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FORUM

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LETTERS

ATMOSPHERIC THREAT

Richard Williams' Comment (April 1988) was a thought-provoking note about some current activities which might develop into a serious threat to the earth's atmosphere. He refers to a recent patent on equipment designed to deliberately alter a region in the earth's atmosphere, ionosphere, and/or magnetosphere by the use of an extremely high intensity beam of radio waves, reportedly using power levels of billions to hundreds of billions of watts. Among the intended uses identified are to disrupt microwave transmissions of satellites or to cause even total disruption of communications over a very large portion of the earth, weather modification, lifting large regions of the atmosphere, and intercepting incoming missiles. His comment indicates that classified work on this topic is in progress at present.

One point that Williams did not make, which I think is also important and worth making, is that some if not all of the modifications and manipulations of the earth's atmosphere and near-space environment which he refers to as resulting from using this technique would appear to have the potential for leading to violations of the Environmental Modification Convention. This Convention, signed in 1977 and ratified by the United States in 1979, prohibits military or any other hostile use of environmental modification techniques, and states that "Each State Party to this convention undertakes not to engage in military or any other hostile use of environmental modification techniques having widespread, long-lasting, or severe effects as the means of destruction, damage or injury to any other State Party." Both the Convention itself and the accompanying Understandings Regarding the Convention make it explicitly clear that the atmosphere, the ionosphere, and near-earth space are included in the Convention.

Please note that the opinions expressed in this letter are my own and should not be interpreted as representing the position of Argonne National Laboratory.

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LAND-MOBILE MIDGETMAN

Art Hobson (April 1988) presents a very interesting analysis of the survivability of land-mobile Midgetman missiles, particularly in the face of barrage attacks by submarine-launched ballistic missiles (SLBMs) with short flight times.

An attack mode with much less warning time is very likely to arise if a (fully or partially) space-based ballistic missile defense (BMD) system is ever believed to be survivable enough to be deployed. The same space-survivability techniques would then make possible at least equally survivable (and therefore unstoppable) nuclear orbit-to-earth missiles (NOEMs), which could masquerade as nuclear X-ray lasers or space mines.

With only half of their mass expended as fuel, NOEMs (accompanied by decoys) could travel from a 500 km-altitude circular earth-orbit to ground in about 4 minutes with, say, a 15 sec-burn-time vertical rocket exhaust velocity of 3 km/sec. Dash-mobile land missiles would then be particularly vulnerable, even with a low-accuracy NOEM barrage attack, as Hobson's Figure 1 makes clear. But modern guided warheads and navigation satellite positioning systems should make NOEMs accurate enough and flexible enough to also make random-mobile and silo-based land missiles vulnerable to targeted attacks.

NOEMs, which were tested by the Soviets in the 1960s, are banned by the 1967 Outer-Space Treaty. However Gorbachev warned, at the 1985 summit, that all arms control "will be blown to the winds" if a space-based BMD (banned by the ABM treaty) is deployed.

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ARTICLES

A CRITICAL LOOK AT LAND-BASED MISSILES, CONTINUED

This issue of *Physics and Society* concludes a brief preview, begun in the April issue, of some of the work of the Forum Study Group on land-based missiles. Although the study is not yet complete, enough material has accumulated to warrant sharing it with you.

WHITHER LAND-BASED MISSILES?

Paul P. Craig

Nuclear weapons systems capable of penetrating to the heartland of the Soviet Union constitute the cornerstone of United States strategic military strategy. These weapons, emplaced on submarines, aircraft, and intercontinental ballistic missiles, comprise the strategic triad. The structure of the triad has evolved over the four decades of the nuclear era. New technological developments on both sides and changing perceptions of threats have over the years led to continuing changes in the triad. At present concerns over vulnerability of the land based leg, and changes in the Soviet Union under Gorbachev (glasnost) make it appropriate to reexamine the role of this leg. The START negotiations for deep cuts in the strategic arsenals of both sides contribute to the need for a new analysis. This article provides some context.

The strategic arsenals of the US and the Soviet Union differ substantially. The Soviet Union emphasizes land based missiles while the United States places relatively equal emphasis on land, air and sea based missiles. Increasing accuracy is making hardened land based missiles vulnerable, while MIRVing (installing multiple warheads) makes them prime first-strike targets. Plans for modernization should deal with both these issues. Most discussions about the START negotiations focus on reductions of total numbers of warheads. Of at least equal importance is the structuring of forces so as to increase both crisis (short term) and strategic (long term) stability.

Strategic weapons are intended to deter a potential enemy. Under concepts of "rational deterrence" this is accomplished by maintaining a national capability to threaten what the enemy holds dear, even after an enemy attack. The very concept of "rational deterrence" raises numerous questions. Only with a clear concept of what strategic weapons are for one can form thoughtful opinions on their characteristics and numbers.

Within the framework of rational deterrence very different perspectives exist. One focuses exclusively on military capability. In this view the civil economy is irrelevant. This perspective was clearly articulated in a presentation to the Forum Land Based Missile Study in Washington in April, 1987. General May of the Air Force Land Based Missile Command told the Study that "the Soviet value structure does not include (emphasis added) its cities". This view stands in dramatic contrast with the philosophy of the French and British. Their nuclear capabilities are designed explicitly to hold major Soviet cities (especially Moscow) at risk.

Targeting philosophy is frequently discussed by military and political leaders, and by analysts. Regardless of announced philosophy, actual targeting plans are not known to an enemy. Weapons characteristics and numbers are known. Potential enemies know too

that strategic weapons can be launched before they can be destroyed. The technical capability for launch-on-warning (LOW) always exists. An articulated LOW strategy can be mistaken for a policy of first strike, and hence looks aggressive. The incentive to LOW is especially severe in systems which are vulnerable and systems with limited warning times. For the latter systems - and these include all systems which are probable objects for attack by ICBMs and SLBMs - launch policy must be turned over largely to computers - with all the risks attendant thereto.

Attempts to develop nuclear strategies must inevitably address the fundamental fact that we are affected by decisions made by other nations. The extreme difficulties inherent in analysis have led to the concept of the "rational decision maker." The central concept is an unprovable assertion: deterrence will occur if the United States can retain, following a Soviet first strike, enough destructive capability to destroy so much of the Soviet Union that the advantage of the first strike isn't worth what is gained.

In classical theory of war (e.g. that of Clausewitz), war may occur if one side feels that by going to war there will be gains which exceed the losses. The potential gains can be economic, or political (as occurred in the Argentinean invasion of the Falkland Islands). Alternatively, war can occur if a nation feels it is boxed in. Leaders may go to war in order to prevent an even worse disaster. The latter situation (forestalling a worse disaster) is sometimes given as the reason for the Japanese initiation of World War II by bombing Pearl Harbor despite clear statements by military leaders that Japan's military advantage therefrom would be short lived.

Rational decision maker arguments assume that a potential enemy will undertake some sort of rational analysis of options. An enemy who does not operate this way is "irrational," and it is then entirely unclear what forms of deterrence might work. Two major problems of deterrence theory, and of MAD, are: what do we do if we begin to suspect that our adversaries are not "rational," and what are the risks of inadvertent war? In times of crisis mistakes can be made as a result of human error (e.g. due to intelligence failure or fatigue) or to errors in machinery. Machine errors can almost always be traced back to some error in design; hence they too can be blamed on people.

A remarkable amount of discussion of nuclear deterrence philosophy boils down to one's choice of metaphor. The metaphors of World Wars I and II are dominant. World War I is seen as accidental,

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driven by structural instabilities which could be set off by a bit of tender (the Archduke Ferdinand incident at Sarajevo). World War II is seen as intentional. A current example of the force of these two metaphors is found in the lead article in the Fall 1987 issue of Foreign Affairs (1). In an article generally optimistic about nuclear stability Hyland expresses his view that war by inadvertence is currently the primary risk: "The specter of Pearl Harbor has been replaced by the specter of Sarajevo." He views the risk of inadvertent war to be acceptably small. Others - myself included - disagree.

The United States seems to prefer technical solutions. This is illustrated in the era lasting roughly from 1972 to 1983, which was characterized on the US side by introduction of smaller strategic nuclear weapons systems with improved accuracy - hence higher kill capability against hardened targets. Delivery systems were MIRVed. United States emphasis on technology is seen currently in the Strategic Defense Initiative. Historically the Soviet Union has always responded in kind, and the United States technological advantage proved short-lived. Though one can argue that we retain stability by running ever faster, this has a certain "Alive-in-Wonderland" flavor (remember the Red Queen).

The arsenals of the United States and the Soviet Union have evolved both quantitatively and qualitatively over the years. Strategic doctrine about the use of nuclear weapons interacts with and coevolves with what is technologically feasible. It is often meaningless to attempt to distinguish which of the two is the primary driving force.

One way to view the evolution of the US strategic arsenal is in terms of the total megatonnage. This reached a peak of about 19,000 Mt (megatons) in 1959, and has since dropped about 5000 Mt (2). The reduction was predominantly following 1961, due to dismantling the enormous weapons deployed on B36 bombers (3). Later reductions resulted from MIRVing of ICBMs and SLBMs. MIRVing results in an increase in warheads per delivery vehicle, but a reduction in total megatonnage on each vehicle. MIRVing occurred at a time when accuracy was increasing rapidly (4). This permitted a reduction in total megatonnage, with no sacrifice in lethality. The United States arsenal retains the ability to destroy the Soviet Union many times over, even in the aftermath of a Soviet first strike.

By the early 1980s the US and the Soviet Union had roughly the same number of strategic weapons - about 10,000 on each side - though the mix and quality of technologies differed considerably. Recognition of essential parity between the two nations has not come easily to the US. There is pressure to try to remain ahead. This philosophy - which is essentially a psychological argument - was clearly expressed by Richard L. Wagner while he was Assistant to the Secretary of Defense for Atomic Energy:

"What it comes down to in the end is to keep [the Soviets'] image of themselves inferior to their image of us, so that if a crisis comes they will have a gut feeling that they won't measure up against us. It is often said that Soviet leaders are conservative. They are when they feel inferior...Our job is to keep them feeling inferior and thus conservative...I believe that our level of technology in itself, quite apart from exactly how it is built into fielded systems, affects their overall image of themselves and of us, and thus can have a significant deterrent effect...By the 90s we'll need some really new technology to keep the image ratio in our favor. The technology of nuclear explosive design is an important part of our overall technological capability."

For a number of years technological developments on the Sovietside have stimulated concern that the land-based leg of the US

triad is becoming vulnerable. A new missile, the MX or Peacekeeper, was developed. This ten-fold-MIRVed missile was designed to have the accuracy to destroy hardened Soviet land based ICBMs. To meet survivability criteria the missile should be sited so as to be invulnerable to a first strike. But Soviet accuracy continues to improve. Numerous proposals have been made for basing the MX - ranging from deployment in extra hard silos to continual movement among shelters, to location on railroad cars which will be scattered throughout the nation. Survivable basing for the MX has proved elusive. This problem led to the proposal for a mobile missile, Midgetman, which by virtue of its single warhead is a less attractive target, and through its mobility is hard to target.

Survivable systems deter by threatening post-attack retaliation. Four major approaches have been proposed:

Deception. This includes hiding. For example the siting scheme for the MX missile in which a few missiles would be hidden amongst a large number of decoys.

Mobility. By moving missiles around it becomes difficult for the enemy to know where any one is. A strategy of mobility may drastically reduce the need for hardening. Mobility is most obvious with submarines. Many deployment schemes for land-based missiles attempt to make hiding possible on land as well as at sea. The Soviet SS-20 and SS-25 are examples of this strategy. So too are the proposed rail garrison MX and road-based Midgetman.

Hardening. The land-based ICBMs of both the United States and the Soviet Union are defended by being placed in hardened silos. This strategy is plausible until the kill capability (accuracy, primarily) of the enemy weaponry increases sufficiently, at which point the hardening no longer provides protection. Such capability has almost been attained on both sides.

Active Defense. (e.g. ABM systems and point defense components of SDI systems). The Soviet Union has long maintained a large air defense system covering the entire nation, and an ABM missile defense in the Moscow area (as permitted by the ABM treaty). The United States has abjured both approaches. Reexamination of the future of the land based leg of the strategic triad should include the possibility of terminal defense.

Survivability cannot be considered in terms of a single leg of the triad alone. The legs of the US Strategic Triad act synergistically. For example, if Soviet ICBMs are fired at the US land based ICBM fleet, it is possible that many of our ICBMs will be lost. However, the tactical warning (up to 30 minutes or so) provides ample time for our bomber fleet to become airborne. As the number and accuracy of off-shore Soviet submarines increases this type of symbiosis will work less well.

An important argument for a triad is based on technological and military change. By having several strategic systems relying on quite different technologies, it is likely that we will never be so surprised by new developments that we lose so much deterrent capability as to be vulnerable to threats. This line of reasoning also underlies the US practice of having at least two different warheads for each leg of the triad.

The vulnerability of the Minuteman silo basing mode for the MX stems from the observation that a first strike would require only two Soviet warheads (the second is to make sure of success in case of a miss by the first) to destroy the 10 warheads in the MIRVed MX (see the April 6, 1983 Report to the President of the Scowcroft Commission).

In contrast to the United States triad, the Soviet strategic system emphasizes primarily land based ICBMs. This Soviet strategy is

viewed by some United States analysts as unfortunate. According to this view we would like the Soviet Union ICBM fleet to be as invulnerable as our own. The recent Soviet moves toward mobile land based missiles (the SS-24 and SS-25) are thus seen as stabilizing. These systems can hide on land in much the way that submarines hide at sea.

The present START negotiations and the ferment over the future of the land based leg of the US strategic nuclear arsenal make the next few years especially important. Decisions will be made which may affect fundamentally the nature of our national defense. They may also determine the feasibility of future arms reductions. The issues are complex and involve military, technical, political, economic, social and perceptual issues.

Deep cuts by themselves could prove destabilizing. Imagine, for example, that both the United States and the Soviet Union reduce their strategic arsenals to only a hundred or so warheads located on highly MIRVed delivery vehicles. The incentive for a first strike would surely be increased. In addition, the arsenals would be comparable to those of France and Britain, and hence the world would no longer be in a mode of bilateral balance.

Today every issue is ripe for reexamination. Some are relatively narrow: Do we even need a Triad? Might not cruise missiles take over the role now played by ICBMs? Should we abandon MIRVing? Should we encourage or discourage mobile ICBMs? Others are

more fundamental: Is it possible that the Soviet Union is changing so much that we may soon no longer need massive arsenals? How do we balance the risk of war against the risk of accident?

The next few years will see renewed examination of all these issues. This is a fascinating period. For the first time in decades conditions appear ripe for major change in our nuclear policy.

REFERENCES AND NOTES

1. William Hyland, "Reagan-Gorbachev III", *Foreign Affairs*, Fall 1987, pp. 7-21.
2. There are numerous ways of expressing the arsenal sizes. Total megatons as used here, and equivalent megatons (EMT) are common. The EMT of an individual warhead is defined as the megatonnage to the two-thirds power. EMT is a measure of the area of destruction produced by the weapon.
3. Many of the enormous warheads used during this period were mothballed. One of these, the 9 Mt B53 bomb deployed at one time on B-52 aircraft is the largest weapon in the US arsenal. In mid-1987 the B53 warheads are again being returned to the US stockpile.
4. The ability of a given weapons system to destroy a hardened target varies as the yield divided by the accuracy cubed. Hence a factor of two increase in accuracy permits an eight-fold reduction in yield for the same kill probability.

THE MX RAIL-GARRISON BASING SYSTEM

Peter D. Zimmerman

The MX program was intended to give the United States the ability to hold the hardest Soviet targets at risk, and to provide a highly survivable land-based strategic ballistic missile to replace the silo-bound Minuteman III. Early plans called for the missile to be deployed in a "race track" system with multiple protective shelters (MX-MPS), the missile being moved periodically from shelter to shelter. With "luck" and very good mimicking of the missile's signatures, the Soviet forces would not know which shelter was occupied, and so would have to shot at least two warheads at each one. Twenty shelters were contemplated for each missile.

The MX-MPS system foundered for several reasons. It was opposed by environmentalists, arms controllers, and those concerned about the size of the budget for strategic offensive arms. The MPS system occupied too much land, required the land to be used only by the Air Force, might have had serious effects on the water supply in generally arid regions, was extremely expensive per surviving warhead, and gave the appearance of being a first-strike weapon because of its lack of manifest survivability (1). A major study conducted by the Congressional Office of Technology Assessment (2) failed to identify any other basing schemes with the requisite manifest survivability which also incorporated the robust communications possible for land-based systems. That study did examine rail-mobile missiles, but with the unstated assumption that such missiles would be on the rails at all times. According to the

OTA, rail-mobile missiles were survivable at any foreseeable level of the Soviet arsenal, but in peacetime would contribute to traffic congestion on the rail system and would be vulnerable to accidents, sabotage and terrorism.

Congress allowed the Air Force to deploy the first fifty MX missiles in silos as direct replacements for Minuteman III missiles, but insisted that no further missiles would be procured until a survivable basing mode was developed. The rail garrison MX program was produced in response to that challenge.

The rail garrison deployment system envisions 25 trains, each with a complement of two MX missiles, each train being permanently stationed on existing Strategic Air Command bases. Between 7 and 17 SAC bases would receive the missile trains. According to Air Force figures, three hours after a decision to sortie from garrison was made, the system could not be barraged by the current Soviet SS-18 inventory assuming a yield of about 500 Kt (kilotons) per warhead. Four hours after sortie, the force would be safe against even the largest projected increases in the SS-18 force. These figures assume a 50-80 km/h speed for the trains and minimal start-up time (possible since the trains will use diesel locomotives) from "track alert" status (3). It is assumed that the first bifurcation in the

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available track occurs where the spur from the garrison meets the main line, a distance of not over 15 km from base. From that point on track is generated at least twice as fast as the train moves since there is at least a two-fold ambiguity as to the course of the train.

The Air Force safety figures for the rail-garrison system are arrived at by assuming that the readily achievable hardness of a loaded rail car is 5 p.s.i. (4,5) and that a single 500 Kt warhead, exploded at optimum altitude, can produce at least a 5 p.s.i. overpressure along a 7 km length of track. Each SS-18 could possibly have a war loading of 12 re-entry vehicles. This is two in excess of the SALT II limit. However, SS-18s which executed 10 real and two additional simulated releases of RVs have been tested. Assuming that the Soviet Union has confined its deployments to the ten warhead SALT II limit reduces the length of track which can be barraged by a single missile. All forms of a Strategic Arms Reduction Treaty (START Treaty) now under consideration would, in fact, cut the SS-18 force roughly in half while permitting the deployment of at least 100 MX missiles.

It is possible that the Air Force figures are, for once, unduly conservative. Trains are significantly harder against explosions either in front of or behind them — up to 90 p.s.i. for explosions where the blast wave strikes the locomotive. If the correct criterion is a blast with a 5 p.s.i. component perpendicular to the track, the length which can be destroyed by a single missile is greatly reduced.

Nevertheless, it is clear that several hours need to be available in order to assure the safety of the entire rail-mobile system. When the survivability of a weapons system depends on warning time, the enemy would be encouraged to strike soon rather than wait. It might perceive the vulnerable missiles to be either allocated to a first strike or operating in a launch-under attack mode. The President can defuse the situation by ordering the trains to sortie from their garrison. The President might be reluctant to give this order for fear of raising tensions in a delicate situation. On the other hand, it could be viewed as a reassuring step. Missiles which are unlocatable and "untargetable" can be considered part of a secure second-strike reserve. Furthermore, because of the vibration and dislocation involved in moving a missile on the rails, it is probable that the guidance system of a rail-mobile missile will be less accurate for several hours after a major movement than would be the same system housed in a silo. This could add to a general perception that scrambling the trains was a purely defensive and stabilizing gesture.

Some argue that rail-mobile missiles complicate the verification of arms control agreements. These points are raised: rail-mobile missiles can roam all over the country, be hidden in tunnels and buildings, or be concealed in trains that resemble civilian trains. But rail-mobile missiles are just that — confined to the railroad net. Rail lines are easily recognized features when seen in satellite photography, even at the 10 meter resolution provided by the French SPOT 1 satellite. The Soviet rail net is particularly easy to inspect, since it is a skeleton whose back bone is formed by the trans-Siberian and BAM rail lines stretching across 7 time zones, but which has few ribs running perpendicular to the spine. Trains on tracks are identifiable in high-resolution imagery, but such pictures necessarily cover only fairly narrow angles of view. Hence, they cannot be used effectively to search for trains which have been ordered to sortie from garrison. Furthermore, the missile train could not be distinguished from any other train from a satellite photo.

Trains cannot be hidden for long periods in tunnels; concealing a missile there would block an entire rail line, and construction of

special tunnels would be observed. Trains cannot circulate at random, but must follow schedules — particularly on a single-track main line such as the Trans-Siberian — since trains in opposite directions can only meet where sidings exist. Rails rarely enter buildings; they stop at loading docks.

Finally, the facilities at which missiles are mated to rail cars will be very distinctive, easily recognized in satellite photography. Relatively straightforward analysis based on imagery of such a facility can provide good estimates of its maximum through-put, and hence an upper limit to the number of deployed rail-mobile missiles. The number of such facilities in each country can readily be made a part of any future arms limitation or reduction agreements.

Since the signing of the INF Treaty in December 1987, it is clear that verification does not have to be conducted solely by national technical means (NTM), in effect from satellites. Co-operative means of inspection and verification will shortly become the rule in strategic arms control agreements. Under such a regime, portal-perimeter monitoring of the rail-missile integration facilities could provide a highly accurate count of the number of missiles deployed on the rails.

Public acceptance of rail mobile missiles would not be forthcoming if such a deployment meant that nuclear-armed missiles would be intermingled with ordinary rail traffic in ordinary times. The *garrison* feature of rail garrison MX directly addresses that problem. Despite Pentagon models of American rail-mobile MX missiles concealed in ordinary box cars, moving in ordinary freight trains, such a deployment is unlikely. The National Command Authority is unlikely to give the order for the trains to sortie except under conditions of DefCon 1 or DefCon 2 when the United States anticipates that a nuclear attack is imminent; such an increase in the state of alert is apt to occur several hours before a premeditated attack occurs. While the garrison facilities are usually shown as simple structures, they can be built as "horizontal silos". One source estimates a hardness of 2000 p.s.i. for such structures, giving garrisoned trains a reasonable chance of survival. The garrison could be designed to permit missiles to be fired after an attack.

Rail garrison mobile ICBMs, generically, provide a nearly indestructible deterrent force because they can "generate trackage" in which the location of the train becomes uncertain so rapidly that they cannot be barraged. The track itself, together with the fiber-optics communications systems which parallel most of the U.S. rail network, virtually guarantee communications even under the conditions of a nuclear attack. The personnel costs of rail garrison missiles are low compared to those for truck mobile systems. Railroad equipment is vastly cheaper than, for example, any proposed version of a hardened mobile launcher. On the used market diesel locomotives can be bought for a few hundred thousand dollars or less; new they are in the one to two million dollar price range. No 35-100 psi hard HML is competitive with the costs of the rail equipment needed to transport a missile. For MIRVed rail-mobile systems, garrison basing is very nearly as cheap, per warhead, as present silos.

But the rail mobile system, by itself, does not address the problem of vulnerability in case of a "bolt out of the blue," or "Pearl Harbor" attack. Under those circumstances, many missiles in garrison will probably be destroyed. Although nuclear bolts out of the blue seem improbable, rail mobility might need to be complemented by other basing modes — such as superhard silos or truck-mobile smaller