Chapter 6

AIR MOBILE MX

Chapter 6.–AIR MOBILE MX

FIGURES

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Air mobile basing offers the prospect of high survivability, since missile-carrying aircraft in flight would move much too fast to be targeted by Soviet missile forces. However, unless the aircraft were airborne continuously, their survival would depend on taking off upon early warning of attack. Moreover, they would have to find surviving airfields to land and refuel if they were to have endurance, i.e., to be a useful force beyond the first few hours of a war.

This chapter discusses three concepts, distinguished by their approaches to the problems of dependence on warning for survivability and postattack endurance beyond the unrefueled flight time of the aircraft. The basic concept (called below "Dash-on-Warning without 'Endurance'") would consist of missile - carrying aircraft on strip alert at a number of inland airfields. The force would take off on warning of Soviet attack and would land and refuel after a few hours at existing civilian and military airfields unless the Soviets had destroyed these airfields. The second concept ("continuously Airborne") would avoid the problem of dependence on warning by maintaining the missiles in the air continuously. Such a system would be exceedingly expensive. The third concept ("Dash-on-Warning with 'Endurance'") would attempt to address the problem of postattack endurance by building a large number of recovery airfields throughout the United States, forcing the Soviets to attack all of them in order to deny endurance to the force. This concept would also be expensive. The base case, involving dependence on warning and no provision for endurance beyond existing airfields, could have a cost comparable to that of the baseline MPS system.

OVERVIEW

The lowest-cost, base case air mobile system would consist of 75 or so wide-bodied aircraft, each carrying two MX missiles, maintained on strip alert at airfields located in the Central United States. Such a "dash-on-warning" air mobile force could be highly survivable. The principal threat to the force would be submarine-launched ballistic missiles (SLBMS) launched from positions near U.S. coasts. Such an attack could arrive in the vicinity of the alert airfields within 15 minutes of launch and seek to destroy the aircraft before they could take off and escape. However, if a high alert posture were accepted for the force, meaning that the aircraft took off immediately *on timely warning* of SLBM attack, almost the whole force would survive even if a large number of SLBMS was launched from positions near U.S. coasts. The Soviet SLBM force is presently incapable of such an attack, Air mobile basing could therefore stress Soviet strategic forces where they would be least able to respond in the short term.

Nevertheless, the difference between survival and destruction of the force would be a very few minutes, depending on timely tactical warning. In this respect an air mobile intercontinental ballistic missile (ICBM) force would replicate a significant failure mode of another leg of the strategic Triad — the bomber force.

ICBMS, arriving later than the SLBMS, could not threaten the survivability of the entire force, since by that time the aircraft would have been in flight long enough to be dispersed over a wide area. Effective barrage attack of this entire area would require the Soviets to build many more large ICBM missiles than they now possess and use them to barrage approximately 1 million square miles (mi^2). The outcome of such an attack would be insensitive both to the fractionation (the apportioning of the missile payload among a small number of large-yield reentry vehicles (RVS) or a large number of smaller yield RVS) and to the accuracy of Soviet ICBM forces.

The principal disadvantage of a dash-on-warning force— the need for reliable, timely warning—could in principle be removed by having the aircraft maintain continuous airborne patrol. However, even with a new aircraft with lower fuel consumption, the cost of operating such a force would be prohibitive. A continuously airborne force of 75 aircraft (150 MX missiles) could have a lifecycle cost of $80 billion to$100 billion (fiscal year 1980 dollars).

A second crucial problem for an air mobile force concerns the question of postattack endurance. After a few hours of flight, the aircraft would have to land and refuel. Since their home airfields would be destroyed, they would have to find other places to land and await further instructions. This problem could be avoided completely if the United States were willing to adopt a policy of “use it or lose it” for the few hours of unrefueled flight. There are also several hundred civilian and military airfields in the United States capable of servicing large aircraft. Many of these airfields are located close to urban areas. If the Soviets wished to deny postattack endurance to an air mobile fleet—tantamount to forcing the United States to “use it or lose it”- they would have to attack these airfields. A serious effort to build more austere recovery airstrips throughout the country than the Soviets possessed ICBM RVS to destroy them would be enormously expensive, would have substantial environmental impact, and would be completely impractical if the Soviet threat grew large. For instance, 4,600 airfields spaced 25 miles apart would fill the entire 3 million mi^2 of the continental United States. Closer spacing might be possible, but beyond a certain point the spacing would become so close that local fallout from attack on one airfield would make extended operations at neighboring airfields impossible. Thus, cost aside, it might be impossible to guarantee survival of usable recovery airfields against a greatly expanded Soviet ICBM arsenal.

There could conceivably be some value in having more airfields suitable for air mobile operations than the Soviets had SLBM RVs. These airfields could be useful if the United States doubted the reliability of its SLBM warning sensors and wished to relax the force’s alert posture (since, in a crisis, false-alarm takeoff might be mistaken by the Soviets for preparation to launch the MX missiles), or if the fleet were somehow “spoofed” into taking off (thus making a portion vulnerable as the aircraft were forced to land).

There are about 2,300 airfields in the United States that, with upgrades, could accommodate an air mobile force in the postattack period. However, to make use of most of them, it would be necessary to deploy smaller short-takeoff aircraft. Since the smaller aircraft could only carry one MX missile, twice as many of them would be required to make a force equivalent to a wide-bodied jet force. Between the cost of the aircraft and the recovery airfields, a force with this dispersal option could cost $10 billion to $40 billion (fiscal year 1980 dollars) more than a wide-bodied jet force with no recovery airfields beyond existing large civilian and military airfields.

Thus, the lowest cost air mobile system would consist of wide-bodied jets, each carrying two MX missiles, with no extra recovery airfields beyond those large civilian and military airfields that exist at present. The cost of such a system would depend on whether it was desired to have 200 MX missiles on alert (100 aircraft), 100 surviving MX missiles (50 aircraft, assuming 100-percent survival with prompt warning and takeoff), or some other number. Although OTA has not performed detailed cost and schedule analysis for such an air mobile option, it appears that the cost of a force with 75 aircraft (150 MX missiles) on alert could be comparable to the cost of the baseline multiple protective shelter system and could be deployed in a comparable time.

An air mobile force would also require several supporting systems. First and foremost would be reliable sensor systems for timely warning of Soviet attack. Providing such systerns would be technically feasible but would require time, money, and continued effort. The complex force management needs of the air mobile force after attack would require a comparably complex communications system.

Last, providing for missile accuracy comparable to (or even better than) land basing would require the Global Positioning Satellite (GPS) system or a Ground Beacon System (CBS).

THREE AIR MOBILE MX CONCEPTS

The Importance of Missile Size

The size and weight of the missile determine the type and number of aircraft needed for an air mobile force. A large missile like MX would require a large aircraft, and only one or two missiles could be carried by each aircraft. Large aircraft require long runways. Since the number of U.S. airfields with long runways is in the hundreds, whereas the Soviet ICBM RV arsenal is in the thousands, an air mobile fleet with large aircraft could not count on finding landing sites when fuel ran low several hours after a Soviet attack.

A smaller missile could be carried by smaller aircraft, and these smaller planes would have many more possible sites — including unprepared surfaces, highways, and even waterways if fitted with pontoons—for postattack reconstitution. On the other hand, a smaller missile would carry fewer RVS, meaning that a small-missile air mobile force would require many more aircraft in order that the total deployment have as many RVS as a large-missile force. This large number of aircraft would in turn be costly.

There is thus a tradeoff in cost between small and large missiles for air mobile deployment. This study considers only the MX missile, capable of carrying 10 RVS to intercontinental range.

The ground-launched MX missile weighs 190,000 lb. For the purposes of air launch, the first stage of the MX could be modified to reduce the missile weight to about 150,000 lb with no penalty in range or payload. This weight reduction would allow large aircraft to carry two MX missiles.

There are two reasons why an air-launched missile can be lighter than a ground-launched missile of equal range and payload. First, an air-launched missile begins its flight 10,000 to 30,000 ft higher than ground-launched missiles and therefore does not need propellant to carry it to that altitude. This effect is actually small. A much larger contribution to weight reduction comes from the fact that a missile that begins its flight at high altitude can accelerate faster. Ground-launched missiles must accelerate slowly because if they attained high speed within the atmosphere they could be damaged by dynamic pressures and aerodynamic heating. Slow flight means that the missile uses much of its propellant just holding itself up against the pull of gravity in the early part of its flight. An air-launched missile can accelerate quickly because by the time it attains high speed the air is too thin to damage it.

The higher thrust-to-weight ratio of the air-launched missile means that the MX first stage could be truncated to a point where the missile weighed only 150,000 lb. (A brand new missile could probably be designed to attain MX capabilities at even lower weight. Cylindrical geometry would also not be necessary for a new missile.)

For the purposes of this chapter, then, the MX missile with a smaller first stage and 150,000 lb weight will be assumed.

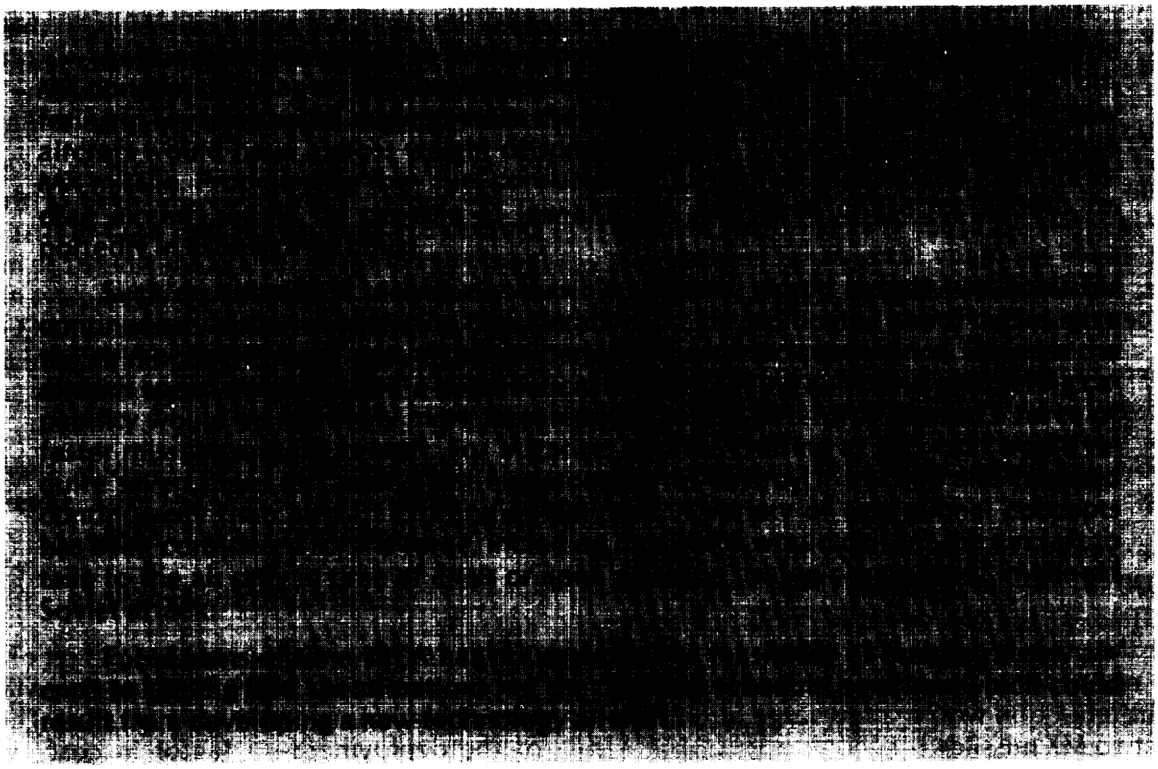
Continuously Airborne

This concept might consist of a fleet of large turboprop aircraft, each carrying two MX missiles, maintaining continuous air alert. The size of the deployment — a factor in cost—would depend on whether it was desired to have 200 alert missiles (100 airborne aircraft), 100 surviving missiles (50 aircraft, assuming perfect survivability), or some other number. The aircraft would maintain relays of 8-hour patrols, with 2-hour turnaround for each aircraft at the end of a patrol. Ocean patrol areas would remove the aircraft from congested overland air corridors and minimize the consequences of accidents involving the explosive propellants and nuclear warheads carried aboard.

Turboprop propulsion would reduce fuel consumption and prolong patrol cycles relative to conventional jet aircraft of the same size. No large turboprop aircraft are presently manufactured in the United States, but it would be technically feasible to develop a new aircraft, with consequent cost and schedule penalties. A four-engine turboprop aircraft of about 900,000-lb gross weight carrying two 150,000-lb MX missiles might be capable of 14 hours of unrefueled endurance and 2,500-mile range.

Continuously airborne operations would be, exceedingly expensive even for a turboprop aircraft. Such an aircraft might consume about 4,000 gal (27,000 lb) of jet fuel per hour. At the present price of $1.17/gal, the fuel costs to maintain 75 aircraft (150 MX missiles) in the air 24 hours per day, 365 days per year, would be $3 billion annually. Thirteen years of deployment (the average of 5 years of start-up and 10 years of full deployment) would mean a contribution of $39 billion to lifecycle cost from fuel alone. Maintenance and crew costs would also be high.

The total lifecycle cost of a continuously alert air mobile system is estimated in the Costs section to be in the neighborhood of $90 billion (fiscal year 1980 dollars) even without provision for postattack endurance. This cost exceeds that of other basing modes by about a factor of 2.



Dash-on-Warning With "Endurance"

This concept calls for aircraft maintaining continuous ground alert at airstrips in the Central United States. A large number of additional airstrips is provided throughout the country for the aircraft to land and refuel in the postattack period.

A force of 150 aircraft, each carrying a single MX missile, would require 50 or more airfields, since the escape timeline would not permit them to line up and wait their turn to take off. Single airstrips wide enough to allow two aircraft to take off simultaneously in opposite directions would be ideal. Basing at least 700 nautical miles (nmi) from U.S. coasts would seek to keep the aircraft as far as possible from Soviet submarines. If the air mobile force were not to displace other Strategic Air Command alert aircraft nor be collocated with urban areas, some new airfield construction would be required. The airfields need not all be major airbases: most could be relatively austere runways with modest support equipment, with major maintenance performed at a few main operating bases.

Assured survival of a large fraction of the force against a large Soviet SLBM force deployed near U.S. shores would require high alert procedures. Since the difference between survival and destruction would be measured in minutes, the crews would have to be prepared to start engines immediately on receipt of a warning message. This preparation might mean stationing the crews in the cockpits at all times, a duty that some could find unattractive. Procedures calling for takeoff in response to a first warning message (not waiting for confirmation) would also imply a willingness to assume the consequences of an occasional false alarm dispersal of the aircraft, carrying their propellants and nuclear warheads. If the aircraft were capable of launching their missiles only while airborne, dispersal in time of crisis could be interpreted by the Soviets as preparation for a first strike.

Most studies of air mobile MX have considered providing a large number of austere airstrips dispersed about the country for the aircraft to land, refuel, and await further orders in the postattack period. The number of airstrips of sufficient length, width, and hardness to accommodate aircraft of air mobile MX size is in the hundreds, whereas the number of Soviet ICBM RVS that could destroy them in the first half hour of the war is in the thousands. It is therefore plain that the air mobile force could not expect to find airfields for postattack endurance unless their number approximated or exceeded the number of Soviet RVS. The "austere" postattack airfields would have to be widely spaced in order that fallout from an attack on one field did not prevent the aircrews from remaining at adjacent fields for the hours or days of postattack endurance sought by building them. Providing 4,600 "austere" fields – equal to the number of aimpoints in the baseline MPS system — could result in a cost of about $30 billion to $40 billion to the air mobile deployment (see Costs section). If the airstrips were spaced 25 miles apart, 4,600 of them would entirely cover the 3 million mi^2 of the continental United States. The question of postattack endurance is discussed further in the Endurance section.

If construction of a large number of austere fields were contemplated, it would be desirable to minimize costs by deploying aircraft capable of using short runways. Several studies have discussed advanced medium short takeoff (AMST) aircraft capable of carrying one MX missile. "Stretched" versions of the YC-14/15 have been considered as AMST candidates, but these aircraft were not originally intended to carry loads as heavy as the MX missile. The resulting designs called for rather extensive modifications and for runway lengths somewhat in excess of those normally considered for the AMST.

Dash-on-Warning Without "Endurance" (Base Case Air Mobile System)

Considerable cost savings could be achieved by abandoning the requirement for a large number of austere airfields for use in the postattack period. Since runway length would no longer be critical, conventional wide-bodied jets could be used, meaning that each aircraft could carry two MX missiles. Such a force could use civilian or military airports for postattack operations or, if these airfields were destroyed, adopt a policy of "use it or lose it" for the few hours of unrefueled flight time. The implications of such a policy are discussed further in the Endurance section.

Where it is necessary to be explicit in the following, a Boeing 747 will be assumed as the air mobile carrier. A Lockheed C5 could also be used. A suitably modified 747 capable of carrying two 150,000-lb MX missiles and their support equipment would have a takeoff gross weight of about 900,000 lb and carry 200,000 lb of fuel at takeoff. The aircraft would have an unrefueled flight time of 5 to 6 hours and a range of 2,000 to 2,500 miles. The missiles would be carried one behind the other along the length of the fuselage, and a "bomb bay" would have to be provided in the aft fuselage for dropping the missiles out at launch. Since many commercial airlines are presently phasing some 747s out of their fleets, it is conceivable that used aircraft could be procured and modified for the air mobile mission. Since the aircraft would rarely fly, there might not be any need to have new ones.

SURVIVABILITY

In comparison to other basing modes, air mobile has the attractive feature that its prelaunch survivability would be relatively insensitive to the size and nature of the Soviet ICBM force. During the half hour it would take Soviet ICBMS to arrive on the United States, the air mobile aircraft could have dispersed to an area so large that a barrage attack consisting of thousands of equivalent megatons would not destroy a majority of the aircraft. The outcome of such an attack would furthermore be insensitive to the number of warheads deployed on each Soviet booster and independent also of missile accuracy. Thus, air mobile deployment would remove all advantage to Soviet fractionation and accuracy improvements even if the Soviets were to contemplate a massive barrage attack on the Central United States.

The true threat to a dash-on-warning air mobile force would come not from the Soviet ICBM force, but from SLBMS, that have a flight time about half that of ICBMS when fired from near U.S. coasts. The area into which the aircraft could disperse in this time would be much smaller than the area they would cover at the end of a half hour, since the first few minutes would be consumed by receipt of the warning signal, engine start-up, taxiing, and initially low-speed flight. Still, SLBM attack would require a relatively large number of Soviet submarines deployed near to U.S. shores. The present Soviet SLBM force is incapable of such an attack. Thus, air mobile basing would stress Soviet strategic forces where they would be least able to respond in the near term.

An air mobile force could therefore be highly survivable. However, the difference between survival and destruction of the force would be measured in minutes and would depend on receipt of reliable, timely tactical warning and high alert procedures. An air mobile ICBM force would share this sensitivity with the bomber force. Moreover, if the aircraft were unable to find airfields to land and refuel in the postattack period, their "survival" would be limited to the first few hours of the war.

There are many uncertainties regarding survival of aircraft to nuclear effects, and the results of calculations are in certain respects sensitive to the assumptions, but the overall trends support the generalizations made above.

Aircraft Vulnerability to Nuclear Effects

Little of a definite nature is known about the effects on aircraft of nearby nuclear detonations. At low altitudes the dominant kill mechanism is probably the blast wave from the detonation and especially the gusting winds that follow the shock front. These gusts could damage extended surfaces such as the wings and vertical stabilizer or cause engine stalling. Such effects would clearly depend on the orientation of the aircraft relative to the position of the detonation. At low altitudes (when escaping from their airfields) the aircraft would be below the "Mach stem" or point on the blast front below which the initial blast wave and the blast wave reflected from the Earth coalesce. For the low overpressures of relevance to aircraft, there is some uncertainty in modeling the front below the Mach stem. These uncertainties could result in rather large variations in the kill radius for aircraft of a given nominal hardness. It is also necessary to take into account the time elapsed between the detonation and the arrival of the shock front at the in-flight aircraft. All considered, a range in hardness from 1 to 3 pounds per square inch (psi) is probably appropriate.

At higher altitudes, the thermal radiation emitted by the detonation is probably lethal to the aircraft at a greater range than the blast wave. As the altitude increases, a smaller fraction of the weapon yield appears as thermal radiation, but since the air is thinner the radiation is attenuated less rapidly. The radiation is also deposited in a shorter time at high altitude. Melting or buckling of aerodynamic surfaces could result. The effects could again depend on the orientation of the aircraft with respect to the detonation. Thermal fluences of 20 to 40 calories per square centimeter (cat/c m^2) or so are probably the limit for conventional aircraft with aluminum surfaces, but thermal hardening (at some weight penalty) could conceivably increase the thermal hardness as high as 100 cal/cm^2. An optimum cruise altitude, considering both blast damage at low altitudes and thermal flash at high altitudes, is probably 10,000 to 15,000 f t.

In addition to the immediate damage done by blast and thermal radiation, an air mobile force could also be affected by electromagnetic pulse (EM P), dust lofted by ground bursts, and crew radiation dose.

EMP would not affect crews or airframes, but could disrupt electronic equipment. There is a considerable amount of effort to harden other military aircraft to EMP, and it appears that with sufficient testing and attention to design details, the risk of disruption can be minimized.

Impairment of several aircraft flying through the dust cloud caused by the Mount St. Helens' eruptions has raised concerns for similar effects on aircraft operating after a nuclear attack involving a large number of groundburst weapons. Up to one-third of a million tons of dust per megaton of weapon yield could be lofted into the altitude range between 40,000 and 60,000 ft. Though aircraft would operate below this altitude, considerable dust densities could exist at lower altitudes for long periods of time as the dust at higher altitudes settled. Turboprop aircraft might fare better than conventional jet aircraft in these circumstances. However, this area is one of considerable uncertainty.

At the ranges from detonation where the aircraft itself would survive, the prompt radiation dose delivered to the aircrews would probably not result in mission-impairing sickness. If the aircraft were required to remain at austere fields subject to local fallout in the postattack period, however, there could be some danger of mission-impairing doses unless care was taken in the choice of airstrips.

In the illustrative calculations that follow, it will be assumed that, for a reference yield of 1.5 MT, the lethal radius for an aircraft at low altitude (during escape) is about 8 miles and at cruise altitude (10,000 to 15,000 ft) about 6 miles. These ranges correspond roughly to aircraft hardened to 1 to 3 psi overpressure and 40 cal/cm^2 thermal fluence. It *should be remembered that there are considerable uncertainties in such calculations.*

ICBM Barrage of In-Flight Aircraft

If the Soviets contemplated ICBM barrage attack on in-flight aircraft, either a continuously airborne force or a dash-on-warning force, expenditure of considerable megatonnage would be required to destroy an appreciable number of aircraft. optimum burst height would be at the aircraft cruise altitude (10,000 to 15,000 ft, as discussed above). The outcome of such an attack would be insensitive to both weapon accuracy and fractionation of missile payload, as discussed further in chapter 8. Because of the burst height, there would be little prompt fallout and less damage to ground structures than for near-surface bursts.

Attack On Continuously Airborne MX Fleet

Five thousand l-MT weapons could destroy all aircraft within an area of about 600,000 mi^2. Since a continuously airborne air mobile fleet could be dispersed over an ocean area totaling millions of square miles, even a very large attack could not significantly reduce the force. If the aircraft could be tracked continuously (methods for tracking are discussed below), and the Soviets could retarget their ICBMS continuously on the basis of up-to-the-minute aircraft locations, the aircraft could travel far enough in the half-hour ICBM flight time to escape direct attack. For instance, if an aircraft cruised at 400 mph, at the end of a half hour it could conceivably be anywhere within a circle of area 130,000 mi^2 about the point where it was located when the ICBMS were launched. A full 1,000 MT would therefore be required to destroy it with certainty.

Attack On Dash-on-Warning Fleet

Within a half hour of takeoff, a fleet of air mobile aircraft located at bases within the north-central region of the United States at least 700 nmi from the coasts could be dispersed over an area totaling about 1 million mi^2. The Soviets could therefore destroy about one-eighth of the force (perhaps 20 or so MX missiles) for each 1,000 MT expended. Destruction of a sizable fraction of the force would therefore require an enormous expenditure of megatonnage. It is not clear that such an attack would in any case be appealing to the Soviets in all circumstances, implying as it would (for the low cruise altitude assumed) widespread destruction in the entire Central United States.

Advanced Threats to Airborne Aircraft

It is possible to imagine several means by which in-flight aircraft over the United States could be tracked continuously by Soviet sensors. All of these means would be subject to U.S. countermeasures. Since, as described above, even continuous retargeting of ICBMS on the basis of up-to-the-minute knowledge of aircraft locations could be unprofitable if the aircraft speed were high, exploitation of a continuous tracking capability would require that the ICBMS be able to be retargeted in flight. This brief section describes some of the means to track aircraft and the possibilities for in-flight correction of ICBM trajectories. However, even if in-flight correction were feasible, Soviet dependence on any such strategy for attacking air mobile MX would entail risk and be subject to U.S. countermeasures.

Probably the easiest means to identify and track aircraft would be to direction-find on their radio emissions. To counter this threat, an air mobile force could observe radio silence whenever possible and stagger broadcasts so that all planes could not be located simultaneously. Above all, it could use communications not susceptible to intercept.

Large over-the-horizon radars based in Cuba could probably maintain coverage of the entire United States but would not be able to localize aircraft well enough to support effective retargeting. They would also be susceptible to jamming. Space-based radars would have to be relatively large in number, would have difficulty with ground-clutter background, and could be jammed. It might be possible to locate the aircraft by intercepting reflected signals from the Federal Aviation Administration radar network. Receivers used for this purpose might be jammable.

Space-based short-wave infrared sensors could attempt to observe the hot exhaust gases from aircraft engines, but the power levels would be exceedingly low, especially if the aircraft cruised at low altitudes. Means to cool and diffuse aircraft exhaust are also possible. Long-wave infrared sensors would seek to observe the cool body of the aircraft against the warm earth. Again, this technique would be difficult in the best of circumstances and could be defeated by emissive body paints and heaters in the skins of the aircraft. All infrared devices could be defeated by cloud cover. if the aircraft cruise altitudes were in the 10,000- to 15,000-ft range, average U.S. cloud cover might obscure about a third of the force at any given time.

Since jet aircraft could travel about 200 miles in a half hour, substantial trajectory corrections would be required if an RV were to be retargeted *during flight* to an impact point near the aircraft. A maneuverable reentry vehicle could not make this large a correction using aerodynamic maneuvers. Midcourse velocity corrections of a few thousand feet-per-second would be needed for ballistic RVS. The link from the sensor tracking the aircraft to the in-flight RV could be jammed. Significant payload penalties (at least 50 percent) would also result from the need for receiving equipment and active propulsion.

SLBM Attack On Dash-on-Warning Air Mobile

Attack on the alert airstrips from Soviet submarines deployed near U.S. coasts would be the principal threat to a dash-on-warning air mobile fleet. Calculations indicate—given the usual uncertainties in such estimates— that the force would be highly survivable even against a rather advanced future Soviet SLBM deployment consisting of large numbers (20 or more) of Soviet submarines stationed very near to U.S. coasts, provided high alert procedures were adopted for the force.

The most important factors influencing the survivability of an air mobile force would be the procedures adopted by the United States to ensure rapid takeoff in the event of attack and the size and deployment of a future Soviet SLBM force. These factors establish the important trends. The precise numerical results also depend on aircraft hardness to nuclear effects, the way the Soviet attack was structured (laydown pattern, height of burst), the flyout pattern of the aircraft (range, altitude, and direction from airstrip as a function of time), and the distribution of escape airstrips with respect to distance from the coasts. The outcome of *any calculation should be viewed with these sensitivities and uncertainties in mind.*

Alert Procedures

It would be crucial to the survivability of air mobile that the time between Soviet SLBM launch and aircraft brake release be as short as possible. This time would be the sum of the times to receive warning of Soviet attack, man the aircraft, and bring engines up to speed. As discussed more fully in the *Support Systems* section and chapter 4, it should be technically feasible to provide reliable warning sensors that would indicate SLBM launch within at least 1 minute. It would be possible to station crews in the cockpits of alert aircraft at all times, though this type of duty might well be unattractive to the crews. A jet engine can be started and brought up to speed in somewhat more than 1 minute.

Thus, a “breakwater to brake release” time delay of between 2 and 3 minutes is feasible, though perhaps optimistic.

Such an extreme alert posture could result in an occasional false alarm dispersal of aircraft, carrying their potentially explosive (at least in the nonnuclear sense) payloads. Public acceptance of this possibility would be important in maintaining this posture in the long term. If time-consuming procedures were instituted to double-check the accuracy of the warning message before the aircraft took off, survivability against surprise attack could be significantly reduced.

If the aircraft were able to launch their missiles only while airborne, such a false alarm dispersal could appear to the Soviets to be preparation for a U.S. first strike.

Soviet SLBM Forces

Attack on air mobile would require large numbers of SLBMs deployed near to U.S. coasts. The effectiveness of an attack would depend on the number of SLBM missiles launched but would be quite insensitive to how the payloads were fractionated into RVS and to RV accuracy. Effectiveness would also depend on how close the submarines were able to approach to U.S. shores and the types of trajectories they flew.

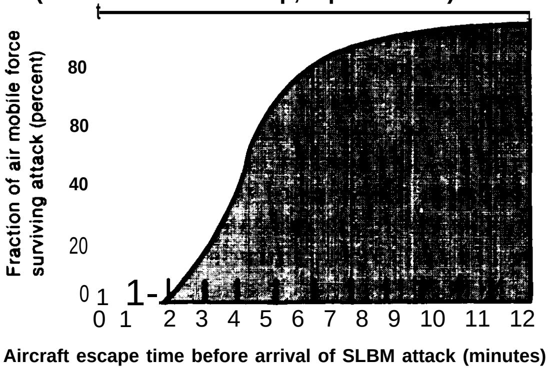
In order to destroy an appreciable fraction of the air mobile force, the Soviets would have to deploy a large number of submarines near to U.S. coasts and launch their missiles on special fast trajectories. The present Soviet SLBM force is incapable of such an attack. Soviet dedication of a future SLBM force to attacking a U.S. air mobile force could compete with other time-urgent missions involving both U.S. and European targets. It is also unlikely that the approach of large numbers of Soviet submarines to U.S. coastlines would go undetected. Short-term U.S. responses to such a "surge" could include diplomatic remonstrance, increased antisubmarine warfare efforts, and very high (perhaps even continuously airborne) alert procedures.

Illustrative Calculations

Figure 89 shows the result of a typical calculation of air mobile survivability. The graph shows the fraction of the air mobile force surviving an attack plotted against "escape time' '–the number of minutes the aircraft had to fly away from their bases (measured from brake release) before incoming SLBM RVS arrived to destroy them. The earlier the aircraft responded to a warning signal, the longer the escape time would be; the shorter the SLBM flight time (depending on the range and the type of trajectory), the shorter the escape time.

(The precise assumptions made in constructing figure 89 are: 747 flyout; simultaneous takeoff of two aircraft per base in opposite directions; about 8 equivalent megatonnage (EMT) targeted at each base; nominal aircraft hardness of 2 psi; inland basing.)

Figure 89.—Survivabilit y v. Escape Time (8 EMT on each airstrip, 2 psi aircraft)



SOURCE: Office of Technology Assessment.

The curve in figure 89 begins at very low values (most aircraft destroyed) and climbs rapidly to rather high values (most aircraft survive). Whether the aircraft survived an attack or not would clearly be a matter of a very few minutes.

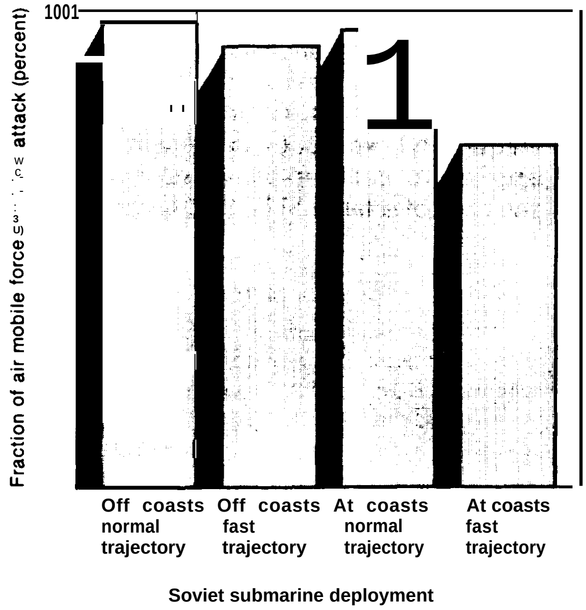
Where the outcome of a given attack fell on the curve of figure 89 would depend on the Soviet SLBM deployment. The various possibilities–launch from offshore patrol areas (hundreds of miles from U.S. coasts) or from positions at the coasts, on normal or special fast trajectories—would result in the approximate values shown in figure 90 for the survivability of the air mobile force. Figure 91 shows the result of delaying takeoff by 2 1\2 minutes, either because crews were not stationed in the cockpits or because confirmation of warning was required before takeoff. Figure 92 shows the effect of increasing the size of the attack (measured in EMT) on each alert airstrip. Figure 93 shows the combined effects of both delayed takeoff and increased attack size. Finally, in figure 94, takeoff is delayed and the attack size increased, but the aircraft hardness is also increased from a nominal value of 2 to 5 psi.

These figures support the following conclusions:

- The dash-on-warning force would be highly survivable against all attacks except those involving fairly large numbers of SLBMS launched on fast trajectories from positions actually at the U.S. coastline.

Figure 90.—Aircraft Survivability y During Base Escape

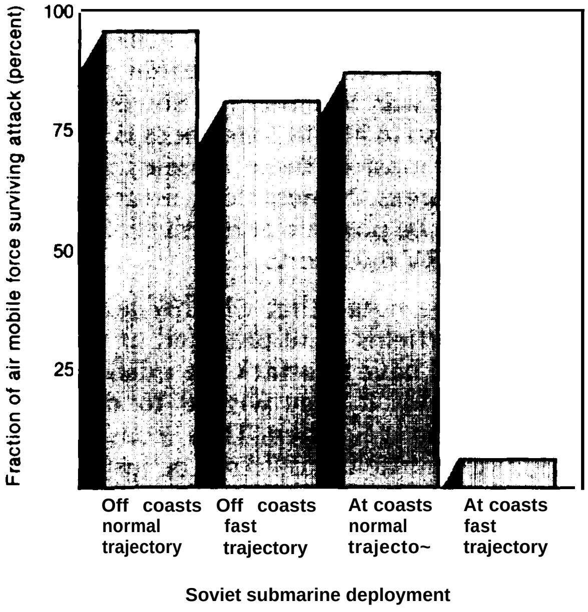
8 EMT per airstrip
2 psi aircraft
Prompt takeoff



SOURCE: Office of Technology Assessment.

Figure 91 .—Aircraft Survivability During Base Escape

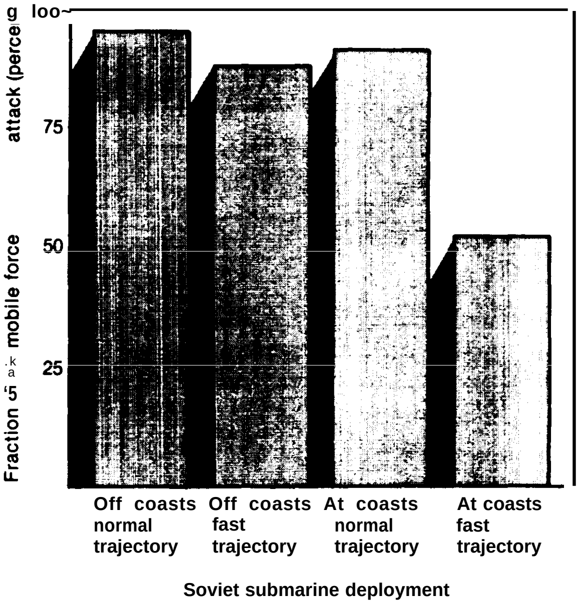
8 EMT per airstrip
2 psi aircraft
Takeoff delayed 2.5 minutes



SOURCE: Office of Technology Assessment.

Figure 92.—Aircraft Survivability y During Base Escape

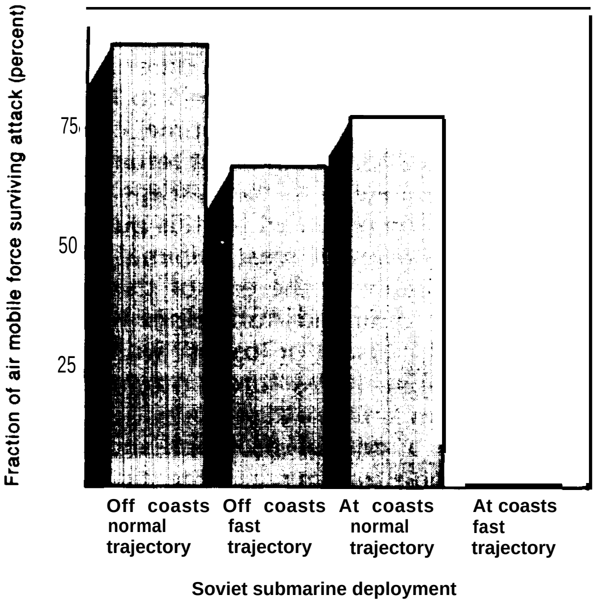
14 EMT per airstrip
2 psi aircraft
Prompt takeoff



SOURCE: Office of Technology Assessment.

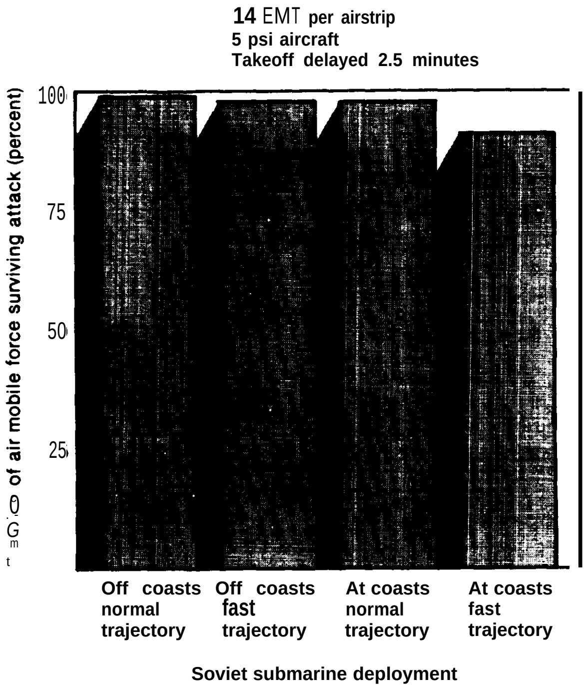
Figure 93.—Aircraft Survivability y During Base Escape

14 EMT per airstrip
2 psi aircraft
Takeoff delayed 2.5 minutes



SOURCE: Off Ice of Technology Assessment

Figure 94.—Aircraft Survivability During Base Escape



SOURCE: Office of Technology Assessment.

- The effect even of this rather advanced threat could be offset somewhat by high alert procedures.
- Significant aircraft hardening, if feasible, would restore high survivability even in the face of an advanced threat.
- Further airfield construction, so that there was one airstrip per aircraft (or even several, with the aircraft moving among them frequently), would, by decreasing the EMT applied to each, improve survivability in the face of a large SLBM deployment.

ENDURANCE

If the air mobile force survived the initial attack, it would only be effective for the first few hours of the war unless provision were made to land and refuel the aircraft. The unrefueled endurance of the aircraft would be 5 to 10 hours, depending on the type. This time could be more than doubled with in-flight refueling, but a fleet of tankers with its own escape airstrips would have to be provided for this purpose. If airfields capable of at least minimal support were not available at the end of this period, the National Command Authorities would be in a position of "use it or lose it" with respect to the air mobile ICBM force. Attempting to ensure endurance for an air mobile force could therefore be a critical problem and, if addressed by constructing a large number of recovery airstrips, a major cost driver.

A first possibility for postattack reconstitution would be use of the several hundred existing military and commercial airfields throughout the U.S. with runways long enough for the large MX missile carriers. Soviet ICBMS could easily destroy these airfields within the first half hour of a war. Whether the Soviets would choose to do so in all circumstances is another matter, since most of these airfields are near large urban areas. Nonetheless, attack on all would clearly be possible at relatively low cost to the Soviet RV inventory.

It should be noted that whether additional postattack airfields were provided or not, the Soviets would have to attack the existing commercial airfields if they wished to deny endurance to the U.S. force. Thus, construction of additional airfields could not be justified on the grounds that failing to do so would invite attack on all the Nation's airports: the very existence of these airfields, sufficient by themselves to support air mobile in the postattack period, would make them targets no matter what else the United States built. Independent of whether extra recovery airstrips were built, air mobile deployment would face the Soviets with the choice of attacking a large number of urban/industrial targets (and forcing the United States to a "lose it or use it" posture) or granting endurance to the U.S. force.

A second approach to endurance would be to construct a large number of "austere" or minimally equipped recovery airstrips throughout the United States. These airstrips would have to have at least an adequate runway and fuel supply. They would have to be spaced far enough apart so that fallout from attack on one would not make it impossible for aircraft crews to remain at neighboring airstrips for the hours or days of postattack endurance sought by building them. It would also be desirable, if not necessary, to equip each field with landing aids (beacons or radar reflectors) and perhaps also crew shacks, floodlights, fences, snowplows, and the like. Equipping each of thousands of airfields with such provisions would be exceedingly expensive. Alternatives could include providing road-mobile recovery teams to meet the aircraft at the recovery sites or providing a fleet of aircraft loaded with supplies, on alert like the missile fleet, to accompany the aircraft.

A serious effort to build more austere recovery sites than the Soviets possessed RVS to destroy them would be enormously expensive and completely impractical if the Soviet threat grew large. There are about 2,300 airfields in the United States with runways 2,500)-ft long and 40-ft wide, that are of medium hardness. Most of these fields are wholly inadequate to support aircraft the size of MX carriers and would need substantial improvement. Construction of an additional 2,300 recovery fields, to make a total of 4,600 (the number of aimpoints in the baseline MPS system), would be much more expensive still. If these recovery fields were located 25 miles from one another, they would cover the entire 3 million mi^2 of the continental United States. If the numbers were made larger still, the packing could be so close that attack on one could make neighboring fields unusable.

It would thus be impossible to *guarantee* postattack endurance for an air mobile MX force against a large Soviet threat. As a practical matter, it would only be possible to force on the Soviets the choice of granting endurance to the U.S. force or attacking a large number of targets spread throughout the country. How many airfields, if any, the United States constructed would thus seem to depend on what number, if any, would induce the Soviets to give up targeting them. Alternatively, the United States could take the position that if the Soviets were willing to attack sites throughout the United States, the United States would be willing to adopt a "use it or lose it" posture. In this case the number of recovery airfields built would be decided according to the amount of damage the United States would tolerate before such a posture became acceptable to U.S. policy makers.

There could conceivably be some value in having more airfields suitable for air mobile operation than the Soviets had SLBM RVS. These airfields could be useful if the U.S. doubted the reliability of its SLBM warning sensors, wished to relax the force's alert posture, or were somehow "spoofed" into dispersing the air mobile fleet. If the number of dispersal fields were larger than the Soviet SLBM inventory, a force that in a crisis moved randomly and frequently among them would have a measure of survivability even in the absence of warning of SLBM attack. ICBM RVS arriving in larger numbers a short time later than the SLBMS could still destroy the force, so the dependence on warning would still not be wholly removed. Transit to a "hop and sit" posture would also allow some relaxation of alert procedures, alleviating the fear that takeoff in response to a false warning message (there being no time for confirmation) could be mistaken by the Soviets for preparation for a U.S. first strike (since the missiles *could only* be launched while airborne). Last, the aircraft would be vulnerable when they had to land following a "spoof" or small attack designed to cause them to take off. A large number of landing sites would make attacking the portion of the fleet grounded at any one time as costly as possible to the Soviets.

Another possibility for recovery sites would be along stretches of the Nation's highways. Since M-X-sized missile carriers would need long and wide stretches of highway to land and take off, it might not be practical to depend on this method. The traffic density on most U.S. highways is prohibitively high, at least in normal circumstances. It is possible that some stretches of Midwestern highway could be used, but fuel caches and support equipment would have to be prepositioned or brought to the landing sites by road mobile vehicles (themselves subject to attack).

Endurance could clearly be a major problem for air mobile MX. The next section estimates the cost of providing large numbers of recovery airstrips.

COSTS

OTA has not performed detailed cost analyses for the three air mobile MX configurations discussed in this chapter. What follows are *rough estimates* that seek to indicate overall orders of magnitude and to highlight the cost drivers. These estimates are based on air mobile MX analyses done by other Government agencies. However, since the outcomes are very sensitive to assumptions concerning the number and cost of aircraft and airfields, etc., these analyses could only provide a guide to the costs of the systems described here. The final results provided here probably reflect the true costs of the systems described to about 10 to 20 percent. Costs quoted are nominally in fiscal year 1980 dollars. These costs do not include the systems described in the *Support Systems* section nor the possible additional costs of hardening aircraft. Larger or smaller deployments than those considered here could lead to substantial changes in system costs.

Continuously Airborne

This system would consist of 75 new large turboprop aircraft (150 MX missiles) continuously airborne and operating out of four new coastal main operating bases. Costs might be:

Aircraft: 75 patrol aircraft plus 50 for training and attrition, each costing $80 million (including development costs): $10 *billion.*

Missiles: missiles modified for air launch, including spares and test missiles: $12 billion, including development.

Bases: Four main operating bases: $4 *billion.*

Operations, excluding fuel: $2 billion per year for 13 years (average of 5 years of startup and 10 years of full deployment): $26 *billion.*

Fuel: Round-the-clock flight of 75 aircraft at $1.17 per fuel gallon for 13 years: $39 *billion.*

Total: $91 billion.

Dash-on-Warning With "Endurance"

This concept consists of 150 AMST aircraft (carrying 150 MX) on continuous ground alert at 75 inland airfields. Also provided are 2,300 to 4,600 recovery airfields. Three cases are considered:

- Case *A:* Minimal upgrades to 2,300 existing airfields, including hard gravel lengthening and fuel caches.
- Case *B:* Same fields as case A with addition of landing aids, floodlights, security fence, snowplow, crew shack, 2-man permanent crew, and other supplies.
- Case C: Additional 2,300 airfields built from scratch and equipped as in case B.

Aircraft: 85-percent reliability implies 180 alert aircraft plus another 50 for training and attrition at $50 million each: $12 *billion.*

Missiles: As above, $12 *billion.*

Alert bases: 75 Central U.S. airfields, including some existing joint civilian/military airports, with 6 main operating bases: $4 *billion.*

Operations (1 3-year average):
Case A: $18 *billion.*
Case B: $24 *billion.*
Case C: $28 *billion.*
Recovery airfields:
Case A: $4 *billion.*
Case B: $10 *billion.*
Case C: $25 *billion.*
Total:
Case A: $50 *billion.*
Case B: $62 *billion.*
Case C: $87 *billon.*

Dash-on-Warning Without "Endurance"

This concept consists of 75 wide-bodied aircraft (150 MX) on ground alert at 38 inland airfields. No provision is made for postattack endurance.

Aircraft: 85-percent reliability implies 90 alert aircraft plus another 40 for training and attrition, at $60 million each: $8 *billion.*
Missiles: As above, $12 *billion.*
Alert bases: 38 Central U.S airfields, 4 main operating bases: $3 *billion.*
Operations: 13 years: $77 *billion.*
Total: $40 *billion.*

SUPPORT SYSTEMS

Warning Sensors

The survival of a dash-on-warning air mobile MX force would be critically dependent on receipt of prompt, reliable warning of Soviet SLBM launch. As discussed more fully in the context of launch under attack (ch. 4), it would be technically feasible with *cost and continued effort* to provide a variety of tactical warning systems which, taken together, would be exceedingly difficult for the Soviets to disrupt. These warning sensors could include high-orbit short-wave infrared satellites, ship-based and coastal radars (the latter defended with a "threshold ABM" if desired), and airborne infrared sensors and radars. It would also be technically feasible, again with cost and effort, to secure the communications links from the sensors to command posts and from command posts to the alert airfields.

Clearly, if the required money and effort were not dedicated to providing such warning sensors, a force that depended for its survival on a very few minutes of escape time would be endangered. No matter how much money and ingenuity were devoted to designing safeguards for the air mobile warning sensors, and even if these safeguards were very robust indeed, it would probably never be possible to eradicate a lingering fear that the Soviets might find some way to sidestep them.

Public acceptance of the possibility of false alarm dispersal of the fleet would be essential to preserving a high alert rate in the long term. If the aircraft could only launch their MX missiles when airborne, false alarm disposal could be mistaken by the Soviets for preparation for a first strike.

Command, Control, and Communications (C^3)

A C^3 system capable of supporting the complex force management needs of an air mobile force would entail relatively low risk but could be quite costly. After dispersal, the aircraft would need to report their status [fuel remaining, missile readiness, etc.) to a central airborne command post and exchange information concerning the location and status of surviving recovery airfields. If a fraction of the force had been destroyed, there could be a need to exchange targeting information to ensure adequate target coverage.

While airborne, line-of-sight communications among aircraft via UHF would be possible at ranges up to about 300 miles. A UHF "relay" from all aircraft to the command post could be established. Adaptive high frequency and very low frequency/low frequency could also be used. If the aircraft were dispersed at many recovery fields throughout the United States in the postattack period, some form of satellite communications would be highly desirable. High-orbit extremely high frequency satellites such as described in other chapters would provide survivable, high data-rate satellite communications to small, trainable dish antennas.

Missile Guidance

Since the MX missile would be on a mobile platform for up to several hours before launch, accuracy would degrade relative to stationary deployment unless additional measures were taken. These measures might take several forms.

The most accurate would be external update, such as by the GPS or CBS that would provide position and velocity update to the missile's guidance system during cruise or during boost. Accuracies could be made comparable to land-based accuracies for update during cruise and better for update during boost. The main disadvantage of these methods would be reliance on the survivability of the external aids. Secondly, in a nuclear environment the update information might not be transmitted through the ionosphere. This problem could degrade accuracy by 25 to 50 percent; however, the precise amount is uncertain.

A second method, that would be self-contained to the missile and aircraft, would be to use a detailed map of gravity disturbances and a high-class inertial measurement unit (IMU), such as the Advanced Inertial Reference Sphere in the missile. Such gravity mapping would be compatible with mapping programs utilizing SEASAT and GPS. Gradiometers might be more applicable to this method in their present state of development than to real-time navigation. Resulting accuracies might be some 70 percent degraded relative to land-based MX.

Finally, doppler radar and a high-class IMU, without external aids or gravity map compensation, might give the missile a circular error probable in the range 2,000 to 2,500 ft.