Chapter 8

LAND MOBILE MX BASING

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FIGURES

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Land mobile MX-basing systems would seek to create uncertainty for the Soviet targeter by constantly changing missile location in an unpredictable way. If the locations of the missile-carrying vehicles were completely unknown to the Soviets, then the only way to attack them would be to barrage or pattern bomb the deployment area, spreading destructive effects over as wide an area as possible. To guarantee survival of a fraction of a land mobile force, the deployment area would have to be larger than the area that the Soviets could "sweep clean" with a barrage. If the Soviets were able to observe the vehicles by remote means and target their attack at individual vehicles on the basis of recent sightings, then the vehicles would have to be fast enough to generate a large uncertainty in their locations in the time elapsed between the last preattack sighting and the arrival of RVS targeted on the basis of that last sighting.

In either case, the Soviets would have to blanket as much area as possible with nuclear effects lethal to the MX-carrying vehicles. The "area kill" mechanism — as opposed to the aimpoint or hard-target kill relevant for missile silos or multiple protective shelters (MPS)— has the important feature of being insensitive to Soviet fractionation. Roughly speaking, the area (or length of road or rail) the Soviets could barrage with nuclear destruction of a given severity would depend on the number and size of Soviet missiles but not on whether the missiles carried a small number of high-yield reentry vehicles (RVS) or a larger number of smaller yield RVS. The small warheads would be more numerous, but each would barrage a smaller area, and the total area covered by all the warheads from a given missile would be roughly the same no matter what the fractionation. Said another way, the vulnerability of a land mobile MX basing system would be sensitive to the total throwweight in the Soviet arsenal but not to how that throwweight was apportioned among RVS.

Because it would be more difficult for the Soviets to increase their throwweight than their number of RVS, the "area kill" vulnerability of Land Mobile systems is attractive in principle. However, it is difficult to realize in practice.

Road mobile MX could either have missile-carrying trucks continuously in motion on the highways (Continuously Dispersed Road Mobile) or stationed at central bases and dispersed onto the highways on warning of Soviet attack (Disperse-on-Warning Road Mobile). Off-Road Mobile could either have hardened vehicles moving randomly throughout a large area or dashing from central bases to dispersed hardened shelters. Rail Mobile MX would travel the Nation's railways.

None of the land mobile concepts turns out to be a particularly attractive option for MX-missile basing, but Continuously Dispersed Road Mobile could be highly survivable, and its survivability would be independent of warning. Disperse-on-Warning systems would require hours of warning time if they were to survive attack, so they would always be vulnerable to surprise. Off-Road Mobile would require a very large deployment area. Dash-to-Shelters would use a smaller amount of land than Off-Road Mobile but would still depend on warning. In fact, MPS basing with preservation of location uncertainty (PLU) could be viewed as an evolution of Dash-to-Shelters with dash reemphasized to achieve independence from warning. Rail Mobile would suffer from the need for right-of-way on intercity lines.

In addition to problems with the fundamental concepts, land vehicles capable of carrying the 190,000-lb MX missile would be very large. A road vehicle would probably be much too large to fit under highway underpasses and too heavy to cross highway bridges. Thus, Road Mobile MX is probably a practical impossibility. Off-road vehicles of MX size could be very destructive of their deployment areas.

BARRAGE ATTACK ON MOBILE SYSTEMS

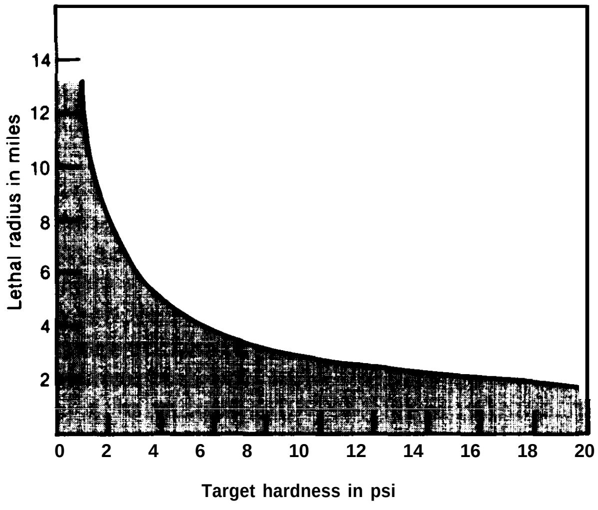
This section discusses some basic features of nuclear barrage attacks, the type of attacks relevant to basing systems consisting of mobile missile-carrying vehicles. In contrast to the survivability of systems of fixed hard aimpoints like silos and MPS, which depends on the number, yield, and accuracy of Soviet RVS, the survivability of mobile systems depends on the total equivalent megatonnage (EMT) in the Soviet missile force. EMT in turn depends on the size and number of Soviet offensive missiles but is insensitive to whether a given missile carries a small number of high-yield warheads or a larger number of smaller yield warheads. That is, the Soviets would obtain little advantage by fractionating their ICBM missiles with large numbers of multiple independently targeted RVS if the United States were to deploy a mobile basing system. RV accuracy would also be irrelevant, since for soft targets it would be sufficient for an RV to detonate a few miles away (rather than a fraction of a mile, as with silos and MPS) in order to destroy the missile-carrying vehicle. Since mobile basing would deprive the Soviets of any substantial advantage from modernizing their ICBM force, the concept is very appealing. Unfortunately, it is difficult to translate this hypothetical concept into a survivable basing system, principally because the Soviets already possess sufficient EMT in their ICBM arsenal to destroy mobile vehicles dispersed over even very large areas of the United States.

The "Area Kill" Mechanism

The distance from a nuclear detonation at which a mobile vehicle could survive depends on the vehicle's "hardness," or resilience to nuclear effects, and on the weapon yield. Hardness is typically quoted in pounds per square inch (psi) of static overpressure. This convention does not necessarily imply that static overpressure is actually the effect that destroys the vehicle or renders it inoperable: gusting winds that follow the shock front ("dynamic overpressures"), thermal radiation, or other effects might be responsible for vehicle impairment. Rather, stating that a vehicle has a hardness of so many pounds per square inch means that it can survive the effects of a weapon at distances from the detonation at which the shock front applies that many psi overpressure. Within the range at which the given overpressure occurs, the vehicle is assumed destroyed; beyond that range, it is assumed to survive. (In practice there is no distance beyond which all vehicles would survive with 100-percent certainty. Instead, there is a "sure-safe" distance, a "sure-kill" distance, and a certain probability of kill at distances between. Also, if overpressure is not the kill mechanism, the "hardness" will actually be a function of yield.)

Figure 111 shows the range to which a given overpressure extends as a function of overpressure for a l-MT weapon (ground ranges from ground zero for optimum burst height). This is the same as a plot of the "lethal radius" for a vehicle v. the vehicle's hardness. For instance, a 5-psi hard vehicle would be destroyed at a range of 4 miles or closer, an 8-psi vehicle at a range of 3 miles or closer, and so on.

Figure 11 l.—Lethal Radius of One-Megaton Weapon as a Function of Vehicle Hardness



SOURCE: Office of Technology Assessment.

For intermediate overpressures, the laws of hydrodynamics prescribe a rough scaling law saying that, for a given hardness, the lethal radius increases as the one-third power of the yield. Figure 112 shows lethal radius as a function of yield for various values of hardness.

if a vehicle is within a circle of radius equal to its lethal radius, it will be destroyed. The area of this circle is "pi" (3.14) times the square of the lethal radius. Since the lethal radius varies as the one-third power of the yield, the lethal area varies as the two-thirds power of the yield. Since the area that can be "barraged" with a given overpressure is proportional to $(yield)^{2/3}$, the area that can be barraged by a given force of nuclear weapons is proportional to the number of weapons times the two-thirds power of their yield. This quantity is called the EMT of the force:

Barrage area proportional to EMT = (number of weapons) x $(yield)^{2/3}$

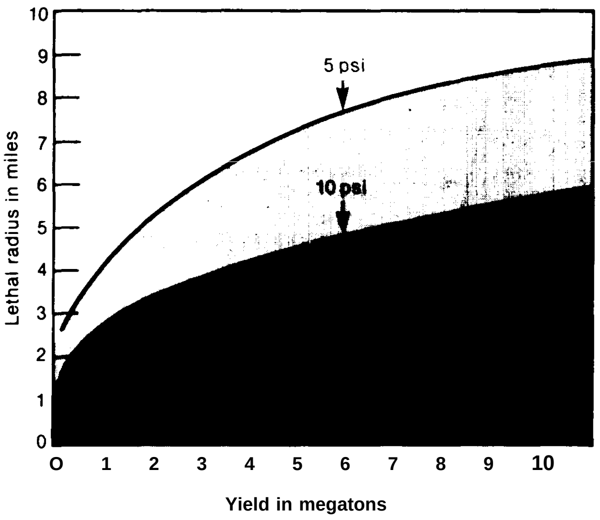
where the yield is measured in megatons. Thus, a force of 4,000 1-MT RVS has 4,000 EMT, and a force of 1,000 8-MT RVS also has 4,000 EMT.

Since mobile basing systems seek survivability by dispersing over wide areas, their survivability depends on how much of the deployment area can be barraged by the Soviets, which in turn depends on the total EMT in the Soviet ICBM force.

It so happens that the EMT that can be delivered by a given ICBM depends (speaking roughly) only on its throwweight and not on how this throwweight is apportioned among RVS. The effectiveness of a given missile in barraging an area is relatively insensitive to payload fractionation. The missile can carry a small number of high-yield RVS or a larger number of smaller yield RVS. The smaller RVS would be more numerous, but each would barrage a smaller area. The total barrage area would be about the same no matter what the fractionation.

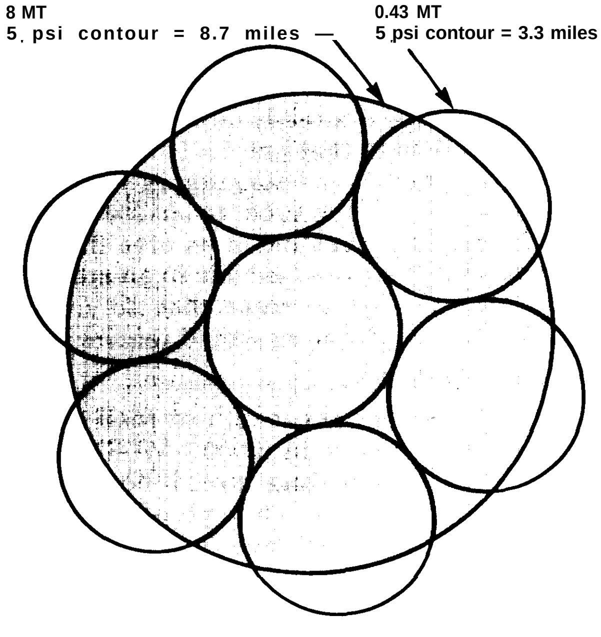
Figure 113 shows the barrage patterns of a single 8-MT RV (4 EMT) and of seven 430-kil -

Figure 112.—Lethal Radius as a Function of Weapon Yield for Various Values of Vehicle Hardness



SOURCE Off Ice of Technology Assessment

Figure 113. —Barrage Patterns of One 8-MT Weapon (4 EMT) and Seven 430.kT Weapons (also 4 EMT)



One 8-MT weapon = 4 EMT
Seven 0.43-MT weapons = 4 EMT

The area covered is about the same no matter how the EMT is apportioned among reentry vehicles

SOURCE. Office of Technology Assessment

oton RVS (also 4 EMT). The circles show the areas within which a 5-psi vehicle would be destroyed. The barrage area is~bout the same no matter what the "fractionation. "

In summary: In contrast to a system of hard point targets (silos or MPS), the survivability of a mobile system which the Soviets had to barrage would depend on the EMT of the Soviet missile force but would be relatively insensitive to the fractionation of each missile. Therefore, to substantially increase the threat to a U.S. basing system subject to area barrage, the Soviets would have to build more missiles. To increase the threat to silos or MPS, they would need only to increase the number of RVS carried by existing missiles. Furthermore, since the lethal radius is a few miles for the overpressures relevant to mobile basing, differences in RV accuracy of a fraction of a mile are irrelevant to the area kill mechanism. Thus, for purposes of attack on a mobile basing system, Soviet accuracy improvements would gain them little.

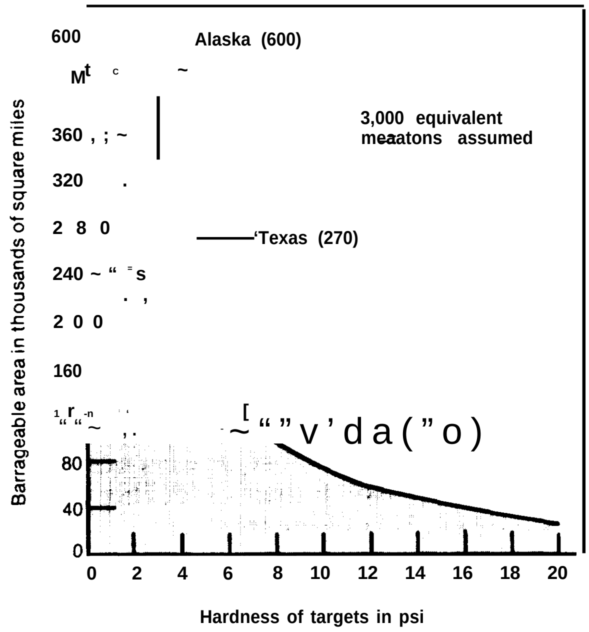
Because their survivability would be insensitive to fractionation and accuracy, mobile basing systems are attractive in principle. However, the area the present Soviet ICBM force can barrage is already quite large. Figure 114 shows the area that can be barraged by a force of 3,000 EMT as a function of hardness. The figure shows that such an arsenal could destroy every 4-psi vehicle in an area the size of Texas and every 7-psi vehicle in an area the size of Nevada. It is clear that survivable mobile MX-basing systems would require large deployment areas.

Figure 115 shows the length of road or rail that could be barraged by 3,000 l-MT RVS. Barrage length, unlike barrage area, is not proportional to EMT, but the outcome of a barrage attack on a road or rail mobile basing system would also be relatively insensitive to fractionation. Such an arsenal could also destroy al vehicles on long stretches of road or rail.

Attack On Mobile Basing Systems

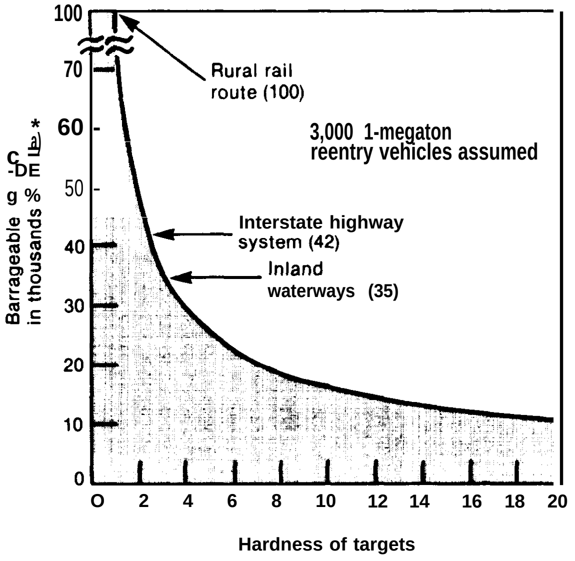
The outcome of an attack on a mobile basing system would depend on whether the Sovi-

Figure 114.—Area Barraged by an ICBM Force of 3,000 EMT as a Function of Vehicle Hardness



SOURCE Office of Technology Assessment.

Figure 115.—Length Barraged by an ICBM Force of 3,000 One-Megaton Reentry Vehicles as a Function of Vehicle Hardness



SOURCE: Office of Technology Assessment.

ets knew where the individual vehicles were at the time of attack in addition to depending on the total EMT in the Soviet arsenal.

If the Soviets did not or could not track individual vehicles as they moved about the deployment area, they would have to barrage as large a fraction of the deployment area as possible. If the deployment area were twice as large as the area the Soviets could barrage, half of the MX force would survive; if the deployment area were three times as large as the barrage area, two-thirds of the force would survive; and so on.

If the vehicles were stationed at fixed bases and dispersed only when attack was imminent, the Soviets would only have to barrage the vicinity of the bases. For instance, if the vehicles dispersed in all directions when warned of Soviet ICBM launch, and if the vehicles were capable of speeds of 50 mph, then in the half-hour flight time of Soviet ICBMS they would be dispersed within a circle of radius 25 miles from the base. Since this circle would have an area of only 2,000 mi^2 it would be easily barraged. Therefore, because of the slow speeds of land vehicles, Disperse-on-Warning Road Mobile systems would be vulnerable to surprise attack.

Even a continuously dispersed system could be vulnerable if the Soviets were able to track the vehicles continuously and retarget their missiles on the basis of up-to-the-minute information. Then they would only have to barrage the vicinity of each vehicle, not the whole deployment area. The time it took the Soviets to determine the location of each vehicle, transmit the locations to their missile fields, program their missiles, and launch them, plus the half-hour ICBM flight time, is called the "intelligence cycle time" (I CT). ICT is thus the time from last sighting to attack arrival. The important quantity in this case is the distance the vehicles could move during the ICT. For instance, if a hypothetical Soviet surveillance system and ICBM force were capable of a 2-hour ICT (and this example by no means intends to suggest that such an ICT is feasible for the present Soviet force), then the vehicles would have two hours to move away from the point where they were at the time they were last sighted (this time would be chosen by the attacker and would be unknown to the U.S. force). If the vehicles patrolled in such a way that they constantly changed direction, moving away from their starting point with *average* speed of 40 mph, then when the Soviet attack arrived they could be anywhere within a circle of radius 80 miles. This circle would have an area of 20,000 mi^2.

If the Soviet surveillance system were such that it could not locate the vehicles precisely, but only localize them within a circle of radius 20 miles, then a 2-hour ICT and 40 mph average speed would result in a "circle of uncertainty" of radius 100 miles and area 31,000 mi^2.

LAND MOBILE MX BASING CONCEPTS

Road Mobile MX: Continuously Dispersed

A system of missile-carrying road vehicles in continuous motion on the Nation's highways would be survivable if the Soviets were unable to keep track of the location of each vehicle. This section first analyzes Road Mobile as a concept and then describes the special problems which arise when the concept is applied to a very large missile like the MX.

Road Mobile Concept

Each missile-carrying vehicle would travel in a convoy of perhaps five vehicles with a total crew of 10 to 12 people. The other vehicles would carry security equipment to defend the nuclear weapons against terrorism, sabotage, etc., and communications equipment to keep them in continuous contact with commanders. One hundred convoys, each consisting of two missile-carrying vehicles, two security vans, and one communications van, might be required for a deployment of 200 MX missiles.

The U.S. Interstate Highway System consists of 42,500 miles of 4-lane highway, not all of which is open to traffic. 1 n addition, there are 81,000 miles of other 4-lane highway, of which 28,000 miles are located near heavily populated urban areas. About 80,000 miles of 4-lane highway located away from populated areas might be available for Road Mobile MX operat ions.

Survivability y

Little of a definite nature is known about the effects of nuclear weapons on road vehicles, but there is agreement that a hardness rating of 15 psi is probably an absolute upper limit, with a more reasonable hardness range being 5 to 10 psi. The principal mechanism of destruction might be overturning of the vehicle by the high winds that follow the shock wave from a nuclear detonation, To alleviate this problem, one could put stakes in the ground and lash the vehicle down shortly before attacking RVS arrived. Other problems for road vehicles might be thermal flash and radiation doses suffered by the crews.

A l-MT weapon would destroy a lo-psi vehicle if it exploded closer than about 3 miles from the vehicle. One thousand l-MT weapons cou Id therefore destroy every 10-psi vehicle on a stretch of road 6,000 miles long. To "sweep clean" the entire 80,000 miles of available U.S. highway would therefore require 13,000 l-MT RVS, which is much more than the present arsenal of Soviet ICBMS is capable of delivering. If the vehicles were 5 psi hard, only 9,oOO MT would be required; if 15 psi hard, then 18,000 MT would be required.

It is important to recall that what matters in these barrage attacks is, roughly speaking, the number of attacking missiles, not the number of RVS they carry. (Barrage length, not barrage area, is relevant here; barrage length does not correlate with EMT, but the results are still relatively insensitive to fractionation.) Thus, for example, a Soviet SS-18 can "sweep clean" about the same length of road whether it carries a few high-yield RVS or a larger number of lower yield RVS. Thus, the survivability of Road Mobile would be insensitive to Soviet fractionation.

A barrage attack on the entire U.S. highway system could cause significant damage to population and industry even if the attack excluded highways in the immediate vicinity of large cities. Road Mobile deployment could therefore conceivably deter the Soviets from attacking U.S. missiles for fear of U.S. retaliation on Soviet population and industry. On the other hand, if a "counterforce" war did begin, the damage to the United States could be considerable.

A theoretical possibility for Soviet attack planners would be to keep track continuously off the locations of the Road Mobile convoys and retarget their missiles on an up-to-the minute basis. Since the average speed of a convoy might be 40 mph, each convoy could travel no more than 20 miles in the minimum possible ICT of a half hour. If the Soviets were capable of this ideal ICT, they would only have to barrage 2,000 miles of highway to destroy all 100 convoys. For this attack, 330 l-MT RVS would suffice. If the ICT were 1 hour, 660 RVS would suffice, and so on.

Cloud cover over the United States and U.S. countermeasures would make reliance on space-based surveillance a risky course for the Soviets. Human agents capable of tracking the convoys or attacking them directly would also be a possibility.

Advantages and Disadvantages

in summary, the principal advantages of the Road Mobile concept are its high survivability in the absence of continuous tracking, the insensitivity of its survivability to Soviet fractionation, independence from warning, little environmental impact, and — at least from some points of view on deterrence— an unclear distinction between attack on U.S strategic forces and attack on U.S. value.

'U S Federal Highway Administration, *Highway* Statistics, A principal disadvantage of Road Mobile would be the exposure of nuclear weapons traveling the Nation's highways to accidents, public interference, sabotage, and terrorism. Though probably difficult to implement in practice, and subject to U.S. countermeasures, a system for continuous tracking and targeting of Road Mobile convoys would allow the Soviets to destroy a Road Mobile force. Finally, attack on Road Mobile could, depending on the highways used, cause substantial collateral damage to U.S. population and industry.

Minimizing accuracy degradation relative to that planned for fixed land-based deployment might require pre-surveying of thousands of launch points along the nation's highways or provision of external navigation aids.

The Problem of Missile Size

The discussion so far has been confined to the concept of Road Mobile missile basing. The problems of actually implementing this concept with the large MX missile would be severe. The vehicle needed to carry MX would exceed by large margins not only the legally permitted loads on the Nation's highways but quite probably the physical tolerances of bridges and underpasses.

According to a rough rule of thumb for design of heavy road vehicles, the gross weight of a loaded vehicle is about twice the weight of the load. The MX missile and its support and launch equipment might weigh 250,000 to 300,000 lb, meaning a 500,000- to 600,000-lb Road Mobile vehicle. To distribute this weight, even with modern independent suspension, could require some 20 axles with 8 wheels each, spaced 8ft apart for a total vehicle length of some 160 ft. By contrast, the maximum load permitted by any State, even with a special permit, is only 100,000 lb, and large tractor-trailers weigh half this amount. The largest load ever moved long distance over the Nation's highways weighed only 335,000 lb and traveled only in good weather.[2] Since the weight of an MX carrier would exceed by large margins the loads for which highway overpasses and bridges are designed, it cannot be said with assurance that these structures could support them.

Size of the vehicle would also be a problem. A large beam under the bed of the vehicle would be needed to support the heavy load. Vertical clearance on Interstate Highway underpasses is nominally 16 ft, but many older segments of the system have only a 14-ft clearance. A Road Mobile MX vehicle would probably be too tall to fit under these underpasses.

Thus, the large size of the MX missile makes Road Mobile MX a practical impossibility.

Road Mobile MX: Disperse-on-Warning

An alternative to keeping missile-carrying vehicles in continuous motion would be to base them at existing military installations and have them disperse onto the highways when given warning of Soviet attack.

For an average vehicle escape speed of 40 mph given tactical warning only, the vehicles could be at most 20 miles from their bases when Soviet RVS arrived. The Soviets would therefore only have to barrage the highways within a 20-mile radius of each base to destroy all the vehicles. If the vehicles were 10 psi hard, then a few tens of l-MT RVS would suffice for this barrage.

If the vehicles were given more warning time, then they could disperse over more road. With about 6 hours of warning time, the vehicles could be dispersed over so much road that a Soviet barrage could not destroy al l of them. Disperse-on-Warning Road Mobile would therefore require hours of warning time to survive. If attack were to come with little or no advance warning, the force would be destroyed.

Even given ample advance or "strategic" warning of imminent Soviet attack, there could be concern for the reaction of the U.S. public and the Soviet Union to dispersal of the vehicles from their bases. Thus, there might be inhibitions on the part of U.S. authorities to disperse the force until the evidence of imminent Soviet attack was absolutely convincing.

[2] *Transportation* **Engineer Magazine, February 1980**

By then it could be too late to guarantee survival of the force.

Traffic might also impede the escape of a Disperse-on-Warning force.

Last, the same problems of missile size would obtain as for Continuously Dispersed Road Mobile.

Off-Road Mobile MX

Off-Road Mobile would be a system of wheeled, tracked, or ground-effect vehicles capable of travelling over relatively rugged terrain. By dispersing over a large area and following random paths, such a sytem would force the Soviets to barrage the entire deployment area to destroy the missiles. The success of such a barrage attack would be insensitive to Soviet fractionation.

Off-Road Mobile would require a large amount of land for deployment, and the random movement of the large, heavy vehicles would make off-road operation destructive of the deployment area. If the vehicles were 15 psi hard (a quite high value), then a single l-MT RV could destroy every vehicle in a 16-mi2 area about the detonation point. Three thousand RVS could destroy every vehicle in a 48,000-mi^2 area. To guarantee 50-percent survival of an MX force against such an attack, a total deployment area of 96,000 mi^2 would therefore be required. If the vehicles were only 10 psi hard, then 150,000 mi^2 would be needed.

For comparison, the area of the State of Utah is 85,000 mi^2, of Texas 267,000 mi^2, and of Alaska 590,000 mi^2. The total amount of land owned by the Departments of Defense and Energy in the Southwest (including Nellis Bombing and Gunnery Range, Yuma Proving Ground, White Sands Missile Range, and Fort Bliss Military Reservation) is about 17,000 mi^2.

An Off-Road system that did not occupy the entire dispersal area at all times, but flushed from central operating bases on warning, would be vulnerable to surprise attack in the same manner as Disperse-on-Warning Road Mobile. The consequences of false alarm dispersal could be serious if the dispersal area were normally used for peaceful purposes, since the vehicles would be quite destructive of the terrain.

As in the case of Road Mobile, design of vehicles to carry the large MX missile safely over rough terrain would be challenging.

Dash-to-Shelters

A large dispersal area would be required for Off-Road Mobile because the vehicles would be relatively soft targets, of order 10 to 15 psi. The deployment area could be contracted by providing many harder garages or shelters throughout the deployment area. The vehicles would take refuge in the shelters shortly before attacking warheads arrived. Such a system would in fact be a multiple aimpoint system, since the Soviets would target each shelter individually rather than bombard the whole area.

The Dash-to-Shelters concept can be seen as a precursor of the MPS system with PLU such as presently under development by the Air Force. A Dash-to-Shelters system would force the Soviets to target all the shelters, since the missile transporter would not choose which shelter to dash to until it received warning that a Soviet attack was underway. Success of this system would therefore depend upon reliable warning. The same objective of forcing the Soviets to attack each shelter could be attained, and the dependence on warning removed, by emplacing the missiles in the shelters before the attack but concealing which shelter actually received the missile. This approach would of course be the MPS concept with PLU.

Rail Mobile MX

Rail vehicles to carry the large MX missile could probably be built much more easily than large wheeled vehicles. Like road vehicles, the rail cars would be vulnerable to overturning by the strong winds that follow a nuclear blast wave. The hardness of a rail vehicle would therefore be in the region of 10 psi, though lashing down the vehicle might result in greater hardness. A l-MT RV could therefore "sweep clean" some 6 miles of rail.

There are about 200,000 miles of rail *route* in the United States. The length of track is larger, since many routes consist of several parallel tracks. Many of these rail routes are in the vicinity of large population concentrations, so a smaller length of route— perhaps 100,000 miles—would be available to a Rail Mobile MX force. This is more track than could be barraged by any foreseeable Soviet arsenal.

The rail vehicles would have to have right-of-way on the tracks, since their survival would depend on their ability to choose their itineraries randomly. Since most intercity rail routes such as those that would be used for the missile force consist of only one track, they are already quite congested. Trains must be routed into sidings to allow others to pass, and so on. Military commanders would therefore be dependent on civilian rail operators and workers for the day-to-day operations of the force.

Rail Mobile missiles would also be subject to accidents, sabotage, and terrorism.

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