point in effectively

meeting these challenges came in the 1970s when:

> NATO planners became increasingly concerned that ground based radars could not give adequate warning of attacks from low level fast jets flying under the ground-level radar screen. The solution was...a group of aircraft which, whilst flying over NATO territory, could maintain a look-down watch on radar contacts across Warsaw Pact boarders, and pass the word to the ground defenses (18:22).

This effort led to the introduction of the AWACS aircraft into the NATO air defense system. This aircraft helped pull together the ACCS concept in two important ways. First, it "corrected one of the major weaknesses of NATO--air defense in the forward regions of Allied Command Europe" (3:151). The second benefit was that it provided a springboard to adjust to current technological changes that eventually became the ACCS program.

This program evolved from individual efforts within the NATO alliance into a forward-looking coordinated system to maintain a credible defense in the skies over Europe. The growth of computer capabilities, which was shared across the alliance, helped drive new advances in radar and command and control. In effect, NATO's increased sensitivity to technological growth enabled it to evolve its air defense system on a real-time basis. During the next twenty years "the need to exploit the flexibility of air power and the principles of employment of air forces are unlikely to change" (23:21). However, the threat from our potential enemies will change as his capabilities improve. One of the most powerful influences in determining military capabilities is changing technology (23:28). This fact is well understood by NATO today as evidenced by its efforts in the ACCS program. The important question that must be considered is how effectively will NATO deal with new technological changes in the future based on their experiences of the past.

Chapter Five

TECHNOLOGY AND ITS EMPLOYMENT--LESSONS LEARNED

The task of an air defense organization today remains the same as it was during the Battle of Britain. It must seek to "attain and maintain a favorable air situation" (16:23). This can be accomplished by nullifying or reducing hostile air activity. The RAF was successful in this task through the courage of its pilots and the development of an air defense system that enhanced its human resources with the latest advances in technology. The success of air defense in the NATO theater depends in large part on how well it analyzes current threats and applies updated tactics and technology to meet them.

PAST PERSPECTIVES

Air Marshal Dowding recognized the importance that technology could play in bolstering British air defenses in 1936. He understood the benefits of developing new weapons systems, the implications of radar, and the importance of an integrated command and control system. Exercises proved that Great Britain was vulnerable to air attack. When science provided the means to counter this weakness, Dowding grasped its significance and fostered the development of a modern, highly effective system of air defense.

By working closely with the technological advances and the people who made them, Dowding ensured these breakthroughs received the proper attention to develop their military applications. He also made sure that an operational system was rapidly put into the field. Systems were then tested, refined, and integrated to strengthen their capabilities and allowed users to become familiar with the system's strengths and weaknesses. In short, the ability of the British to understand the importance of new technology, and the foresight to carefully plan its application against potential threats, helped set the foundation for the successful defense of Great Britain by the RAF against the Luftwaffe. They were able to deny the Germans air superiority and forestalled an invasion by their success. By analyzing the impact of technology in the past in a similar vein today, one can draw some conclusions regarding NATO's capabilities through the ACCS.

NATO AIR DEFENSE TODAY

The NATO ACCS program represents a commitment by the allies to provide the best possible air defense of Europe. The organization recognized that technology has made and will continue to make a significant impact on the nature of aerial warfare. Some of the more widely accepted future trends that NATO considered include the following ideas:

1. Warfare is becoming more deadly in terms of lives and equipment.

2. Mobility and stealth are growing in importance.

3. Smart weapons are making all stationary targets more vulnerable.

4. Defense is growing in its capabilities.

5. Expensive, heavy equipment is losing ground to expendable, stealthy equipment (1:39).

A realization of these and related circumstances helped provide an integrated, interoperable system. By applying a systems approach to plan and design the ACCS, NATO will be able to keep pace with rapidly changing technological developments (20:80). This process recreates on a broad scale what Dowding did in the 1930s. A threat was assessed, future trends were analyzed, and available technology was applied to meet it.

The importance of a comprehensive system is just as essential today as it was in the past. NATO recognizes this fact as pointed out by General Larry D. Welch, USAF Chief of Staff, who stated "an integrated air command and control system is essential to any air defense operation. ACCS...will be a network of ground, airborne and space sensor systems, and command and control facilities netted to ensure the right people get the right information at the right time" (17:44). The development of the AWACS with its vast capabilities and its integration with improved ground defense radars and missile systems testifies to the fact that NATO has learned the lesson of developing and fielding technology as rapidly as possible. This action roughly parallels Dowding's efforts to develop and employ radar prior to World War Two. Another key point one must consider is how well NATO is analyzing the future for new trends and threats in light of changing technology.

THE FUTURE

The nature of warfare has been profoundly changed by the development of the computer and the micro-chip. Advances in this

area have led to great strides in precision guidance for weapons at a much lower cost. It also led to improvements in command, control, and communication equipment, and enhanced target acquisition and designation capabilities. NATO has made a strong attempt to keep pace with these and other related issues. A key feature of the ACCS program is that it is being developed to expand as technology changes. It is designed to continuously adapt to changing threats (20:81).

Despite the strides that NATO is taking in the area of keeping up with critical technological changes, two key problem areas still remain. First, is the development of a standard NATO IFF system, and second is the provision for electronic counter-measures resistant communications (19:18). Both of these areas have proven to be extremely difficult to master from a technological standpoint. It should be noted that this is not the real issue in this case. While it is true that these critical areas as yet have no solution, the important issue is that they have been recognized and are being worked.

Technology will help solve these present problems and provide the foundation to address future weaknesses. However, it is not the be-all and end-all to solving all our problems in air defense. Solutions must be well thought out and proper equipment deployed. "We...need to be careful that we are adding real value to our military. If we do not focus the technology explosion on our real needs, we risk being overwhelmed by the changes around us. Our ability to deter aggression will depend in large measure on our ability to apply technology to meet operational requirements" (22:48). In reality, NATO has attempted to avoid becoming a captive to technology. The ACCS program provides the framework for the rational development and deployment of effective air defense systems during the next two decades. If NATO can adhere to its own plan, then the program should be effective in providing for a credible air defense. The commitment of the NATO allies to make the system work will ultimately determine its impact.

CONCLUSION

The ability to access technology and to clearly plan its impact on future conflicts has been a prerequisite for the success of military operations throughout history. Technological advances like the machine gun, the airplane, radar, and now the computer have caused drastic changes in military strategy and tactics. The British were able to grasp this reality prior to World War Two through their development of radar and its related command, control and communications systems. This use of technology provided them with a critical edge over the Germans in the Battle of Britain. The Germans failed to understand this reality and it led to their inability to gain the air superiority they required to carry out their invasion plans of England. Similar circumstances exist today.

NATO must continually assess new technological changes and determine their implications regarding air defense capabilities. The ACCS program has done this by adopting a formula for growth that provides a significant step forward in developing a solution to these complex problems (20:78). The lessons of the past have been applied, and a program for harnessing the latest changes in technology is now in place. Like the British in the past, NATO is actively using technology to field new integrated systems that have the capability and growth potential to provide a credible defense in the NATO theater for many years to come.

A review of a past conflict like the Battle of Britain and an analysis of how technology was used can provide insight for the development of future air defense systems such as the NATO ACCS. The value lies not in the study of the technology itself, but in the way it helps us channel our efforts to assess the implications that new technology has for the future. Foresight and its application to field a viable system is part of a process that remains as true today as it did during World War Two. NATO has demonstrated an awareness of this process through its work with the ACCS program. Technology and its applications are being addressed head-on. Threats are constantly being evaluated and the collective talents of the NATO alliance are being pooled to meet them. As long as this process continues, NATO's ability to deter an attack from the air will remain credible and the prospects for maintaining peace in Europe will be enhanced.

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