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ADC HISTORICAL STUDY NO. 33

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Downgraded at 12 year intervals
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THE BIRTH OF SAGE

1951 - 1958

by RICHARD P. McMULLEN

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FOREWORD

Almost from the time of its activation in 1946, the Air Defense Command sought creation of an active, in-being network of air defense radar, similar to that deployed in the early years of World War II. While virtually everybody agreed that air defense was necessary, the strategic and tactical forces had first call on available funds during the immediate post-war years and little was left for air defense.

But, as the years passed the international climate changed and the Cold War began. The Soviet Union blockaded Berlin in 1948, successfully exploded an atomic device in August 1949 and supported North Korea in an attack on South Korea in June 1950. The Truman administration and Congress agreed that the time had come to do something more for air defense. By the end of 1950 a 75-station radar network, composed mainly of post-war radar of the AN/CPS-6B and AN/FPS-3 types, had been authorized and construction was underway.

This account describes the earliest discussions of a computerized aircraft control and warning system and how the idea grew and was implemented as SAGE (semi-automatic ground environment). Another study (ADC Historical Study No. 35), examines the search for a more sophisticated and survivable command and control system after 1958. A third segment of this series will detail ADC attempts to acquire an adequate ground environment from 1946 to 1951 (ADC Historical Study No. 36).

Although every effort has been made to make this historical study as accurate as possible, errors of omission or commission might have crept in. Consequently, readers are warned not to make the contents of this history the basis of official action.

CONTENTS

CHAPTER ONE

THE AUTOMATION DEBATE

1951 - 1953

While the authorization for a radar network of 75 permanent stations was highly encouraging, various authorities could not see that much had really been changed. Using World War II experience and the information provided by post-war air defense exercises, it was claimed in some quarters that the air defense system under construction in late 1950 would stop no more than 5 to 30 per cent of an attacking bomber force. These contentions so disturbed Secretary of the Air Force Thomas K. Finletter that he was willing, in January 1951, to approve a recommendation of the Air Defense Systems Engineering Committee of the Air Force Scientific Advisory Board that Western Electric be

hired to determine methods by which the radar net under construction could be made to work with maximum efficiency. General Hoyt S. Vandenberg, USAF Chief of Staff, had already, 15 December 1950, requested that the Massachusetts Institute of Technology undertake a somewhat wider study of the general problem of air defense. The Western Electric effort, which was concerned primarily with the improvement of the capability of various components of the ground environment, became known as the Continental Air Defense System (CADS) Project and the MIT study was given the name of Project CHARLES.[1]

Although the initiative came from the Air Force, the formal Project CHARLES, which began in February 1951, was jointly sponsored by the Army, Navy and Air Force. The contract was administered by MIT, but only 11 of the 28 scientists and engineers involved in the initial six-month study effort (Phase I) were MIT faculty members. The director of the group was Dr. F. W. Loomis, head of the physics department at the University of Illinois. Chairman

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1. Memo. Thomas K. Finletter, Sec/AF for Gen Hoyt S. Vandenberg, C/S, USAF. no subj, 26 Jan 1951 [HRF]; USAF to ADC "Continental Air Defense Systems Project (Western Electric-Bell Telephone Laboratories Contractor," 8 May 1951 [HRF]; Final Report, Project CHARLES, 1 August 1951 [HRF].

of the panel (Phase I) studying a long-range program for aircraft warning and control was Dr. George E. Valley, Jr., of MIT. Phase II, which began before Phase I was complete, involved those activities of the MIT Research Laboratory) directed toward experimental solution of air defense problems. Phase III of Project CHARLES was expected to be a research and development program based on information gained during Phases I and II.[2]

With respect to command and control of the air battle, Dr. Loomis, in transmitting the results of the Phase I study, 1 August 1951, warned against anticipation of any spectacular new technique which would completely solve the problem overnight, although he had come to the conclusion that definite improvement was possible.

"We are unable," he reported, "to point to any new invention, comparable with radar, that would provide a simple solution to the air defense problem. Indeed, the virtues of radar, which contributed immensely to air defense in World War II, have been rather thoroughly exploited, and much of the development effort must now be devoted to making up for its intrinsic weaknesses in low cover and in identification. Our restrained views regarding any spectacular

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2. Final Report, Project CHARLES, 1 Aug 1951, Preface [HRF].

solution of the air defense problem are counterbalanced by considerable optimism about the contribution to air defense that will be made by new basic technology. We think the electronic high-speed digital computer will have an important place in air defense and the revolution that the transistor will bring about in electronics will open up quite new possibilities in aircraft and weapons control."[3]

Automation was the key thought in this general statement of Project CHARLES conclusions and one that was not very common at that time. Automation was just beginning to come into use in industry and its future was but dimly seen. MIT proposed to test this concept with its WHIRLWIND digital computer, built in 1947, and a proposed "Cape Cod Air Defense System" of 10 to 15 radars of height-finder and gap-filler types.[4]

The report acknowledged that the Air Force was currently investigating the British Comprehensive Display System (CDS), which sought to improve air defense operations by using electronic devices to expand the amount of information available to air controllers. Most of the techniques

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3. Ibid., Letter of Transmittal [HRF].

4. Ibid., p. 118.

being used by the British were at least six or seven years old, however, and Project CHARLES, therefore, did not think CDS was the answer. Project CHARLES felt that this, and similar efforts along this line, should be brought under centralized management (such as Lincoln Laboratory) in order that coordinated direction be provided. Project CHARLES predicted that an automated air defense system covering roughly the area of an existing Air Division could be installed by the end of 1956.[5]

The recommendations of Project CHARLES were acceptable to the Air Force and in September 1951 MIT was given a contract to proceed with the research indicated in the August report. Lincoln Laboratory (mentioned above) was thereby established by MIT to build the model Cape Cod system and conduct the necessary experiments. Secretary Finletter characterized Lincoln Laboratory as the "Manhattan Project of air defense."[6]

There was a small group of well-known atomic scientists, however, who, according to Fortune, did not

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5. Ibid., pp. xxvi and 89.

6. Samuel P. Huntington, The Common Defense, (New York, 1961), p. 329. Subsequently cited as Huntington.

believe Project CHARLES was moving far enough or fast enough in the direction of iron-clad air defense. This group was called ZORC for the names of its members -- Drs. Charles L. Zacharias, J. Robert Oppenheimer, I.T. Rabi and Charles Lauritsen. According to Fortune (and not confirmed elsewhere), ZORC was formed to take part in what the scientists saw as essentially a moral struggle between scientists who deplored development of the hydrogen bomb and a segment of Air Force opinion which held that thermonuclear weapons were the only practical deterrent to the expansion of the Communist powers. ZORC was organized in the spring of 1952, Fortune said, and set out to prove that establishment of an impregnable air defense would make an atomic offense unnecessary. The ZORC group was also said to have the support of Dr. Lloyd V. Berkner, who had headed the team of scientists that had just completed Project EAST RIVER for the Federal Civil Defense Administration. EAST RIVER had concluded that civil defense was almost useless unless the active air defenses were so strong that penetration of enemy bombers could be reduced to mere leakage.[7]

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7. "The Hidden Struggle for the H-Bomb," Fortune, May 1953.

Fortune further contended that Dr. Berkner and ZORC were also responsible for organization of the Summer Study Group, a gathering of 30-odd scientists from both within and without Lincoln Laboratory which met in the summer of 1952 to discuss what had been learned by Lincoln Laboratory and what this portended for the future. In war games conducted by the Group. ZORC strategists reportedly drafted not only the tactics of the Soviet Long Range Air Force but those of the defenders as well. One non-ZORC participant commented that ZORC showed a fine grasp of electronics, but lost the simulated war. The Summer Study Group did not buy the full ZORC defense package. but did conclude that in two or three years the Russians would have sufficient bombers and atomic bombs to cripple the United States, that existing and planned defenses were inadequate and improperly integrated and, at best, could achieve only a kill probability of 20 per cent. It also concluded that concentrated effort and expected technological breakthroughs could hope to achieve a system that would offer a kill probability of from 60 to 70 per cent. Specifically, the Summer Study Group recommended construction of a distant early warning (DEW) line of radar across Canada and establishment of integrated and fully automatic communications for control of

the air defense system. Admittedly such improvements, including improved interceptors and air-to-air missiles, would cost several billion dollars.[8]

Presumably because of the cost involved, the Air Force was not completely enthusiastic about the report of the Summer Study Group and it was not immediately approved by either the Air Force or the Department of Defense. The Air Force declined to recommend the report to the National Security Council. Nevertheless, the report somehow found its way to the National Security Resources Board in September 1952. Jack Gorrie, NSRB chairman, took the report before the National Security Council and recommended that construction of the DEW Line begin at once. This action prompted Brig. Gen. John K. Gerhart, Deputy Director of Operations, USAF, to comment that "the Air Force position in the development of new air defense systems is being forced out of context and should be put to rights before we are forced, by NSC decision, to program billions on

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8. Ibid., Huntington, pp. 329-30; Pers ltr, Lt. Gen. L. C. Craigie, DCS/D, USAF to Gen. B. W. Chidlaw, Cmdr, ADC, 23 Jul 1952 [Doc 22 in Hist of ADC, Jan-Jun 1952].

defense gadgetry at the expense of our deterrent strike and air superiority forces."[9]

The National Security Council, however, took no concrete action on the report of the Summer Study Group. merely recommending that a more intensive effort be made to improve air defense. Secretary of Defense Robert P. Lovett also appointed a civilian committee, under the chairmanship of Mervin J. Kelly, president of Bell Telephone Laboratories, to study the air defense problem. In effect. then. the outgoing Truman administration left the incoming Eisenhower administration a warning that improved air defense would be necessary and a study-in-progress designed to review and evaluate the recommendations of the Summer Study Group. Unfortunately. from the standpoint of the Air Force, the report of the Summer Study Group. or at least a summary of its findings and recommendations, had also been made available to Joseph and Stewart Alsop, columnists of the New York Herald-Tribune. who proposed to make the findings public in a context that made it appear that the Air Force was dragging its feet in the matter of improved

9. Memo, Brig. Gen. John K. Gerhart, Dep Dir/Opns, USAF for DCS/O, USAF, no subj, 5 Nov 1952 [HRF]; Huntington, p. 330.

air defense. General Nathan Twining, Vice Chief of Staff, USAF, hoped the Alsops might be persuaded to forego publication of this material while admitting that the breach of security involved was not sufficient to support censorship and conceding that the authors had the editorial prerogative of proceeding with publication if they wished. The Alsops refrained from immediate publication, but made no promises as to the future.[10]

Meanwhile, the British Comprehensive Display System (CDS) was still far from a dead issue, even though PROJECT CHARLES had given it short shrift on the grounds that it was applicable only to a single radar or closely associated group of radars and therefore could not be used to create a control network covering a wide geographical area. General Benjamin W. Chidlaw, who had assumed command of ADC from General Whitehead in August 1951, had formed some opinions of his own on this subject. General Chidlaw had no quarrel with the Summer Study Group, but felt that the highly automated control system recommended was too far in the future. He recommended to USAF, in October 1952, that

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10. Memo, Gen. Nathan Twining, VC/S, USAF, for Sec AF, "Alsop Article on Air Defense Early Warning System," 24 Dec 1952 [HRF]: Huntington, p. 331.

the air defense system outlined by the Summer Study Group be re-oriented toward defense against ballistic missiles. For the "here and now" (meaning operational readiness in 1955). General Chidlaw favored a proposal of the Willow Run Research Center of the University of Michigan. Michigan proposed "Americanizing" CDS by making it possible to transfer CDS data from place to place electronically, thereby appearing to meet Project CHARLES objections to CDS. ADC rechristened the modified CDS the Air Defense Integrated System. or ADIS. USAF however, was not ready to give unqualified approval to the Michigan, or any other, plan for improved air defense. At the end of 1952, therefore, ADC was planning a test of the Michigan proposal in the 30th Air Division (located in the Great Lakes region), in hopes that a successful test would lead to USAF approval.[11]

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11. University of Michigan Report UMM-100, "Michigan Air Defense System Proposal," 18 Sep 1952 [HRF]; Pers ltr. Chidlaw to Vandenberg, no subj, 13 Oct 1952 [Doc 97 in Hist of ADC. Jul-Dec 1952]; Pers ltr. Twining to Chidlaw. no subj, 13 Nov 1952 [Doc 106 in Hist of ADC. Jul-Dec 1952]; ADC to EADF, "Air Defense Integrated System for Surveillance and Weapon Control (ADIS) Test Sector," 1 Dec 1952 [Doc 107 in Hist of ADC. Jul-Dec 1952].

The soul-searching over the findings and recommendations of the Summer Study Group continued into 1953. The opening gun was fired by General Hoyt S. Vandenberg, soon-to-retire Air Force Chief of Staff, in 6 March testimony before the House Appropriations Committee on the Truman administration's version of the budget for Fiscal 1954. These hearings lasted only one day before the new Secretary of Defense, Charles E. Wilson, announced that he was subjecting the budget document to thorough re-examination. Hearings resumed in May 1953.

At any rate, General Vandenberg was given an opportunity to give his views on air defense. Congressman Gerald R. Ford, Jr., of Michigan introduced the topic by saying he had previously heard General Vandenberg report that a substantial number of enemy bombers would get through our air defenses regardless of improvement. Had this situation changed? General Vandenberg answered the question at length, although he seemed to be talking to the supporters of the Summer Study Group rather than to Mr. Ford. There was, General Vandenberg explained, a law of diminishing returns that applied to air defense. Any defensive system that stopped 25 per cent of attackers was highly capable, in his opinion. He expanded on this theme by reporting on

a World War II conversation with General Carl Spaatz in which General Spaatz said that if his bomber formations consistently lost four per cent of its planes, air crew morale would fall so low the air war would have to stop. General Vandenberg added that during the Battle of Britain, the greatest defensive effort of all time, the German air force lost between six and eight per cent of its bombers. It was therefore gilding the lily, it seemed to General Vandenberg, to spend massive sums to improve an existing system which might be brought to a point of efficiency where it could destroy 25 per cent of an attacking force, especially since such use of scarce funds could reduce the amount available for improvement of the offensive force. "Our greatest defensive and offensive weapon," he concluded, "is our strategic force plus that part of our tactical force that is based within striking range of the airdromes that would be used by the Soviets."[12]

Supporters of the Summer Study Group lost no time in making reply. While the columnist Alsop brothers of the New York Herald-Tribune had apparently been dissuaded from

12. House Hearings on Air Force Appropriations for Fiscal Year 1954, 6 Mar 1953, pp. 28-29.

publishing the recommendations of the Summer Study Group and commenting on them in December 1952, they did not seem to feel the same compulsion following General Vandenberg's testimony. The Alsops broke the story in columns published 16 and 20 March 1953. The burden of the Alsop series was that the Air Force was attempting to suppress technological developments which would greatly improve the air defense posture of the United States. The backers of Strategic Air Command and the policy of nuclear deterrence were painted as the villains involved. General Vandenberg's position was indirectly supported by publication, in May, of the Fortune description (outlined above) of the alleged activities of the ZORC group of atomic scientists before and during the deliberations of the Summer Study Group.[13] Predictably, two semi-official Air Force publications (Air Force Times and Air Force magazine) took the editorial position that major spending on air defense could lower the effectiveness of the "first line of defense," the strategic air force.

13. New York Herald-Tribune, 16 and 20 Mar 1953; "The Hidden Struggle for the H-Bomb," Fortune, May 1953; Air Force Times, 28 Mar 1953; "The Truth About Our Air Defense," Air Force, May 1953.

Meanwhile, the new National Security Council of the Eisenhower administration seemed to be deeply split on the issue. Elected on an economy platform, the new Republican government was caught in a vicious dilemma, since approval of major expenditures for extensive new air defense measures would force it to renege on campaign promises to reduce expenditures balance the budget and cut taxes. Vice President Richard M. Nixon, Secretary of State John Foster Dulles, Undersecretary of State Walter Bedell Smith and Mutual Security Administrator Harold Stassen favored a more extensive effort. Secretary of the Treasury George Humphrey, Director of the Budget Joseph M. Dodge and Secretary of Defense Wilson vigorously opposed it. President Eisenhower admitted to congressmen that the matter was "giving him sleepless nights."[14]

Both schools of thought appeared to take heart from the May 1953 report of the Kelly committee, appointed in late 1952 by the outgoing Secretary of Defense, Robert P. Lovett. The Kelly committee agreed with an important segment of Air Force opinion by concluding that the principal element of the defenses of the United States was the strategic

14. Huntington, pp. 331-32.

air force. At the same time, the Kelly group urged creation of an air defense system much better than that assured under the existing program. The Kelly committee, however, saw no particular need for haste in the improvement of the air defense system, discounting the requirement for a "crash" project. Different people read the conclusions of the Kelly committee in different ways. Charles J. V. Murphy of Fortune, one-time special assistant to General Vandenberg, saw in it an "impressive rebuttal of the Summer Study Group." The Alsop brothers argued that "the Lincoln warnings have been fully confirmed."[15]

Still there was irresolution within the Eisenhower administration as to what to do about air defense. Secretary of Defense Wilson appointed yet another committee, this one under the chairmanship of Army Maj. Gen. Harold Bull, a long-time associate of President Eisenhower, to study the question. It was considered something of a surprise, in view of the divided state of opinion, when the Bull committee accepted most of the recommendations of the Summer Study Group. In its report of 22 July 1953 to the National Security

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15. New York Herald-Tribune, 29 May 1953; Charles J.V. Murphy, "Air Defense: Kelly vs. 'Summer Study Group.'" Fortune, Jul 1953.

Council, the committee concluded that existing plans for air defense were entirely inadequate and that the necessary improvements would cost 18 to 25 billion dollars over a five-year period. Although the Bull report produced no immediate reaction within the NSC, the August 1953 intelligence that the Soviet Union had successfully exploded a thermonuclear device apparently served to dissolve opposition, within the Eisenhower administration, to automation of air defense. In his first press conference as Chairman of the Joint Chiefs of Staff, 26 August 1953, Admiral Arthur C. Radford said that Soviet possession of the hydrogen bomb made it imperative that the United States improve its air defenses. Some six weeks later, 6 October 1953, the NSC approved NSC Paper No. 162 which included a number of improvements to the air defense system. One of these was the automation of data handling. The NSC figured the five-year cost of the complete improvement program at $20 billions.[16]

As for methods of automation, two systems were under consideration in early 1953. One was the Air Defense Integrated System (ADIS), based on an advanced British concept.

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16. Huntington, pp. 332-34.

in which control of the air battle would be decentralized to the Air Defense Direction Center, of which there would be roughly 25 across the United States. ADIS was being developed by the University of Michigan. The other possibility was the Lincoln Transition System, which would lodge control of the air battle in the Air Defense Control Center of which there would be less than 10. The Lincoln Transition System was under development at the Lincoln Laboratory of the Massachusetts Institute of Technology. Theoretically, the Air Research and Development Command (ARDC) was obligated to make a choice between the two systems. In order to make the competition fair, Lt. Gen. Earle E. Partridge, ARDC commander, asked MIT to cooperate with the Michigan organization as much as possible and asked ADC, which favored the Michigan proposal, to look upon the Lincoln Transition System with as much objectivity as possible. It had been the ADC position that the Lincoln System be developed with ballistic missiles in mind, with AIDS to be used for defense against manned bombers.[17]

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17. Pers Ltr, Lt. Gen. Earle E. Partridge, Cmdr, ARDC to Dr. James R. Killian, Pres, MIT, no subj, 28 Jan 1953 [Doc 6 in Hist of ADC, Jan-Jun 1953]; Pers Ltr, Partridge to Chidlaw, no subj, 11 Feb 1953 [Doc 7 in Hist of ADC, Jan-Jun 1953].

The competition lasted only a short while. In May 1953 General Partridge informed General Chidlaw that "for reasons which will not be enumerated here, the Air Force has found it necessary to...initiate a unilateral approach... oriented toward the Lincoln Transition Air Defense System."[18] All support for the Michigan system was withdrawn. Thus relieved of competion, Lincoln Laboratory proceeded with the construction of a model air defense system on Cape Cod. At the end of 1953, Lincoln was getting ready to run tests involving a maximum of 64 aircraft radar tracks from data generated by one long-range radar and two short-range radars.[19]

Therefore, by the end of 1953 the need for automation of the air defense system had been acknowledged by the National Security Council and that body was convinced that the large sums necessary to bring it about should be made available. At the same time, automation was an infant art and it was readily apparent that nobody was really sure what

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18. Pers Ltr, Partridge to Chidlaw, no subj, 6 May 1953 [Doc 9 in Hist of ADC, Jan-Jun 1953].

19. Lincoln Lab to ADC, "Status of the Lincoln Laboratory 1953 Cape Cod Model Air Defense System," 9 Sep 1953 [Doc 5 in App VII in Hist of ADC, Jul-Dec 1953].

obstacles lay in the way of such large-scale application of automation. Lincoln Laboratory, however, was devoting considerable effort to the preparation of charts for what was essentially an uncharted area.

CHAPTER TWO

DEVELOPMENT AND ORGANIZATION OF SAGE

1954 - 1956

Once the National Security Council had ordered the automation of air defense, it was obvious that one of the first actions required of ADC was the preparation of operational plans for use of the Lincoln Transition System, chosen in May 1953 as the method of automation to be developed by the Air Force. As early as January 1953 the Lincoln Laboratory had suggested several possible arrangements of computers which might be used to bring about the desired degree of automation. The plan favored at that time was one in which an air defense sector (air division) would be supported by three high speed digital computers,

geographically separate. Each computer would receive the same information as the other two, making it possible for any of the three computers to conduct the air battle for the entire sector.[20]

This arrangement struck ADC as too costly in both personnel and communications and by the time the initial planning conference on the Lincoln Transition System was held 14 November 1953, ADC had developed a concept of operations which called for all three computers within a sector to be placed at one location. ADC believed this arrangement would have the advantage of giving the division commander the capacity to observe 800 simultaneous radar tracks and thereby provide him with a highly integrated air defense capability. Lincoln Laboratory, however, did not feel such a triplex computer arrangement was technically feasible, because development of the switching facilities required to shift radar inputs among the three computers and from the computers to the various display boards was

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20. Transition System Program, ADC, 18 Jan 1954, pp. 3-4 [Doc 1 to Appendix VII in Hist of ADC, Jan-Jun 1954].

likely to be so difficult as to delay the entire program of automation at least a year.[21]

Lincoln then proposed three other alternative computer arrangements, all of which involved using computers in pairs, the combination being known as a duplex computer. The duplex computer approved by ADC would employ common input, output and display facilities, thus costing less than provision of separate facilities for each individual computer. The duplex computer and its attendant equipment was to be known as a direction center, the heart of the automated air defense system. The geographical area to be covered by the direction center was limited by the volume of radar input which could be accepted by the computer. Lincoln had determined that this limitation could be established in accord with a sliding scale:

Heavy radars	2	3	4	5	6
Small automatic (gap-filler) radars	22	17	12	7	2

Based on these criteria, the 26th Air Division would require two direction centers. For the country as a whole it was decided that the 16 air divisions programmed for 1955 would

21. Ibid., p. 4.

remain and that these 16 divisions would require 46 direction centers. This information was forwarded to USAF in early December 1953.[22]

The size of the total system having been determined, the matter of operational priority was approached. An examination of funding requirements brought the conclusion that ADC should request enough money in Fiscal Years 1954 and 1955 to provide six direction centers. Determining where the first six duplex computers should be located was relatively simple, since the highest defense priority was always given to the northeastern United States. Highest on the list was the 26th Air Division, followed by the 85th Air Division and the 32nd Air Division. The planners were not sure exactly where they wanted each of the first six direction centers placed, but they offered three possibilities in each case:[23]

Priority 1 -- 26th AD. Subsector (Direction Center) A
a. Roslyn, New York
b. Navesink, New Jersey
c. Palermo, New Jersey

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22. Ibid., p. 6; Msg ADOPR 2349, ADC to USAF, 5 Dec 1953 [HRF].

23. Transition System Program, ADC. 18 Jan 1954, pp. 20-23 [Doc 1 to Appendix VII in Hist of ADC, Jan-Jun 1954].

Priority 2 -- 26th AD, Subsector B
a. Stewart AFB, New York
b. Grenier AFB, New Hampshire
c. North Truro, Massachusetts

Priority 3 -- 85th AD, Subsector A
a. Andrews AFB, Maryland
b. Manassas, Virginia
c. Fort Custis, Virginia

Priority 4 -- 85th AD, Subsector B
a. Roanoke Rapids, North Carolina
b. Langley AFB, Virginia
c. Cherry Point Marine Base, North Carolina

Priority 5 -- 32nd AD, Subsector B
a. Syracuse, New York
b. Watertown, New York
c. Schuylerville, New York

Priority 6 -- 32nd AD, Subsector A
a. Charleston, Maine
b. Presque Isle, Maine
c. Caswell, Maine

It was anticipated that the first subsector could become operational by 1 January 1957. The completion of the 46th direction center was expected by 31 January 1961. The decision to duplex computers ($6.3 million for a single computer as against $11.8 million for a duplex computer) greatly increased the anticipated need for funds in Fiscal Years 1954 and 1955. Before the duplexing decision, the need for $48.9 millions in Fiscal 1954 and $91 millions in Fiscal 1955 was foreseen. After the decision to use the duplex computer, the anticipated fund requirements jumped to $49.4 millions for Fiscal 1954 and

$133 millions for Fiscal 1955. The complete system of 46 direction centers was expected to cost $1.128 billions.[24]

Two other major decisions affecting the automated ground environment were also taken during late 1953. Primarily because of the excellence of services rendered during the course of the Continental Air Defense System (CADS) Project which began in the spring of 1951, Western Electric and the Bell Telephone Laboratories were chosen as joint engineering consultants for the installation of the Lincoln Transition System.[25] The engineering consultants were formed into a group known as Air Defense Engineering Service (ADES), with headquarters in New York City. To perform liaison with ADES, a special staff unit -- Project Group for ADES -- was formed within the ADC staff. To indicate the importance of the Project Group, it was ordered to report directly to the Vice Commander.

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24. Ibid., pp. 28-29.

25. Pers ltr, Col. E. F. Carey, Jr., ADC Liaison Officer with Lincoln Lab. to Maj. Gen. F. H. Smith, Jr., V/C ADC, 21 Jan 1954 [HRF]. See also ADES Bulletin No. 2, Jan 1954 [HRF].

The other major decision was the selection of International Business Machines to build the all-important computers, although this choice was almost a foregone conclusion, because IBM was pre-eminent in the computer field at this time. The computer for the Lincoln Transition System was named AN/FSQ-7 and in early 1954 IBM estimated that the first machine would be complete by 1 May 1956.[26]

The Transition System Program of 18 January 1954, which called for 46 computerized direction centers divided among 16 sectors began to spring leaks soon after publication. Almost immediately it was discovered that the Washington and Chicago target areas were so divided that the responsibilities of commanders of adjoining subsectors were not adequately defined: the closely integrated Cleveland-Detroit target complex was divided among two subsectors; the small size of some subsectors unduly complicated weapons hand-over and radar overlap problems and the geographical irregularity of some subsectors made it difficult to display the area

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26. Transition System Program, ADC, 18 Jan 1954, p. 24 [Doc 1 to Appendix VII in Hist of ADC, Jan-Jun 1954].

on a cathode ray tube. Revision of the January program began 15 February 1954 and produced a revised plan which called for 42 subsectors (two of which -- covering Colorado, Utah and Wyoming -- would not be automated) and only nine sectors (air divisions), although 16 divisions would be utilized by the full manual system. The locations of the first seven subsectors (the January program named only six) were also substantially changed. The new priority list was as follows:

1. McGuire AFB, New Jersey
2. Westover AFB, Massachusetts, or Stewart AFB, New York
3. Byrd Field, Richmond, Virginia, or Fort Lee, Virginia
4. Brunswick NAS, Maine
5. Hancock Field, Syracuse, New York
6. Fort Custer, Michigan
7. Truax Field, Madison, Wisconsin

These changes were approved by the ADC Command Council on 6 March 1954 and forwarded to USAF on 30 April. Subsequently, a joint study by ADC, ADES and Lincoln Laboratory came to the conclusion that it was not practical to collocate subsectors and sectors as had been recommended in the January Program. In June 1954, therefore, ADC asked that the January document be further changed to include separate combat centers (sectors) that were equipped with either a stripped-down FSQ-7

plus a reduced display system or an essentially complete FSQ-7 less the complete display system.[27] The combat center was subsequently designated AN/FSQ-8.

USAF approval of the nine sector, 42 subsector concept of Transition System operation came 17 May 1954, making it possible for ADC to turn its attention to the construction aspects of the automated ground environment. After a summer spent in discussion of the matter, ADC, by October 1954, was ready to specify where (in most cases), and in what order, it wanted the first 16 direction centers and first four combat centers built. This schedule covered 16 of the 40 automated subsectors planned:[28]

Recommended Installation Priority	Type	Location
1	Direction Center	McGuire AFB, N.J.
2	Direction Center	Stewart AFB, N.Y.

27. ADC to USAF, "Selection of Transition System Direction Center Locations," 30 Apr 1954 [Doc 19 to Appendix VII in Hist of ADC, Jan-Jun 1954]; ADC to USAF, "Air Defense Transition System (Air Division Combat Center)," 18 Jun 1954 [Doc 9 to Appendix VII in Hist of ADC, Jan-Jun 1954].

28. USAF to ADC, "Selection of Transition System Direction Center Locations," 17 May 1954 [Doc 400 in Hist of ADC, Jul-Dec 1954]; ADC to USAF, "Selection of Transition System Direction Center and Combat Center Locations," 1 Oct 1954 [Doc 402 in Hist of ADC, Jul-Dec 1954].

Recommended Installation Priority	Type	Location
3	Combat Center	Syracuse, N.Y.
4	Direction Center	Syracuse, N.Y.
5	Direction Center	Fort Lee, Va.
6	Direction Center	Brunswick NAS. Me.
7	Direction Center	Ft. Custer, Mich.
8	Direction Center	Truax Field. Wisc.
9	Combat Center	Truax Field. Wisc.
10	Direction Center	Traverse City. Mich.
11	Direction Center	Duluth, Minn.
12	Direction Center	Sioux Falls, S.D.
13	Direction Center	McChord AFB. Wash.
14	Combat Center	McChord AFB. Wash.
15	Direction Center (Alternate)	Camp Adair, Ore. Corvallis, Ore.
16	Direction Center (Alternate)	Redding, Calif. Medford, Ore.
17	Direction Center	Larson AFB, Wash.
18	Direction Center (Alternate)	Pendleton, Ore. Walla Walla, Wash.
19	Direction Center	Beale AFB, Calif.
20	Combat Center	Hamilton AFB Calif.

The rate at which the automated system was expected to grow[29] was also outlined by ADC at this time:

	FY57	FY58	FY59	FY60	FY61	Total
Direction Centers	2	9	10	9	10	40
Combat Centers	1	1	2	3	2	9

Meanwhile, work had begun on a SAGE (the name Lincoln Transition System had been dropped in the late summer of 1954)

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29. Msg ADHPG 1737, ADC to USAF. 1 Oct 1954 [Doc 403 in Hist of ADC. Jul-Dec 1954].

Operational Plan, the document which was to control the installation of the most extensive automated system yet conceived. The basic Plan was a joint effort of ADC's SAGE Project Group and Lincoln Laboratory, assisted by ADES, and IBM. In late November 1954, the draft Plan was made available to the ADC staff for comment. When the various comments had been written and digested, Maj. Gen. Kenneth P. Bergquist, DCS/O, ADC, noted a general air of pessimism concerning the practicality of the Plan. There was skepticism concerning the ability of IBM to deliver FSQ-7 computers according to schedule, the continued lack of complicated components (such as Slowed-Down Video -- SDV -- and Fine-Grain Data -- FGD) needed to make the system work, doubt about the timely availability of the necessary communications circuits and qualms about the readiness of Congress to provide the required funds. There was also some doubt that all 40 subsectors required automation. General Bergquist mentioned six that might be considered for manual operation in the SAGE era. Finally, it was suggested the first five subsectors and the combat center at Syracuse might be completed and tested for a reasonable period before proceeding with the full SAGE program.[30]

30. Memo, DCS/O, ADC for ADES Project Group, ADC, "Review of SAGE Operational Plan," 11 Dec 1954 [Doc 404 in Hist of ADC, Jul-Dec 1954].

After the ADC staff comments and those of Air Research and Development Command, Air Materiel Command and Air Training Command were considered, the final Plan was published 7 March 1955 and submitted to USAF 20 April 1955. The principal difference between the draft plan and that eventually published was a reduction from 42 to 34 subsectors (now known as sectors and given geographical names) and from nine to eight sectors (now known as numbered air divisions). As before, only the Colorado and Wyoming sectors were to be manually controlled. The area covered by each of the 32 remaining SAGE sectors was merely enlarged, in accordance with advice from Lincoln Laboratory that the FSQ-7 would be capable of dealing with a larger radar input than had previously been thought possible. The suggestion for extended testing of the first SAGE "module" could not be accepted because of the limited time available for installation of the complete SAGE network. Nothing much could be done to expedite development of SDV or FGD or other elements of the FSQ-7, since such matters were in the province of the developer, not the prospective user.[31]

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31. SAGE Operational Plan, ADC, 7 Mar 1955 [Doc 449 in Hist of ADC, Jan-Jun 1955].

Under the March plan, the 40 SAGE installations (32 direction centers and 8 combat centers) were to become operational between 1 March 1957 and 1960 in accordance with the following schedule:[32]

Direction Centers

Installation Priority	Sector	Operational Date
1	McGuire	Mar 1957
2	Stewart	Apr 1957
4	Syracuse	Sep 1957
5	Fort Lee	Nov 1957
6	Brunswick	Dec 1957
7	Fort Custer	Feb 1958
8	Truax	Mar 1958
10	Cadillac	May 1958
11	Duluth	Jun 1958
12	Fargo	Jul 1958
13	Sioux Falls	Aug 1958
14	McChord	Sep 1958
16	Adair	Nov 1958
17	Larson	Dec 1958
18	Pendleton	Jan 1959
19	Beale	Feb 1959
21	Bakersfield	Apr 1959
22	Norton	May 1959
23	Stead	Jun 1959
25	Minot	Aug 1959
26	Great Falls	Sep 1959
27	Pope	Oct 1959
28	Fort Knox	Nov 1959
30	Robins	Jan 1960
31	Gunter	Feb 1960
32	Phoenix	Mar 1960
33	Albuquerque	Apr 1960

32. Ibid., pp. 29 and 77-78.

Installation Priority	Sector	Operational Date
35	San Angelo	Jun 1960
36	San Antonio	Jul 1960
37	Shreveport	Aug 1960
39	Oklahoma City	Oct 1960
40	St. Louis	Nov 1960

Combat Centers

Installation Priority	Air Divisions	Operational Date
3	26th (Syracuse)	Jul 1957
9	30th (Truax)	Apr 1958
15	25th (McChord)	Oct 1958
20	28th (Hamilton)	Mar 1959
24	29th (Minot)	Jul 1959
29	32nd (Fort Knox)	Dec 1959
34	34th (Albuquerque)	May 1960
38	33rd (Oklahoma City)	Sep 1960

In his foreword to the SAGE Operational Plan, Maj. Gen. Frederic H. Smith, Jr., ADC Vice Commander, cautioned recipients of the Plan that SAGE was not like anything they had ever experienced before. "It does not represent just another step forward," he wrote, "but represents complete departure from many of the tried, true and somewhat archaic concepts of today's operation and equipment. Some changes will appear radical, but it must be understood that complete revitalization of an entire system necessitates new thinking and new ideas if we are to reach our goal."[33]

33. Ibid., Foreword.

In the spring of 1955, ADC also began to give concentrated attention to the matter of computer programming, a new and rare art that would be of supreme importance to SAGE. The computer program was the set of instructions which told the computer what to do. Without a program the computer was helpless. With an incorrect program the computer was ineffective. Of immediate importance were two master programs, one to control direction centers and one to control combat centers. Once the master programs were written, specialized programs tailor-made for each combat center and direction center could be designed. Each local program would be different, because of differing geography, differing weapons and differing arrangements of the ground environment. All computer programs would change continually, because of changes in radar, weapons, tactics and SAGE capability. A massive, and continuing, computer programming effort could be foreseen.

Lincoln Laboratory agreed to prepare the two master programs. Supervision over the programming effort was vested in the 4620th Air Defense Wing (SAGE-Experimental), established by ADC at Lexington, Massachusetts, adjacent to Lincoln Laboratory, 1 June 1955. The major programming chore was to be performed under contract by the RAND Corporation of

Santa Monica, California. RAND was chosen for this job by reason of previous experience in the development of a System Training System for the manual air defense system and the availability of computer programmers within the RAND organization.[34]

Hints that the SAGE installation schedule contained in the ADC SAGE Operational Plan of March 1955 might require revision began to be heard in the summer of 1955. A July "management survey" of SAGE by USAF suggested that possibly it would not be necessary to implement SAGE as rapidly as planned and that perhaps ADC could absorb a proposed cut in Fiscal 1956 funds without greatly harming the total semi-automatic system. On the contrary, ADC replied, it was essential that SAGE be completed as rapidly as planned in order that the threat posed by Soviet supersonic bombers could be met in a timely manner. In the ADC view, the biggest danger SAGE faced was the lack of adequate funds.

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34. ADCR 24-13, 9 Jul 1955 [Doc 466 in Hist of ADC, Jan-Jun 1955]; ADC to USAF, "Establishment of Air Defense Wing (Experimental-SAGE)," 15 Jun 1955 [Doc 467 in Hist of ADC, Jan-Jun 1955]; Msg ADHPG 2057, ADC to ADES PO, 28 Apr 1955 [Doc 468 in Hist of ADC, Jan-Jun 1955]; ADC to AMC, "Supplemental Agreement to Contract AF 33(600)-26134," n.d. [Doc 469 in Hist of ADC, Jan-Jun 1955]; Plan for Accomplishing Computer Programming for SAGE, ADC, 6 Jun 1955 [Doc 470 in Hist of ADC, Jan-Jun 1955].

ADC pointed out that requirements for funds would rise substantially as SAGE became operational and recommended that USAF make the necessary fiscal preparations.[35]

But there were apparently fiscal pressures at work that ADC could not control. Despite ADC protests, USAF asked AMC to submit a revised SAGE schedule that would reflect reduced funding in Fiscal Years 1956, 1957 and 1958. ADC was not asked to participate in this budget exercise and did not appear to realize that it was taking place until AMC submitted the proposed schedule revision to USAF in early October 1955. The two main points of the AMC proposal were the limitation on the delivery of FSQ-7 computers to the rate of one every two months through Fiscal 1957 and the extension of the installation and test period on each computer from eight to 10 months. The effect of this slowed-down procurement would be delay of the completion of the total SAGE system (32 direction centers and 8 combat centers) from November 1960 to March 1962. In essence, the

35. ADC to USAF, "Management Review of SAGE," 30 Aug 1955 [Doc 350 in Hist of ADC, Jul-Dec 1955].

revised installation schedule would reduce the financial risks involved in a concurrent development-production program.[36]

The major points of the AMC proposal were accepted by USAF and a changed SAGE implementation schedule was announced in December 1955. Also in December, a survey of SAGE by the various agencies involved revealed that delays in construction and delivery of equipment at radar sites was likely to prevent the achievement of planned operational dates at the first three SAGE installations. It appeared that initial operations at the McGuire direction center would have to be postponed from March to July 1957; at the Stewart direction center from April to August 1957; and at the Syracuse combat center from July to October 1957. Further, it had been determined that one direction center would have to be used for training purposes, so it was decided that the direction center in the Cadillac area of Michigan (Priority No. 10) should be placed at Grandview AFB, Missouri, and

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36. Memo, ADOPR, ADC for C&E, ADC, "Possible Change in SAGE Schedule," 11 Oct 1955 [Doc 348 in Hist of ADC, Jul-Dec 1955].

function as a training center. The SAGE implementation schedule was as follows at the end of 1955:[37]

Direction Centers

Installation Priority	Sector	Operational Date
1	McGuire	Jul 1957
2	Stewart	Aug 1957
4	Syracuse	Nov 1957
5	Fort Lee	Jan 1958
6	Topsham (Brunswick)	Mar 1958
7	Fort Custer	May 1958
8	Truax	Jul 1958
10	Grandview (Cadillac)	Nov 1958
11	Duluth	Jan 1959
12	Grand Forks (Fargo)	Mar 1959
13	McChord (Sioux Falls)	May 1959
15	Adair	Sep 1959
16	Kalkaska	Nov 1959
17	Sioux Falls	Jan 1960
18	Larson	Mar 1960
19	Pendleton	May 1960
20	Beale	Jun 1960
22	Shafter (Bakersfield)	Sep 1960
23	Norton	Oct 1960
24	Stead	Nov 1960
26	Minot	Jan 1961
27	Great Falls	Feb 1961
28	Pope	Mar 1961
29	Fort Knox	Apr 1961
31	Robins	Jun 1961
32	Gunter	Jul 1961
33	Phoenix	Aug 1961
34	Albuquerque	Sep 1961
36	San Angelo	Nov 1961
37	San Antonio	Dec 1961
38	Shreveport	Jan 1962
40	St. Louis	Mar 1962

37. SAGE Quarterly Progress Report, ADES, 31 Jan 1956, Exhibit 3 [HRF].

Combat Centers

Installation Priority	Air Division	Operational Date
3	26th (Syracuse)	Oct 1957
9	30th (Truax)	Oct 1958
14	25th (McChord)	Aug 1959
21	28th (Hamilton)	Sep 1960
25	29th (Minot)	Jan 1961
30	32nd (Fort Knox)	Jun 1961
35	34th (Albuquerque)	Nov 1961
39	33rd (Grandview)	Mar 1962

By the end of 1955, SAGE equipment assembly and building construction had begun. The first experimental model of the FSQ-7, a simplex version known as XD-1, had been installed and was operating at Lincoln Laboratory, except for the command post and some display consoles. The XD-1 was to be used in the direction center of the Experimental SAGE subsector located in New England. The second experimental set (XD-2), to be retained by IBM at Kingston, New York, for test purposes, was being assembled. Production of the FSQ-7 was essentially on schedule.[38]

This was not the case, however, with the AN/FST-2, the Coordinate Data Transmitting Set, through which data gathered by long range radars would be transmitted to the

38. Ibid., pp. 13-16.

FSQ-7. The FST-2 encompassed three operating units -- Fine Grain Data equipment, Semi-Automatic Height Finding equipment and Mark X IFF Data Transmitting equipment. The Experimental subsector was scheduled to use the first six simplex models of the FST-2. Operating SAGE radars were to get duplex models. Unfortunately, Burroughs had run into a number of technical problems during the design of the FST-2 and production of completed sets was sure to fall considerably behind the schedule established when the basic production contract was written in January 1955. For one thing, the FST-2 was becoming increasingly complex as time went along. It was originally estimated that the simplex model of the FST-2 would contain 800 vacuum tubes. By the end of 1955 the tube count for the simplex model had grown to 3,300. For that reason, and others, it had proved impossible to meet the original schedule calling for delivery of two simplex versions in November 1955, two in December 1955 and two in January 1956. None were delivered in 1955 and the schedule in effect at the end of the year anticipated delivery of the first simplex FST-2 in February 1956, the sixth in August of that year. The delivery of duplex models was expected to fall at least six months behind schedule.[39]

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39. Ibid., pp. 18-19.

Construction was underway on the direction centers at McGuire, Stewart, Fort Lee, Topsham and Fort Custer and on the combined direction/combat centers at Syracuse and Truax (priorities 1 through 9). It was expected that construction on the direction center at McGuire (the first) would be complete in May 1956. Construction had been delayed somewhat by tardy receipt of building funds.[40]

SAGE was much more than an idea by the end of 1955. Operational plans had been laid, assembly of complicated equipment had begun and concrete was being poured. Only two potential worries could be discerned. One concerned the technical difficulties Burroughs was experiencing with the FST-2. The other was the possibility that sufficient money might not be made available to assure total completion of the planned system.

A jurisdictional problem involving SAGE operations arose in late 1955 when Continental Air Defense Command (CONAD)

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40. Ibid., p. 54.

attempted to write an operational plan for SAGE control of antiaircraft weapons. The creation of CONAD itself had laid the basis for the problem, because at the time SAGE was conceived, air defense had been considered essentially an Air Force responsibility and SAGE had been designed with Air Force use in mind. The Army ground forces, however, had held responsibility for antiaircraft artillery from its initial development and still held it in the early fifties. In order to bring all air defense capability under one roof, the Joint Chiefs of Staff, after seven years of discussion, authorized creation of the joint CONAD force in 1954 to exercise operational control over air defense elements of the Air Force, Army and Navy. The CONAD commander was an Air Force officer and until the CONAD and ADC headquarters physically separated in late 1956, many ADC officers also occupied a counterpart CONAD position. It was not surprising that the non-Air Force components of CONAD were inclined to think of CONAD in terms of the Air Force.

This was the atmosphere when CONAD called a conference, 15 December 1955, to discuss an operational plan for SAGE control of NIKE and antiaircraft guns. The chairman, an

Air Force officer, explained that such a plan was required by USAF, JCS Executive Agent for CONAD. One of the representatives of the Army Antiaircraft Command (ARAACOM), the Army component of CONAD, immediately pointed out that ARAACOM and Continental Army Command already had operational plans for the use of antiaircraft and wondered, therefore, what type of plan it would be possible for CONAD to write. Another ARAACOM representative added that he would be unable to serve on a working group in connection with the plan until he had checked the USAF-furnished guidelines with ARAACOM to determine their consistency with Army concepts of operation.[41]

The planning project came to an immediate dead end, because ARAACOM was dead set against any type of SAGE control over antiaircraft. "The (USAF) directive," wrote Lt. Gen. S.R. Mickelsen, ARAACOM commander, "furnishes detailed guidelines for the development of a plan which embody principles with which this headquarters has expressed disagreement in the past, since they operate to weaken the capability of the antiaircraft weapons available to this Command...."[42]

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41. Memo, SAGE Project Group, ADC to P&R, ADC, "Minutes of Conference--CONAD Operation Plan for NIKE and AA Guns," 15 Dec 1955 [DOC 1].

42. ARAACOM to CONAD, "Integration of SAGE into CONAD

Thus was reopened an old controversy that had exacerbated Army-Air Force relations in the air defense field for many years. Antiaircraft weapons had relatively short range and were used in "point defense" of citites and military establishments. The manned interceptors of ADC had longer range and were used in "area defense" of a much wider geographical area. The difficulty was that the two types of defense impinged. An interceptor engaged in hot pursuit of a target might enter the airspace defended by antiaircraft. Interceptor crews were convinced that antiaircraft gun crews had a penchant for shooting at anything airborne, "sorting them out on the ground later." For that reason, the Air Force had constantly sought to impose controls on the unrestricted use of antiaircraft. The Army had resisted all attempts to put restrictions on its freedom of action. ARAACOM could not see that SAGE had changed anything.

"The extension of the function of target assignment to the individual (antiaircraft) battery by the SAGE system," General Mickelsen pointed out, "to the complete exclusion of antiaircraft control of its own weapons, leaves no adequate provision for fire distribution in the likely event

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[Cont'd] perations," 20 Dec 1955 [DOC 2].

that SAGE radars are jammed, or SAGE communications are disrupted, to both of which contingencies the SAGE system will be dangerously sensitive. Antiaircraft missile systems are characterized by very short time of flight, and almost instant redeployability to a new target. This flexibility is unequalled by other weapons in the air defense system, and deserves maximum freedom of action."[43]

General Mickelsen also saw in the proposed plan a device by which the Army requirement for the AN/FSG-1, a control system called "Missile Master" which included a long-range radar and increased the degree of automation of antiaircraft operations, might be "disregarded." It was true that the CONAD guidance supplementing the USAF directive on the operational plan had noted that SAGE would provide targets to antiaircraft units. By inference this would appear to obviate the need for "Missile Master." Also, there had been discussion within ADC over the likelihood that the radar proposed for "Missile Master" would offer range equivalent to that of ADC radar and might result in duplicate radar coverage. Finally, in his capacity as principal adviser to CONAD on antiaircraft matters,

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43. Ibid.

General Mickelsen felt constrained to recommend that "the principles to be employed by SAGE as advanced by ADC, which have been enlarged upon by the Chief of Staff, U.S. Air Force, and further prescribed by tentative CONAD principles, be re-examined with a view of permitting the employment of Army weapons in the functional manner contemplated by the JCS."[44]

General Earle E. Partridge, CONAD Commander, acknowledged that General Mickelsen had previously voiced similar objections to both him and the JCS. Nevertheless, General Partridge added, he was "concerned that the entire weapons family be employed in an optimum manner bearing in mind that we may never have enough fire power to deny some measure of enemy success. We cannot afford to waste any weapons once the air battle starts, nor can we afford to waste any dollars through unnecessary duplication of equipment and tasks in building our air defense system."[45]

To get around the impasse which had developed in the preparation of the SAGE Plan for antiaircraft, General

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44. Ibid.

45. 1st Ind (ARAACOM to CONAD, "Integration of SAGE into CONAD Operations," 20 Dec 1955), CONAD to ARAACOM, 3 Jan 1956 [DOC 2].

Partridge directed that ARAACOM prepare a plan acceptable to it, while CONAD/ADC did the same. General Partridge then proposed to consolidate the two plans into a single CONAD plan which would be submitted to USAF.[46]

The requested operational plan was submitted by ARAACOM on 15 February 1956 and, as expected, rejected the idea of SAGE assignment of targets to antiaircraft defenses. In forwarding the ARAACOM plan, General Mickelsen reiterated his belief that "a mode of operation which would integrate AA weapons into the SAGE system is not consistent with the principles of 'Joint Action Armed Forces'...or the Collins (Army)-Vandenberg (Air Force) Agreement."[47] To make his point clearer, General Mickelsen added his opinion that "early warning and target information from Air Force sources will enhance the effectiveness of AA weapons; detailed control will most certainly degrade it."[48]

The Secretary of Defense also expressed interest in the control problem. Early in February 1956 he asked the

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46. Ibid.

47. 2nd Ind (ARAACOM to CONAD, "Integration of SAGE into CONAD Operations," 20 Dec 1955), ARAACOM to CONAD, 15 Feb 1956 [DOC 2].

48. Ibid.

Joint Chiefs of Staff to provide him with an interpretation of the extent of CONAD's authority to control antiaircraft weapons. Specifically, he wanted to know if CONAD's control extended far enough to assign specific targets to individual antiaircraft batteries and whether or not approval of procurement of Missile Master, including the long-range FPS-8 radar, by the Army would result in conflict in the operation of the total air defense system.[49]

The JCS thereupon asked CONAD for a briefing on the matter and on 21 February 1956, Maj. Gen. Frederic H.Smith, Jr., CONAD Deputy Commander presented the CONAD point of view to the operating deputies of JCS. General Smith took the position that it was imperative that antiaircraft weapons be taken into the larger air defense family, where SAGE would assign targets and generally direct the air battle The Army Signal Corps presented the case for divorce between SAGE and Missile Master.[50]

The CONAD operational plan for the employment of antiaircraft weapons in the SAGE period was published

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49. Msg AFOPD 55803, USAF to ADC, 8 Feb 1956 [DOC 3].

50. Briefing, Maj. Gen. Frederich H. Smith, Jr., Dep CINC CONAD, to Operating Deputies, JCS, 21 Feb 1956 [DOC 4]; Memo, Smith to Partridge, 29 Feb 1956 [DOC 5].

15 March 1956. It was similar in context to General Smith's briefing to the JCS and included a prefatory note to the effect that the plan had the concurrence of neither the Army nor the Navy. In his letter forwarding the plan to USAF, General Partridge explained that he had not been able to use any part of the ARAADCOM plan because acceptance of the Army position would result in two air defense systems, a situation which he could not permit. As a result, the CONAD plan was essentially the same as that submitted by ADC. General Partridge was convinced that centralized SAGE control of all elements of the air defense system was imperative. Therefore he concluded that the Army had no need for separate Antiaircraft Operations Centers (AAOC), Missile Master or surveillance radar.[51]

Meanwhile, preparations were made during March and early April for further briefings of either the JCS or the Secretary of Defense in order to, as General Partridge put it, "refute those portions of the Army Signal Corps presentation which were at variance with the facts of life."[52]

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51. CONAD to USAF, "Operational Plan for Employment of NIKE in the SAGE Era," 23 Mar 1956 [DOC 6]; CONAD, "Operational Plan for Employment of AA Weapons in the SAGE Era," 15 Mar 1956 [DOC 7].

52. Memo, Partridge to Smith, 5 Mar 1956 [DOC 8];

The JCS answered the February query of the Secretary of Defense in April 1956, but that answer was inconclusive. The Air Force backed the CONAD position. The Army and Navy took a contrary view. The Chairman of the JCS reviewed the split views on 9 April and did not concur with either view. He did, however, recommend clarifying CONAD's Terms of Reference to strengthen CONAD's operational control over component forces.[53]

Since nothing much seemed to have been accomplished as the result of JCS review of CONAD-ARAACOM difficulties, a joint CONAD/USAF briefing of the Secretary of Defense and the Armed Forces Policy Council was conducted 3 May 1956. General Partridge represented CONAD and Maj. Gen. Herbert B. Thatcher, Assistant Deputy Chief of Staff for Development and Maj. Gen. Kenneth P. Bergquist, Director of Operations, appeared for USAF. This briefing was similar to the JCS briefing of February in that it concentrated on the advantages of centralized SAGE control of the total air defense force, including antiaircraft. A new feature was a strong

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[Cont'd] Memo, Smith to Partridge, 14 Mar 1956 [DOC 9]; Memo for Record, Smith, "Visit to Washington by the Undersigned on 3 Apr 1956," 4 Apr 1956 [DOC 10].

53. Memo, ADOPR-2, ADC to ADOPR-6, ADC, "Operational Control of Weapons Systems in Continental Air Defense," 12 Apr 1956 [DOC 11].

refutation of derogatory statements about SAGE by Army Signal Corps briefers during the February presentations.[54]

Secretary of Defense Charles E. Wilson came to a Solomon-like decision in June 1956. He agreed that SAGE should have complete control of all weapons intended for air defense of the United States. At the same time he agreed that the Army should have Missile Master and that SAGE commands should be relayed to antiaircraft batteries through Missile Master. Since neither decision did violence to the concept of close centralized control of air defense, CONAD/ADC raised no objections and by August 1956 had prepared a plan for the integration of Missile Master with SAGE. It was unlikely that integration testing could begin before 1958.[55]

For the first time since SAGE had been approved in 1953, misgivings about cost began to appear in 1956. The information that the annual communications cost of a fully

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54. CONAD and USAF Presentations to the Armed Forces Policy Council, 3 May 1956 [DOC 12].

55. USAF to CONAD, "Continental Air Defense," 10 Jul 1956 [DOC 13]; Memo, CONAD to ARAACOM, 23 Jul 1956 [DOC 14]; ARAACOM to CONAD, "Integration of SAGE and Missile Master," 27 Jul 1956 [DOC 15]; CONAD to ARAACOM, "SAGE/FSG-1 Integration," 31 Jul 1956 [DOC 16]; CONAD to USAF, "Integration of SAGE and Missile Master," 24 Aug 1956 [DOC 17].

operational SAGE system might run to $200 million or more was given to Congress in connection with the budget for Fiscal 1957. The thought that anybody could run up a phone bill of $200 million a year seemed to stagger the imaginations of members of the House Appropriations Committee. So serious were the implications of this revelation that the Committee directed its own research staff to make an exhaustive study of the situation. The staff report was completed in early 1956 and concluded that the Air Force had been lax in seeking reductions in telephone rates and that the communications charges could probably be appreciably reduced if the Air Force were more aggressive in this regard.[56]

It fell to Maj. Gen. Gordon A. Blake, USAF Director of Communications and Electronics, to unravel the laws and regulations that governed telephone tariffs in the United States and explain why the Air Force had not been as lax as it appeared. In the first place, General Blake pointed out. the Air Force was bound by the provisions of the Communications Act of 1934 which specifically prohibited telephone companies

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56. House Hearings on the Air Force Appropriation for Fiscal 1957, 14 Mar 1956, pp. 678-83.

from allowing preferential rates to any customer, including the Federal Government. In the second place, also by law, the General Services Administration (GSA) was obligated to represent other government agencies in dealings with the Federal Communications Commission, the agency which set interstate telephone tariffs. It followed that GSA would also represent the Air Force in dealings with state public utilities commissions on intrastate rates. To further complicate matters, telephone rates were set by local communities in Iowa and Texas.

In spite of laws which seemed to inhibit effective action, the Air Force had not been sitting on its hands. On 6 September 1955 it had written the American Telephone and Telegraph Company, asking that AT&T consider reducing rates in view of the great volume of service to be required. It was estimated that 55 per cent of the SAGE business would be handled by the Long Lines Division of AT&T, 30 per cent by local Bell systems subsidiary to AT&T and 15 per cent by independent telephone companies. As a result of this Air Force suggestion, AT&T petitioned the Federal Communications Commission for establishment of a lower "bulk rate" which would apply to customers who used a large volume of communications. SAGE and the broadcasting networks were

two such customers who came immediately to mind. AT&T estimated that approval of the bulk rate would save SAGE $14 millions a year.

The GSA, of course, should have represented the Department of Defense and the Air Force in this proceeding before the FCC. But the GSA was not prepared to deal with a communications matter of this magnitude. So, after a series of discussions involving GSA, DOD and the Air Force, GSA approved of DOD petitioning FCC, 12 March 1956, for permission to intervene in this proceeding on behalf of the Air Force. The FCC had rendered no decision on this question by the end of 1956.

As to dealings with state regulatory agencies on intrastate rates, General Blake, in effect, threw up his hands. The Air Force, he told the committee, was reluctant to hire a large group of telephone tariff experts to haggle with state agencies. The committee agreed that this hardly seemed worthwhile even though considerable sums were involved.[57]

The existing schedule for the deployment of SAGE was reduced to fantasy in June 1956 when Lincoln Laboratory

57. Ibid., pp. 673-722.

admitted that it had fallen nearly a year behind in preparing the master computer program for SAGE Because of a shortage of time available on the XD-1 -- a prototype FSQ-7 computer installed in the Experimental Subsector -- and a shortage of qualified computer programmers, the master program would not be available by the promised date of 24 August 1956. It was not likely to be ready until 1 July 1957. Since it was necessary to test the master computer program at the Experimental Subsector before applying it to an operational direction center, it would obviously be impossible to expect the McGuire AFB direction center to attain operational capability by the previously scheduled date of 15 July 1957. A date of 1 July 1958 suddenly seemed much more realistic.

The rescheduling job fell to the ADES Project Office, Air Materiel Command, an organization responsible for USAF liaison with the Western Electric ADES group. The project Office had completed an evaluation of the situation by early August 1956. This effort, which became known as Schedule No. 4, was based on the premise that SAGE should become operational as soon as possible. It dropped the operational date of the first direction center (McGuire) back to July 1958, but called for an acceleration in the

production of computers to the point where the total SAGE system would be operational by March 1962, the same completion date mentioned in the schedule in effect at the end of 1955. Schedule No. 4 also called for the provision of an FSQ-7 computer to the RAND Corporation at Santa Monica, California, in order to hasten computer programming. The RAND computer was given Priority 6 and raised the total number of FSQ-7/8 computers to be procured from 40 to 41.[58]

The proposed schedule was not entirely satisfactory to USAF and, on 27 August 1956, the Project Office was asked to prepare another SAGE schedule which would retain the Schedule No. 4 operational dates for the first "module" (McGuire DC, Stewart DC and Syracuse CC), reduction of the computer production rate to the minimum necessary to maintain a production base until the first module was operating successfully at full capacity.[59] This request indicated the existence of some doubt as to the validity of the existing development/production concept of SAGE implementation. It revealed the presence of a school of thought

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58. Final Report on Comparison of SAGE Schedule Studies Nos. 4 & 5 by Air Defense Engineering Services Project Office, 19 Oct 1956 [HRF].

59. Msg AFMPP 55394, USAF to AMC, 27 Aug 1956 [HRF].

that believed the workability of SAGE should be proven before a final commitment was made to complete the total expensive system.

The result was Schedule No. 5. This alternative proposal called for reduction of computer production from one every 60 days to one every 90 days, with improvement of the production rate to come in 1958. By 1961 the production rate was to reach one per month. Under Schedule No. 5, completion of the entire system would be delayed until July 1963. The differences between the three schedules are shown in the following Chart I.[60]

Since ADC was vitally interested in having SAGE completed as soon as possible, ADC strongly favored Schedule No. 4. In one of his last acts as ADC commander (he relinquished command of ADC on 17 September 1956 to give all his attention to CONAD), General Partridge, 13 September, told USAF that Schedule No. 4 must be approved, because "it is imperative that your headquarters take all action required to provide the full capability of the SAGE system to this command on a most urgent basis."[61]

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60. Final Report on Comparison of SAGE Schedule Studies Nos. 4 & 5 by Air Defense Engineering Services Project Office, Attach No. 1, 19 Oct 1956 [HRF].

61. ADC to USAF, "Implementation of the SAGE System,"

CHART I

Direction Centers

Installation Priority	Sector	Operational Dates 1955 Schedule	Schedule 4	Schedule 5
1	McGuire	Jul 1957	Jul 1958	Jul 1958
2	Stewart	Aug 1957	Sep 1958	Sep 1958
4	Syracuse	Nov 1957	Dec 1958	Dec 1958
5	Fort Lee	Jan 1958	Jan 1959	Mar 1959
6	Topsham	Mar 1958		
	Santa Monica (Rand)		Aug 1957	Aug 1957
7	Fort Custer	May 1958		
	Topsham		Mar 1959	Jun 1959
8	Truax	Jul 1958		
	Grandview (Training)		Apr 1959	Apr 1959
9	Gunter (BOMARC testing)		May 1958	May 1958
10	Grandview	Nov 1958		
	Fort Custer		Apr 1959	Dec 1959
11	Duluth	Jan 1959		
	Truax		May 1959	Feb 1960
12	Grand Forks	Mar 1959		
13	McChord	May 1959		
	Duluth		Oct 1959	Jun 1960
14	Grand Forks		Dec 1959	Aug 1960
15	Adair	Sep 1959		
	McChord		Jan 1960	Oct 1960
16	Kalkaska	Nov 1959		
17	Sioux Falls	Jan 1960		
	Adair		Mar 1960	Feb 1961
18	Larson	Mar 1960		
	Kalkaska		Apr 1960	Apr 1961
19	Pendleton	May 1960		
	Larson		May 1960	Jun 1961
20	Beale	Jun 1960		
	Pendleton		Jun 1960	Jul 1961
21	Beale		Jul 1960	Sep 1961
22	Shafter	Sep 1960		
23	Norton	Oct 1960		
	Shafter		Sep 1960	Dec 1961

Installation Priority	Sector	1955 Schedule	Operational Dates Schedule 4	Schedule 5
24	Stead	Nov 1960		
	Norton		Oct 1960	Jan 1962
25	Stead		Nov 1960	Feb 1962
26	Minot	Jan 1961		
27	Great Falls	Feb 1961		
	Minot		Jan 1961	Apr 1962
28	Pope	Mar 1961		
	Great Falls		Feb 1961	May 1962
29	Fort Knox	Apr 1961		
	Sioux City		Mar 1961	Jun 1962
30	Pope		Apr 1961	Jul 1962
31	Robins	Jun 1961		
	Fort Knox		May 1961	Aug 1962
32	Gunter	Jul 1961		
33	Phoenix	Aug 1961		
	Robins		Jul 1961	Oct 1962
34	Albuquerque	Sep 1961		
	Luke		Aug 1961	Nov 1962
36	San Angelo	Nov 1961		
	Albuquerque		Oct 1961	Jan 1963
37	San Antonio	Dec 1961		
	Webb		Nov 1961	Feb 1963
38	Shreveport	Jan 1962		
	Lackland		Dec 1961	Mar 1963
39	England		Jan 1962	Apr 1963
40	St. Louis	Mar 1962		
41	St. Louis		Mar 1962	Jun 1963

Combat Centers

Installation Priority	Air Division	1955 Schedule	Operational Dates Schedule 4	Schedule 5
3	26th (Syracuse)	Oct 1957	Dec 1958	Dec 1958
9	30th (Truax)	Oct 1958		
12	30th (Truax)		Aug 1959	Apr 1960
14	25th (McChord)	Aug 1959		
16	25th (McChord)		Feb 1960	Dec 1960
21	28th (Hamilton)	Sep 1960		
22	28th (Hamilton)		Aug 1960	Nov 1961

Installation Priority	Sector	Operational Dates 1955 Schedule	Schedule 4	Schedule 5
25	29th (Minot)	Jan 1961		
26	29th (Minot)		Dec 1960	Mar 1962
30	32nd (Fort Knox)	Jun 1961		
32	32nd (Fort Knox)		Jun 1961	Sep 1962
35	34th (Albuquerque)	Nov 1961		
	27th (Luke)		Sep 1961	Dec 1962
39	33rd (Grandview)	Mar 1962		
40	33rd (Grandview)		Feb 1962	May 1963

Earlier the same day, during an ADES Project Office briefing on SAGE scheduling, General Partridge said that if USAF approved Schedule No. 5 he intended to take the matter to the Joint Chiefs of Staff.[62]

Meanwhile, ADES polled the five major Non-Air Force SAGE participants (Western Electric, Lincoln Laboratory, IBM, Burroughs and Rand) as to their preferences between Schedules Nos. 4 and 5. Lincoln, IBM and Burroughs recommended adoption of Schedule No. 4. Rand said it could live with either. Western Electric, disappointed at not meeting SAGE schedules for 1956, preferred Schedule No. 5. USAF, perhaps swayed by

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[Cont'd] 13 Sep 1956 [Doc 210 in Hist of ADC, Jul-Dec 1956].

62. Memo for Record, "ADES Project Office SAGE Status Briefing, 13 Sep 1956." [Doc 209 in Hist of ADC, Jul-Dec 1956].

ADC representations and the results of the ADES poll, announced in December 1956 that Schedule No. 4 (SAGE completion in March 1962) would be controlling.[63]

Another disquieting revelation made by Lincoln during 1956 was that the FSQ-7, as currently being produced, would not be able to handle the 100 simultaneous tracks mentioned in the design specifications. The trouble was that the present FSQ-7 included a core memory of 8,000 register. Lincoln recommended that the size of the core memory be increased to 65,000 register. This recommendation was accepted by USAF and IBM was authorized in October 1956 to begin engineering development of the new memory core. It was hoped that this improvement could be incorporated into the 15th FSQ-7 (McChord DC). Earlier models would be retrofitted with the 65,000 register memory.[64]

The extensive construction program entailed by SAGE was reasonably close to schedule during 1956. The first direction center, at McGuire, was occupied in May, one month

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63. Final Report on Comparison of SAGE Schedule Nos. 4 & 5 by Air Defense Engineering Services Project Office, 19 Oct 1956 [HRF]; Msg AFODC 59338, USAF to ADC, 4 Dec 1956 [quoted in Doc 214 in Hist of ADC, Jul-Dec 1956].

64. SAGE Quarterly Progress Report, ADES, 1 Dec 1956 [HRF].

behind schedule. Earlier plans had called for the acceptance of the first combined direction center/combat center at Syracuse in December, but changes in the building design and shortages of skilled labor acted to delay the probable completion date to March 1957. It was hoped that the SAGE buildings at Fort Lee, Topsham and Fort Custer would be finished during the first half of 1957, bringing the total to six by the middle of that year. Construction was underway at Truax, Grandview, Duluth, Gunter, Grand Forks and McChord.[65]

Progress was also made in development of the essential FSQ-7/8 computers and FST-2 coordinate data transmitting sets. Two experimental models of the computer (XD-1 and XD-2) were installed at the Experimental SAGE Subsector and the IBM plant at Kingston, New York. The Kingston computer was being used for training purposes. The first two production models of the FSQ-7 were delivered to McGuire and Stewart in June and November, 1956, respectively. As to the FST-2 that was to transfer data from the radar site to the direction center, none of the duplex production models to be used in the operating SAGE system were delivered during

65. Ibid.

1956. Four of the six simplex models to be used experimentally were made available, however. Three of these went to ESS radar sites at Bath, Maine (February), Montauk New York (June) and South Truro, Massachusetts (August). The fourth (October) was retained at the Burroughs plant at Paoli, Pennsylvania, for training purposes.[66]

To point up the geographic orientation of SAGE, General Partridge recommended to USAF in August 1956 that the areas covered by the 32 SAGE direction centers be given geographic rather than numerical designations. At the time the organization operating the McGuire direction center was to be known as the 4621st Air Defense Wing (SAGE). General Partridge proposed that it be known as the New York Air Defense Sector. USAF agreed and the changes became official in October 1956. Also, miscellaneous changes were made in installation priorities and operational dates in the waning months of 1956. At the end of the year the SAGE program for direction centers was as shown in Chart II[67]

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66. Ibid.

67. Ibid.; ADC to USAF, "Redesignation of SAGE Units," 29 Aug 1956 [Doc 222 in Hist of ADC, Jul-Dec 1956]; 1st Ind (ADC to USAF, "Redesignation of SAGE Units," 29 Aug 1956), USAF to ADC, 5 Oct 1956 [Doc 222 in Hist of ADC, Jul-Dec 1956].

CHART II

Installation Priority	Location	New Name	Operational Date
1	McGuire AFB	New York ADS	Jul 1958
2	Stewart AFB	Boston ADS	Sep 1958
4	Syracuse. N.Y.	Syracuse ADS	Nov 1958
5	Fort Lee, Va.	Washington ADS	Jan 1959
6	Topsham. Me.	Bangor ADS	Feb 1959
7	Santa Monica. Cal.	(Computer programming)	Jul 1957
8	Fort Custer. Mich.	Detroit ADS	Apr 1959
9	Truax Fld, Wis.	Chicago ADS	May 1959
10	Grandview AFB	Kansas City ADS	Apr 1959 (training)
12	Gunter AFB	Montgomery ADS	May 1958 (BOMARC testing)
13	Duluth IAP. Minn.	Duluth ADS	Oct 1959
14	Grand Forks AFB	Grand Forks ADS	Nov 1959
15	McChord AFB	Seattle ADS	Dec 1959
17	Camp Adair. Ore.	Portland ADS	Feb 1960
18	K.I. Sawyer AFB	Sault Ste.Marie ADS	Mar 1960
19	Larson AFB	Spokane ADS	May 1960
20	Pendleton. Ore.	Pendleton ADS	Jun 1960
21	Beale AFB	San Francisco ADS	Jul 1960
23	Shafter Aprt. Cal.	Los Angeles ADS	Aug 1960
24	Norton AFB	San Bernardino ADS	Sep 1960
25	Stead AFB	Reno ADS	Oct 1960
27	Minot AFB	Minot ADS	Jan 1961
28	Malmstrom AFB	Great Falls ADS	Feb 1961
29	Sioux City. Ia.	Sioux City ADS	Mar 1961
30	Pope AFB	Raleigh ADS	Apr 1961
31	Fort Knox. Ky.	Fort Knox ADS	May 1961
33	Robins AFB	Atlanta ADS	Jul 1961
34	Luke AFB	Phoenix ADS	Aug 1961
36	Albuquerque. N.M.	Albuquerque ADS	Oct 1961
37	Webb AFB	San Angelo ADS	Nov 1961
38	Lackland AFB	San Antonio ADS	Dec 1961
39	England AFB	Shreveport ADS	Jan 1962
41	Scott AFB	St. Louis ADS	Mar 1962

During 1956 the SAGE system began to take physical shape. Two blockhouses were completed. four others were near completion and construction was underway at six more. Two

FSQ-7 computers were delivered and the production line got into high gear. Delivery of FST-2 coordinate data transmitters was about to begin.

CHAPTER THREE

THE DRIVE FOR OPERATIONAL CAPABILITY

1957 - 1958

The Air Defense Command, CONAD, Lincoln Laboratory, IBM and Burroughs had won a hard-fought victory in December 1956 in winning USAF acceptance of Implementation Schedule No. 4 over Schedule No. 5. The completion date for the complcie SAGE system of 32 direction centers and eight combat centers was thus retained at March 1962. Schedule No. 5 would have delayed completion until June 1963.

But this victory was effective for only a matter of weeks. USAF approved Schedule No. 4 on 4 December 1956. As soon thereafter as 14 December, General Partridge was being informally told in Washington that USAF was about to direct a delay in SAGE implementation along the lines of

Schedule No. 5. The thinking was similar to that used previously in support of Schedule No. 5. There was still an active USAF school of thought that felt it was inexpedient to risk large amounts of money on the presently planned short-of-specification SAGE system (100-track capacity) in the face of the strong possibility that additional large sums would be needed to retrofit the initial system with the equipment needed (mainly the 65,000 register memory core) to bring it to the specified 400-track capacity. General Partridge announced his intention of going again "as forcefully as I am able to bring out to the Secretary of Defense, or to such other agency as I can reach, my view that it is mandatory that we get the SAGE system running as soon as possible and with whatever capacity it may enjoy in the initial type of installation."[68] It was the opinion of the CONAD commander that even degraded SAGE was a vast improvement over the existing manual system.[69]

Nevertheless, USAF soon asked ADES for a new stretched-out SAGE schedule and promptly, 8 January 1957, approved the

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68. Memo, Gen. E.E. Partridge, CONAD C-in-C for Chief of Staff, CONAD, "Further Emphasis on SAGE," 17 Dec 1956 [Doc 330 in Hist of ADC, Jan-Jun 1957].

69. Ibid.

one provided. The new Schedule No. 6 was a compromise between Schedules 4 and 5, pushing the SAGE completion date back to September 1962 (as against March 1962 in Schedule No. 4), but not as far as had been the case with Schedule No. 5 (June 1963). The differences between Schedules 4 and 6 as regards direction centers were as follows:[70]

Installation Priority (Schedule 6)	Sector	Operational Date Schedule No. 4	Operational Date Schedule No. 6
1	New York	Jul 1958	Jul 1958
2	Boston	Sep 1958	Sep 1958
4	Syracuse	Nov 1958	Jan 1959
5	Washington	Jan 1959	Feb 1959
6	Bangor	Feb 1959	Mar 1959
SM	Santa Monica (computer programming)	Jul 1957	Sep 1957
7	Detroit	Apr 1959	Apr 1959
8	Chicago	May 1959	May 1959
9	Kansas City (training)	Apr 1959	Nov 1958
11	Montgomery	May 1958 (BOMARC testing)	Jun 1959 (BOMARC testing) Mar 1960 (air defense)
12	Duluth	Oct 1959	Oct 1959
13	Grand Forks	Nov 1959	Nov 1959
15	Seattle	Dec 1959	Feb 1960
16	Portland	Feb 1960	Mar 1960
17	Sault Ste.Marie	Mar 1960	May 1960
18	Spokane	May 1960	Jun 1960
19	Pendleton	Jun 1960	Aug 1960
20	Los Angeles	Aug 1960	Oct 1960
22	San Francisco	Jul 1960	Jan 1961
23	San Bernardino	Sep 1960	Mar 1961
24	Reno	Oct 1960	Apr 1961
26	Minot	Jan 1961	Jul 1961

70. SAGE Quarterly Progress Report, ADES. 15 Jul 1957 [HRF].

Installation Priority (Schedule 6)	Sector	Operational Date Schedule No. 4	Operational Date Schedule No. 6
27	Great Falls	Feb 1961	Aug 1961
28	Sioux City	Mar 1961	Sep 1961
29	Raleigh	Apr 1961	Oct 1961
30	Fort Knox	May 1961	Nov 1961
32	Atlanta	Jul 1961	Jan 1962
33	Phoenix	Aug 1961	Feb 1962
35	Albuquerque	Oct 1961	Apr 1962
36	San Angelo	Nov 1961	May 1962
37	San Antonio	Dec 1961	Jun 1962
38	Shreveport	Jan 1962	Jul 1962
40	St. Louis	Mar 1962	Sep 1962

Schedule No. 6 almost immediately began to receive a succession of damaging body blows. The defense budget for Fiscal 1958, presented to Congress in early 1957, recommended that air defense expenditures be "stretched out" over a number of years. This was interpreted by many Congressmen to mean that the Department of Defense felt the threat had lessened. Not so, argued a series of Air Force witnesses. Then did this mean, asked Representatives Jamie L. Whitten of Mississippi and George H. Mahon of Texas, that published reports that SAGE was sluggish in operation and would be inadequate for its purpose were true? Air Force witnesses made no stirring defense of SAGE, most being content, like Lyle C. Garlock, Assistant Secretary of the Air Force for Financial Management, to reply that the National Security Council

decision of October 1953 to build an automated ground environment made it necessary for the Air Force to "build the best that we know how to."[71]

The House subcommittee was particularly irritated about the sharply rising trend of operations and maintenance costs in the air defense field. The operations and maintenance budget for ADC had climbed from $150 millions in Fiscal 1955, to $198.7 millions in Fiscal 1956, to $252.3 millions in Fiscal 1957. For Fiscal 1958, $305 millions were requested for this purpose. ADC had asked for $420 millions for Fiscal 1958. The Air Force did have some good financial news, however, reporting that the Federal Communications Commission had approved the AT&T request for a "bulk rate" for SAGE communications and that the annual telephone bill for the fully operating SAGE system would approximate $148 millions rather than the earlier more-than-200-millions estimate. Even so, a Congress that was eager to build an improved air defense system in the immediate post-Korea period was not nearly so eager to pay for it in 1957.[72]

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71. House Hearings on the Air Force Appropriation for Fiscal 1958, 3 Apr 1957, pp. 115-18.

72. Ibid., pp. 114-20 and 136-38; 8-9 Apr 1957, pp. 282-96 and 307-20.

Not long after the House testimony indicated increasingly rough financial sledding for SAGE, Schedule No. 6 was dealt another blow in a Department of Defense directive that all advertising for construction bids be halted as of 1 July 1957 in order to permit a comprehensive review of the entire military construction program. This "freeze" involved three direction centers and 30 of the SAGE annexes required to house the FST-2 equipment at radar sites. Long before the freeze was lifted in November 1957, it was evident that irreparable damage had been done to the operational dates shown in Schedule No. 6.[73]

As if this were not enough, USAF decided to hold production of FSQ-7/8 computers to one every two months. Schedule No. 6 was based on production of one computer a month after the 21st article. Finally, ADC had reached the conclusion that it was feasible to feed the input of a greater number of radars into the FSQ-7 than had previously

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73. Msg ADORQ-D 79, ADC to USAF, 17 Jul 1957 [Doc 332 in Hist of ADC, Jan-Jun 1957]; Msg MCG 2347E, AMC to USAF, 24 Jul 1957 [Doc 333 in Hist of ADC, Jan-Jun 1957]; Msg ADRSI-C 1262, ADC to USAF, 3 May 1957 [Doc 334 in Hist of ADC, Jan-Jun 1957]; Minutes, SAGE Phasing Group Meetings (ADESPO), 10 Jul [DOC 18], 14 Aug [DOC 19] and 13 Nov 1957 [DOC 20].

been thought possible. As a result, ADC recommended that the Pendleton, San Bernardino and San Angelo sectors and the 34th Air Division be deleted from the SAGE schedule. Schedule No. 6 was patently outdated, so in October 1957 ADES drew up Schedule No. 7, approved by USAF 1 November 1957. The completion date for SAGE, as a result, dropped back from September 1962 to September 1963. The differences[74] between Schedules Nos. 6 and 7 were as follows:

Installation Priority (Schedule 7)	Sector	Schedule No. 6	Schedule No. 7
1	New York	Jul 1958	Jul 1958
2	Boston	Sep 1958	Sep 1958
4	Syracuse	Jan 1959	Jan 1959
5	Washington	Feb 1959	Feb 1959
6	Bangor	Mar 1959	Mar 1959
7	Detroit	Apr 1959	Aug 1959
8	Chicago	May 1959	Oct 1959
9	Kansas City (training)	Nov 1958	Nov 1958
11	Montgomery	Mar 1960	Mar 1960
12	Duluth	Oct 1959	Nov 1959
13	Grand Forks	Nov 1959	Dec 1959
15	Seattle	Feb 1960	Mar 1960
16	Portland	Mar 1960	Jun 1960
17	Sault Ste. Marie	May 1960	Jun 1960
18	Spokane	Jun 1960	Aug 1960
19	San Francisco	Jan 1961	Mar 1961
20	Reno	Apr 1961	Apr 1961
21	Los Angeles	Oct 1960	May 1961
22	Great Falls	Aug 1961	Aug 1961
23	Minot	Jul 1961	Sep 1961

74. SAGE Quarterly Progress Report, ADES. 1 Dec 1957 [HRF].

Installation Priority (Schedule 7)	Sector	Operational Dates Schedule No. 6	Schedule No. 7
25	Phoenix	Feb 1962	Nov 1961
27	Sioux City	Sep 1961	Mar 1962
28	Raleigh	Oct 1961	Apr 1962
29	Miami (Atlanta)	Jan 1962	Jul 1962
30	Albuquerque	Apr 1962	Sep 1962
31	San Antonio	Jun 1962	Oct 1962
32	Shreveport	Jul 1962	Feb 1963
34	Fort Knox	Nov 1961	May 1963
36	St. Louis	Sep 1962	Sep 1963

Planning for the testing of SAGE/Missile Master (FSG-1) integration continued during 1957, but no actual testing was accomplished because no Missile Master equipment was yet operational. The Army was installing the first set at Fort Meade, Maryland, and when this equipment was ready, tests involving the Fort Meade FSG-1 and the FSQ-7 computer at Fort Lee, Virginia (Washington ADS), were to begin, probably in late 1958 or early 1959. But before integration testing could begin, certain technical inconsistencies between the Army and Air Force equipment had to be overcome. The most evident problem was that presented by the fact that SAGE used a 1300 bit-per-second data rate, while Missile Master used a 750 bit-per-second rate. Development of a converter was essential. Also, development of a SAGE computer program which would make allowance for antiaircraft

weapons was imperative. Lincoln Laboratory was hopeful that this could be done by October 1958. Finally, formulation of a digital message structure usable by both SAGE and Missile Master was necessary. Lincoln Laboratory had formed a joint committee to study this problem. At the end of 1957 it was becoming fairly evident that SAGE/Missile Master integration might be a long time in coming.[75]

During 1957 the construction of SAGE buildings was slowed by the July-November "freeze," but the fabrication of essential equipment proceeded generally according to schedule. The direction center buildings for the New York and Boston sectors were completed in 1956. Six more similar buildings were accepted in 1957 -- Washington and Syracuse (including the 30th Air Division combat center) in July and Duluth in November. The direction centers for the Kansas City and Montgomery sectors were expected to be completed in early 1958. The FSQ-7/8 computers, heart of the

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75. CONAD to ADC. "Draft Plan for Testing SAGE/Missile Master Integration," 15 Jul 1957 [DOC 21]; Memo, ADORQ-D for ADODO, "Draft of CONAD Plan for Testing SAGE/Missile Master," 31 Jul 1957 [DOC 22]; ARDC Study Group Report. "Extension of NIKE Battery Data Loop to the SAGE Direction Center," 1 Sep 1957 [DOC 23]; ADC to ARADCOM (Army Air Defense Command). "SAGE/AADCP Intercommunications," 21 Oct 1957 [DOC 24]; USAF to ADC. "Draft CONAD Test Plan for SAGE/Missile Master Integration," 17 Oct 1957 [DOC 25].

SAGE system, had been delivered to eight locations (seven delivered to direction centers and one to a combat center) by the end of 1957. Sets 9 through 16 were being produced on schedule. The initial contract for the first 24 FST-2 coordinate data transmitter sets was completed in October 1957 and work on a supplemental contract was underway at Burroughs by the end of the year.[76]

The SAGE system first reached token readiness in 1958. The New York Sector was declared operational on 26 June 1958, the Boston Sector on 11 September 1958. Also, the Syracuse Sector and the 26th Air Division (also at Syracuse) reached operational readiness on 1 January 1959. The first SAGE "module," involving control of the New York. Boston and Syracuse sectors by the combat center at the 26th Air Division, was in operation at the end of the year. An area running from southern Vermont and New Hampshire to Delaware along the east coast and inland to Ohio was covered by automated air defense.

Although this was a matter of some pride, it was sobering to note that 26 direction centers and six combat centers still remained to be brought to operational status

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76. SAGE Quarterly Progress Report, ADES, 1 Dec 1957 [HRF].

before the complete SAGE system was finished. Old timers in the SAGE project could also recall that 1954 planning had called for operational readiness of the first sector by 1 January 1957. But the continual slippage of SAGE operational dates stopped in 1958. A Schedule No. 7 (Improved), approved by USAF in June 1958, indicated that the date for completion of SAGE could be moved forward from September 1963 to July 1963 through speedier construction and shorter test periods. The improvement would be noticeable beginning with the San Francisco sector. The changes in operational dates for direction centers would be as follows:[77]

Installation Priority (Schedule 7, Improved)	Sector	Schedule No. 7	Schedule No.7 (Imp)
19	San Francisco	Mar 1961	Dec 1960
20	Reno	Apr 1961	Feb 1961
21	Great Falls	May 1961	Feb 1961
22	Los Angeles	Aug 1961	Apr 1961
23	Minot	Sep 1961	Jun 1961
25	Phoenix	Nov 1961	Sep 1961
27	Sioux City	Mar 1962	Dec 1961
28	Raleigh	Apr 1962	Mar 1962
29	Miami	Jul 1962	Apr 1962
30	Albuquerque	Sep 1962	Jul 1962
31	San Antonio	Oct 1962	Sep 1962
32	Shreveport	Feb 1963	Nov 1962
34	Fort Knox	May 1963	Mar 1963
36	St. Louis	Sep 1963	Jul 1963

77. Semi-annual SAGE Progress Reports, ADES, 1 Jul 1958 and 1 Jan 1959 [HRF].

A great spurt of productivity as regards SAGE was noted in 1958. In addition to the attainment of operational status by three sectors and one division, the blockhouses for 11 additional direction centers and two combat centers were completed by the end of the year. Direction center buildings through Sault Ste. Marie (Installation priority No. 17) were ready. Seven other direction center blockhouses were between 27 per cent (Phoenix) and 99 per cent (Spokane) complete at the end of 1958. As to the FSQ-7/8 computers, 14 systems had been shipped by IBM by the end of 1958 and production was strictly in tune with Schedule No. 7 (Improved). There was similar satisfaction over the production of FST-2 Coordinate Data Transmitters by Burroughs. The number of sets under contract had risen to 98 by the end of 1958 and 50 had already been delivered to SAGE radar sites. No difficulty was foreseen in meeting future delivery schedules.[78]

In November 1958, ADC submitted to USAF a proposal for installation of solid-state (transistorized) SAGE computers in hardened underground locations to be known as Super Combat Centers. This proposal was brought forward

78. Semi-annual SAGE Progress Report, ADES, 1 Jan 1959 [HRF].

as a means of countering a probable Soviet intercontinental ballistic missile. USAF had taken no action on this matter by the end of 1958 and the subsequent fate of the SCC proposal is discussed in a subsequent study in this series, Command and Control Planning, 1958 - 1965.[79]

At the end of 1958, ADC was driving ahead toward the completion of a SAGE system that would include 29 direction centers and 7 combat centers. There were rumblings of discontent over the cost of SAGE, but no concrete proposals for reducing the size or scope of the automated system of ground environment had been presented at that time.

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79. Ibid.