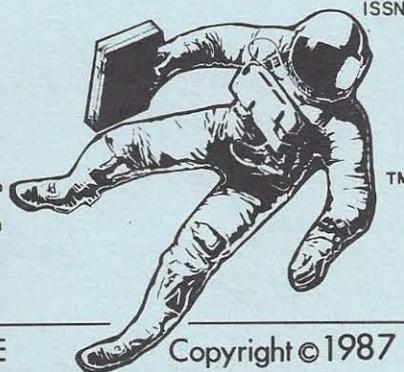


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Private Rocket Companies Going After Small Military Payloads

A new interest in small satellites on the part of the U.S. Department of Defense may be a shot in the arm for small commercial launch vehicle companies. The Defense Advanced Research Projects Agency (DARPA) is investigating potential missions for small (600 - 1,500 lb.) satellites launched by small launch vehicles into low earth orbits. The objective is to make such satellites--called generically "Lightsats"--cheap and "disposable," allowing them to be launched on short notice to perform specific, short-term missions. Lightsats would not replace more expensive, long-duration satellite systems, but would supplement them as needed. One possible mission for Lightsats would be to provide on-the-spot battlefield tactical support, such as supplying field commanders with targeting information and a rapid communications relay. Other missions might involve a large group of Lightsats in orbit, acting as a multiply-redundant data relay network, capable of routing information around any damaged or destroyed satellites.

An important feature of the Lightsat program is the need for a small, low-cost, easily-launched rocket to place these satellites in orbit from a wide variety of locations and on short notice. Some solutions to this problem involve modifying existing launch vehicles to carry Lightsats, but new vehicles will be considered as well.

DARPA is encouraging private rocket companies to submit their launch systems for Lightsat, including not only large, established companies like Lockheed or Martin-Marietta, but small, entrepreneurial ones as well. DARPA (somewhat untypically for the military) considers low launch costs an important factor in the Lightsat project, and low launch costs are often the main feature of the launch systems proposed by these small companies.

The response from the small companies has been rapid and eager. Companies vying to land DARPA as a customer include Space Services, Inc. (SSI), Pacific American Launch Systems (PacAm), and the American Rocket Company (AMROC).

This eagerness is easily explained. One of the most difficult tasks for these companies in developing new commercial launch systems has been convincing investors to supply the capital required to design and build these systems (some entrepreneurs claim that the technical problems are small in comparison!)

Until recently, only geosynchronous communications satellites were recognized as profitable payloads for commercial launchers--at least by members of the venture capital and financial communities who were unfamiliar with the potentials of other space applications. Launching such satellites requires a large booster, with the capacity to place up to two tons into geosynchronous orbit. Existing companies and launch vehicles such as Arianespace (Ariane), McDonnell-Douglas (Delta), Martin-Marietta (Titan), and General Dynamics (Atlas-Centaur) are already fighting for this market. Newer launch vehicle companies attempting to develop geosynchronous launchers have had difficulty raising the large quantity of investment capital required, despite the fact that once built, these new launchers would be much less expensive to fly.

The entrepreneurial commercial launch vehicle companies have always been on the lookout for lucrative markets for small launch vehicles. Requiring much less money to develop than geosynchronous launchers, and cheaper to build and operate, small launch vehicles are considerably more attractive to start-up companies and their investors.

Unfortunately, most of the potential customers for small payload launch services are small themselves--universities, government scientists on low-budgeted projects, stranded organizations with payloads originally intended to fly on the Space Shuttle as Getaway Specials, and entrepreneurs with new applications for small satellites in low orbits, among others. As a collection, they may represent a sizable market for any existing low-cost launch service, but individually their financial clout is too low to either fund the development of, or to attract investors to (by signing up in advance as paying customers), such a service.

So, DARPA's entry into the business as a customer is being well-received by the entrepreneurs. A contract with DARPA, representing as it does a single customer with the potential for a large number of orders, would make any of these companies very attractive to the investment community. Following are updates on some of these companies (although all of them have expressed interest in the DARPA proposal, no specific information on any of their responses is available since the DARPA request for proposals is still pending).

Space Services, Inc. Customer Starfind Hits FCC Snag

Space Services, Inc. has been held up by problems with their most recent customer, Starfind, Inc. Starfind, a navigational satellite company, has been blocked by "technical problems" in obtaining a license for their system from the Federal Communications Commission (FCC). Apparently, Starfind's proposed use of the radio frequency spectrum assigned by U.S. and international authorities for navigation satellite use is incompatible with other navsat proposals which have already received FCC approval (one of these competitors is Geostar, which had its proposal approved in 1985).

SSI, which has an agreement in principle to launch five Starfind satellites into geosynchronous orbit for about \$30 million each (*C.S.R.*, June 1987, pp. 2-3), will be unable to proceed with development of the company's Conestoga solid-fueled launch vehicle unless Starfind's problem can be resolved.

SSI has a painful familiarity with the previously-mentioned problems of the small payload market--since its founding in 1981, the company has been concentrating on that market almost exclusively without much success. An earlier potential Conestoga customer was Celestis, Inc., which wants to put cremated human remains into orbit (*C.S.R.*, Jan. 1985, pp. 1-2). That project has been held up by a shortage of "clients"--10,000 people would need to sign up at a cost of a couple of thousand dollars each to have their cremated remains sifted into a tiny two-inch capsule and packed up with 9,999 others in a single 500-lb. payload canister before SSI could launch it into space (SSI will be charging Celestis \$20 million for the launch).

SSI has received some support from the Houston investor community (*C.S.R.*, Feb. 1987, p. 1), but, five years after the company's first and only flight (a suborbital test flight of a modified Aries sounding rocket in September of 1982), SSI's customers have yet to solidify to the point where construction of an operational Conestoga can begin.

SSI intends to go after the DARPA Lightsat project. If the launch company's other potential customers are unable to fly for some time, or don't pan out at all, Lightsat could be a lifesaver for SSI.

Pacific American Launch Systems Developing New Liberty Launch Vehicle

Pacific American Launch Systems, in addressing the new market for small payloads, has hit the ground running. Earlier, PacAm had been having difficulty in financing its large, pressure-fed Liberty 2 launch vehicle concept (*C.S.R.*, Aug. 1986, pp. 4-5). The Liberty 2, 15 feet in diameter and 147 ft. long, was aimed specifically at the previously-mentioned geosynchronous satellite market. It was designed to reliably carry 4,000 - 6,000 lbs. into geosynchronous transfer orbit for about half the price of existing vehicles. Despite the potential for millions in sales and profits, investors, faced with Liberty 2's \$25 million development cost (low for a launch vehicle, but high for a venture capitalist) and concerned about an area of technology most of them were not familiar with, were largely leery about the project.

Pacific American, like the other entrepreneurial launch vehicle companies, has been keeping an eye on the small payload market. When the military market began to open up, PacAm was ready with a design for a small, expendable launch vehicle. The Liberty 1, originally conceived as a subscale test version of the Liberty 2, was modified and improved to become a profitable system in its own right. The vehicle was renamed the Liberty 1A, and development work began.

The Liberty 1A is a two-stage, expendable, pressure-fed launch vehicle. It is 62 inches in diameter, about 60 feet long, and has a gross lift-off weight of about 50,000 lbs. It can accommodate payloads up to 60 inches in diameter and, in its basic version, is designed to place from 300 - 500 pounds into low earth orbit. PacAm plans on offering the Liberty 1 as a complete launch service to customers, rather than selling the hardware. Launch prices for the basic vehicle are expected to be around \$4 million per flight. The development and testing program of the Liberty 1 is being internally financed by Pacific American.

The propellants for the first stage of Liberty 1A are liquid oxygen and kerosene. Stored helium is used as the pressurizing gas. The first stage engine operates at 250 psi combustion chamber pressure and 64,000 pounds of thrust. The engine is ablatively cooled using a silicone compound as a liner, and a graphite insert protects the throat area of the engine from erosion. Thrust vector control is produced by gimbaling the entire engine via two hydraulic actuators.

The second stage of the Liberty 1 burns storable propellants (nitrogen tetroxide and hydrazine). This engine operates at a chamber pressure of 130 psi and has a thrust of 6,000 pounds. This engine is also ablatively cooled, and is steered by gimbaling the engine using electric actuators. A cold gas auxiliary propulsion system provides roll control during flight as well as full 3-axis control following engine shutdown. Off-the-shelf avionics for the vehicle's flight control are mounted on this stage.

The engines for both stages use a coaxial pintle-type injector design. Engines of this type have, in the past, been built and operated in many different thrust ranges and have been designed for both storable and cryogenic propellants. According to PacAm, such engines can be easily scaled up or down, and are highly reliable, being largely immune to problems such as combustion instability. PacAm anticipates that this will result in a simple and straightforward development, fabrication and testing program for the Liberty 1A propulsion system.

Liberty launches will take place from a simple, water-cooled "milkstool" style pad, fabricated from steel. The pad may be set up at a launch site in less than two days, since it will be manufactured as a prefabricated unit. All umbilical connections are designed to be at the base of the vehicle (with the exception of custom umbilicals required by unique payloads), eliminating the need for an extensive gantry structure. A payload would be encapsulated in the fairing at a payload preparation building and transported, fully enclosed, with the booster to the pad. About three hours will be required to fuel and preflight the Liberty vehicle for launch. Propellants will be loaded from tankers, obviating the necessity for a propellant tank farm. Launch can

then occur when the trajectory window opens.

Mission control facilities are designed to be simple and inexpensive, incorporating large quantities of off-the-shelf hardware. Eventually, PacAm intends to incorporate the entire mission control function into a single, stand-alone, workstation-type of console.

Pacific American is planning to eventually develop a wide range of launch services using the Liberty 1A as a basic module. Sounding rocket and clustered versions of the Liberty, combined with payload recovery and on-orbit support options, would be able to accommodate almost any small-payload customer (the Liberty 1A is illustrated with its various permutations on the opposite page).

The Liberty SR (Sounding Rocket) is a suborbital version of the Liberty. Payloads may employ either a single first stage or a first and second stage. Typical cost per flight will be in the range of \$500K to \$1.5 million.

The Liberty 1A, 1B and 1C are the orbital versions of the Liberty. The 1A was described earlier. The 1B and 1C variants are produced by taking a core Liberty 1A and strapping on additional first stage modules for performance augmentation. Payloads for these growth versions could be as high as 4,500 lbs. to low earth orbit. The Liberty 1C features a larger-diameter fairing.

PacAm also plans to develop small, ballistic payload recovery capsules, which will allow payloads to be returned to earth. These capsules are similar in design to those used to recover film packages from orbiting reconnaissance satellites. Depending on the size of the capsule (a large and small version are envisioned), and the Liberty configuration used, payloads weighing anywhere from 250 to 1500 lbs. could be accommodated.

The design of the second stage of the Liberty launch vehicle permits it to easily be converted into a spacecraft bus, providing the payload with propulsion, power, and orientation. The conversion would involve alterations in the second stage power supplies, adding a solar power array, providing additional gas for thrusters, and adding a thermal protection covering. By using this converted stage, a customer who has an instrument or sensor (but no funds for the development of a full spacecraft) would be able to obtain essentially all of the benefits of a custom bus while not taking excessive time or money to build a unique spacecraft.

Pacific American intends to make the Liberty 1 launch system available to customers by 1989, and hopes to be able to eventually launch up to 12 flights per year.

AMROC Shaken By Stock Market Crash

The American Rocket Company has furloughed most of its employees in an attempt to recover from an investor pullout in the wake of the October stock market crash. AMROC reported that it was suspending some of its operations at company headquarters in Camarillo, Calif., and at the company test site at Edwards Air Force Base. Most of AMROC's workforce (reported to exceed 80 people) was affected by the layoffs, although some personnel are apparently continuing to work without pay to keep the company running.

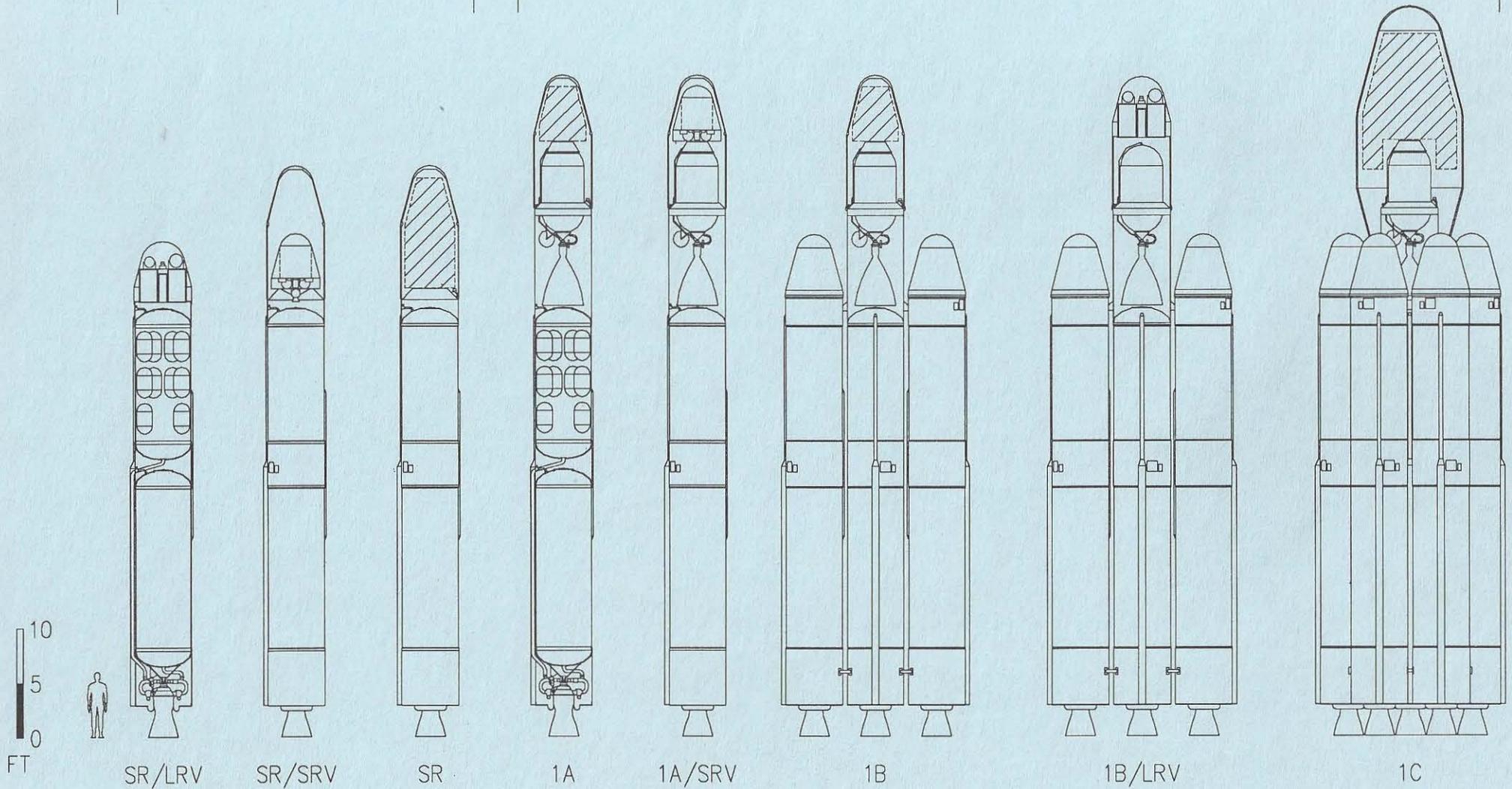
AMROC was in the middle of a private placement to raise almost \$7 million in development funds when October 19th--Black Monday--struck. A few frightened investors pulled out of the project, and took other investors with them in what AMROC president George Koopman called "a ripple effect." The market crash was felt by other private rocket companies as well, but AMROC was particularly vulnerable due to the high overhead costs (reported to be about \$500,000 per month) being incurred by the company's current large-scale development and testing program.

SUBORBITAL

GTO/GEO

GTO/GEO

ORBITAL



LIBERTY LAUNCH VEHICLES

LRV = Large Re-entry Vehicle
SRV = Small Re-entry Vehicle
SR = Sounding Rocket

GTO = Geosynchronous Transfer Orbit
GEO = Geosynchronous Orbit

AMROC's funding problems are exacerbated by technical difficulties with the hybrid engine concept. A static test in October revealed combustion problems which must be solved before launch vehicle development can proceed further. AMROC claims to have solutions to these problems, but ironing out the kinks in the system will not make the company's development program any cheaper.

AMROC representatives insist that the company is not going out of business, and that the present reorganization will allow the resumption of normal operations shortly. Work is under way to seek new sources of investment.

AMROC was negotiating to fly two Department of Defense payloads on its suborbital test flights (*C.S.R.*, Sept./Oct. 1987, p. 11), and is also pursuing the DARPA Lightsat payloads. Unless AMROC can resolve its current difficulties, both prospects may be threatened. AMROC personnel are confident, but long-time readers will note the parallels of AMROC's current situation with the demise of Starstruck, Inc.--AMROC's predecessor in the development of hybrid launch vehicles (*C.S.R.*, Aug., Oct., and Dec. 1984; June 1985).

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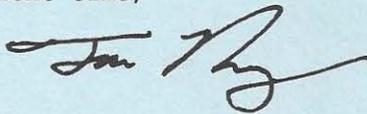
Articles of Interest in Other Publications

The December, 1987 issue of the Smithsonian *Air and Space* magazine takes a look at the history of the American Rocket Company and Pacific American Launch Systems. The article, "The California Rocket Race" written by T. A. Heppenheimer, tells where these rival companies got started, and how they got to where they are now.

AMROC, E-Prime and Space Services are written up in an article in the November 9, 1987 issue of *Business Week* titled "Starship Enterprise: Chasing NASA's Unfinished Business." It contains a few good tidbits (such as a new sounding rocket company called Conatec which I will report on in the future) but mostly old news to *C.S.R.* readers.

A detailed overview of the current status of the U.S. Strategic Defense Initiative (SDI) appears in the Nov. 23, 1987 issue of *Aviation Week and Space Technology* (pp. 48-87). Despite continued opposition from some, research continues to show that effective defenses against ballistic missiles are not only feasible, but that deployment of a kinetic energy weapon system could begin as early as 1992. (Normally, I don't point out specific articles in *Aviation Week*--anyone with an interest in space systems should be reading it cover to cover every week--but this SDI overview is worth special mention.)

Until next time,



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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