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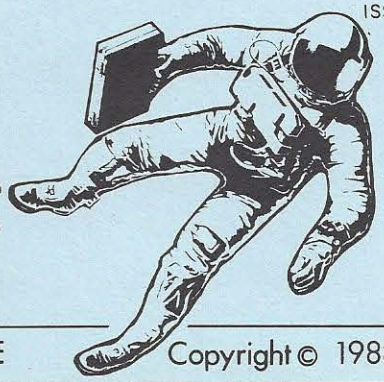

A MONTHLY NEWSLETTER ON FREE ENTERPRISE IN SPACE

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Major Aerospace Companies Sweep DARPA Lightsat Contracts

On May 4, the Defense Advanced Research Projects Agency (DARPA) finally announced the winners of its "Lightsat" launch vehicle study contract competition. The DARPA Lightsat program received a great deal of publicity in the space industry last year as a search for new and innovative methods of producing and operating low-cost launch vehicles and satellites (*C.S.R.*, Nov. 1987).

Four $300,000 cost-plus-fixed fee contracts were awarded to: Lockheed Missiles and Space Co. of Sunnyvale, Ca.; TRW Space and Technology Group of Redondo Beach, Ca.; LTV Aerospace and Defense Co. of Dallas, Tex.; and Space Services, Inc. (SSI) of Houston, Tex. Although no official list was released, DARPA stated that nine companies had submitted bids.

The four companies will have until August 5 to submit their final study results, and, in August, one of the four will be selected for further Lightsat launcher development contracts.

The results surprised and disappointed many who had been following the competition closely. Of the four contracts, three were awarded to major aerospace companies, while only one was awarded to a new, entrepreneurial launch vehicle company, Space Services (of the five bidding companies that did not receive contracts, at least three fall into this latter category: the American Rocket Company [AMROC], E-Prime, and Pacific American Launch Systems [PacAm]).

Another surprise was all four contract winners' choice of solid propellant motors for their proposed launch vehicle designs. Solid propellants are currently the most expensive method of rocket propulsion, and it had been understood that launch costs would be a major factor in DARPA's selection of the winners.

Some general technical information on the vehicle concepts submitted by the four companies is available (of course, since these companies are still in competition, detailed designs are not forthcoming). TRW, teamed with Space Data of Tempe, Az., may be developing a three-staged solid-fueled vehicle using Hercules motors. Lockheed is investigating launch vehicle designs based on the company's Trident D-5 submarine-launched missile, currently under development. LTV wants to build a completely new version of its Scout expendable launch vehicle (the current Scout boosters do not have sufficient payload capacity). SSI will most likely submit a configuration based on its Conestoga designs, which will use the Castor 5, a new solid-fueled motor to be developed by Morton-Thiokol.

Whoever wins the final development contract, launch prices for these solid-fueled vehicles will be high, ranging from $10 to $20 million for a payload of about 1,500 lbs. into low earth orbit. DARPA ignored the much less expensive liquid-fueled and hybrid launch systems proposed by PacAm and AMROC, respectively. This is particularly disappointing to small, non-military payload customers who had hoped that the DARPA program would help facilitate the development of small, affordable launch vehicles.

DARPA has not released any information on the reasons for its selections, and speculation is not much help.

Why solid propellant rockets exclusively? As mentioned earlier, launch costs were not as important to DARPA as was thought, but could there have been other reasons for selecting solids despite the additional expense?

From an operational standpoint, solid propellant systems have traditionally been considered more reliable, easier to store, and ready to launch on short notice.

However, in light of recent experience, these assumptions seem to rest on shaky ground. After the *Challenger* disaster, the Titan 34D explosion in 1986, the misfire of three sounding rockets at Wallops Island due to a lightning strike, and three Minuteman test flight failures in the past two years due to motor malfunctions, the reliability record of solids is not all that it might be. The safe storability of solids is also questionable--a Pershing 2 missile exploded in Europe due to static electricity buildup on the case. More importantly, some solid-fueled motors in long-term storage have demonstrated serious flaws, such as propellant debonding and/or cracking. The aforementioned Minuteman test failures, all in vehicles drawn from the existing strategic missile force, are thought to be due to such flaws. Solid fueled rockets can be launched at a moment's notice, but so can liquid-fueled rockets using storable propellants, and there are even proven procedures which allow liquid and hybrid vehicles using low-cost cryogenic propellants to be launched no less rapidly.

In failing to spread the study contracts among a number of different propulsion technologies, DARPA missed a good bet. Now that all the eggs are in the solid propellant basket, DARPA is likely to find that the basket has a large hole in it due to recent events--but more on this later in this issue.

While DARPA made its decisions, the Lightsat program came under attack by Air Force Secretary Edward Aldridge Jr. Aldridge says that the economic advantages of small satellites launched by small boosters are outweighed by the operational advantages of large, more complex satellites launched by the Shuttle or larger expendable launch vehicles. These larger satellites, says Aldridge, have features such as extended operational lifetimes, greater reliability, real-time transmission, resistance to electronic or physical interference, and other attributes not available on Lightsats.

Lightsat proponents claim that Aldridge is representing the interests of Air Force factions associated with existing military reconnaissance satellite programs. These programs are heavily classified on many levels, and funded as "black" programs. This means that the funding levels and project details are not subject to the public scrutiny that other types of programs must deal with.

Reportedly, these "black" spy satellite programs have been supremely lucrative for aerospace corporations which are contracted to develop and build these spacecraft. Certain such satellites have been rumored to cost as much as a billion dollars each. This is another example of a technology which is essential for national security--military reconnaissance spacecraft--ending up grossly overpriced and inefficient. It is not surprising that the beneficiaries of such programs find the concept of low-cost military satellites threatening.

There is more to it than economics--the controversy is also based on a conflict of interest between strategic and tactical missions for reconnaissance satellites. Strategic applications include detection of launch activity, surveillance of Soviet facilities and operations, and verification of arms control treaties. Tactical applications include supplying targeting information for tactical weapons, weather data, rapid communications relays, and similar functions.

The existing military reconnaissance satellite organizations are tightly classified--so much so that even their names, such as the National Reconnaissance Office, are

not officially acknowledged. Access by tactical commands to the capabilities under the control of these organizations is tightly restricted. It is easy to see why tactical commanders chafe under these restrictions, and why Lightsats are attractive to these commanders, who see them as a possible means for acquiring valuable tactical information quickly, and under the direct control of the commander. It is less easy to see why the current secret hierarchy of reconnaissance satellites is adopting a "dog-in-the-manger" attitude against Lightsats, restricting access to their satellites yet preventing low-cost alternatives from being developed. Unfortunately, such senseless battling over the proper "turf" that different agencies will occupy is all too common within the Defense Department. It is feared that the Lightsat may become a casualty of such a battle.

It is worth noting in this context that Aldridge--unofficially of course--is reported to be head of the National Reconnaissance Office.

Orbital Sciences Developing Small Launch Vehicle

DARPA has issued a letter of intent to Orbital Sciences Corp. (OSC) to develop a small military launch vehicle to be air-launched from a B-52, according to an article in the May 29th issue of the *New York Times*. The proposed vehicle would be part of the DARPA Lightsat effort. OSC, based in Fairfax, Va., is better known as the developer of the Transfer Orbit Stage (TOS), which is designed to propel payloads in low earth orbit to higher orbits or onto planetary trajectories.

OSC's air launched vehicle, called Pegasus, is a three-stage, solid-fueled rocket, about 50 feet long, 4 feet in diameter, and weighing about 40,500 lbs (see illustration on page 4). It would be dropped from beneath the wing of a modified B-52 bomber, at an altitude of about 40,000 feet (current test plans call for the use of an existing B-52 which was previously modified to launch the X-15 experimental rocket plane). The first stage of the Pegasus, which is outfitted with wings, would then ignite, and the vehicle would start out along a horizontal trajectory. As the first stage burns out, and the upper stages fire, the vehicle would climb into orbit (see illustration on page 5). Payload capacity would be about 600 lbs. into a 250-nautical-mile polar orbit.

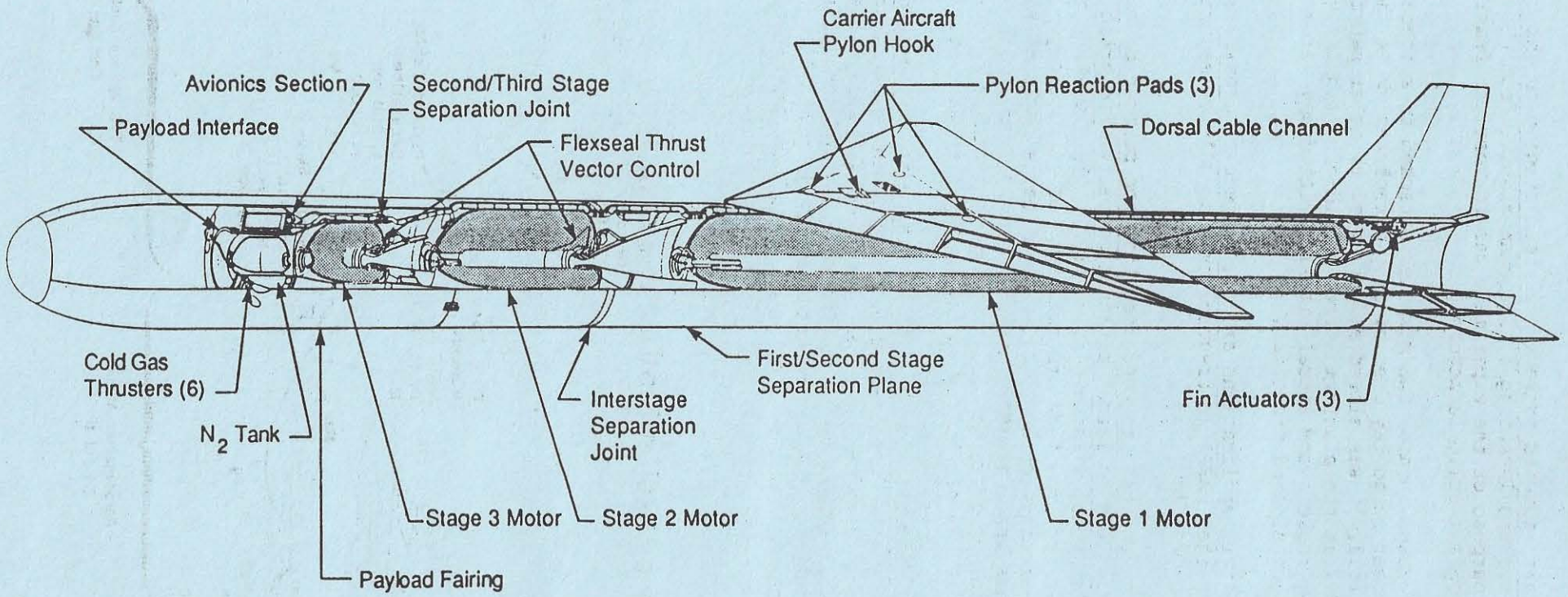
DARPA's letter of intent calls for the agency to buy one test rocket, with an option for five more. OSC's price for one vehicle would be about $6 million--considerably lower than projected prices for the four launch systems proposed for DARPA's Lightsat program. The first launch is scheduled for June of 1989.

The Pegasus has been in development since early 1987, as part of a joint venture between OSC and the Hercules Aerospace Co. Both companies are investing private funds to develop and test the system. OSC is responsible for systems engineering, hardware integration and operation, while Hercules is responsible for design, qualification, and production of the three new solid rocket motors used in the Pegasus vehicle.

OSC gives several reasons for launching Pegasus from an aircraft rather than from the ground. Some are technical: lower atmospheric pressure at launch altitude results in decreased drag, and increased specific impulse from the first-stage rocket motor. In addition, the wing-generated lift during the horizontal boost helps reduce gravity losses. Other reasons are operational: OSC states that launching from a airborne platform increases the flexibility of the system, allowing flights into a wide variety of orbital inclinations from a greater number of locations than are normally available to ground-launched vehicles.

The mobility of an air-launched vehicle has many advantages for military users. According to some planners in the Pentagon, air-launched systems are less vulnerable to attack than ground-based systems, and could be ideal for quickly lofting Lightsat-type small tactical reconnaissance satellites (other military planners say that ground-based launch systems, such as the Lightsat launchers, can be built to be survivable and flexible with less trouble).

PEGASUS Cutaway Drawing



Military air-launched rockets have been studied in the past. One such study, in August, 1984, involved launching a Minuteman missile from the cargo bay of a C-5 cargo airplane. The purpose of the experiment was to test the feasibility of using aircraft as mobile strategic missile launchers.

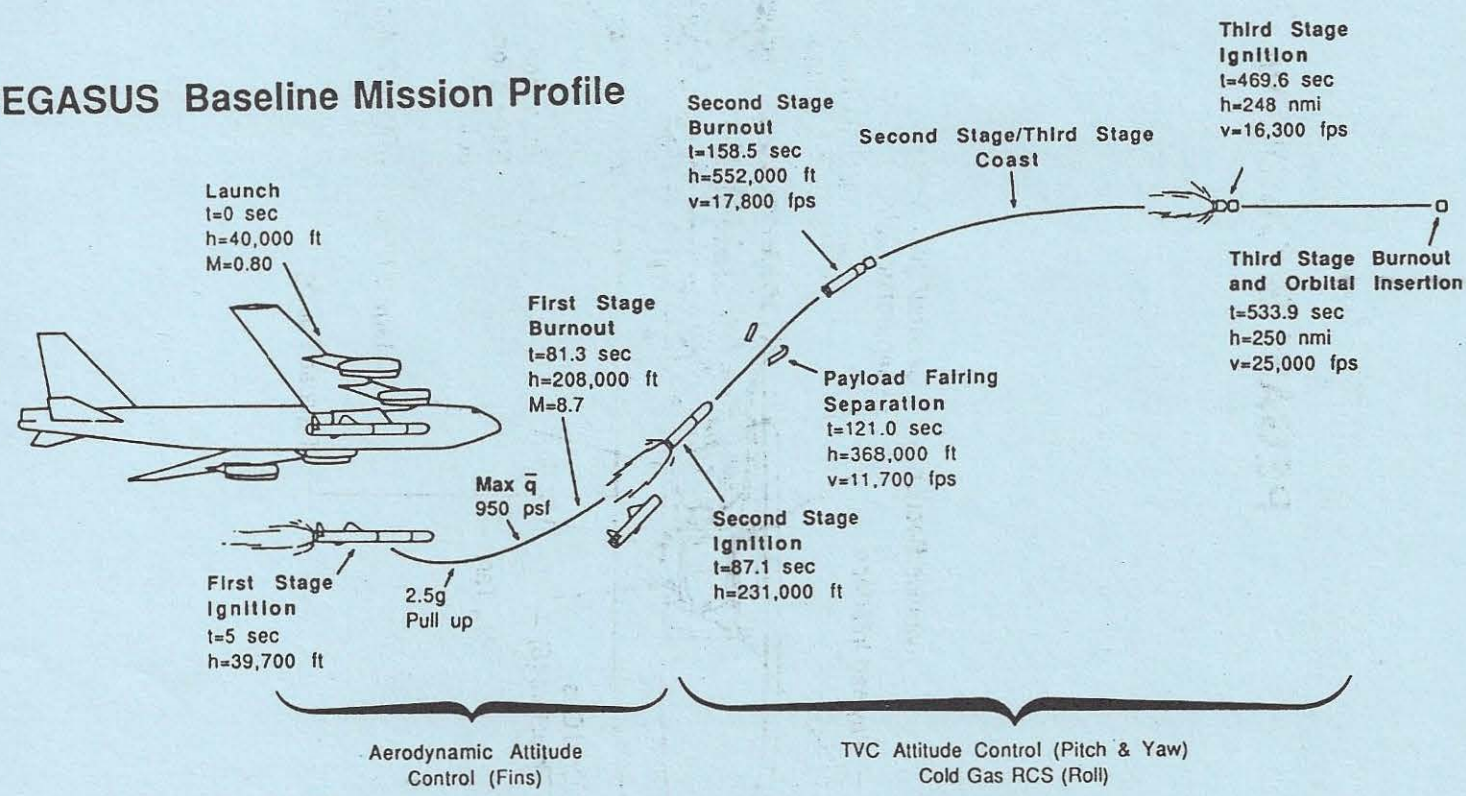
During the experiments, the missile, attached to a special platform, was pulled from the open rear cargo bay door by drag parachutes while the airplane flew on. As the platform fell, it was slowed and oriented by other parachutes. The missile was then separated from the platform, fired in mid-air, and launched upward. While tests with both dummy rockets and actual missiles with dummy warheads were successful, the concept was not considered practical.

OSC's military applications are the subject of considerable flak in Washington, despite the fact that DARPA is treating this as only an experimental project and not a full development program.

Some in the Congress are concerned that the purpose of an air-launched vehicle is to enable the military to launch payloads secretly into orbit during peacetime. A 1976 United Nations convention, signed by the U.S., the Soviet Union, and most other space-faring nations, requires that orbital launches be publicly registered. A rocket carried aboard an aircraft could be flown from remote parts of the world away from Soviet detection systems which monitor launches from regular launch sites. Although the Pentagon has given no indication that this is what such a system would be used for, some have said that such a capability would be useful in wartime.

Others in Congress fear that the Pentagon is trying to develop an anti-satellite weapon on the sly (the Congress has been continuously blocking the development of anti-satellite weapons, despite a real military need for such systems). Pentagon officials say that there are easier and more effective ways of accomplishing such a mission than using the type of air-launched rocket that OSC is proposing. In any case, Congress has asked space experts from the Congressional Research Service to look into the situation.

PEGASUS Baseline Mission Profile



In contrast to the military uses, the advantages of an air-launched vehicle for commercial missions seem limited at best. Although the proposed launch price is competitive, there seems to be no compelling reason to carry commercial payloads on an air-launched rocket instead of one launched from the ground. A wide range of orbital inclinations--air launching's main feature--is certainly useful, but can be achieved by ground-based multi-staged systems simply by selecting the proper launch site. An island, for example. Unlike Cape Canaveral or Vandenberg, many existing space launch facilities offer easy access to polar, low-inclination, or even equatorial orbits from the same site. One of the largest and best-known of these is the Kourou Space Center in French Guiana, where the Ariane rockets are launched, but there are others as well.

* * *

Propellant Plant Explosion Threatens U.S. Solid-Fueled Rocket Capability

On May 4, a series of violent explosions destroyed a plant which manufactured nearly half of the U.S. supply of a critical ingredient used in solid rocket propellants. A fire, followed by several explosions, completely obliterated the Pacific Engineering and Production Co. plant near Henderson, Nevada. Two people were killed, and over 300 others injured. Serious damage was done to nearby structures, and to the town of Henderson, located about two miles away. Total damages are estimated at about $74 million. The cause of the fire is still under investigation.

The plant manufactured ammonium perchlorate, a primary ingredient of solid rocket propellants. Ammonium perchlorate, or AP for short, acts as the oxidizer for solid-fueled rockets, and comprises about 70% of the propellant mix by weight in typical formulations. While normally considered safe to handle, AP is capable of detonation under the proper conditions.

Pacific Engineering and Production produced about half of the total supply of AP for the U.S. The Henderson plant was planning to produce 20 million lbs. of AP in 1988 (the plant had a total production capacity of 30 million lbs.) It is estimated that it will take up to three years to rebuild and qualify a new plant.

Almost all of the rest of the U.S. AP supply is produced only two miles from the Pacific Engineering plant site at the Kerr-McGee Chemical Corp. plant, located near the city limits of Henderson (this juxtaposition of the only two producers of a strategic material is not as bizarre as it seems--the Hoover Dam power generation facility is nearby, and AP production apparently requires a lot of energy). The Kerr-McGee plant sustained minor damage from the explosion, but was able to restart production soon after the accident with little fuss. However, the local community was not about to let Kerr-McGee go on making AP without some questions being answered.

Under pressure from the inhabitants of Henderson, the Kerr-McGee plant was shut down on May 12 pending safety reviews. The town's nervousness is understandable--Henderson suffered considerable damage from the Pacific Engineering explosion, and the Kerr-McGee plant is two miles closer to the town. Safety inspectors and others are checking the plant out, and Kerr-McGee hopes to be back in production sometime in June. Kerr-McGee was planning to produce 32 million lbs. of AP in 1988, out of a capacity of 36 million. It is likely now that the actual production will be somewhat smaller.

The Pacific Engineering disaster and Kerr-McGee shutdown will result in a serious shortage of solid propellants for U.S. launch vehicles. Launchers which currently use solid rocket motors include the U.S. Space Shuttle, and expendable launch vehicles (ELVs) such as the commercial Titan 34D, the Air Force Titan 4, and the Delta (the only operational U.S. ELV that does not use solids is the Atlas-Centaur).

The Shuttle solid rocket boosters consume 1.7 million lbs. of AP per mission. Morton Thiokol, builder of the Shuttle boosters, has enough AP on hand from Pacific Engineering for four flight sets of the Shuttle boosters, and has ordered AP for a

fifth set from Kerr-McGee. The current Shuttle flight schedule calls for two missions in 1988, and nine in 1989. An AP shortage could put a serious crimp in this schedule.

Pacific Engineering was the only qualified supplier of AP for the Titan 4 program, the only U.S. ELV with a payload capacity comparable to the Shuttle. The Titan 4's huge solid boosters consume nearly as much AP as do the Shuttle's. Enough AP was delivered before the accident to fuel three Titan 4 launches. Pacific Engineering was the only qualified supplier because there are small differences in the structure and purity of the AP produced by Pacific Engineering and Kerr-McGee. These differences, although minor, can still affect solid-fueled motor performance sufficiently so that AP from the two facilities is not completely interchangeable. Needless to say, this will make recovery from the shortage even more complicated.

There are also many other rockets and missiles that are not normally used as orbital launch vehicles, but that also use solid propellants. These include strategic nuclear missiles, various orbital transfer stages, anti-tank missiles, missiles for ships and aircraft, and artillery rockets (these last are a major military consumer of AP--75,000 are built per year, using about 13 million lbs. of AP). Manufacturers of all of these systems are going to feel the pinch.

An ironic point: all the Lightsat launch vehicle designs selected by DARPA for further study use solid-fueled motors, as was discussed in the earlier article.

To handle the shortage, the government has activated the Defense Priorities and Allocations System. Current estimates show AP supplies exhausted by 1990 if nothing is done. Government planners will analyze long-term defense and civilian requirements and decide how best to allocate the scarce oxidizer if alternative sources can't be found. Several courses of action are under consideration. One option might be drawing on foreign suppliers of AP in Europe and Japan, which produce propellants for their own programs. This could help, although the total capacity of these other nations is less than that of either of the two U.S. plants. Other options include providing government assistance to rapidly rebuild U.S. capacity.

It remains to be seen how all the various solid-fueled launch vehicle programs will fare in the coming months. Kerr-McGee will eventually return to full production, when safety concerns have been addressed. Pacific Engineering will rebuild its plant (wisely, the new plant will be located some 35 miles away from the current site in an uninhabited area).

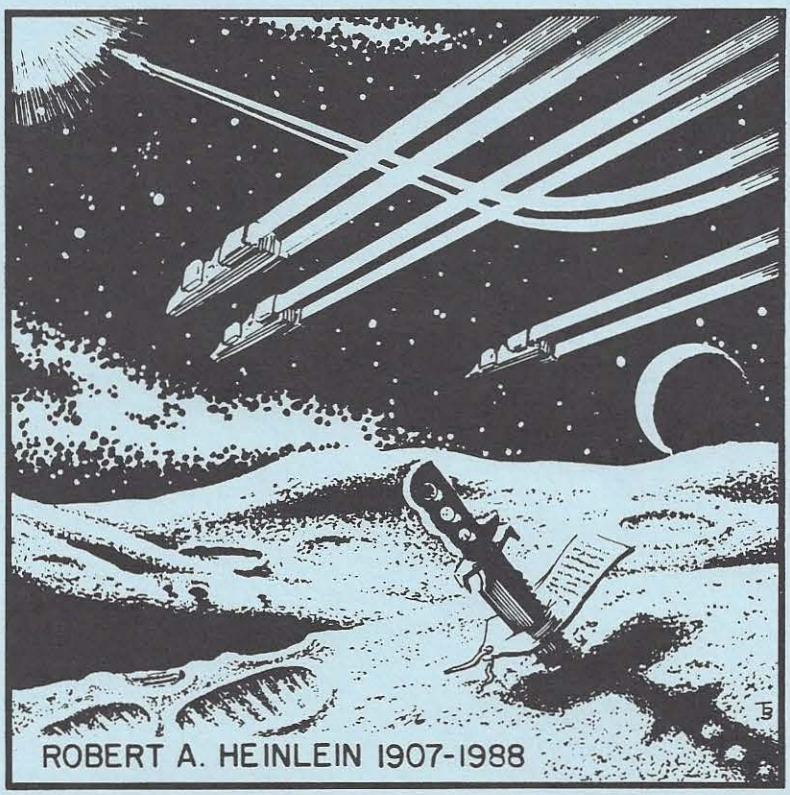
In a strange coincidence, an explosion also occurred in a solid-propellant chemical plant in the Soviet Union on May 12. According to U.S. officials, the plant was the production facility for the solid-fueled motors for the Soviet SS-24 strategic missile. The Soviets, while admitting to the explosion, deny that the facility was used for rocket manufacture, claiming that the plant produced industrial explosives.

* * *

Robert A. Heinlein died in his sleep on May 8, 1988 at the age of 80. His innumerable contributions to the field of science fiction have been described in detail elsewhere--I recommend the June, 1988 issue of *Locus* for an excellent overview of his life and work, and for the tributes he has received from many of the other great names of science fiction.

In Heinlein's books, space was usually presented as a challenging frontier, the place where men and women would go to find freedom when Earth lay drowning in tyranny. His vision of space has stayed with me, as I am sure it has stayed with many others, and it has played no small part in leading me to spend my life working to open this frontier to humanity.

I am sorry that he did not live to see Americans return to space, or the pioneers finally heading out along the long and shining road he saw so much clearer than most. He will be remembered, though, and if there is any justice, at least one of the ships that eventually takes us to new worlds will proudly carry his name.



I had the privilege of meeting Mr. Heinlein in person several times, and I wish I could have gotten to know him better. We are fortunate that so much of who he was is in his work, which will continue to be read again and again through the coming years, in times when paper books will be found only in museums, and in places where Earth's sun is just another star in the nighttime sky.

Until next time,

Tom Brosz

The Commercial Space Report (C.S.R.) is published monthly, and endeavors to report and analyze developments in the field of private initiatives in space transportation and exploitation.

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