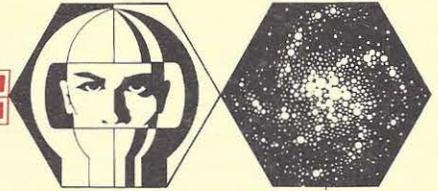


# COMMERCIAL SPACE REPORT



## MILITARY APPLICATIONS OF ADVANCED SPACESHIPS

### Conceptual Systems May End Balance of Terror While Opening Space Frontier

by Gary C. Hudson

#### The Present State of Affairs

Today the strategic security of the United States is insured by a policy of Mutual Assured Destruction (MAD) enforced by a triad of nuclear armed offensive forces. While this nuclear umbrella also covers certain of our allies, we additionally rely upon conventional tactical forces to insure the territorial integrity of Western Europe and other areas of the globe.

Neither the strategic nor conventional force structures are fixed by natural law: they must change and adapt to new threats as well as to the opportunity to lessen tensions where that goal can be seen to be in the best interests of the nation. Already flaws can be seen in both force structures. First, our triad is rapidly becoming a diad or

or less. As our land-based Minuteman II and IIIs and Titans come under the threat of the new generations of Soviet ICBMs, and as the Soviet capability to prevent penetration of our manned bombers into their airspace increases, the only effective nuclear force will become the SLBM fleet. The only way to insure that the land and air nuclear forces are effective is to embark upon costly new programs to upgrade to the MX, provide an ABM force (later if not sooner), and/or a new penetrating bomber, probably armed with ALSCMs. If we fail to counter the threat to one or two arms of the triad, we could well be maneuvered into the position where we cannot respond to a Soviet counterforce strike without using the lower accuracy SLBMs against population centers,

#### Editor's Note

With this article, the *Report* begins the first of three parts on the military applications of space. This first issue covers the new concept of Kinetic Energy Weapons as a replacement for the present Balance of Terror which grips our world. (The idea was first suggested by science fiction author Robert A. Heinlein in *The Moon is a Harsh Mistress*.) A second issue this summer will discuss other technical questions involving space and military uses. A final fall issue will look at the implications for business and space commerce.

No doubt much of what is said and reported here will upset some of our readers who wish space to remain an inviolable sanctuary for peaceful uses.

In reality, space is already militarized, and it can be argued that this has improved the chances for peace on earth, rather than lessened them. The intent of this first article is to show that space offers a way by which we can retain our strategic strength while at the same time replacing nuclear weapons with ones that have far fewer side effects. Read it in that spirit.

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*"There has been a great deal said about a 3,000 mile high-angle rocket. In my opinion such a thing is impossible for many years. The people who have been writing these things annoy me . . . have been talking about a . . . rocket shot from one continent to another, carrying an atomic bomb and so directed as to be a precise weapon which would land on a certain target, such as a city.*

*I say, technically, I don't think that anyone in the world knows how to do such a thing, and I feel confident that it will not be done for a very long period of time to come . . . I think we can leave that out of our thinking. I wish the American people would leave that out of their thinking."*

—Dr. Vannevar Bush,  
December 3, 1945

*"Space travel is utter bilge."*

—Dr. Richard van der Riet Woolley,  
Astronomer Royal, 1956

which would no doubt force a wider and more total nuclear conflict.

One potential option to provide protection of our land based forces and at the same time give us a general defensive capability against attack has been suggested. It is the space-based laser (or particle beam) weapon. Besides providing a powerful ABM system, the laser weapons would also have tactical advantages at least equal to the strategic uses.

Another suggestion, is that the triad weapons, or more properly, their equivalent energy yields, be moved off-planet and into deep space. Advanced propulsion systems capable of delivering velocities of as much as a million feet per second (fps) can make such a plan both economical as well as practical.

### Kinetic Energy Weapons

Nuclear devices are by their very nature weapons of mass destruction which have more than localized destructive effects. The reason for the great public fear (and policy problems) relating to use of nuclear energies in weapons is not so much the nature of the powerful blast and heat effects of the bomb, but rather the widespread and lingering radioactive materials release which accompanies detonation. Additionally, for many strategic applications the blast effects of nuclear weapons are not ideal from a military point of view, but since there are practical limits on bomb sizing it is generally not feasible to use very small weapons against

equivalent nuclear device. Such kinetic "bombs" could replace the existing nuclear inventory, while at the same time remaining out of reach of enemy counterforce strikes by virtue of the fact that the bomb carriers must remain in deep space to provide them room to accelerate. From this it follows that the carriers could not easily be used as a first-strike weapon since it requires several hours for them to reach "release bombs" velocity, during which time they could be observed from earth or other spacecraft. They thus have the advantages of a manned bomber. They also add the advantages of SLBM submarines, the latter because an enemy would have trouble locating the quiescent deepspace bombers when they were not underway, and because the weapons cannot be stopped by any present technology.

To allow the deployment of kinetic energy weapons, advanced propulsion systems are required which would provide the rocket power necessary to accelerate the weapons carriers.

### Advanced Propulsion Systems

We define an advanced propulsion system to be one that has both high thrust and high specific impulse (Isp). High thrust means thrust/weight ratios greater than 5:1 and high specific impulse means impulses exceeding 2500 seconds. The combination of these parameters leads to the

variants: the diluted antimatter annihilation engine and the antimatter energized boron-proton fusion engine. We will discuss each of these concepts in the following paragraphs.

• *The Gas Core Fission Engine.* The gas core engine was conceived to overcome the thermal limits imposed by metal engine structure on propellant heating. Translated into Isp, such limits fall in the range of 800 to 1200 seconds. In a gas core engine, primary energy transfer from fissioning fuel is effected through radiation, rather than conduction. Upper limits on Isp (perhaps 10,000 seconds) are enforced by the transparency of the candidate propellants and by the approximately 10% waste heat (in the form of gamma and x-rays) which the engine produces.

Both NASA and the Air Force have in the past sponsored research into the gas core engine for both propulsion and prime power missions, however no working reactor-engine has yet been built. Serious material problems have been primarily responsible for the slow progress in this field, and work has all but stopped. Yet much of the difficulty with the concept is due to the lack of a specific mission requirement, which has led to underfunding of the effort. It should be noted that there are several ideas of a practical nature which will minimize or obviate the materials problems, and no doubt if we required the performance of a gas core engine in the next several years, one could be built. Further, while it would be desirable to have an engine which could be integrated

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most targets. If we could find a way of concentrating the energy release of a nuclear device into a package about the same size, yet without the attendant radiation problems associated with nuclear weapons, we would move a long way from the balance of terror which today influences our strategic planning. Further, if high energy weapons could be made in almost any size, with appropriate targeting accuracies, the use of such devices could be more readily considered in theater operations.

Such a possible weapon exists. It has been given the name "Kinetic Energy Weapon". It uses nuclear power (in the form of fuel for rocket engines) to efficiently accelerate masses of high density (to minimize observable radar cross-section). Consideration of the relation of energy and momentum ( $E=0.5mv^2$ ) leads to the realization that masses traveling at high velocity can yield energy releases in thermal form that equal nuclear weapons. For example, a one metric ton body moving at one million fps has the kinetic energy of about a 10 kiloton TNT

observation that such engines would have high power levels (measured in thousands of MW) and would be capable of running for thousands or tens of thousands of seconds continuously.

No operational rocket engine has such performance parameters at this time. While chemical engines can reach very high T/W ratios and high power levels (the Saturn V has a total 40,000 MW in the first stage), they are unable to maintain the energy release for periods beyond a few minutes. Ion or MHD engines which are capable of Isp's of several thousands of seconds have T/W's of 0.001 or less. Neither type of engine is remotely suitable for the application we have in mind.

Three types of conceptual engines are possible candidates for what we call "The Solar System Spaceship" and the application discussed in this paper using kinetic energy bombs. They are: 1) the gas core fission engine, 2) the hybrid pulsed fission/fusion engine, and 3) the antimatter energized engine. The latter engine has two

into an operational spacecraft which could boost from the surface of earth to escape, such is not an absolute requirement. Early gas core engines could still power deepspace bombers which would be first carried into earth orbit by the Space Shuttle. Such a system may be simpler to develop from the point of view of "engineering credibility" than a direct earth launch system. Obviously, other types of engines could also be deployed from the Shuttle, rather than launched on their own.

• *The Hybrid Pulsed Fission-Fusion Engine.* This concept, originated by Foundation Inc. and independently (in another context) by F. Winterberg, uses a combination of both fission and fusion fuels in conjunction with electron or ion beam pellet implosion technology. With e-beams which are state-of-the-art, it should be possible to achieve a pellet hybrid that will produce a number of fusion neutrons (but less than breakeven) which will help start of fission reaction in a plutonium or U-235 core which has been compressed to about 250 times normal den-

sity. By employing multiple layers of alternating fission and fusion fuels, it may be possible to bootstrap a total nuclear reaction from a pellet a few millimeters in diameter into a yield of several thousands of MJ (on the order of 1-10 tons of TNT equivalent). Initial calculations seem to suggest that e-beams on the order of a few MJ would be adequate to begin the reaction. (Recent work on soft x-ray compression techniques suggest the beam energy may be lowered by an order of magnitude or more.) The energy from the nuclear event is used directly, or in combination with a propellant of low molecular weight (water is a good possibility). The most economical engine concept seems to be a miniature version of the "Orion" fission bomb engine concept of the early 1960's. The blast wave from the event strikes a "pusher plate", compressing a "momentum conditioner" which imparts a constant acceleration to the vehicle.

Variations on this basic engine concept are possible, but in most cases it seems that either chemical or airbreather engines are needed for initial boost phase, so that the vehicle is above the large part of the sensible atmosphere at nuclear engine ignition. Again this engine could be lofted into space on-board the Shuttle.

From open literature analysis of the technology, it appears that the USSR may be using the hybrid fission-fusion burn concept at the facility in Central Asia (Semipalitinsk, PNUIS). According to published accounts in *Aviation Week & Space Technology*, a US satellite designated KH-11 has reported

• *The Antimatter Energized Engine.* As mentioned earlier, this class of engine has two distinct types: diluted antimatter annihilation and antimatter-energized boron-proton fusion.

*Antimatter Annihilation Engine.* Several early studies of the use of antimatter for rocket propulsion (generally interstellar flight) have been conducted. For the most part, these studies have concluded that use of antimatter is impractical for three reasons: we can't make it, we can't store it, and we can't handle the reaction products, which are assumed to be gamma rays. All three conclusions are false. While a present day linear accelerator (for example, SLAC) would require  $10^8$  years to manufacture one kilogram of antimatter at present production rates, there are at least three ways of reducing the time needed. Besides upgrading colliding proton beam facilities, antimatter breeders may be possible, as pointed out by a researcher at the Lawrence Livermore Laboratory. An outgrowth of ion beam fusion studies, these breeders would produce up to a gram per year at power levels of 3 GW. Even more interesting is another proposal that a large (500 GW) laser could produce up to a kilogram a day. It would seem that inroads to the manufacture problem are already being made.

Following a JPL-funded study, work at Livermore has concluded that antimatter can be stored successfully in a reasonably hard vacuum against accelerations of 100 g. They have also studied the annihilation phenomena of antihydrogen, and have

mediate term engine which can provide nearly the same performance as the annihilation concept, but with much lower antimatter requirements.

*Antimatter Energized Boron-11/Proton Fusion Engine.* This concept uses the energy released from a small antimatter/matter annihilation event to trigger the fusion of an "advanced" fusion fuel: boron-11 and a proton. If about 1000 MJ of energy (less than  $10^5$  gms of antihydrogen) could be concentrated for a short period of time at the center of a boron-hydride pellet, the light elements should begin to fuse. By proper control of the density and hydrodynamic history of the target, very large yields of charged particles should be produced from the thermonuclear fission of the boron. This concept would then use a pusher plate and momentum conditioner similar to the hybrid fission-fusion engine, with the exception that the pusher plate might be modified to include a magnetic cusp which could be used to reflect the charged particles. The primary advantage to this scheme is the small amount of antihydrogen which would be necessary to fuel the deepspace fleet for its primary mission.

All advanced engine concepts presently under study at Foundation, Inc. have the advantage of being roughly interchangeable. This means that early gas core engines could be replaced by antimatter energized engines in a retrofit program at some later date, should this prove technically desirable. In this respect, the advanced engines are similar to the interchangeability of turbojet

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detection of tritium, xenon and krypton in the upper atmosphere from this site. If this is the case, pure fusion detonations would not account for the presence of the fission fragments noted. It should be pointed out that pure fission detonations would not be suitable for the engine of an deepspace bomber, since the average power level of the engine would be very low, and the T/W far less than 1. Fission fuel is needed to increase the yield of the pellet burn to make a rocket engine perform such a mission.

Our reading of the state of affairs in the inertial confinement fusion and directed energy weapons community leads to the belief that this engine would actually be as easy to develop as the gas core system mentioned earlier. At the very least, research into this possibly should be considered, both for the propulsion aspects as well as to determine feasibility of the USSR conducting similar experiments and as a miniature nuclear device source for weapons effects testing, in anticipation of a new test ban treaty.

reached the conclusion that either a pure or diluted annihilation engine can be conceived with present-day knowledge. Rather than producing high energy photons directly, the annihilation event first generates three to five pions. The reaction is directly controllable through the use of magnetic fields and not as difficult to handle as was previously believed. One interpretation of this work also suggests that the annihilation event, if it occurs outside the engine (i.e., in the fuel tank), would not be as catastrophic as the mass-energy equations suggest.

Thus it appears that there is scientific evidence for the consideration of annihilation engines. If operated in a diluted mode (say at 1000:1 or 100:1 matter/antimatter flow rates), such engines would be matched very well to the velocity requirements for deepspace bombers, while at the same time being compact, versatile and relatively low-cost. They could also be operated in an atmosphere or as stationary power plants. If the low-cost production of antihydrogen is delayed, however, there is a possible inter-

and turbofan engines.

### **The Deepspace Bomber and National Security**

With so many types of advanced propulsion systems to choose from, it appears that within the foreseeable future one of them will be integrated into an operational solar system spaceship. While this action will have profound implications for space commerce, and thus for space industrialization, it will also mean that any spaceship, even if it were built to be a freighter, can serve as a weapon once it leaves near earth orbit.

In this respect, the solar system spaceship and its engines are similar to another proposed space system: precision laser weaponry. Both may be used for commercial purposes; the spaceship for transportation and the laser (assuming it is sun-pumped) for power generation on earth, as well as several other innovative service roles. However, both have important defense implications. The lasers would provide an ideal

defensive system which could be used to turn back assaults of both strategic as well as conventional forces, while the spaceship can be used to deploy the lasers, service them, and provide mobile platforms for laser fire near the earth by serving as relays for the laser beam. Finally, the spaceship, in its role as a deepspace bomber using kinetic energy weapons, stands as the ultimate response of the nation to surprise attack.

A marriage between the two systems suggests the development of a diad force structure, balanced between offense and defense, rather than relying upon our present triad offensive structure. The advantages of this should be obvious. Policy and decision makers would no longer be faced with the awful prospect of having to initiate either major conventional operations or limited nuclear war in order to respond to an aggressor's challenge. The radiation effects of nuclear combat would be eliminated.

Transition to such a diad would be relatively straightforward. The first step seems to be deployment of a initial laser system, followed by the first generation of advanced spaceships. A slow phaseout of ground based nuclear weapons can then be begun. By the first two decades of the next century the need for strategic or tactical nuclear devices on earth will be minimal, possibly non-existent. The pressure upon other members of the nuclear club to phase-out their weapons would become tremendous, since they would be put in a very bad light should they continue to plan nuclear "retaliation" with their arsenals. Indeed, the only way that they could probably justify continued manufacture or reliance upon such devices would be if they announced their intention to use them in a first strike (since such weapons would no doubt be a prime target for the kinetic bombs, which themselves could not be used as a first strike weapon).

The deepspace bomber has more than the simple application of strategic bombing. With the use of orbital laser target designation, no doubt the ship could be used for tactical bombardment, should high power lasers not be able to fulfill this role for some reason. Additionally, the ships could be mobile surveillance and battle management platforms while operating near earth. Finally, the spaceships have the delta-v capability to transport troops to any part of the globe within an hour (without refueling at either

terminus), limiting the need for expensive and difficult to maintain overseas military bases. Solar system spaceships simplify logistics both on earth and in space.

### Directions for Study

The dual purpose role of the advanced propulsion system discussed here should suggest the possibility of some sort of joint effort between the defense establishment and the private sector with regard to engine development. (The same might be said of precision space laser weaponry, and the suggestion is hereby advanced.) This project promises to be nearly unique in defense history . . . a weapons system which can have commercial possibilities. (The 717/707 Boeing aircraft comes to mind, or the wide-body cruise missile carrier.) Such a dual function should be investigated.

The technology for the advanced propulsion system also needs a great deal of effort. Near term studies should focus on conceptual possibilities and engineering questions. In fact, it may be possible in the immediate future to test some of the concepts in a laboratory mode, using existing electron beam (or maybe laser) facilities at the national laboratories. Such work should be very inexpensive, relative to the potential gains, and should be undertaken immediately. Analysis of the past advanced propulsion

work should also be done in more detail, especially a review of the still partly classified ORION work at General Atomic.

System trade studies relating the type of advanced engine and the potential mission also need to be done in more detail. Given a "rubber" engine concepts from the technology review proposed above, engineers can determine models for the deepspace bomber, and begin to make trade studies as to whether ground launch or Space Shuttle deployment is best, for example.

Finally, studies of policy use of the system should be undertaken. If the bomber proves technically feasible, it still faces the challenge of economical and political feasibility. Alternatives should be investigated, including use of kinetic weapons of much lower velocity, launched by stationary nuclear-driven gas guns on the lunar surface, as an example.

In closing, it must be stressed that it is inevitable that advanced engine systems will be used in space. When they are, the entire matter of strategic balance must perforce be reevaluated. Considering the pace of technological progress in the US and abroad plus the number of times that we have been surprised in the past, now is an ideal and appropriate time to begin such a reevaluation. □

### GLOSSARY

|                  |   |
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| DELTA-V          | Change in Velocity  |
| SLBM             | Sea Launched Ballistic Missile  |
| MJ               | MegaJoules—1MJ for 1 sec = 1MW  |
| SLAC             | Stanford Linear Accelerator   |
| ALSCM            | Air Launched Supersonic Cruise Missile  |
| COUNTERFORCE     | Attacking Enemy Missiles vs. Civilian Targets   |
| SPECIFIC IMPULSE | A Measure of Engine Fuel Use Effectiveness—(an Isp of 2500 means 2500 lbs of thrust can be obtained from one lb of fuel per second) |
| MW, GW           | Megawatts, Gigawatts  |

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# NEWS NOTES:

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**OTRAG EXPELLED FROM ZAIRE...**Belgium...According to UPI and published accounts by the London Daily Telegraph, the OTRAG company of Germany has been expelled from its launching facility in Zaire. The announcement, made by the ambassador for Zaire to Belgium, is believed to be aimed at placating Zaire's neighbors, including Angola (from which one of the recent rebel invasions of Shaba province was staged). A government spokesman in Kinshasa stated that the decision to abrogate the contract was made unilaterally by President Mobuto. No explanation was given. Only three launch tests were ever conducted at the OTRAG site, which covered nearly 100,000 square kilometers. The disposition of OTRAG assets within Zaire is unknown at the present time, as is the fate of OTRAG subsidiary companies in Zaire involved in quarrying, bridge building and other construction related activities. Exactly what effect the ouster will have on the company is also uncertain, but it may turn out that, if OTRAG can weather the immediate financial storm, the forced move away from Zaire will prove to be the best thing that could have ever happened to it.

**L.A. SPACE EXPO CANCELLED...**We have been informed that the planned L.A. Space Expo, scheduled for the weekend of the 10th anniversary of the first moon landing, has been cancelled due to organizing problems.

**SHUTTLE WOES...**Washington...As the Enterprise and the rest of its launch stack prepares to move to Pad 39 at the Kennedy Space Center for tests, word comes that the apparent earliest that the first Orbital Flight Test can be attempted will probably be about May, 1980. According to NASA sources the problem is no longer with the main engines but rather involves the thermal protection tiles which are necessary as a heat shield for the Orbiter during atmosphere reentry. The pace of installing tiles has been much slower than anticipated, leading to a present rate of 40 tiles per week (about 20 square feet). Additionally, during the ferry flight to KSC, permanent tiles were damaged by exposure to ice crystals. Earlier, the damage to tiles was mainly confined to "fake" tiles used to make a smooth aerodynamic flight configuration for the 747-Orbiter pair.

**PLANETOID MINING...**Alaska...An economic study done by Farmers Loop Interplanetary, a space study company based in Alaska, shows that planetoid mining should be profitable. According to the study, the materials to be mined are not rare materials but rather iron, aluminum, chromium, nickel, cobalt and other commonly used metals of our industrial economy. The Space Shuttle would provide initial transportation to orbit, then various techniques now available on a small scale would be used on a large scale to transport mining equipment to the asteroid belt. Finally, the products would be transported back to earth. According to the study, the overall profitability should range from 8% to 19%. Address questions to FLI, Box 82037, College, AK 99708.

**NASA XT RESOURCES CONCERN...**Washington...Though they aren't talking about it, NASA officials are known to be concerned that the final report of General Dynamic's study on the use of extraterrestrial resources vs. earth

resources for space solar power manufacturing will be too optimistic in favor of XT resources. The study, which focuses on lunar materials, is thought by industry insiders to have been contracted for to put an end to the idea of XT resources by an unfavorable finding. However, it now appears that it will have the opposite effect.

**SPACE PROCESSING HARDWARE...**Huntsville, AL...The NASA Commercial Processing in Space Task Team has published a preliminary handbook which lists the various items of space qualified hardware which can be used for materials processing experimentation in space. The catalog provides information on the apparatus which could be used for conducting small scale materials processing experiments using research rockets, the KC-135 aircraft, or the Space Shuttle. For a copy of the catalog contact: "Commercial Materials Processing in Space", Code LA/41, ATTN: W.A. Vardaman, MSFC, Alabama 35812, Phone (205) 453-4880.

**REACH FOR THE STARS...**Houston...A one-hour documentary on space futures was aired April 24 during prime time in the Houston local TV region. Produced by Public Works, Inc., a Houston-based TV production company with the assistance of Art Dula, a Houston attorney active in space affairs, the show was very favorably received according to opinions solicited from area viewers. A local large Houston bank financed the presentation, and national sponsors are being solicited for a nation-wide telecast.

**ISI IN OPERATION...**International Satellite Industries, an investment company organized by Christian Basler (an attorney) has reportedly received a go-ahead to sell stock from the SEC in Washington. At press time we have been informed that New York State has also given approval, but that the State of California is presently balking. Among the members of the board of directors of ISI are Phil Chapman (A.D.Little), Keith Henson (L5 Society), and Ed Stearns (Lockheed). A preliminary prospectus is under development. The aim of ISI is to use investment proceeds to begin to develop the SPS concept, including space settlement activities.