electronic components of modern C^3 equipment, particularly to computers and other equipment incorporating digital electronic technology. 10/ Technical experts disagree over the precise implication or effect of EMP. Some analysts envision prompt, widespread disruption; others offer a less pessimistic prognosis. Nevertheless, it can be said, even without full knowledge of the scope of EMP's effects, that such shocks would negatively affect functioning of the command and control system. Though it is possible to harden systems against EMP, older installations or systems were not so protected. Consequently, only a small fraction of C^3 systems--generally the newer ones--have been hardened.

Communications links might also be disrupted by perturbations in the ionized atmosphere produced by a nuclear explosion. These effects would dissipate over time but could be expected to disrupt certain communications channels for hours, or even days, after a nuclear blast. Their severity and duration would vary for different radio frequencies. Existing high-frequency (HF) transmissions using 1960s technology, which relies upon deflection by the ionosphere, could be blacked out for hours. Higher frequencies, such as Ultra High (UHF) and Extremely High (EHF), would be subject to less disruption as operating frequencies increase. Nonetheless, not all frequencies would be available during a nuclear attack.

Effects of Jamming

Electronic jamming of radio transmissions poses the same challenge to strategic C^3 as sabotage. Electronic interference of warning information or communications links, if effective over a period of minutes, holds potentially devastating consequences. The likelihood and effect of jamming vary according to which war scenario one considers, and jamming may or may not be significant. Given known Soviet interest and ability in electronic jamming, however, this threat cannot be ignored.

10/ Digital electronic equipment, similar to but far more complex than conventional hand-held electronic calculators, operates on extremely low voltages. A sharp pulse of electromagnetic energy can easily disrupt and sometimes burn out components. See U.S. Department of Defense and Department of Energy, The Effects of Nuclear Weapons (1977), pp. 518-525.

The Soviets would probably attempt to jam U.S. military transmissions during a nuclear attack. The Soviet Union has extensive nonmilitary experience jamming transmissions by the Voice of America, as well as those of national radio services in other NATO countries. The Soviets have fielded numerous electronic jamming devices, both fixed and mobile, and have organized special electronic warfare units for such purposes.

RECENT C^3 MODERNIZATION EFFORTS

The prospect of these conditions threatening strategic C^3 systems has existed for some time, though they have become considerably more pressing in recent years. Several developments have made these conditions more urgent. First, the accuracy of Soviet ICBMs has reached a point at which virtually any fixed ground-based facility has little chance of surviving a direct nuclear attack. Though most public debate has focused on the vulnerability of U.S. ICBMs, the impact of Soviet strikes against command and control installations has become, if anything, a more severe problem.

Second, the shift in modern electronics toward digital technologies has exacerbated the problem of EMP disruption. A far greater proportion of C^3 systems today is potentially subject to EMP disruption than was the case only 20 years ago. And third, pressure to find more economical ways to operate in peacetime has led to consolidation of various functions into fewer and fewer installations. This consolidation process has produced a series of "critical nodes," with failure of any one potentially jeopardizing major functions and activities.

In the course of the past decade, the Defense Department has proposed, and the Congress has authorized, a number of important programs to overcome these difficulties. Those programs contributing most directly to improved system performance are:

- o Development of mobile ground terminals (MGTs) for the satellite early-warning system;

- o Conversion of E-4 command-post aircraft to the "B" configuration by installing satellite-communication terminals and higher-power VLF transmitters aboard them and by hardening the aircraft against EMP;

- o Deployment of a new collection of satellite communications links, known as the Air Force Satellite Communications System (AFSATCOM), especially providing terminals aboard bomber and command-post aircraft; and
- o Installation of higher-power VLF transmitters aboard the existing fleet of EC-135 command-post aircraft, called the Post Attack Command and Control System (PACCS).

Fielding MGTs will greatly lessen the vulnerability of the satellite early-warning system either to direct attack or to sabotage, and it will thereby assure a "survivable" source of tactical warning information so long as the satellites themselves are not attacked. The E-4 conversion, deployment of AFSATCOM, and the PACCS VLF power upgrade will improve performance by hardening critical systems against EMP and by making radio communications more resistant to jamming and nuclear effects.

These programs certainly increase the prospects that nuclear forces would receive a President's retaliation directive. They were designed to improve the C^3 system's capability to support force survival actions (notifying alert bombers to launch, for example) and to guarantee that nuclear forces receive orders. These functions have always been the basic requirements of the command and control system. They ensure that forces will survive a Soviet attack and provide the prompt, large-scale retaliation that was intrinsic to past strategic doctrine. Confidence that the C^3 system could alert forces so they might survive a nuclear attack and respond as directed remains the bedrock of deterrence, and likely will always remain so. It is obvious, though worthy of explicit mention, that nuclear war would be catastrophic. Indeed, one can hardly imagine circumstances or developments that national leaders feel portend greater disaster. As such, the assured ability to deliver prompt, large-scale retaliatory strikes may be judged a sufficient goal of C^3 modernization. In that case, further investments beyond those currently planned may be unnecessary. If, however, the Congress concurs with the logic of Presidential Directive 59, embodying the new doctrine of preparedness for a wide range of types and scales of nuclear war, the current system may be inadequate. Thus, the Congress would now face a new set of questions regarding what course of modernization to pursue for the future.

CHAPTER III. ALTERNATIVE STRATEGIES FOR ADAPTING C^3 TO THE NEW STRATEGIC DOCTRINE

Because the current Administration's thinking about nuclear war contemplates a protracted trans-attack period lasting days or even weeks, not just minutes, the Defense Department now devotes more attention to this interval than it has in the past. Similarly, the post-attack period, once envisioned as a time of primarily civilian recuperation but now seen as an extension of the initial military hostilities, now receives greater attention. This outlook dramatically increases the potential demands on the C^3 system in both the trans-attack and post-attack periods.

Emphasis on either of these two areas suggests mutually exclusive strategies for C^3 modernization. As mentioned in Chapter I, investments that would improve system responsiveness, for example, would not contribute to endurance. Similarly, investments that would enhance the ability of the system to function over long periods would not improve its ability to manage the complicated tasks associated with launch under attack or battle management. Were both goals judged to be of equal importance, it would be necessary to pursue both options simultaneously. Table 2 summarizes the various program initiatives included in the three major options discussed in this chapter.

OPTION I. IMPROVE SYSTEM RESPONSIVENESS IN THE TRANS-ATTACK PERIOD

Improved responsiveness in the trans-attack period suggests two areas in which additional investment in C^3 modernization might be required. First, one set of initiatives would seek to provide more timely and accurate attack information. The warning system must not only give unequivocal evidence that an attack is in progress, but it must also deliver more precise information about that attack than is now available, so the President can tailor retaliation directives appropriate to the level of provocation. And should the President and other command authorities be targets of the attack--which is likely--the warning information must reach its designated recipients before the missiles do.

TABLE 2. COMPONENT MODIFICATIONS OF STRATEGIC C^3 IMPROVEMENTS FOR THE FUTURE

System Function	Option I. Improve System Responsiveness
Sensor/Warning System	Deploy MGTs for satellite early-warning system
	Deploy Integrated Operational Nuclear Detonation Detection System (IONDS)
	Modify PAVE PAWS radars
	Deploy two additional PAVE PAWS installations
Command Centers	Complete E-4A conversion to "B" configuration
	Procure two additional E-4Bs
	Continue EC-135 modernization, including EMP (electromagnetic pulse) hardening
Communications Systems	Develop STRATSAT as successor AFSATCOM system
	Procure Very Low Frequency (VLF) receivers for bombers
	Develop advanced High Frequency (HF) radio system

SOURCE: Congressional Budget Office.

TABLE 2. (Continued)

Option II. Improve System Endurance	Option III. Improve System Responsiveness and Endurance
Deploy MGTs for satellite early-warning system	Deploy MGTs for satellite early-warning system
Deploy IONDS	Deploy IONDS
	Modify PAVE PAWS radars
	Deploy two additional PAVE PAWS installations
Complete E-4A conversion to "B" configuration	Complete E-4A conversion to "B" configuration
Terminate further E-4 procurement	Procure two additional E-4Bs
Continue EC-135 modernization, including EMP hardening	Continue EC-135 modernization, including EMP hardening
Develop and deploy ground-mobile command posts	Develop and deploy ground-mobile command posts
	Develop STRATSAT as successor AFSATCOM system
Procure VLF receivers for bombers	Procure VLF receivers for bombers
Develop advanced HF radio system	Develop advanced HF radio system
Develop mobile VLF radio system	Develop mobile VLF radio system
Develop survivable launch satellite system	Develop survivable launch satellite system

NOTE: Explanation of terms can be found in Appendix Glossary.

These functions are often discussed under the rubric "launch under attack." While Soviet warhead accuracy was insufficient to destroy U.S. ICBMs in hardened silos, launch under attack was considered necessary only for bombers. Now, however, the term is widely interpreted to imply the capability to launch ICBMs before they could be destroyed by incoming missiles. Soviet missile accuracy is now thought to have improved to the point that Minuteman ICBMs are, or soon will be, vulnerable. Launch under attack has recently been offered by some observers as an alternative to deploying ICBMs in multiple protective structures (blast-hardened silos) to counter the growing Soviet ability to destroy fixed silos. Others contend it should be considered a force employment option until the vulnerability of current forces has been offset by procurement of the MX mobile missile or, alternatively, by expansion of the SLBM force.

Second, efforts might be made to expand direct control over force execution in the trans-attack period. How much capacity those command centers and communications systems should have is subject to debate. U.S. nuclear war plans have traditionally consisted of finely detailed, relatively rigid attack plans containing a limited set of predetermined options. Successive Presidents, seeking greater flexibility, have pushed for more options, though they remain relatively rigid, pre-set options. The call for even greater responsiveness in the trans-attack period has led some analysts to call for trans-attack "battle management."

Trans-attack battle management represents a substantial development in strategic policy and planning. Unlike previous strategic guidance, which emphasized the execution of detailed attack plans, trans-attack battle management would allow commanders to modify those plans as events and circumstances dictated. The most ambitious proposals would permit battle management while a nuclear attack was in progress. Battle management would require nearly instantaneous information on which U.S. forces, as well as which Soviet targets, had been destroyed, so that surviving U.S. forces could be reassigned to targets of higher priority.

Tactical Warning and Attack Assessment

Current warning systems provide information on the approximate number and general launch locations of attacking Soviet missiles, as well as on the general areas and numbers of U.S. targets under attack. 1/ The Defense Department has, however, argued that greater accuracy in predicting target areas and determining attack size is required to support new nuclear policies, especially to enhance the credibility of launch-under-attack options.

Quality of warning information could be improved by refining the performance of existing early-warning facilities, especially the ICBM and SLBM radar systems. 2/ The Congress has already authorized one important initiative that will upgrade the ICBM detection radar at the BMEWS site at Thule, Greenland, to sharpen its resolution. These radar upgrades will improve detection and assessment of an attack, permitting more precise estimates of attack size and more accurate predictions of target areas. The Defense Department has also proposed modifications to the two existing PAVE PAWS SLBM radars located at Otis Air Force Base, Massachusetts, and Beale Air Force Base, California (see Figure 2 in Chapter II). These radar upgrades would more accurately determine the size of a raid as well as target areas.

The Defense Department has also proposed to expand coverage of the PAVE PAWS SLBM early-warning system by constructing two additional PAVE PAWS radar installations--one in the southeastern United States and the other in the Southwest. To lessen the chances of a retaliatory U.S. strike based on a faulty alert, the new radars would give independent verification of an attack. In addition, if the early-warning satellites failed for any reason, primary responsibility for detection of an SLBM attack from potential southern launch areas would fall to the two new PAVE PAWS radars.

If implemented, the warning system initiatives would improve the precision and detail of information about an impending attack, but they would probably not allow more time for the President to make a decision about retaliation. Significant improvement to the warning time afforded by the early-warning

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1/ "Improved U.S. Warning Net Spurred," Aviation Week and Space Technology (June 23, 1980), p. 40.

2/ Improvements in information quality for the early-warning satellites are being implemented through the Sensor Evolutionary Development program.

satellites is very unlikely. Total reaction time is governed by missile flight time, which, as noted in Chapter II, could be as short as 15 minutes.

The Defense Department is developing a sensor system that, while not a warning system per se, would provide information about the actual size and targets of a Soviet attack, as well as about the success of a U.S. retaliatory strike. The Integrated Operational Nuclear Detonation Detection System (IONDS) could potentially furnish U.S. commanders with almost instantaneous information on the number, scale, and location of aboveground nuclear detonations anywhere in the world. 3/ Detailed knowledge of nuclear detonations in the United States would aid in determining which U.S. forces had survived an attack and could be used in a retaliatory strike on the Soviet Union. Timely information on counterstrike detonations in the Soviet Union would allow U.S. commanders to determine which Soviet targets had escaped damage in the initial retaliatory attack and should be covered in a second U.S. strike. Finally, U.S. commanders could identify those areas of the United States that had escaped destruction, and direct recovery of U.S. forces (bombers, command-post aircraft, and the National Command Authorities) to them. Because the IONDS sensors would be carried aboard the 18-satellite NAVSTAR/GPS constellation, at least some of these detection devices would be expected to survive a Soviet antisatellite attack, allowing the system to endure over time, though with potentially degraded performance capacity. 4/ Terminals to receive the IONDS transmissions could be placed aboard command-post aircraft or on trucks.

3/ Data reported by satellites outside direct line-of-sight of the United States would have to be relayed via other satellites or ground stations to be immediately available. To date, funds have not been authorized for development of the data cross-link subsystem. If not fielded, the satellites would have to store the data and transmit it to receivers later in their orbit over the United States. This would mean that nuclear detonation data would not be immediately available to force commanders.

4/ The House Armed Services Committee has recommended termination of the NAVSTAR/GPS system, which would also terminate the IONDS program.

Command Centers

As Soviet missile accuracy improved in the 1960s, the Defense Department fielded a fleet of command-post aircraft to provide a survivable complement to vulnerable ground command posts. While only SAC's Looking Glass command post is on continuous airborne alert (see Chapter II), other command-post aircraft are kept on ground alert. 5/ With tactical warning supplied by early-warning satellites, command and communications aircraft on strip alert could take off and fly to safety. These planes, especially with aerial refueling, could remain airborne--and hence "survivable"--during the trans-attack period. Commanders on the aircraft could issue force-execution orders, receive reports from the nuclear forces, and direct subsequent strikes against targets not destroyed in the initial counterattack, as directed by the President.

From the start, EC-135 aircraft have formed the backbone of the airborne command network. In the late 1960s, the Air Force proposed procurement of a number of larger Boeing 747 aircraft, designated the E-4, to serve the Looking Glass mission and to function as the National Emergency Airborne Command Post (NEACP). 6/

5/ The entire fleet of command-post aircraft is called the Worldwide Airborne Command Post System (WWABNCP). Each commander-in-chief of nuclear forces has command-post aircraft. SAC also has a large fleet of such aircraft. In addition to those needed for the Looking Glass mission, SAC maintains the Post Attack Command and Control System (PACCS), one segment of which can launch Minuteman missiles by remote control.

6/ This substantially larger aircraft was sought for four reasons: to accommodate higher-power VLF transmitters and satellite terminals and the generators needed to power them; to carry a much larger battle staff and crew (45 personnel compared to the EC-135's 20); to provide for extensive computer support; and to enable the plane to remain airborne for a much longer period than the EC-135. Original plans called for the E-4 to be fitted with new, more sophisticated communications and data-processing equipment than the EC-135 carries. Because of the expense and uncertain availability of the equipment, however, the first three 747s (designated E-4A)

The Air Force intends to purchase two additional E-4Bs in 1983 and 1984, contending that a fleet of at least six is needed to maintain both a continuous airborne alert for Looking Glass and a constant ground alert for NEACP. Since the NEACP mission has had the higher priority, the current fleet would allow only part-time use of an E4-B in the Looking Glass role, unless additional E4-Bs were procured.

Replacement of existing EC-135s with the larger E-4B for the Looking Glass mission would potentially enhance U.S. capability to execute a quick retaliatory strike against the Soviet Union. In particular, the larger battle staff of the E-4B would be better able to determine the status of surviving U.S. forces and to reassign and retarget those forces to maximize precision and the extent of damage inflicted on the Soviet Union. Recent studies have concluded that such ad hoc modification of attack plans, called battle management, could improve the effectiveness of a U.S. counterstrike.

Communications Systems

Communication with forces during a nuclear attack is a difficult problem. Not only must systems survive physically, but they must also be able to function in an environment that might well be disrupted by nuclear "blackout" on certain radio frequencies and by Soviet jamming activities.

Satellite Communications. The Defense Department has chosen satellite communications as the preferred medium for improving communications with the nuclear forces, especially with the bomber force. As noted in the previous chapter, deployment of the AFSATCOM system is a major improvement initiative already under way to strengthen communications links. AFSATCOM consists of two elements: a ground component that includes all of the communications terminals necessary to transmit and receive messages, and a space segment that includes the satellites to

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were fitted with the same communications sets as the EC-135. The fourth aircraft (designated E-4B) was equipped with satellite terminals and a higher-power VLF transmitter and was hardened against EMP effects. As noted earlier, the Congress has subsequently directed that the Air Force convert the first three E-4A aircraft to the improved "B" configuration.

facilitate those communications. The existing satellite component consists of communications packages aboard other satellites, notably the Fleet Satellite Communications (FLTSATCOM) satellites, as well as certain polar satellites. 7/

Current system deficiencies and the need to replace the predominant space segment for AFSATCOM have prompted a search for an AFSATCOM successor program. Originally, only five FLTSATCOM satellites carrying AFSATCOM transponders were deployed. These satellites were expected to operate through the middle of the 1980s. With the delay in initiating a follow-on satellite program, the Senate Armed Services Committee has recommended procurement of three additional FLTSATCOM/AFSATCOM satellites to avoid interruption of service until a successor system is fielded. Two primary objectives have been set for the program: to improve satellite resistance to jamming, and to improve satellites' prospects for surviving an antisatellite attack.

During the last three years, an intense debate has arisen over the preferred satellite segment successor to AFSATCOM. The Air Force favored procurement of single-purpose satellites, designated STRATSAT, which would orbit at an altitude of about 110,000 nautical miles to achieve "survivability." To fortify resistance to jamming and to improve performance in a disturbed electromagnetic environment, STRATSAT would use EHF frequencies and new, highly sophisticated electronic techniques. Such satellites could relay messages to each other to provide global coverage independent of overseas ground stations. Most important, because of their very high altitude and maneuvering capability, they would be well able to survive an antisatellite attack.

Important groups within DoD, notably the Defense Science Board, favored an alternative approach to survivability: as the space segment of AFSATCOM, they suggested deployment of single-channel transponder packages (SCTs) aboard numerous future military satellites, especially NAVSTAR. Proponents of this approach argue that an array of dozens of transponders in space would be more likely to survive a Soviet attack than would a system

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7/ Current plans call for AFSATCOM transponders to be carried aboard Defense Satellite Communications System (DSCS-III) and Satellite Data System (SDS) satellites. At one time, DoD also proposed to place single-channel transponders aboard the Global Positioning System (NAVSTAR/GPS) satellites.

confined to just four STRATSAT satellites. Proponents also point to the substantially lower cost of the SCT alternative as another advantage over STRATSAT.

In three consecutive years, the Congress rejected Air Force requests to begin work on STRATSAT, apparently persuaded that proliferated transponders would be a more durable and less expensive solution.

Single-channel transponders would be cheaper than STRATSAT, though the cost differences would narrow substantially if an SCT system were designed to have the capacity, availability, and jam-resistance projected for STRATSAT. In short, the cost advantages of the SCT alternative appear to be modest, at best, if the SCT alternative is to match STRATSAT's two-way communications potential.

In terms of vulnerability, STRATSAT's proposed high altitude and maneuvering capability would render it potentially much better able to survive than proliferated transponders. Even if it did not maneuver to escape an approaching antisatellite vehicle, 8/ STRATSAT would function at least until a potential direct-ascent satellite-killer would reach the substantially higher altitude at which it would orbit. Because of its advantages in two-way communications, continuous worldwide coverage, communications capacity, and endurance--and in view of the fact that SCTs would provide little, if any, cost savings--STRATSAT appears preferable to a system of proliferated single-channel transponders.

The STRATSAT/proliferated transponder controversy has become muted, somewhat, because the Defense Department chose not to pursue either option in the fiscal year 1982 budget request. 9/

8/ STRATSAT might not be able to execute escape maneuvers, however, if previous maneuvers had already depleted its fuel or if all satellite control stations had been destroyed. It may be possible, should a threat to STRATSAT develop, to place satellite control terminals on PACCS aircraft, thereby enhancing the likelihood that a STRATSAT maneuver could be executed.

9/ Last year, the Congress directed DoD to choose between these two contending approaches and report its recommendations to the 97th Congress.

Instead, the department has undertaken a major "satellite architecture review," which has suggested a need for a multi-mission satellite. The satellite communications system might consist of a number of 70 EHF-channel satellites at geosynchronous altitude (see Chapter II, footnote 2). The satellites would offer communications links to a broad spectrum of strategic and tactical forces.

This multi-mission satellite contains all the liabilities that the Defense Science Board identified in STRATSAT, but none of the compensating advantages. Its positioning at geosynchronous altitude offers little "survivability" improvement over current systems and considerably less than offered by STRATSAT. According to unofficial reports, these would be extremely large and expensive satellites. The Defense Science Board was critical of STRATSAT because they would be very expensive "critical nodes," though this argument would be even more applicable to the multi-mission satellite. STRATSAT still appears to be the most practical approach to ensuring "survivable" two-way communications for strategic forces.

Advanced HF Radios. Were the Congress to direct DoD to proceed with STRATSAT as the successor satellite segment for AFSATCOM, many of the pressing communications requirements associated with speedy response in the trans-attack period would be satisfied. Nonetheless, to avoid total dependence on satellite communications in a nuclear conflict, another alternative--equipping C^3 aircraft and all nuclear forces with advanced high frequency (HF) radios--might be considered. 10/ Advanced HF transmitters split messages into separate "packets" and transmit each packet over different frequencies. HF receivers then reassemble the messages, picking the strongest signal for each information packet. This process provides a high degree of resistance both to jamming and to frequency blackout caused by ionospheric disturbances resulting from nuclear blasts. Transmissions in this mode would be limited to a low data rate, but that rate would suffice for dissemination of emergency action messages and could serve as a two-way communications link to supplement AFSATCOM. Though an advanced HF system would probably be of primary benefit to communications with the bomber force, it could also serve as a backup system for submarine communications,

10/ These advanced HF radio concepts are frequently referred to generically as "adaptive HF."

should TACAMO aircraft be destroyed, and for satellite communications, should their operations be disrupted.

VLF Receivers for the Bomber Force. A third communications initiative would provide for the installation of small VLF receivers aboard bomber aircraft. 11/ This would establish, at low cost, another one-way communications path that might help assure execution of an emergency action message in the trans-attack period. Since the continuously airborne Looking Glass aircraft could transmit a VLF message to the bombers, this communication link would not rely on surviving ground stations to relay the message to distant bombers. 12/ Whereas UHF line-of-sight systems currently used between command-post aircraft and the bombers are limited to approximately 300 miles, or less, VLF transmissions at higher powers could reach as far as 3,000 miles.

Costs and Effectiveness of Option I

Option I seeks to improve prospects for launch under attack and battle management. The prospect of launching missiles under attack and battle management must be tempered by acknowledging that both depend on presidential actions in the extremely short times available. Should Soviet planners tailor an attack to maximize confusion and create ambiguity in those few minutes, which is certainly likely, the time available to make critical decisions could be extremely short. And were the attack to occur as a surprise, the President might not survive the initial strikes, thereby requiring time to reestablish NCA control over the nuclear forces. This certainly would affect prospects for successful launch-under-attack, but would apply as well to battle management.

Battle management refers almost exclusively to redirecting attack plans of the bomber force, based on knowledge of the impact

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11/ Ballistic missile submarines are already equipped with VLF/LF receivers, as are ICBM launch control facilities.

12/ Nuclear blackout effects would not appreciably disturb transmissions at very low frequencies, and modifications such as those already approved for VLF systems on command-post aircraft could make receivers aboard bombers more jam resistant.

of the first strikes by both sides. Force commanders could make these directives only after having received initial release authority from the President. Therefore, battle management is just as time sensitive as launch under attack, and both depend on the President's and the Defense Secretary's having survived. Elaborate precautions have been taken to improve their survival prospects. Nonetheless, it is impossible to gauge the precise nature of circumstances accompanying a Soviet attack, leaving this critical issue open to doubt. And the major shortcoming of this option is its limited contribution to long-term endurance prospects.

The Congressional Budget Office estimates that the current C^3 system and programmed improvements will cost \$13.9 billion over the next decade. Table 3 at the end of this chapter presents a breakdown of the costs of the current system as well as the three options over the next 10 years. Option I would increase those costs by \$2.4 billion over the decade. Approximately \$600 million would go for two more E-4B command-post aircraft, and \$420 million would fund expansion of early-warning radar systems as discussed above.

OPTION II. IMPROVE SYSTEM ENDURANCE IN THE POST-ATTACK PERIOD

The evolving new U.S. strategic doctrine has also led analysts to focus to a greater degree on the post-attack period. The prospect of subsequent strikes in the post-attack period--and indeed the existence of reserve forces for use precisely in this period--has led to greater attention to post-attack system endurance. System endurance would become critical if a nuclear conflict were to extend into weeks or even months. The C^3 system's ability to endure would be an important goal, however, even if greater flexibility were not desired and the MAD concept continued to prevail in U.S. deterrence strategy, since the C^3 system would permit the President or his designated successor more than a brief period in which to assay the situation and decide on a response.

In view of the vulnerability of C^3's present fixed ground facilities--especially the command centers--aircraft are now considered the only "survivable" command centers; yet they could not be expected to function indefinitely without elaborate support, which would be most unlikely in the aftermath of a nuclear conflict. The Congress could therefore choose to emphasize endurance as the primary objective for C^3 modernization.

Implicit in such an alternative is the conviction that nuclear war can be better deterred if an assumed adversary knows it cannot destroy its opponent's command structure or wait until it collapses.

A modernization policy that stressed endurance would seek to ensure that the strategic C^3 system could remain in operation for the long periods of conflict envisioned in the new strategic doctrine. Key elements or functions destroyed in the initial attack would have to be reconstituted afterwards. Such an enduring command and control system would be necessary to manage strategic reserve and other nuclear forces throughout a protracted nuclear war.

A strategic C^3 system designed to operate for long periods after a Soviet attack, either through endurance of its initial elements or after their reconstitution, might provide the only investment alternative to hedge against a surprise attack. If the United States received no strategic warning of an attack, and if Washington, D.C. were quickly destroyed in an SLBM attack, critical functions would probably have to be reconstituted before retaliation directives could be given.

The following sections discuss several alternatives that might be considered to improve system endurance.

Tactical Warning and Attack Assessment

If strategic forces are designed to escape an attack or absorb losses with a usable proportion surviving, and U.S. leaders choose not to rely on a policy of launch under attack (both of these being stated goals of the past Administration), none of the improvements to tactical warning and attack assessment sensors described in Option I, except IONDS, would seem necessary. All of the early-warning upgrade programs noted in Option I entail investments in large, fixed, land-based systems. Easily targeted by nuclear weapons, these installations might well be destroyed within the first 10 to 15 minutes after an attack was launched.

A Soviet strike aimed solely at U.S. military targets, avoiding population and economic centers, might conceivably leave tactical warning systems untargeted, with the effect that the U.S. commanders might correctly interpret the type of attack and not launch a massive counterstrike against Soviet cities. Such an assumption would seem not to justify additional investment in the radar warning systems discussed under Option I, however. The PAVE PAWS improvements considered in that option would not be necessary to ensure force survival, since the bomber and command-post aircraft would take off at the first sign of multiple Soviet ICBM or SLBM launches reported by the early-warning satellites. Nor would these improvements be needed to assess an appropriate retaliatory response, since information about actual nuclear detonations in the United States would probably constitute the basis for making counterattack decisions, especially if U.S. nuclear forces were designed to survive a first strike. This information would be much more reliable than preliminary indications of probable targets provided by the PAVE PAWS system. As noted in the discussion of Option I, the IONDS system would provide this information, and, as such, is the most appropriate program initiative if the Congress sought to pursue this option.

Construction of additional PAVE PAWS radars would also not seem critical to improving system endurance. As long as the early warning satellites continued to function, the primary purpose of PAVE PAWS would be to provide independent verification of Soviet SLBM launches. The need for two independent warning systems would diminish in importance, though, if the likely U.S. response to an attack were based on actual nuclear detonations on U.S. soil. Should information from early-warning satellites be disrupted, the two new PAVE PAWS radars proposed would gain importance, becoming the primary mechanism for detecting an SLBM attack from the south. Unexpected loss of satellite early-warning data, however, would be potentially so threatening that it could be considered sufficient justification to launch bombers and command-post aircraft as a precautionary action, since one of the advertised advantages of bombers is the ability to recall them after launch. And even in that extreme case, the existing FPS-85 radar at Eglin Air Force Base, Florida, would cover much of the potential southern SLBM launch areas.

Command Centers

An investment strategy that sought to enhance the endurance of the strategic forces command system would require a substantially different approach to enabling the C^3 system to survive a protracted war.

Procurement of additional E-4B aircraft for the Looking Glass mission, bringing the fleet from four planes to as many as six, would not substantially benefit system endurance; regardless of the size of this fleet, how long the Looking Glass aircraft could remain in operation in the post-attack period is uncertain. Though aircraft have definite advantages over fixed or mobile land-based command posts in the trans-attack period, they probably could not function continuously following a major nuclear strike. Maintenance requirements, the need for runways in good condition, and the limited range of most aircraft communications systems while the planes are on the ground would limit the endurance and utility of aircraft command posts in the post-attack period.

A more appropriate investment for command-post endurance might be a system of small command centers mounted in trucks, similar to commercial moving vans. Like mobile ground terminals for early-warning satellites, these trucks would move randomly and covertly in locations away from major target areas, and they could be moved as often as necessary to prevent Soviet strategists from discovering their locations. These ground-mobile command posts would supplement operations of command-post aircraft in the initial stages of a conflict, and they would gradually take over full operations in the post-attack period. With fuel, food, and critical spare parts stored in advance in areas not expected to be targeted, ground-mobile command centers that survived an initial attack might be able to conduct sustained operations indefinitely. A portion of the ground-mobile command center fleet would be deployed on a continuous basis, with the remainder available for deployment upon strategic warning. At present, a prototype ground-mobile command post is being developed by the World Wide Military Command and Control (WWMCCS) System Engineer's Office under the Post-Attack WWMCCS Program.

A useful refinement of this idea might incorporate truck-mounted command centers that could be loaded on transport aircraft, permitting the command centers to conduct operations while airborne as well as on the ground. 13/ Some of the command centers could be boarded on aircraft on ground alert; upon warning of an attack, the planes would fly to safety, and the command centers would conduct operations in the air during

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13/ The Army is developing such a system under its Joint Crisis Management Capability (JCMC) program. The command truck could be placed in a specially modified C-130 or C-141 aircraft that had been equipped with antennae and electric power cables to allow the van to function while the aircraft was airborne.

the trans-attack period. When it became necessary for the planes to land, the command-post trucks could be unloaded to continue operations on land. Such a concept could be incorporated as a successor system to the current fleet of EC-135 command-post aircraft.

The cost of this new system of ground-mobile command posts could be covered by savings associated with termination of further procurement of E-4B command-post aircraft. The Congress could limit the E-4 program to the planned conversion already authorized and could continue to use the EC-135s without compromising much capability in the Looking Glass mission. A program is already under way to fit the EC-135s with larger VLF transmitters and to install the same computers aboard them as the Air Force intends to place on the E-4Bs. An SHF/EHF satellite terminal is now in the advanced testing stage, and such a terminal could be fielded for existing EC-135 aircraft. These initiatives will correct several of the deficiencies that prompted support for the original E-4 program. And while the EC-135 still could not match the endurance of the E-4, the E-4's superior endurance would be of uncertain value if the remaining network of EC-135 aircraft could not sustain airborne operations after a nuclear attack. In any event, long-term endurance would be supplied by ground-mobile command posts used to supplement Looking Glass operations. As such, endurance of the EC-135 fleet, not of the E-4s, will largely determine overall system endurance, potentially reducing the advantages of the E-4.

The one continuing weakness of the EC-135 is its lack of EMP hardening. Effects of EMP remain only imperfectly understood. Nonetheless, DoD has considered the problem sufficiently important to initiate a program in fiscal year 1982 to harden the TACAMO EC-130Q aircraft against EMP effects. Since EC-135 aircraft would be required to function in comparable circumstances, selective hardening of them might be beneficial as well. The Congressional Budget Office estimates the cost of hardening the 27 EC-135s in the airborne command-post network at $65 million.

Communications Systems

After even a massive nuclear attack, substantial communications assets would be expected to survive. Commercial telecommunications systems are extensive and redundant. Though major switching stations would likely be destroyed, hundreds of smaller stations would survive, and these could form the foundation for any subsequent military and civilian communications needs. 14/ If further investment in communications systems were made for purposes of improving endurance, it might be desirable to limit it to those areas in which surviving civilian or military assets may prove insufficient. Of particular concern would be communications with the ballistic missile submarines, since they would be the most important component of surviving residual forces. Two systems seem to be the likeliest prospects for improving endurance in this area.

Because very low frequencies provide long-range communication and can penetrate seawater to some degree, VLF transmissions constitute the primary means of communicating with U.S. ballistic missile submarines at sea. 15/ While TACAMO aircraft would take over VLF transmissions upon destruction of the ground-based stations, total reliance upon TACAMO for VLF communications to submarines in the extended post-attack period might seem unwise. Only a small number of planes--those actually airborne at the time of an attack--could be expected to survive, and their usefulness would be limited to weeks or even days because of the loss of support facilities.

14/ Presidential Directive 53 (PD-53), issued by President Carter in 1979, calls for greater emphasis on the use of surviving civilian communications systems for national purposes in the post-attack period. The proposal embodied in PD-53, however, calls for decentralization and homogenization of future communications systems. While this clearly would be helpful, it probably conflicts with peacetime commercial goals, which stress efficiency through hierarchical organization and protection against monopolies. While PD-53 is a useful statement of planning objectives, it will undoubtedly prove quite contentious when the government attempts to implement it. Specifically, who will pay for the inefficiencies incorporated in such future arrangements? The telecommunications industry will likely press for government relief if forced to move to an inefficient market structure.

15/ To receive UHF communications, a submarine would have to raise an antenna above the water's surface, potentially disclosing its location to any nearby Soviet searchers. This might be a less threatening prospect after a nuclear exchange in a prolonged conflict.

One alternative for reconstituting VLF communications in the post-attack period would involve deployment of a system of mobile ground-based VLF transmitters. Existing VLF stations are enormous, covering dozens of acres of land with extensive, heavy antenna grids suspended from steel towers. A mobile VLF station, by definition, would be substantially smaller. If a mobile VLF system were deployed, and the system had sufficient power to transmit at an acceptable data rate, 16/ continuous broadcasts to submerged submarines could perhaps be maintained. Potentially, the system could also transmit messages to ICBM launch control facilities and to bombers that were equipped with VLF receivers. Since the system would permit only one-way communications, however, the nuclear force elements could not report back to U.S. commanders on VLF channels.

The Defense Department is also considering methods for reconstituting satellite communications in the post-attack period, in view of the likelihood that a Soviet nuclear attack might well include an attempt to destroy U.S. communications satellites. By using a launcher system with good survival prospects, such as patrolling submarines, it might prove possible to reestablish satellite communications by launching a small transponder into orbit. Such a system would enable two-way communications with nuclear forces in the post-attack period, and it would provide a communications link between the National Command Authorities and surviving nuclear force commanders. This alternative could have disadvantages, however. To receive communications from the satellites and transmit messages to them, a submarine would have to raise an antenna above the water's surface, making the ship more easily detectable. If the satellites were in low orbits that did not permit them to transmit messages simultaneously to widely separated receivers, they would have to store the messages for transmission when they passed over their intended receivers later in their orbits.

Though the major contribution of advanced HF radio systems and VLF terminals for the bomber force noted in the previous option would be to improve communications in the trans-attack period, such radio systems could also prove useful in extended post-attack operations. After nuclear blackout had diminished

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16/ If the data rate were too low, the system could act only to signal a submarine to deploy the appropriate antennae to monitor a message on a different frequency.

in the post-attack period, advanced HF radios could be used to determine the best transmission path between two points and would obviate a need for scattering transmissions across the spectrum in packets. The radios could automatically shift to different frequencies as ionospheric conditions changed. Indeed, an advanced HF system could enable greatly improved peacetime HF communications (during training missions, for example), and it might seem worthwhile for that purpose alone. 17/ Installation of VLF terminals in bombers would represent an additional means for a widely dispersed bomber force to receive messages from U.S. commanders in the post-attack period. The usefulness of this system for days, weeks, or even months after an attack could depend, however, on the existence of reconstitutable VLF transmitters, since whether or not C^3 aircraft equipped to broadcast on this wavelength could maintain operations indefinitely after an attack is uncertain.

Cost and Effectiveness of Option II

Option II would improve system endurance. But covert movement of small mobile units--the key to survivability and endurance--also limits the prospect that this new system would improve system responsiveness in the trans-attack period. Indeed, since this option proposes ground-mobile command and communications units to augment existing survivable units, trans-attack operations would not differ substantially from those of the current system.

Option II is estimated to cost $15.7 billion over the next 10 years, or $1.8 billion more than the current system.

The cost of procuring ground-mobile command posts, a mobile VLF system, and a reconstitutable satellite system is estimated to be $1 billion. Since such operations are relatively labor intensive, annual operating costs could reach an estimated $130 million. These costs are largely offset by the $1 billion in savings associated with terminating the E-4B program and with limiting investment in additional warning systems to improvements in the current satellite early-warning system.

17/ Current HF communications are often difficult to establish, since optimal frequency paths are affected by location, time of day, solar flares, and other variables.

OPTION III. IMPROVE BOTH SYSTEM RESPONSIVENESS AND ENDURANCE

Obviously, the Congress could direct that steps be taken to improve both the C^3 system's responsiveness in the trans-attack period and its endurance in the post-attack period. Indeed, if both goals were judged equally pressing needs for modernization, the program alternatives discussed under Options I and II would have to be pursued simultaneously, since improved system responsiveness and enhanced system endurance require different investment approaches.

Option III would cost substantially more, since the programs contained in Options I and II would be pursued simultaneously. Consequently, the cost of the program alternatives in one option would not be offset by foregoing programs contained in the other. The Congressional Budget Office estimates that Option III would cost $17.8 billion over the next 10 years. Even then, Option III would cost only $3.9 billion more than would be needed to keep the current system in operation over the next 10 years. The incremental cost for this "high" option would be less than 3 percent of the funds likely to be available for strategic forces over just the next five years. The following table summarizes the projected costs of the three C^3 modernization approaches discussed in this chapter.

TABLE 3. PROJECTED COSTS OF C^3 MODERNIZATION ALTERNATIVES, FISCAL YEARS 1982-1991 (In millions of fiscal year 1982 dollars)

Options, by System Function	1982	1983	1984	1985	1986	1987 to 1991	Ten-Year Total
Continuation of Current Policy a/							
Warning	790	680	680	530	670	3,220	6,570
Command	500	260	360	260	260	1,280	2,920
Communications	390	420	470	410	530	2,190	4,410
Total	1,680	1,360	1,510	1,200	1,460	6,690	13,900
Option I							
Warning	980	850	680	540	680	3,270	7,000
Command	500	560	660	260	260	1,650	3,890
Communications	400	540	650	610	760	2,460	5,420
Total	1,880	1,950	1,990	1,410	1,700	7,380	16,310
Option II							
Warning	790	680	680	530	670	3,220	6,570
Command	530	330	420	320	330	1,570	3,500
Communications	410	570	700	610	800	2,560	5,650
Total	1,730	1,580	1,800	1,460	1,800	7,350	15,720
Option III							
Warning	980	850	680	540	680	3,270	7,000
Command	530	630	720	320	330	1,940	4,470
Communications	420	600	790	730	960	2,850	6,350
Total	1,930	2,080	2,190	1,590	1,970	8,060	17,820

SOURCE: Congressional Budget Office estimates.

NOTE: All estimates include both investment and operating costs. IONDS costs are excluded for reasons of national security.

a/ Includes costs of modernization programs already authorized.