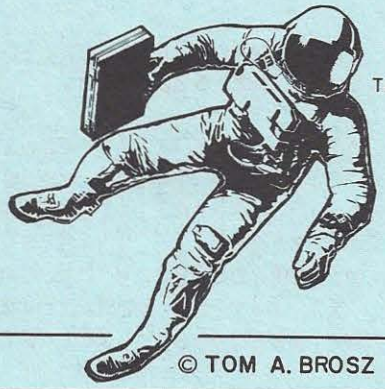
THE
COMMERCIAL SPACE REPORT

PUBLISHED MONTHLY



Dear Subscriber: August, 1982

Last month a concept called "Thor" was introduced in the Report, featuring a method of utilizing a non-nuclear orbiting weapons system for attacking surface targets. This month, the Report presents a detailed technical and operational description of this new factor in the potential military uses of space. The information is taken from a paper entitled, "Thor: One Approach To Global Force Projection" by Gary C. Hudson. I will have some comments afterwards.

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The Thor Weapon System. "Thor" is a versatile orbital weapon system which projects military force to virtually any place on the globe without the use of nuclear energy. The Thor system destroys its intended target by means of the kinetic energy in a moderately heavy, dense projectile which, released from an orbiting satellite, is guided to a target on the surface of the earth while continuing to move at near-orbital velocities. By shaping the projectile to have a minimum cross-section, Thor rounds can penetrate the atmosphere to strike land, air and naval targets with deadly speed and pinpoint accuracy (circular error probabilities of 10-20 feet). Thor projectiles could also be employed against hostile satellites and for ballistic missile intercepts during boost phase, using the same basic tactics as the Global Ballistic Missile Defense arm of the High Frontier system.

A sufficient number of projectiles, possibly tens of thousands, in specially selected orbits, could launch one or more projectiles to any point on the earth's surface at a few minute's notice.

The Thor Projectile. The major objective, considering the large number of projectiles in a complete system, is to keep costs low. For guidance, the approach which seems to be the most economical is to use a "beamriding" projectile. In this approach, the projectile is guided to the target by means of a simple, rearward-looking sensor mounted on aft portion of the round. This sensor is in contact with a laser beam from an orbiting targeting satellite, which uses the beam to send guidance information to the projectile. (The laser would be of a frequency that will penetrate clouds, such as the blue-green low-power space communication laser systems presently under development.)

Many types of complex (and expensive) sensors are required for the location and tracking of many varied kinds of target. If these target acquisition sensors were placed on the projectile itself, creating a "smart" round, these costly devices would be destroyed with each projectile. The "beamrider" approach places these sensors out of harm's way on board the targeting satellite, where they can be re-

used, allowing the exploitation of these more complicated sensors with a minimum of expense.

All that is required on board the projectile for guidance purposes is the laser sensor, and enough electronics to translate the targeting satellite's instructions concerning the nature and location of its target. This suggests that the total avionics of each projectile might be very uncomplicated and inexpensive. With VLSI technology, it may be possible to make a single chip with the optical sensor and the processor for steering and fusing commands.

Propulsion systems must also be incorporated into the projectile. The Thor round is deployed from an orbiting projectile satellite. Initial analysis suggests that each projectile should have its own rocket motor capable of imparting to the projectile a delta-vee ranging from a few thousand to as much as 10,000 feet per second, depending on the orbit from which it starts. Steering may be accomplished by an off-axis, high thrust rocket engine integrated into the afterbody of the vehicle. A single rocket motor will suffice because the projectile is given a high spin rate at deorbit.

Upon reaching the target, the kinetic energy must be utilized for the maximum destructive effect. For many targets, this would require fragmentation of the round. One method of doing this is to fill the core of the projectile with a small amount of chemical high explosives. At a selected time, this core may be detonated, fragmenting the projectile. Based on the time of fragmentation, a pattern of expanding fragments will spread out over an increasing diameter. The nature of the target would indicate the exact method and timing of the fragmentation. For certain targets, the core might not be detonated at all. This would leave the projectile as an intact rod, which would be designed to pierce harder targets. Different attack strategies will be discussed later in this article.

As for the material of the projectile itself, it seems at first that the denser the material the better the performance. This suggests the use of materials such as tungsten or depleted uranium. However, keeping cost of material and availability in mind, it may be that ordinary steel might prove adequate.

A typical projectile design is shown below in FIGURE 1.

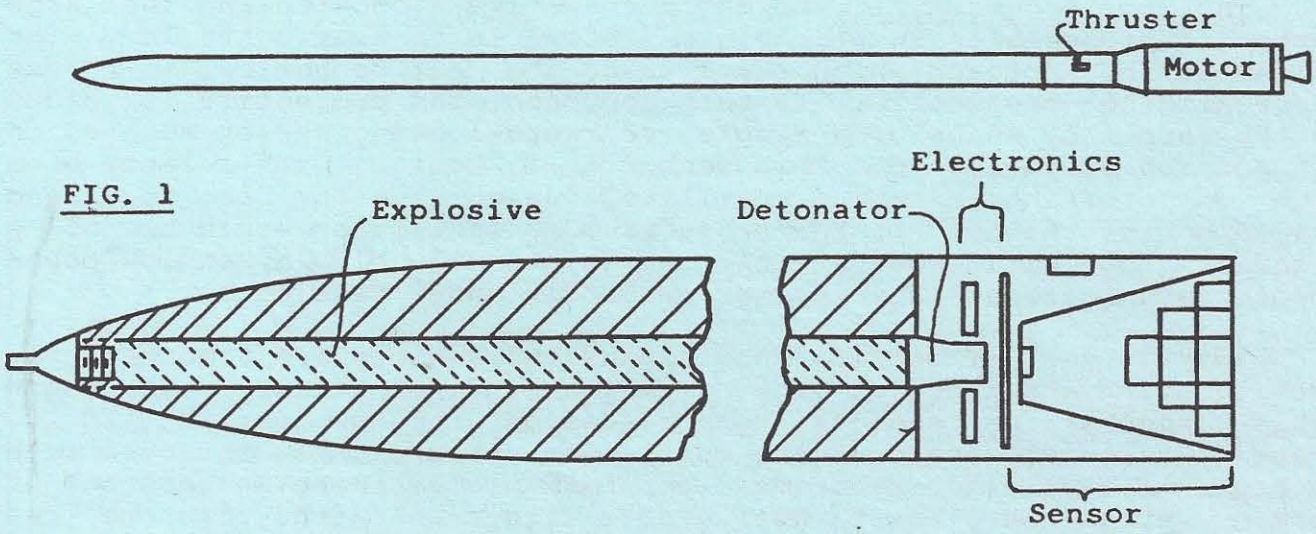

FIG. 1

The Thor Satellite System. A typical Thor system makes use of projectile satellites to store and launch projectiles, and targeting satellites, to acquire, identify and illuminate targets. (It is assumed here that they are separate systems, although it may be possible to combine these functions into a single type of satellite.)

The Thor projectile satellites are quite simple, consisting of a structure to hold the projectiles and a navigation/communications capability to determine the satellite position and to communicate with the Thor targeting satellite. Either 3-axis stabilization or spin stabilization may be used, but in the latter case the launching process of the projectile might be more complex. Potentially, thousands of Thor projectile satellites might be launched into low earth orbits of varying altitudes and inclinations.

The Thor targeting satellites contain the complex sensors required to locate the relevant targets and plan the engagement scenario. It is expected that these sensors could include SAR (Synthetic Aperture Radar), IR detectors, and possibly mm (millimeter) wave sensors. Additionally, some form of LIDAR (Laser Radar) might prove useful along with optical tracking in visible wavelengths. Much work is presently going into many types of sophisticated sensors for just such purposes, and no doubt the results of current research efforts will find a place on the Thor spacecraft.

Thor targeting spacecraft might be relatively few in number for an initial system for land or sea conflict, but would have to increase to several hundred spacecraft if the system is to be used as a ballistic missile defense. Anywhere from dozens to hundreds of targeting satellites might be emplaced in low orbits. Some special classes of targeting spacecraft may require geosynchronous locations.

Placement On Orbit. The Thor system requires fairly large masses to be launched into many different orbits. A full system might require 10,000 tons of projectile and targeting satellites. As mentioned before, the numbers of satellites might be in the thousands. For example, a full system might require over 300 shuttle launches.

However, Thor is operational as soon as even one Thor projectile satellite and one Thor targeting satellite are on station. Only a few shuttle launches (or even one) would get the system started. This incremental nature is another factor which enhances the economic and operational features of Thor as compared to many other proposed or existing military systems.

Sample Attack Scenarios. Several engagement scenarios will be briefly explored, beginning with the simplest and proceeding to the most challenging.

Naval. The Thor system could incapacitate a battle fleet in minutes. Surface ships are large radar targets, easily spotted from space, and a single Thor projectile has close to the explosive energy equivalent of the now-infamous French Exocet missile. Only a few thousand Thor rounds, guided by a few targeting satellites, would destroy even the largest surface fleet. Non-fragmenting projectiles, striking as intact rods, would probably be most effective against heavily armored ships.

A diagram of a naval engagement is shown in FIGURE 2 (next page).

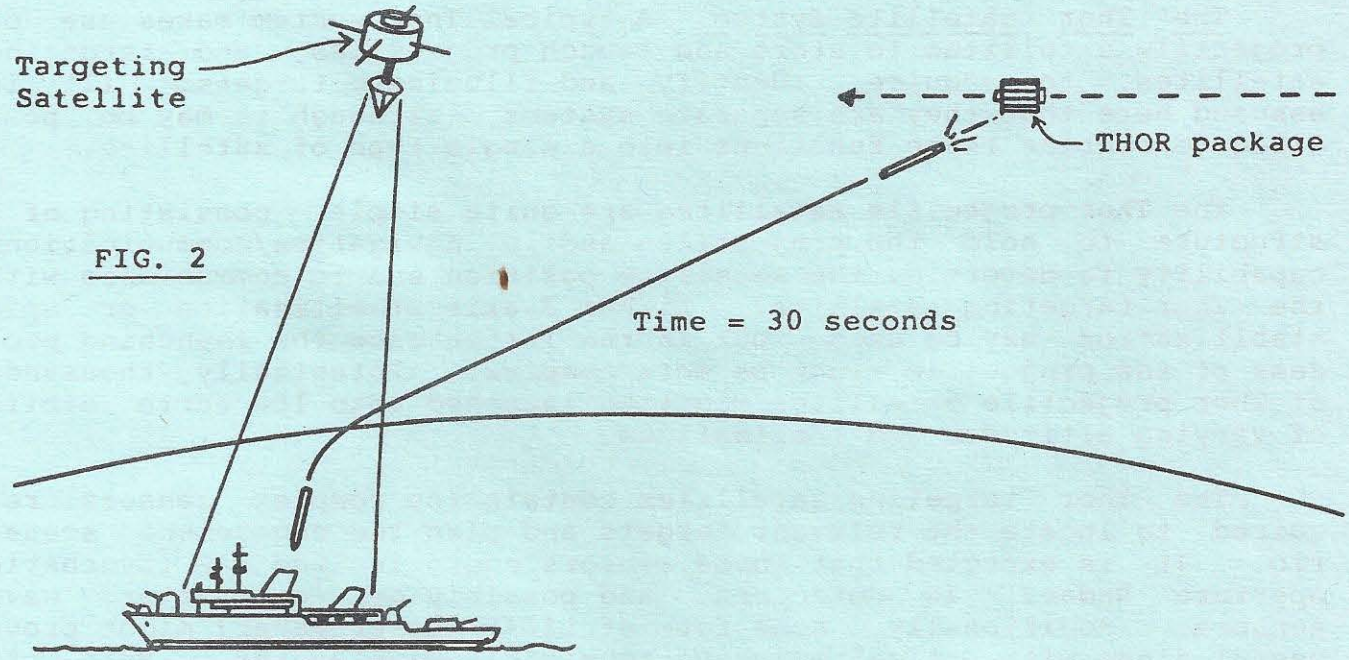

FIG. 2

Area and Precision Land Attack. If massive bombardment of an area is required, Thor can be guided with much less accuracy, using widely fragmented rounds, provided the targets are relatively "soft". Against hard targets and some mobile armor, it is probably best to use intact rods. These rods should be able to penetrate very heavily reinforced structures (i.e. missile silos) with devastating effect.

Air Superiority. If airborne targets can be acquired with radar or IR sensors and continuously tracked, then they are vulnerable to Thor. A Thor projectile would be fragmented at a distance of a few hundred yards from the aircraft, yielding hundreds of fragments spread over a few hundreds of square yards. The combination of the aircraft's own speed and the rapidly moving Thor fragments should create a high probability of a kill. This probability can be enhanced by committing several Thor projectiles to each target.

Antisatellite/Ballistic Missile Defense. As with the air superiority engagement, Thor projectiles committed to either antisatellite or ballistic missile defense roles will have to be fragmented some distance from their targets. This distance is a function of the velocity of the target, its maneuverability, its "hardness", and the pointing and tracking accuracy of the Thor targeting satellite. If necessary, entire missile approach corridors can be rendered lethal by salvo attacks of Thor rounds. It might not be unreasonable to dedicate 100 Thor rounds to each ICBM threat, or to blanket missile fields near the surface of earth with thousands of Thor fragmentation rounds at the first sign of massive missile attack. Since Thor does not carry a sophisticated sensor, but rather a simple beamrider, it is much cheaper than any target it is attacking, thus many Thor rounds may be economically used to effect a certain kill.

Countermeasures. The primary means to defeat Thor would be an attack at command facilities on earth or targeting/relay satellites in space. If both were proliferated, and hardened against nuclear burst, this type of attack would fail. A DARPA study indicated that a laser battle station could be hardened against 1 megaton at 20 km. (See Aviation Week, June 14, 1982, p. 27)

Civilian Applications. The existence of many Thor targeting satellites brings up a unique opportunity for military/civilian dual-use spacecraft. These satellites, equipped with 3-axis stabilization, power processing, clocks, computers and sensors on board, each in communication with each other via in-space laser optical links, could be utilized in peacetime for non-military, commercial functions. Global navigation, geodesy, remote sensing, data collection and mobile communications are but some of the areas where both the civil and military sectors would benefit. It is even possible that the civil revenues could pay for deployment of the Thor system.

* * *

Editorial Commentary: The concept of Thor, as mentioned earlier, is highly similar to the first generation Global Ballistic Missile Defense that forms a critical part of the High Frontier concept, except that the GBMD did not have earth surface attacks as one of its missions. Nevertheless, it seems to me that neither system can be constructed without creating most of the technological groundwork for the other. If you build one, you assume the capabilities of both can easily be made available. This should be considered carefully when proposals for either system are weighed, in light of the following.

Thor is similar in strategic terms to designs for orbiting beam weapon systems. Neither utilize nuclear warheads, and both are so precise as to preclude being considered "weapons of mass destruction". However, Thor presents a new view of space weaponry, which differs from existing beam weapon concepts in a number of important ways.

First, the technology involved is far simpler. Thor is based on technology which is almost "off-the-shelf", with most of the groundwork having been done with surface missile technologies. Beam weaponry is often considered to be a twenty-first century, long-range factor in the balance of power, not to be taken too seriously. Thor is possible now, and at a relatively low cost.

Second, and most important, unlike most existing beam weapon concepts which are effective only in space or at high altitudes, a complete Thor system is capable of attacking, almost without warning, targets anywhere on the earth's surface within minutes of being commanded to do so. Thor is not only a strategic system, for antimissile use, but a tactical system as well. The attack is basically as conventional as an artillery barrage, without the use of nuclear warheads. It is generally considered that a full scale nuclear war would probably be triggered by the first use of a nuclear weapon. Thor does not fall into this category, but operates as a "legitimate" tool of war, no different from tanks and artillery in its effect, tanks and artillery which are being used almost constantly in battles taking place around the globe at this very moment.

The critical difference between Thor and standard weapons lies in the deployment time required. Unlike Rapid Deployment Forces, tank columns, planes or fleets, the deployment time of Thor ranges from a few hours for a prototype system, to minutes for a complete system.

The existence of a complete Thor system is the tactical equivalent of having an invisible tank gun within firing range of every conceivable target on land and sea, waiting for the command to attack. Borders become meaningless, and the arms race may very well be ended.

It is instructive to imagine the impact of such a system on present and recent political situations such as the Falklands crisis, the Mideast situation, and last but not least, the defense of Europe, where at present, due to overwhelming odds, NATO forces may be forced to defend against conventional weapons with nuclear warheads.

Thor has been presented as a highly effective weapon with a wide variety of military applications. It has been assumed in this article that control of Thor would be in the hands of benevolent people, with peace and self-defense as their goal. Like any weapon, however, Thor could be used for conquest. With the global reach of an ICBM, but without the restraint of the suicidal, all-embracing consequences of the ICBM's nuclear warhead, Thor makes a tempting device for the initiation of force. Hitherto, the nuclear bomb has normally been considered to be the "ultimate weapon". In point of fact, a true ultimate weapon would not be a weapon of total destruction, but rather a weapon of total control, preferably with minimal destruction. A system such as Thor, which can project instantaneous, massive force against a pinpoint target, could easily be placed into this category. It could be a "terror weapon", similar to but orders of magnitude more effective than the V-1 and V-2 during WW II. Ask anyone who lived in London at that time what the psychological effect was of destruction falling from the sky without warning. Even "blank rounds", projectiles set to harmlessly destroy themselves with a brilliant flash far above the target, may be sufficient to convince an unnerved populace to capitulate. That this would be a powerful influence on enemy nations is obvious, but it cannot entirely escape one's notice that Thor has a frightening potential for civil control as well. It would certainly be much more effective than rolling tanks through the streets to keep a population in line.

It is this capability--unmatched by any other weapons system--to control an entire globe rather than simply destroying it, that makes Thor one of the sharpest of all two-edged swords. This is not to say that Thor should not be built. In the right hands, it might become a force for peace without parallel in its effectiveness. It could also become an equally effective force for domination. In this, it is like any other weapon, only more so, and to which use it will be put depends solely on whose fist will grasp the handle of the hammer of Thor.

Until next time,

Tom A. Brosz

THE COMMERCIAL SPACE REPORT™

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