Chapter4

LAUNCH UNDER ATTACK

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Another approach to MX survivability is to accept vulnerable silo basing and resolve to launch silo-based MX missiles before attacking Soviet reentry vehicles (RVS) could arrive to destroy them. This type of response to a Soviet attack is called launch under attack (LUA) Adopting this approach to MX survivability would imply relying on LUA as opposed merely to preserving it as a possibility The United States now preserves the capability to LUA as a matter of stated doctrine, Some, though not all, of the other basing modes described in this report would also allow this capability to be preserved. This chapter does not in any way address the present U. S doctrine or the status of means to support that capability, but only potential future systems of reliance on LUA.

OVERVIEW OF RATIONALE FOR LUA AND POSSIBLE DRAWBACKS

The chief attraction of LUA basing is that it can be implemented faster and more cheaply than other basing modes since there is no basing "mode" to speak of. The United States could in principle put MX missiles in the Minuteman silos as they came off the assembly line, meaning MX deployment in the second half of this decade However, some of the hardware needed to support the LUA capability (warning sens.ors, communications links, and the like) might have longer lead-times. A truly robust and dependable system might therefore take Slightly longer to deploy.

Even with a wide range of sophisticated, redundant support hardware–just about everything one could think of buying in the way of sensors and communications— the price of an LUA system (excluding the missiles themselves) would come to billions of dollars rather than tens of billions as for other basing modes. Some of the systems required for LUA would in fact be desirable, perhaps even necessary, to deploy with *any* basing mode.

This hardware– warning sensors, command posts, and communications links–could be made virtually impossible for the Soviets to destroy or disrupt. What cannot be assured with confidence is that competent National Command Authorities (NCA) would in all circumstances have access to this system in the short LUA timeline; this is essentially a matter of procedures and national policy, not technology.

Because already-existing silos (or a small number of new ones) could be used, there would be little new construction and hence little environmental and societal impact.

LUA would preserve familiar features of silo basing, including weapon effectiveness as measured by accuracy, time-on-target control, and the like; familiar force management procedures; and familiar arms control verification procedures.

From the point of view of strictly military utility, the possibilities for an LUA force differ very little from those available to a survivable force, The same targets (and perhaps more) would be available in the first few minutes of a war as in the first few hours or days. Essentially the same targeting flexibility could be provided with technically feasible hardware.

Reliance on LUA also has potentially serious drawbacks.

Depending on the circumstances, decision-makers could lack crucial information regarding the extent and intent of the Soviet attack — information necessary to gauge the proper response It is not clear, however, that much better information would always be available to the commander of a survivable force within a short period after a n uc l ear attack

Decisionmakers would also lack an interval between attack and response during which intelligence information could be assessed, diplomatic measures considered, and the intent of the U.S. response signaled — assuming the circumstances of nuclear war permitted such things at al 1.

Decision time would obviously be very short. NCA would have to make unprecedentedly weighty decisions in less than 15 m i nut es.

To guarantee the LUA capability against some contingencies it might be necessary to adopt unpalatable procedures regarding, for instance, delegation of launch authority.

No matter how much money and ingenuity were devoted to designin, safeguards for the U.S. capability to launch under attack, and even if the safeguards were very robust indeed, it would probably never be possible to eradicate a lingering fear that the Soviets might find a way to sidestep them.

Finally, despite all safeguards, there would always remain the possibility of error, either that missiles were launched when there was no attack or that they failed to launch when the attack was genuine.

POSSIBILITIES FOR LUA SYSTEMS

There is a wide variety of possibilities for LUA systems, and which is "best" is not really a matter of technology but of doctrine, procedures, and national policy. Doctrine determines the types of attack which the system is designed to meet and those which it is not, For instance, it would be easier to configure an LUA system on the assumption that a Soviet attack would be directed at missile silos and perhaps other military targets but would not be preceded by attack on Washington, If Washington were attacked first, an LUA system designed on this assumption might fail. But since the intercontinental ballistic missile (ICBM) vulnerability problem is perceived generally within the context of counterforce attacks excluding U.S. cities, it is not clear that an LUA force must be required to meet such a contingency; in this case it might be thought that an appropriate response could be executed with surviving submarine, cruise m issile, and bomber forces. These are clearly issues of doctrine. Regarding procedures— and to take a more extreme example— it would also be easier to design an LUA system on the assumption that launch authority were vested in certain circumstances in persons other than the President and other duly constituted NCA or even that the response to be made to a Soviet attack of a given sort were decided in advance and, so to speak, "wired into" the ICBM system.

Doctrine and procedures — issues of national policy, not technology— more than anything else therefore determine the architecture of an LUA system.

This section outlines the *technically feasible* hardware elements and procedures that could go into an LUA system. It seeks to give a sense both of the breadth of possibilities and of the fundamental limitations. The next section shows how some of these elements might come into play in the circumstances of a Soviet attack. It should be emphasized that what is being described here are elements of a *hypotheticl future* LUA system, *not* means which support the present U.S. LUA capability.

The principal elements to analyze from the technical point of view are targets and the military utility of an LUA force, the timelines of possible attacks, early warning and attack assessment systems, command posts, and communications I inks. Possible procedures by which decisions could be made and launch orders given can be laid out, but a selection among them would be a decision for the highest levels of political authority.

Targets and Military Utility

The first question to ask of an LUA force is whether there are important and identifiable differences, in terms of the military effectiveness of a U.S. response to Soviet attack, between immediate LUA response and a delayed response executed by a survivable force, Though there are some d inferences, on balance it appears that little or nothing from a purely military point of view is sacrificed by immediate response,

In the first place, there would seem to be no targets which would be absent or untargetable early in the war but which would somehow appear later on, Thus, there can be from this point of view no disadvantage to retaliating immediately; on the contrary, it would seem that a difference between early and delayed response, if one were to exist, would favor the early response. The most stressing case for an LUA system is one in which the Soviet attack came with no indications of preparation for attack before the actual launch of Soviet missiles. In this case, a prompt U.S. response could destroy other Soviet military assets before they had time to disperse from their ordinary operating bases. I f the Soviet attack came from a generated posture, some assets might be difficult to target, but this situation would not necessarily improve with time Even if there were significant Soviet target complexes that "appeared" later, it is unlikely that they would be hardened to such an extent that their destruction would require ICBMS, although if they were mobile a rapid response-time for U.S. attack could be useful. Such rapid response is most easily accomplished with ICBMS, Even assuming the existence of targets which a survivable force could target but an LUA force could not, one must assume in addition that the U.S. intelligence assets required to locate these targets would survive an initial Soviet attack.

As to the nature of the targets that should be assigned to an LUA MX force, the important issue for this purpose is not what these targets might be, but how the selection might differ from those assigned to a survivable retaliatory force. Again, there do not appear to be significant differences. I n either case, the actual targets attacked might well depend upon the nature of the Soviet provocation and have the goal of inflicting on the Soviet Union a level of damage – measured overal l — commensurate with the damage anticipated from the Soviet attack, as well as the latter could be judged at the time the U.S. decision to respond had to be made. If Soviet silos were among the targets marked for destruction by the LUA force, one might want to have some means for determining which were still full and which empty, and one would also have to take the chance that the Soviets would themselves launch under attack when our missiles were in flight. Both problems exist for a survivable force as well. In practice it is likely that the same information, obtained at launch, would be used to support retargeting to avoid attacking "empty holes" whether by survivable or LUA forces; the only difference would be the retargeting time available. In practice it is also possible to guess in advance which Soviet missiles would be used in an attack on U.S. silos. There is also an analytical basis upon which to question the utility of bothering with any sort of "empty hole" retargeting. (It might even be thought desirable to attack empty holes to preclude "reload,") As to Soviet LUA, with a survivable force there would be a time delay before retaliation during which efforts could be made to destroy Soviet sensors capable of indicating a U.S. launch.

Since decisions would have to be made quickly, and since extensive ad-hoc retargeting would be difficult to carry out in the short LUA timeline, some preplanning would have to be done regarding the responses to be made to a given Soviet attack. Such preplanning would also be done for survivable forces. To the objection that such preplanning is unpleasant or "commits" the United States to certain types of response, it can only be noted that the concept of deterrence presupposes, independent of the forces concerned, that Soviet attack will provoke with high certainty a U.S. response. Whether the United States would *actually* choose to retaliate if deterrence failed cannot be said on the basis of the forces deployed. Of course, LUA allows little time for reflection if Soviet attack did occur.

There might be no need to have the *entire* U.S. ICBM force postured for LUA, Since a *survivable* force of, say, 1,000 RVS might be considered adequate for a delayed response, no more than this number of RVS need be included in the force which "survives" by launching under attack.

Time lines

Soviet ICBMS take about a half hour to make the journey from their silos to U.S. ICBM fields in the Central United States, The time from first launch to first impact could in principle be shortened by a small amount, but this would be likely to cause some degradation in accuracy, A realistic Soviet laydown would also occur over a span of time, from just under 30 minutes until somewhat later.

Speaking roughly, receipt of the launch message or Emergency Action Message (E AM) by the missile force as late as a few minutes before Soviet RVS arrive would be sufficient to guarantee safe escape of the missiles, This brief time period would be accounted for by the time taken for the EAM to be transmitted to the missile fields, decoded, and authenticated; the time taken to initiate the launch sequence; the time from first missile takeoff to last; and the time needed for the last missile to make a safe escape from the lethal effects of the incoming Soviet RVS.

Thus, the time available for ICBM attack assessment and decisionmaking" would be the half-hour ICBM flight time minus this small time period for missile launch.

Soviet submarine-launched RVS targeted at command posts and communication nodes could arrive earlier than the ICBMS. It is assumed here that the Soviets would not possess submarine-launched ballistic missiles (SLBMS) deployed near U.S. coasts of sufficient accuracy and in sufficient numbers to constitute themselves a primary threat to U.S. silos. Forward-deployed SLBM RVS could arrive in the Central United States within 8 to 15 minutes of launch and at coastal targets, such as Washington, within 5 to 10 minutes. This means that relatively soft targets such as command bunkers and communications nodes, if targetable, could be destroyed early in the attack. One of the principal goals of a robust LUA system must be to survive such a precursor SLBM attack in order to support execution of a launch decision,

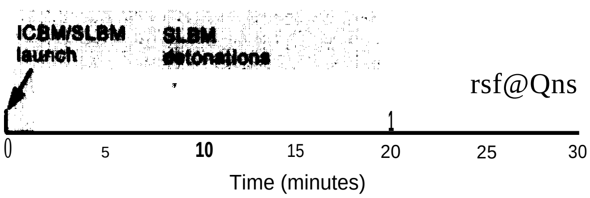
Assuming simultaneous launch of Soviet ICBMS and SLBMS, the timetable which results is shown in figure 65.

The LUA timetable could be extended somewhat by a "dust defense" such as described in chapter 3. In this scheme, the dust cloud formed by deliberate detonation of buried nuclear weapons in the silo fields would destroy the first wave of Soviet RVS. The United States would have until the dust cleared — tens of minutes — since a second attack could not be mounted during this time.

Overview of Technical Requirements

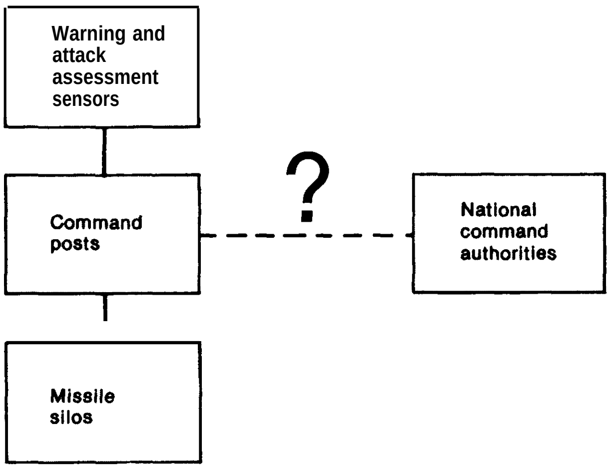
In order to meet the timeline and attack constraints outlined above, a U.S. LUA capability would require warning and attack assessment sensors impervious to disruption; survivable command posts to digest and organize sensor information; and secure, reliable communications linking the command posts with the warn ing sensors and with the missile fields. The most important requirement, and the most diff i cult to meet in practice, would be providing a connection from the survivable command posts to NCA empowered to make launch decisions. This architecture is shown i n figure 66.

Figure 65. —Attack Timeline



SOURCE Office of Technology Assessment

Figure 66.— Launch-Under-Attack System Architecture



SOURCE Off Ice of Technology Assessment

The paragraphs below indicate the range of technically feasible candidates for these system elements It will be apparant that no single element can be made survivable against a determined Soviet effort to disrupt it. One must instead make disruption as difficult and time-consuming as possible, provide redundant backup systems, and seek to make price of disruption so high that Soviet attack on all U.S. LUA assets would virtually be cause itself to retaliate against the Soviet Union.

Early Warning and Attack Assessment Systems

The important features of warning and attack assessment systems are when in the course of an attack they could be expected to provide information, what information they could furnish at that time, and how *difficult to* disrupt they would be. In general, the first two features are related in that the more complete the information they furnish, the later in the attack they do so. Timely information concerning the size and character of the attack would be vital to the confidence a decision maker could have in his judgment to fire U.S. nuclear weapons at the Soviet U n ion. There would be a premium upon confirmation of the facts of the situation from as many sources as possible. For this reason it is desirable to have sensors based on a variety of distinct physical principles.

The following paragraphs outline in general terms the important features of a wide range of warning and attack assessment systems that the United States could deploy to support LUA. Since even in aggregate the cost of these systems would be less than the costs of other MX basing modes, it is not inconceivable that the United States would deploy all of them and more.

Satellites

The booster motors of large ballistic missiles, which operate for some minutes after launch, emit huge amounts of power (hundreds of kilowatts) in the short-wave infrared portion of the electromagnetic spectrum. This radiation could be detected by satellites at very great distances from the earth. It would be virtually impossible for the Soviets to conceal this evidence of their attack.

Such satellites could provide an accurate count of the number of launches, the types of missiles launched (from comparing the brightness of their infrared emission to data from test launches), and at least the approximate (wing level)) locations of the launch points. This information could be available to U.S. command posts (discussed below) almost immediately. Several minutes more observation could lead to at least a very rough indication of the intended targets, to the extent of predicting whether the Central United States (where U.S. silos are) only was under attack or whether coastal targets were included as well. This information might suggest whether the attack was directed only at U.S. silos or whether it was a massive attack on all U.S. targets, cities (many of which are on the coasts) included. It would not be possible on the basis of this early information to tell whether the Soviets had withheld attack on certain specific targets, an indication of their intentions.

It would not be possibe to secure such satellites absolutely against attack on them, but such an attack could be made very difficult.

Though geosynchronous orbit would be most convenient for such satellites, it could perhaps be desirable to deploy them in other, higher orbits. Geosynchronous orbit is that unique orbit 22,300 miles from the Earth at which the orbital period of satellites is equal to the rotation period of the Earth. Thus satellites in geosynchronous orbit remain over the same point on the Earth's surface as both they and the Earth go round. A single satellite could therefore keep watch over the Soviet Union at all times. Because of its convenience, however, geosynchronous orbit is somewhat crowded, It would therefore be possible for the Soviets to station a "space mine" near to a U.S. warning satellite and answer in response to U.S. protests that the mine was in fact some other sort of satellite (e. g., communications) which it was convenient to position over the Soviet Union. The United States would then not be in a position to assert that the Soviets had no business there, because it would be quite plausible that they did have legitimate purposes for positioning a satellite in this unique, convenient orbit. If on the other hand the U.S. satellites were in an orbit chosen more or less randomly from amongst the infinite number of possible altitudes, we would be in a better position to assert that the only possible purpose for a nearby Soviet satellite must be to interfere with ours. The United States might then justify on these grounds measures against such interference. Nonsynchronous orbit means that more than one satellite would be required to keep continuous watch on the Soviet Union, however, since at any one time most of them would be over other parts of the Earth.

Satellites could also be threatened by direct attack from a missile launched from the Soviet Union. However, the U.S. satellites could be positioned high enough that it would take many hours (18 or so) for an attacking vehicle to reach them. What is more, since the interceptor missiles required to reach high orbits would be quite large, the Soviets would probably launch them only from the Soviet Union. Most of the satellites would be on the other side of the Earth when the first interceptor was launched, and launch of other interceptors would have to be staggered so as to intercept the rest of the satellites as they "came a round. " Direct-ascent anti satellite attacks on high orbits would therefore present a timing problem to the Soviets. The United States would most certainly be aware that the satellites were under attack hours before they were destroyed.

Measure can also be taken to insure the survival of satellites. For instance, they could be provided with sensors to allow them to determine when they were under attack. They could maneuver to avoid a horning interceptor and deploy decoys or chaff to confuse horning sensors. Satellites at such distances from the Earth might also be able to be hidden entirely by giving them small optical, infrared, and radar signatures. One might also hide dormant backup satellites amongst a swarm of decoys; the satellite would be turned on when the primary satellites encountered interference, Last, backup satellites could be deployed on missiles i n silos in the United States and launched into low orbits to replace the primaries. These reconstituted satellites could also be attacked, but it would take time for the Soviets to acquire data on their orbits, even assuming the United States allowed them unhindered operation of the means to acquire this data. Some of these techniques for satellite security are more effective than others.

Last, the United States might not choose to show patience indefinitely with persistent Soviet attacks on our warning sensors, particularly if we had chosen to rely on LUA as the guarantor of our land-based missiles,

Radars

Radars could be either land-based or deployed on oceangoing ships, Radars deployed near the United States would provide warning information rather later than satellites — perhaps 15 minutes or so after launch — but they would provide much more accurate prediction of the impact points of attacking RVS, This information would be sufficient to determine which silo wings and which metropolitan areas were under attack.

Powerful radars of this sort would be rather large and soft targets and therefore susceptible to SLBM or even paramilitary attack, jamming is also a potential threat. An endo-atmospheric ballistic missile defense could be provided around such radars. For instance, the Perimeter Acquisition Radar at Concrete, N Dak., happens to be in the area selected by the United States as the only site where an ABM system can be deployed within the ABM Treaty and Protocol. The purpose of such an ABM system would not be to protect the radar against any level of attack, but to force the Soviets to send so many warheads to destroy it that such an attack would constitute a major provocation

Sensor Aircraft

Aircraft carrying radars (similar to AWACS aircraft used for tactical purposes) or infrared sensors could be used either as a backup for other sensors, taking off from a strip-alert status at U.S. bases, or as a primary system maintaining continuous airborne patrol. The aircraft could be on station within several hours of takeoff and could provide detailed attack assessment inform at ion (similar in character to the land-based radars) within about 15 minutes of impact.

Such aircraft would be a hedge against disruption of satellite or fixed land-based systems If on continuous patrol, they would be very resistant to ballistic missile attack.

Since the aircraft would take some time to arrive on station if they were not maintained on continuous airborne patrol, there could be a gap between destruction of the primary U.S. systems and reconstitution by the aircraft. This gap could be filled by rocket-launched probes.

Rocket-Launched Probes

These probes, carrying long-wave infrared sensors, would be similar to the probes proposed for the Overlay exoatmospheric ballistic missile defense system to acquire its targets, They would arrive on station in minutes and provide detailed attack assessment information similar to that provided by the aircraft until they fell back to Earth about 20 minutes or so after launch. Housed in silos, they would be vulnerable only to nuclear attack. The probe silos could be located far from ICBM silos so that their launch could not be confused with ICBM launch by Soviet warning sensors.

Nuclear Detonation Detectors

Since SLBM RVS could arrive on U.S. territory well in advance of the ICBMS aimed at the silos and before the time that a launch decision wou Id have to be made, these detonations could provide further confirmation that the United States was under attack. Such detectors could be bolted on to large numbers of satellites deployed for other purposes Alternatively, U.S.-based sensor stations employing seismic or electromagnetic pulse detectors could verify that the U.S. was under nuclear attack. It is very unlikely that natural phenomena could mimic the effects of nuclear detonations.

Though the detonation of nuclear weapons on the United States would not by itself necessarily identify the Soviet Union as the attacker, the other warning systems would either indicate the origin of the attack or be of such a nature that their disruption could be accomplished only by the Soviets.

Covert Warning Sensors

It might be possible to deploy warning sensors the existence of which could reasonably be kept secret from the Soviets. Even if this did not actually turn out to be possible, it would be a factor the Soviets would have to consider before they satisfied themselves that the United States would be without advance notice of their attack.

Warning Sensors for SLBMS

So far discussion has concentrated on warning of ICBM attack, All of the means described so far are applicable to the SLBM case as well The satellites would give a launch count immediately and coastal SLBM radars impact point prediction within minutes of approach to the coasts. Planes and probes would be rel-

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atively inefficient in the SLBM role since many of them would be required to cover all attack corridors.

Command Posts

Fixed land-based command bunkers of a hardness sufficient to withstand attack even by inaccurate SLBMS would be difficultt to construct. The United States now operates a network of fixed command posts including the National Military Command Center (NMCC) in the Pentagon, the Alternate National Military Command Center (ANMCC) at a rural site outside Washington, Strategic Air Command (SAC) Headquarters in Omaha, and North American Aerospace Defense Command (NORAD) Headquarters in Cheyenne Mountain, Colo. An improvement on fixed sites would be to deploy a fleet of wide-bodied aircraft with the necessary communications equipment to receive and process warning information, communicate with NCA, and launch U.S. silo-based missiles if given proper authorization. Some of these aircraft, called Airborne National Command Posts (A BNCPS), could be on continuous airborne patrol and others on strip alert. The United States deploys a fleet of such aircraft at present. If there were advance indication of imminent Soviet attack, the President himself or other NCA could take to the air in these command posts.

Consideration might also be given to ground mobile command posts, disguised as vans traveling the Nation's highways.

Concerns could be raised about possible means to destroy or disrupt such command posts, but since they are considered for use with just about all MX basing modes, any such problems would not distinguish LUA basing. In fact such disruption would be very difficultt.

Communications Links

Studies of command, control, and communications (C^3) systems to support strategic nuclear forces of any kind, LUA or otherwise, indicate that there is a wide variety of possibilities for wartime communications and just as wide a range of means to disrupt and impede such communications. The nature of the disruption would depend on the amount of damage done to U.S. communications installations and the extent of disruption of the atmosphere due to nuclear explosions. An LUA C‘ system would have an advantage over systems supporting survivable basing because it would be needed at a time when the United States had suffered less damage. On the other hand, it would be at a disadvantage in that there might be little time to attempt to reconstItute disrupted I inks.

Many of the same considerations apply to the communications links which applied to the warning sensors. None can be protected absolutely against Soviet attack, but disruption can be made difficult, time consuming, and provocative.

Communications links are required from the warning sensors to the command posts, from the command posts to the missile fields, and between the command posts and responsible launch authorities. The first two are easier to specify than the last, since this last depends sensitively on where the launch authorities are assumed to be and upon whether they are under attack or not. A fuller discussion of the problems of providing communications systems to support strategic nuclear forces in general is contained in a separate chapter. The following discussion seeks to sketch some of the considerations relevant to LUA.

Warning Sensors to Command Posts

It appears that satellite communications would be needed for this purpose, at least for the warning satellites, since they would not be connected to the command posts by line of sight. The same cons ideations regarding survivability apply here as for the warning satellites, but the situation is in some respects easier. To avoid jamming and ionospheric disruption due to high altitude nuclear detonations, these satellites could operate at millimeter wavelengths. They could be stationed in unusual, deep-space orbits so the Soviets could have no pretense for stationing space mines near them, and direct-ascent interceptors would require a long time to reach them Since the communications satellites would be cheaper than the warning satellites, there could be many of them. other measures — deep-space storage, concealed dormant satellites, decoys, maneuverability, etc. — such as described for the warning satellites could also be tried here, Rocket-launched reconstitution satellites could be on-station in a short period There are many U.S. communications satellites of al I sorts in space, and arrangements could also be made to use them if the primary system failed.

Fixed ground stations for the downlinks would be vulnerable to attack, but such attack would at least be *required* to disrupt them, They could be proliferated throughout the United States and even defended with ballistic missile defense An improvement on fixed ground stations would use mobile ground terminals, highway-going vans with concealed receiving dish and data processing equipment, Data could be transferred from ground stations— fixed or mobile—to the airborne command posts by radio (line-of-sight if necessary) and satellite uplink

Ground stations would not be necessary at al I if arrangements were made for the airborne command posts to receive data in semiprocessed form directly from the warning satellites via the communications satellites using millimeter wave or laser I inks.

The sensor aircraft would use satellite links to communicate with the command posts. The fixed radars could use radio (line-of-sight if necessary) or satellite to send their data to the command aircraft. The rocket-launched probe would be in line-of-sight with the command posts and could communicate directly.

Command Posts to Missile Fields

If an order were given to launch MX missiles from their silos, the command posts could transmit the EAM to the launch control centers in the silo fields or directly to the silos by a variety of means, including line-of-sight ultra high frequency (UHF) radio and satellite injection. These methods provide for high probability of correct receipt of the EAM within minutes, even in a disturbed environment.

Between Command Posts and National Command Authorities

This is the most difficult part of the communications system to specify, The reason for this is not that technology does not provide solutions, but because these solutions could depend on where the NCA might be, which depends on who the NCA are, which in turn depends on what procedures are adopted for NCA continuity.

Roughly speaking, there are three cases to consider. I n the first, the President or other NCA is in Washington, and Washington has survived at least to the point in time where a launch decison is required, Communicant ions in this case can be by satellite or airborne relay using a number of aircraft, maintained on strip alert in peacetime, which form a net over the United States for UHF line-of-sight communi cations,

In the second case, the President or other NCA is himself in a command airplane, Communications is by satellite or airborne relay.

In the third case, Washington is destroyed and the President did not manage to make it to a survivable location, I n this case the important questions are, first: Who and where is the NCA and can it be arranged that they take command in time to launch under attack? and second: Does it matter if we could not LUA? since it might appear in this case that war was not going to remain limited and our other nuclear forces would be sufficient to acheive U.S. objectives, The first is a question of procedures and authority and the second of doctrine. They obviously cannot be answered by technology assessment. Some suggestion of alternative responses to these questions will be made in the section below entitled Procedures.

Pindown

Pindown refers to the possibility that the Soviets could force our missiles to remain in their silos by threatening to explode nuclear weapons in their paths and destroy them in flight. In practice, however, pindown of silo-based MX would require a huge expenditure of Soviet weapons for an uncertain result and is therefore not an important threat to LUA.

In a pindown attack, nuclear weapons from SLEMs and, later in the attack but before ICBM arrival on U.S. silos, low-trajectory ICBMs could seek to create an environment lethal to U.S. missiles in flight. These warheads would be exploded at high altitudes— about 300,000 ft– in the flyout corridors above the missile fields. The relevant parameter here is the number of weapons of a given yield which must be exploded every *minute* in the flyout corridors to ensure that any missile passing through them is destroyed or disrupted. The damage is caused by X-rays from the nuclear explosions, and there are two possible kill mechanisms. In the first, X-rays are deposited on the exterior of the missile and vaporize the surface. When the surface layer is removed, the recoil momentum is transmitted through the missile as a compression wave which can damage the interior of the missile or blow the backside off. The other method by which the X-rays could disrupt the missile is by causing ionization in the electronic circuits of, for instance, the guidance computer.

The flyout corridors above the existing Minuteman wings are in fact rather large, and their precise dimensions can to some extent be made uncertain to the Soviets. In addition, the MX missile is planned to be much more resistant to X-rays than Minuteman. The Soviets would also not know with confidence just how hard U.S. missiles were.

On the other side, if the Soviets were genuinely determined to try a pindown attack, they could design warheads especially for this purpose. These warheads would not need heat shields since they would not reenter the atmosphere. Thus a warhead of a given yield would be lighter, meaning more megatonnage on a given booster.

"The upshot of all this is that, if MX missiles were distributed throughout the Minuteman fields, the Soviets would have to explode hun*dreds of megatons per minute* in the flyout corridors to guarantee pindown. If the Soviets assumed that no U.S. launch decision could possibly be made until at least 10 minutes into the attack, 15 to 20 minutes of pindown would be required. Timing constraints would demand that much of this megatonnage be launched from submarines remote from their home bases. Pindown would therefore compete with other time-urgent missions of the forward-deployed Soviet submarine force and with secure reserve missions of the remaining force. These time constraints, combined with the huge numbers of weapons needed, make pindown an unattractive, if not impossible, Soviet strategy against LUA for silo-based MX. (Reckoning strictly on the size of deployment area, the amount of megatonnage required to pin down MX in MPS basing would be about ten times less than for silo basing.)

Procedures

For the U.S. threat to launch under attack to be credible, procedures would have to be devised to **guarantee** that the president or other NCA were able to communicate in timely *fashion* with the command posts in a position to receive attack assessment data from the sensors and execute the missile force. The issue here is not whether the U.S. instruments of command would eventually reconstitute themselves to wage and terminate a nuclear war, but whether there would be continuity of command in the first half hour of the war. Devising an acceptable set of procedures is a matter for decision at the highest levels of political authority. It is not the intention of this discussion to suggest or speculate what these procedures might actually be should the United States adopt reliance on LUA, still less what procedures support the present LUA capability, but merely to set out the logical possibilities.

These possibilities are quite distinct depending on the circumstances of the attack In particular, it matters whether the possibility of attack was foreseen before the actual launch of Soviet missiles (i.e. whether "strategic" warning preceded "tactical" warning) or whether the attack was a "bolt from the blue" surprise. Realistic or not, much fear about reliance on LUA focuses on the second circumstance. Surprise attack is clearly most stressing as regards the physical capability of the United States to launch under attack.

It would also be vital whether the Soviet attack had the specific aim of disrupting the U.S. chain of command supporting LUA. As has been discussed above, every effort can be made to preclude the possibility that the Soviets could deny the LUA capability by means *short ot* physical attack upon the NCA, It appears that such efforts could be quite successful indeed: sensors, command posts, and communications links could be provided, with cost and effort, which were very difficult to disrupt. Thus, as a practical matter, the Soviets could be faced with the choice *either* of permitting LUA *or* of attacking directly the U.S. political leadership. To make this choice the Soviets would have to ask themselves whether they preferred to be at war with a nation in possession of intact national leadership and usable ICBMS or with a nation in possession of neither. The U.S. perception of what the Soviets would intend in making such a choice could affect the procedures the United States selected for its LUA system. For instance, if it were agreed that the Soviets could not intend anything but total war if they were willing to "decapitate" the U.S. Government, then it might be concluded that U.S. bombers, cruise missiles, and SLBMS were sufficient weapons to wage such a war. U.S. doctrine might then state: LUA seeks to deter Soviet attacks *short of* decapitation; decapitation attacks are to be deterred by threat of retaliation upon Soviet value. On the other hand, if the United States judged such a doctrine to be inadequate, a determined effort would have to be made to devise procedures which would permit LUA in al I circumstances, The United States might further judge it imprudent to state a doctrine covering all possibilities, preferring to add uncertainty to the Soviet decision.

Questions of doctrine would thus have an obvious effect upon which procedures were adopted for LUA basing and are just as obviously not susceptible to technical analysis, In what follows, it is assumed that the United States would wish to assure the LUA capability in al I circumstances, and various possibilities are explored to satisfy this wish. At the point where these procedures are judged to become unacceptable, one has the choice of abandoning LUA basing altogether or determining that the circumstances in question would no longer require a "survivable" (via LUA) U S. ICBM force.

The National Command Authority

NCA is the phrase used to describe the operational institution of the U.S. Government responsible for decisions to initiate the use of nuclear weapons. The individuals who occupy institutional roles comprising the NCA are called the National Command Authorities (also NCA). These individuals consist of the President and, upon his death or incapacitation, his successors as designated by the Constitution and the Presidential Succession Act; the Secretary of Defense and his successors; and the joint Chiefs of Staff and their successors, these designated by Defense Department regulat ions.

The process by which the NCA might order the use of nuclear weapons by U.S. Armed Forces has for obvious reasons not been discussed publicly. Hearings conducted by the House Foreign Affairs Committee in 1974 made clear that no military officer may initiate the use of nuclear weapons unless authorized by the President or his successor. In practice, it appears that many of the procedures for NCA operation are decided by each President on the basis of personal preference.

Attack With Advance "Strategic" Warning

In a period of crisis, it might become apparent either from Soviet statements, from intelligence indications, or from estimation of

Soviet reaction to U.S. moves, that nuclear attack was imminent. Such advance warning is called "strategic" warning to distinguish it from warning indicating that an attack is actually in progress ("tactical" warning).

One reaction to strategic warning would be for the President or other NCA to take to the air in airborne command posts for the duration of the crisis. There could be concern that this action, if made known, could heighten tensions and provoke panic in the U.S. public. For this reason the President himself might wish to remain on the ground and have a lesser official assume airborne alert. Whether this could be accomplished covertly could be questioned since the command planes would be rather distinctive. Even disguising them to look like freight aircraft would be pointless if they took off from military airfields like Washington's Andrews Air Force Base. Disguising the movements of high U.S. officials from the press, particularly under the circumstances, might also prove cliff i cult.

An alternative to providing a "survivable" NCA would be for the President to decide in advance the responses to be made to certain sets of attack assessment data and order that these responses be executed unless he were able to intervene to veto or change them. The responses would be transmitted to ABNCPS, the crews of which (presumably military officers] would be the executors. Whether such an arrangement would actually constitute delegation of command authority to others is not clear, since the precise instructions could be encrypted and thus totally unknown to the executors.

Surprise Attack Without Decapitation

A "bolt from the blue" attack whose object was not to disrupt the U.S. chain of command could in principle be dealt with by arranging for the President and other NCA to be at all times in instantaneous, reliable communications with the command posts which monitor warning data and launch the ICBMS. As a practical matter, of course, account must be taken of circumstances when the President is traveling abroad or shaking hands in a crowd. 'Though it would seem that adequate procedures could be worked out for such cases, they might be burdensome and obtrusive for the President and other NCA.

Surprise Attack With Decapitation

I-his would be the most stressing circumstance for a system of LUA. There are several procedures that could be devised to meet this circumstance:

LUA fails. This "response," discussed previously, considers that this circumstance, implying Soviet willingness to destroy the political leadership of the United States, would be outside of the range of contingencies for which ICBM "survivability" is intended. U.S. doctrine could so state or imply.

2. Responses decided on in advance by the President would be executed by ABNCPS *unless* the President or other NCA intervened to veto or change them. This option is identical to the second option discussed for the case of advance or "strategic" warning except that in this case these procedures would be in force at all times, even when no particular crisis were occurring. The character of the response to be made to a given set of warning data could be encrypted and known only to the President. As a hedge against espionage or revelation of the President's choices, the instructions could be arranged to establish only the *probabilities* that certain responses would be made, These probabilities could be made to change on a day-to-day basis according to the world situation. The whole set of responses could be "wired into" the ICBM force or executed by the intervention of the crew of the ABNCP.

3 Launch authority could devolve on the crew of the survivable command posts. The NCA could override command post

decisions *if* they survived and were in communication. It has been suggested that the time during which such NCA intervention could take place might be lengthened by preserving the option to disarm missiles in flight if the NCA chose to veto or change a l au nch decision made by others.

OPERATIONAL POSSIBILITIES FOR LUA

This section illustrates the operational possibilities for a system of reliance on LUA in the form of attack "scenarios " These scenarios a i mat technical verisimititude, but no claim is implied that what happens in them is in any other sense plausible, much less acceptable.

The range of possible LUA scenarios is limitless, and each could be embellished At each juncture, many different paths could be taken. The choices made here, when they have any particular rationale at all, are made to illustrate the workings of the technical hardware, It is not thought appropriate for a technology assessment to adopt any other approach.

All the scenarios described assume no advance or "strategic" warning and that the United States makes every effort to preserve its capability to launch under attack,

As a reminder of the elements of the LUA system described in the previous section, the following list is provided. It should be recalled that these are elements of a hypothetic/ *future* system to support *reliance* on LUA, not elements of the system that presently supports the U.S. LUA *capability.*

- National Command Arthorities (NCA)
- Fixed Ground Command Post
- Airborne National Command Posts (ABNCPs), continuously airbornc or backup strip-alert at Central U S airbases
- Warning satellites
- Fixed ground radars
- Sensor aircraft, continously airborne or backup strip -alert
- Rocket- launched sensor probes
- Coastal SLBM radars
- Nuclear detonation detectors
- Communcations satellites, primary and reconstitutable

The scenarios are organized by timeline with, T = indicating the time in minutes

Illustrative Soviet ICBM Attacks on U.S. Silos Only

These "scenarios" illustrate the LUA timelines for pure countersilo attacks in which no effort is made by the Soviets to deny the U.S LUA capability. One might imagine any number of sequences of events leading up to these attacks. The only important assumption for these examples of LUA is that strategic warning has either not been received or has not caused the United States to assume an alert or "generated" posture. The first, small attack is termed a "demonstration" since, apart from destroying a subset of US, ICBMS, it would seem to have no clear purpose other than to demonstrate Soviet willingness to use nuclear weapons and to test U.S. willingness to respond, The Soviet attack in the second scenario is the standard " limited counterforce" attack whose purpose is to destroy the U.S. ICBM force completely,

Illustrative Small "Demonstrate **ion" Attack**

T = O: Soviets launch fifty SS-18 ICBMS.

Interim: U.S. fixed and airborne command posts receive satellite data indicating number and type of missiles launched and Soviet silo wings of origin. No evidence that SLBMS are included in the attack. Immediate measures taken to open communications links with President or other NCA. Backup ABNCPS, sensor aircraft, and perhaps other forces alerted,

T = 5: Further satellite data indicates Central United States as location of targets. Coastal targets known to be excluded, but targets in Central United States not further specified. Backup ABNCPS and sensor aircraft ordered to take off. Military commanders order launch of infrared probe.

T = 10: NCA in communication with command posts and alerted to situation, Probe on station and acquiring data.

T = 15: Infrared and radar planes, probe, and land-based radars all indicate that attack consists of about 500 RVS. Predicted impact points correlate with locations of three out of six U.S. ICBM wings, No evidence of any other targets.

T = 20: NCA orders no LUA since only half of ICBM force under attack, OR: NCA orders launch of 50 U.S. RVS targeted at Soviet SS-18 and SS-19 silos. Simultaneously U.S. embassies, including Moscow, informed of intent of U. S, response. *OR:* Et cetera.

Interim: U.S. ICBMS launch (if applicable).

T = 30: Soviet RVS impact U.S. silos.

Illustrative Full Attack on U.S. ICBMS

T = O: Soviets launch several hundred ICBMS.

Interim: As before.

T = 15: Aircraft, probe, and radars all indicate attack of over 2,000 RVS targeted at all ICBM wings. No evidence of other targets.

T = 20: NCA orders launch of the half of the ICBM force postured for LUA at Soviet silos and perhaps other military targets. *OR:* NCA orders entire ICBM force launched. *OR:* Et cetera.

T = 20-30: As before.

Illustrative Soviet ICBM/SLBM Attack on U.S. Silos and LUA Capability Excluding Washington

T = O: Soviets launch ICBMS at U.S. ICBMS. Simultaneously, SLBMS from submarines near U.S. coasts launch at fixed command posts, fixed communications nodes, fixed sensors, and airfields supporting airborne sensors and command posts. All of these targets are assumed to be located in Central United States or, if near coasts, not to be attacked. Coastal SLBM radars are not attacked since they collect most of their information before they can be destroyed.

Interim: Continuously airborne ABNCP receives satellite data' indicating: number and types of ICBMs and silo fields of origin; number, type, and launch locations of SLBMs. No information about intended targets at this time; therefore not yet clear whether Washington and other coastal targets under attack. Immediate efforts taken to open communications links with NCA. Backup ABNCPS and sensor aircraft scrambled.

T:5: Further satellite data indicates Soviet ICBMS and SLBMS targeted at Central United States, not coasts; actual Central U.S. targets not specified. Coastal radars, however, indicate SLBMS targeted at inland fixed ground command posts and communications nodes, radars, and airfields where backup ABNCPS and sensor aircraft are based. One SLBM RV appears to have ballistic trajectory which will carry it far from any U.S. military installation. Military commanders order launch of infrared rocket probe,

T = 7: SLBM RV with "odd" trajectory bursts at very high altitude over Eastern United States. No damage whatever to buildings or population from this very high-altitude burst, but electromagnetic pulse and ionospheric disturbances disrupt some long-range radio and land line communications. Satellite communications linking NCA, fixed command posts, and ABNCPS is undisturbed.

Interim: SLBM RVS impact Central U.S. targets. Fixed command posts destroyed; command shifts exclusively to ABNC P. Large number of RVS targeted at fixed radars saturates ballistic missile defense; radar destroyed. Some, though not al 1, backup ABNCPS and sensor aircraft escape.

T = 15: Sensor aircraft and probe indicate that Soviet ICBMs are targeted at U.S. silo fields only. Nuclear detonation detectors confirm SLBM detonations, Data made **available to** NCA.

T=15-20: NCA concludes on basis of information available that Soviet countersilo attack in progress SLBM attack evidently attempted to deny U.S. LUA capability,

T = 20: NCA orders LUA.

Interim: U.S. ICBMs launch.

T = 30: Soviet ICBM RVS impact empty silos,

Illustrative Soviet ICBM/SLBM Attack on U.S. Silos, Other Military Targets, LUA Capability, and Washington

This attack adds the crucial ingredient of direct attack on Washington, It would seem reasonable to assume that if the Soviets were willing to target the U.S. National Capital and political leadership, they would target also military targets unrelated to the U.S. ICBM force or LUA capability such as submarine and bomber bases. This assumption, made here, would not affect the U.S capability to LUA but could make Soviet intentions clearer in the early minutes of the attack.

T =0: Soviets launch ICBMS and SLBMS,

Interim: Satellites indicate ICBM and SLBM launches. Number and type of ICBMS launched consistent with countersilo attack. Number of SLBM launches indicates determined effort to destroy time-urgent U, S, military capability as well as LUA capability, Attack judged massive by command posts. Immediate measures taken to assure communications between NCA and ABNCP. Backup ABNCPS and sensor aircraft, as well as strategic bombers, alerted.

T = 5: Further satellite and coastal SLBM radar data indicate Washington under attack. impact expected at T = 10. NCA notified urgently by command posts.

Soon after. SLBM impacts on Washington. ABNCP loses contact with NCA. No procedures to reconstitute NCA in time to LUA. LUA fails.

OR, as above, until:

T = 5: Peacetime procedures allow for full two-way communications between NCA and command posts at this time. Informed of situation, NCA authorizes LUA if Washington destroyed and makes choice among retaliatory options. Crews of command posts do not know character of response chosen by NCA. NCA stays on the line.

Interim: Nuclear detonations on Washington. NCA goes off the I inc.

T = 12: ABNCP receives confirmation of nuclear detonations on Washington and many other U.S. targets from nuclear detonation detectors.

T = 15: Probe and sensor aircraft continue to indicate countersilo ICBM attack. ABNCP executes LUA according to NCA'S wishes.

Interim: U.S. ICBMS launch.

T = 30: Soviet ICBM RVS impact empty silos.

Attempt to Disrupt U.S. Technical Capability to LUA Precedes Soviet Attack

This kind of "scenario" imagines a prolonged "war of nerves" preceding actual Soviet nuclear attack in the course of which the Soviets attempt, by means contrived not to provoke U.S. preemption, to destroy critical *hardware* elements of the U.S. LUA capability. These hardware elements include warning sensors and communications I inks, but not the NCA. Scenarios like this are sometimes cited as reasons to distrust reliance on LUA.

No system of warning sensors and communications can be made absolutely resistant to disruption. Rather, the United States could make such disruption time consuming for the Soviets, thus removing any element of surprise, and requ ire that the means to disruption be extensive, provocative, and even overtly hostile. As a practical matter, one can also make a *subset* of the system virtually immune to disruption. Whether this residuum could be considered sufficient to support a U.S. LUA decision is not clear, but it could impose on the Soviets the concern that even if they accomplished the disruption of the rest of the system, the United States might still be able to launch under attack. Above all, of course, the Soviets would have to consider that before their attempts at disruption had succeeded, the United States might preemptively attack them or at least inflict comparable damage on their systems.

The satellites are the element which, while susceptible to disruption, would take the longest to destroy. Direct-ascent antisatellite interceptors would take some 18 hours to reach the high orbits where the satellites could be placed. The United States would thus have ample warning that disruption was in progress. As a practical matter, such high-altitude direct attack would also be quite difficult for the Soviets to execute and would be subject to various U.S. countermeasures, as discussed in the previous section. It would also seem that Soviet preparations for such an attack could scarcely be concealed; for one thing, the boosters required would be the size of SS-18s or larger.

Space mines are a means whereby the satellites could be destroyed instantly, once the Mines *were emplaced.* As discussed in the previous section, unusual orbits could be chosen for U.S. satellites. The United States could reasonably assert that Soviet placement of space vehicles in the same or nearby orbits could have no other purpose than to disrupt the U.S. LUA capability.

1 n either case – direct-ascent interception or space mines — there would be no question of "surprise" attack. The United States could in addition possess the capability to launch a set of replacement satellites (perhaps less sophisticated and presumably in lower orbits) before Soviet disruption of the primary system were complete. These replacements, too, could be attacked, but this attack would also take time.

Supposing the United States permitted disruption of its warning satellites, still the airborne sensors, land-based (and perhaps ship-based) radars, and the rocket-launched probe would remain. One can conceive of threats (sabotage, close-in jammers) to the ground-based radars, but barring this, they could be hardened to the point where their destruction required nuclear attack. The probes could also be in hardened silos. Associated BMD systems could increase the price of destruction by ballistic missile attack.

Supposing now that the satellites and the radars *and* probes were destroyed, the sensor aircraft would still provide warning and attack assessment. It is generally believed that aircraft operating i n North American airspace in wartime would be difficult for the Soviets to attack. These aircraft could operate out of their home airfields and, presumably, civilian airfields for long periods. Thus in a period of prolonged conflict, in which other U.S. sensor assets were destroyed and the United States wished maintain an LUA capability, these aircraft might provide enduring warning and attack assessment. Though not providing warning of Soviet attack at launch, they would still provide notice of attack within 15 minutes of the time a launch decision was required. Under the circumstances, U.S. decision makers would presumably put themselves in a position to make rapid decisions.

"Thus, a Soviet attempt to deny the **U.S.** warning and attack assessment capability could be made exceedingly difficult and risky, if not impossible. A similar analysis could be performed for the communications links described previously. Thus, vulnerability of the ***technical*** elements of the LUA capability **need** not be an "Achilles' heel" for reliance on LUA. Whether the *procedures* supporting decision-making can be made as robust is another matter, as has been discussed extensively.

SUMMARY OF CRITICAL ISSUES FOR LUA

This section summarizes the critical issues that might enter into a decision to rely on LUA as the guarantor of ICBM "survivability. " As is apparent from this chapter, **some of these** issues, and most certainly judgments regarding them, are in the end nontechnical. Though technical analysis can further define these issues, it cannot resolve them. Certain of these issues apply in some measure to survivable basing as well as to LUA; what matters for purposes of comparison are the *differences* between the two types of basing. For instance, that certain circumstances of LUA are unpleasant is obvious, but it is not clear in al I cases that they are improved by delaying response.

It must be borne in mind that the observations made here apply to a hypothetical future system of reliance on LUA, not the means which support the present LUA capability.

Information Available to Decision makers

Decisionmakers would require information concerning the extent and intent of a Soviet attack and confidence that this information was accurate. Technical analysis can specify which data might be available at certain times in the course of an attack but cannot suggest what information might be considered adequate to support a decision to launch offensive missiles.

In general, the earlier in the attack a sensor acquired information, the less detailed it would be Thus, at the time of launch, the number, type, and origins of boosters launched could be specified Several minutes later, it could **be possible to determine whether the entire** United States was under attack or just a portion thereof By midcourse (15 **minutes from launch and 15 minutes before impact), the impact points of** RVS could be predicted. The locations of detonations of submarine-launched RVS on the United States might also be known By this time, only **5 to 10 minutes would remain** for decision making

One might legitimately question whether, if the United States possessed a *survivable* ICBM force, *better* information that this would be available to support a retaliatory decision within a short time. That is, given the widespread confusion and disruption of communications following even a small attack, the information supplied by warning sensors in the first few minutes might in fact be the most complete available for a long time after the attack. Deployment of a survivable force might actually lead the United States to deploy fewer and less robust sensors than it would deploy it relying on LUA, Thus, as a practical matter, the information upon which to gauge response could conceivably be less with survivable forces than with LUA

Despite the redundancy and technical variety of the warning sensors, there could be reluctance on the part of decision makers to base launch decisions on information collected by such remote means.

Decision Timelines

Depending on the circumstance, the amount of time available for deciding on a response to Soviet attack could range from an upper limit of 20 minutes to no time at all. Meeting this timeline would probably require at least some provisional advance planning by the President and other NCA.

Possibilityies for Diplomatic and Other Activities

The LUA timeline would leave no time for diplomatic activities between attack and response. At very least, such activity could serve to signal to the Soviets U.S. perceptions of their attack and the intent of any U.S. response, Communication with other governments, U.S. overseas installations, and U.S. military forces worldwide might also be accomplished at this time.

However, it is not clear to what extent the circumstances of nuclear war, especially as regards disruption of communciations, would permit such activities within a short period of an initial attack anyway.

Providing for Launch Authority

Timely command decisions by authorized NCA is clearly a requirement for reliance on LUA,

This requirement would be most difficult to satisfy if the Soviets intended deliberately to destroy or “decapitate” the NCA. In this circumstance, possible options might be: LUA fails (not intended for this extreme case); provision is made for very early NCA decision; decisions decided on in advance by the NCA are executed by others if the NCA does not veto or change them; launch authority is delegated to others than the NCA.

Which of these options, if any, would be acceptable is a matter not of technology but of decision at the highest levels of political authority.

Even in the less extreme case in which no attack on the NCA is intended, provision **must be made for** the NCA to be available at all times for rapid decision. Such procedures might be onerous for the President and other NCA,

Fear That U.S. LUA Capability Could Somehow Be Sidestepped

The analysis presented here indicates that, from a technical point of view, sensors and communications could, with money and effort, be provided to make at least the technical elements of the LUA capability exceedingly difficult, if not impossible, for the Soviets to disrupt. Procedures to support decisionmaking are another matter, Even if both hardware and procedures were devised which were very robust indeed, it might not be possible to eradicate completely a lingering fear that the Soviets might find some way to "sidestep" the system. These fears could become aggravated at a time of crisis.

Risk of Error

There are two risks of error in a basing system of reliance on LUA: the risk that launch Wou d take place when there was no attack, and the risk that launch would fail to take place when there was an attack.

Insofar as technology is concerned in the assessment of these risks, one can in principle make arbitrarily small the probability that electronic systems by themselves make either kind of error, though beyond a point efforts to decrease the chance of one error could increase the chance of the other.

But it would seem that the principal source of error might not be electronic or mechanical malfunction by itself, The odds that a sensor indicates something out of the ordinary might be quite high, but the chances that it indicates something resembling a plausible Soviet attack would be much smaller, The probability that *severa* sensors based upon different physical principles indicated the *same* plausible attack would be much smaller still. That is, electronic systems tend to make random, rather than highly structured, errors. On the other hand, electronic systems have a very limited ability to correct errors once made. Human beings, by contrast, have a high capacity to correct errors, but also a high capacity to commit highly structured errors. The risk of error for an LUA system would seem highest when the human being's ability to make highly structured errors combines with the machine's limited ability to correct them. Mistakenly initiating a "simulated" attack by, e.g., loading the wrong tape into a computer, would be an error of this type. It is obviously not possible to set and enforce a bound on the probability that such an error could occur in an LUA system.