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Private Launch Companies Roll Out Vehicles, Prepare For Flight

The American Rocket Company (AMROC) and Orbital Sciences Corporation (OSC) have publicly rolled out their first launch vehicles and are preparing for test flights in September and October, respectively.

American Rocket Company:

AMROC's initial suborbital test flight, originally scheduled for August, has been postponed until September 20. The flight, designated Single Engine Test-1 (SET-1), will be the first commercial launch from Vandenberg Air Force Base. The vehicle, called the AMROC Industrial Research Rocket (IRR), will test AMROC's H-500 engine, the building block of the multiple-engine Industrial Launch Vehicle (ILV) family of rockets that will eventually take payloads into low earth orbit.

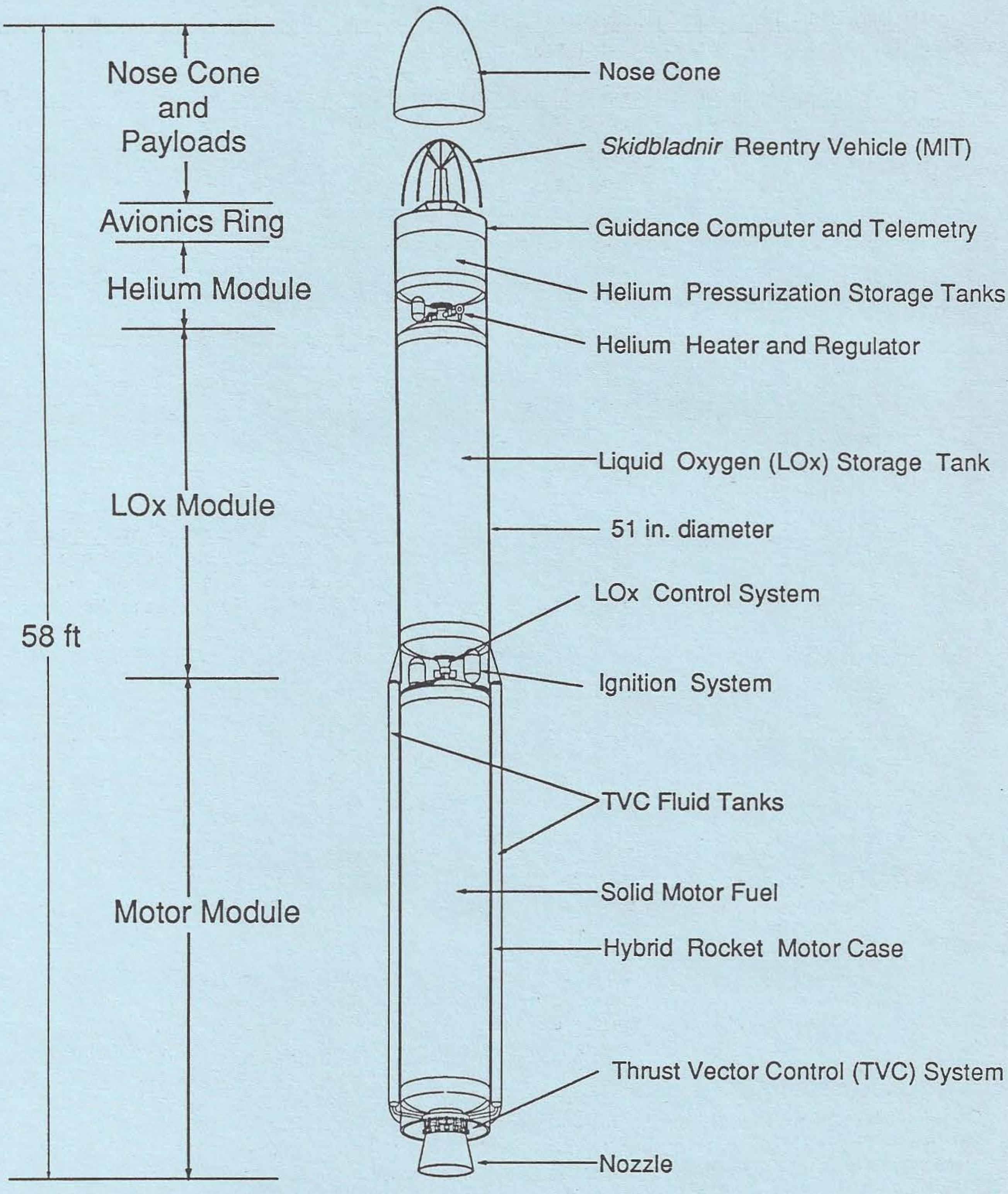
AMROC rolled out the SET-1 on August 24 in a traditional ceremony for employees and invited guests. The rollout took place at the AMROC manufacturing facility in Camarillo, California. In a speech given by AMROC acting president James Bennett, the rocket was named "The Koopman Express" in honor of the company's former president, George Koopman, who was killed in an automobile accident in July.

The rocket is 58 feet tall, 51 inches in diameter, weighs 32,000 lbs., and has a thrust of 75,000 lbs. The vehicle is an assembly of five major modules: the motor module, the liquid oxygen (LOX) module, the helium module, the avionics ring, and the nose cone and payloads (see illustration on page 2).

The motor module consists of the solid-fuel-filled combustion chamber of the H-500 hybrid rocket engine, the thrust vector control (TVC) system, and the vehicle aft skirt. The 75,000 lb.-thrust engine contains 6,800 lbs. of rubber-like polybutadiene solid fuel, formed along its length into a cross-section resembling a 12-spoked wagon wheel. This leaves 12 triangular combustion ports into which LOX is injected to burn the fuel. The motor case is constructed of a graphite-epoxy filament-wound composite. Ignition of the engine is accomplished by injecting triethylaluminum (TEA) into the engine just before the liquid oxygen is introduced. The TEA ignites spontaneously on contact with oxygen, lighting off the fuel.

The TVC system steers the rocket by injecting hydrogen peroxide through 16 small ports positioned around the engine nozzle. Injection of the hydrogen peroxide through one or more of these ports deflects the main engine thrust sufficiently to turn the rocket. Two storage tanks for the hydrogen peroxide are mounted in long fairings along the outside of the engine casing.

The vehicle aft skirt supports the rocket on the launch pad and protects the TVC valves during flight.



AMERICAN ROCKET COMPANY
INDUSTRIAL RESEARCH ROCKET
prototype vehicle

The LOX module consists of the LOX tank and the intertank area. The LOX tank stores the liquid oxygen to burn the fuel in the rocket motor, and is comprised of filament-wrapped stainless-steel liner. The intertank area, between the LOX tank and the motor, contains the TEA ignition system, the flight control gyroscopes, the main LOX valve, a pressurization source for the vehicle's pneumatically-activated valves, and the roll control thrusters. These thrusters are mounted on the outside of the intertank area on the forward portion of the peroxide storage tanks, and function by using catalytic decomposition of hydrogen peroxide as a monopropellant.

The helium module, mounted forward of the LOX tank, provides pressurization gas to force the liquid oxygen from its tank into the engine combustion chamber. The helium is stored in eight filament-wrapped high-pressure bottles. From these bottles the helium flows through a heater, then a pressure regulator, and then into the LOX tank.

Heating the helium gas greatly increases its effectiveness as a pressurizing gas. Usually this heating is done by forcing the helium through some form of heat exchanger which taps heat from the rocket engine. AMROC accomplishes this heating differently, and quite cleverly. Instead of just helium, the gas storage bottles contain a mixture of helium and hydrogen. This mixture is fed into a small heating chamber where the hydrogen reacts catalytically with oxygen from two small pressure bottles. This reaction heats the gas effectively, and avoids many of the engineering problems of engine-mounted heat exchangers.

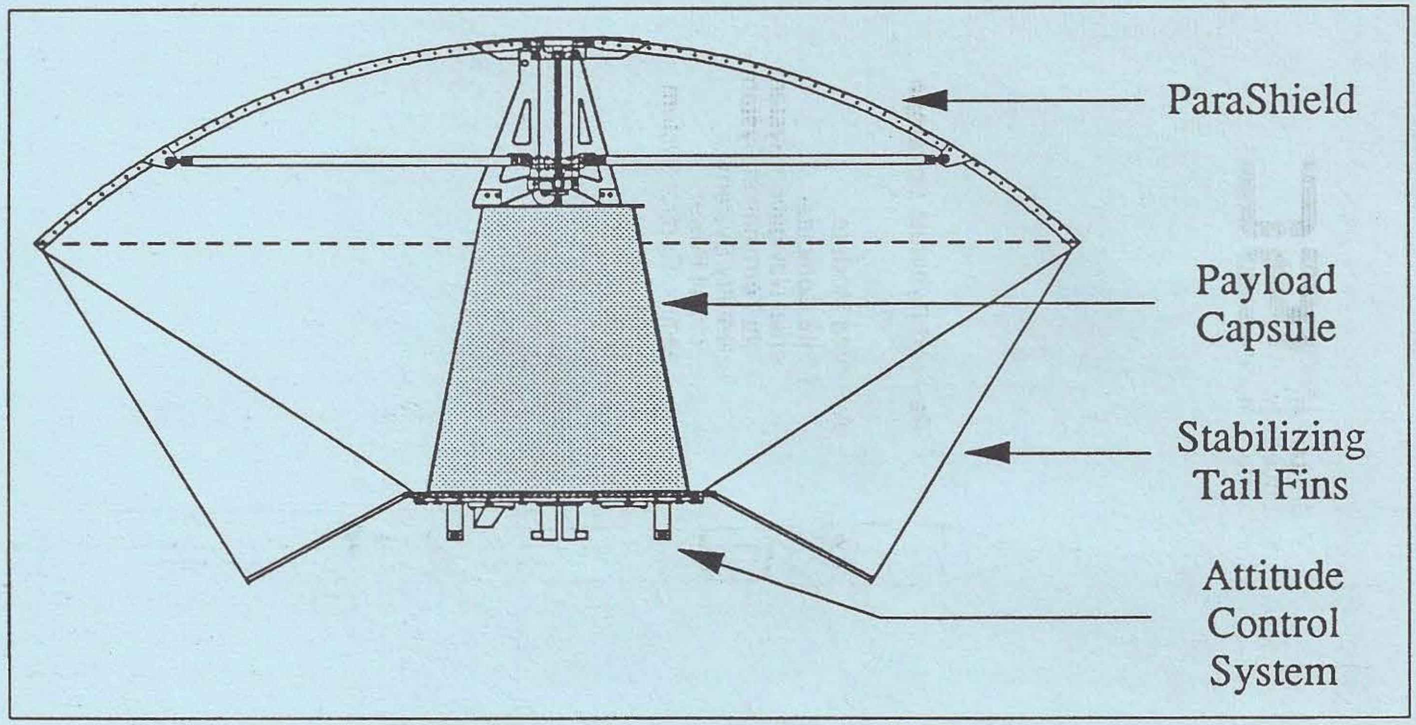
The avionics ring houses the guidance and control computer, a telemetry system to transmit information from the rocket to the ground, a tracking transponder to monitor vehicle position during the flight, and flight batteries to provide on-board power to vehicle systems.

The onboard guidance and control computer is an industrialized IBM PC-type computer specially configured and tested for use on launch vehicles. The use of an IBM-compatible computer makes powerful peripheral hardware and software development tools available for flight code development and implementation. The computer receives signals from the flight gyroscopes and controls the valves on the thrust vector control system.

The nose cone houses the payloads for the flight, and consists of a 60-inch-tall spherically-blunted cone attached to the top of the avionics ring. At the proper time, an explosive release mechanism separates the forward portion of the cone to release the payloads.

The SET-1 test vehicle contains two payloads, one for the Massachusetts Institute of Technology (MIT) Space Systems Laboratory and one for the Strategic Defense Initiative (SDI). The SDI experiment has not been specifically identified, but is described by AMROC as "a passive, environmentally safe experiment."

The MIT payload is a test of a flexible, deployable heat shield for atmospheric entry. Called a "ParaShield," the heat shield is constructed of a thermally-resistant lightweight fabric, and is carried folded around the exterior of a payload capsule. When the shield is deployed, it unfolds in front of the payload in much the same way as an umbrella is unfolded (see illustration on page 4). This greatly increases the surface area of the heat shield without increasing the payload weight. The result is a lower heating rate on the heat shield during reentry--well within the limits of the ParaShield's fabric construction--and lower aerodynamic loading, which means lower deceleration rates for the payload. As the payload slows and reaches the lower atmosphere, it flips over, and the ParaShield then acts like a parachute to slow the payload's fall. This lower terminal velocity means that in many cases landing parachutes and their deployment systems could be replaced by simpler impact-attenuation systems like small retrorockets.



The advantages of the ParaShield over conventional heat shield technology are reusability and benign entry conditions for the payload. In addition, a large volume protected from reentry airflow is available, which means the payload's shape need not be dictated by reentry aerodynamic requirements.

The MIT/AMROC test of the ParaShield is called Project *Skidbladnir*, after a ship in Norse mythology which was, according to Bulfinch, "so large that it could contain all the deities with their war and household implements, but so skillfully was it wrought that when folded together it could be put into a side pocket."

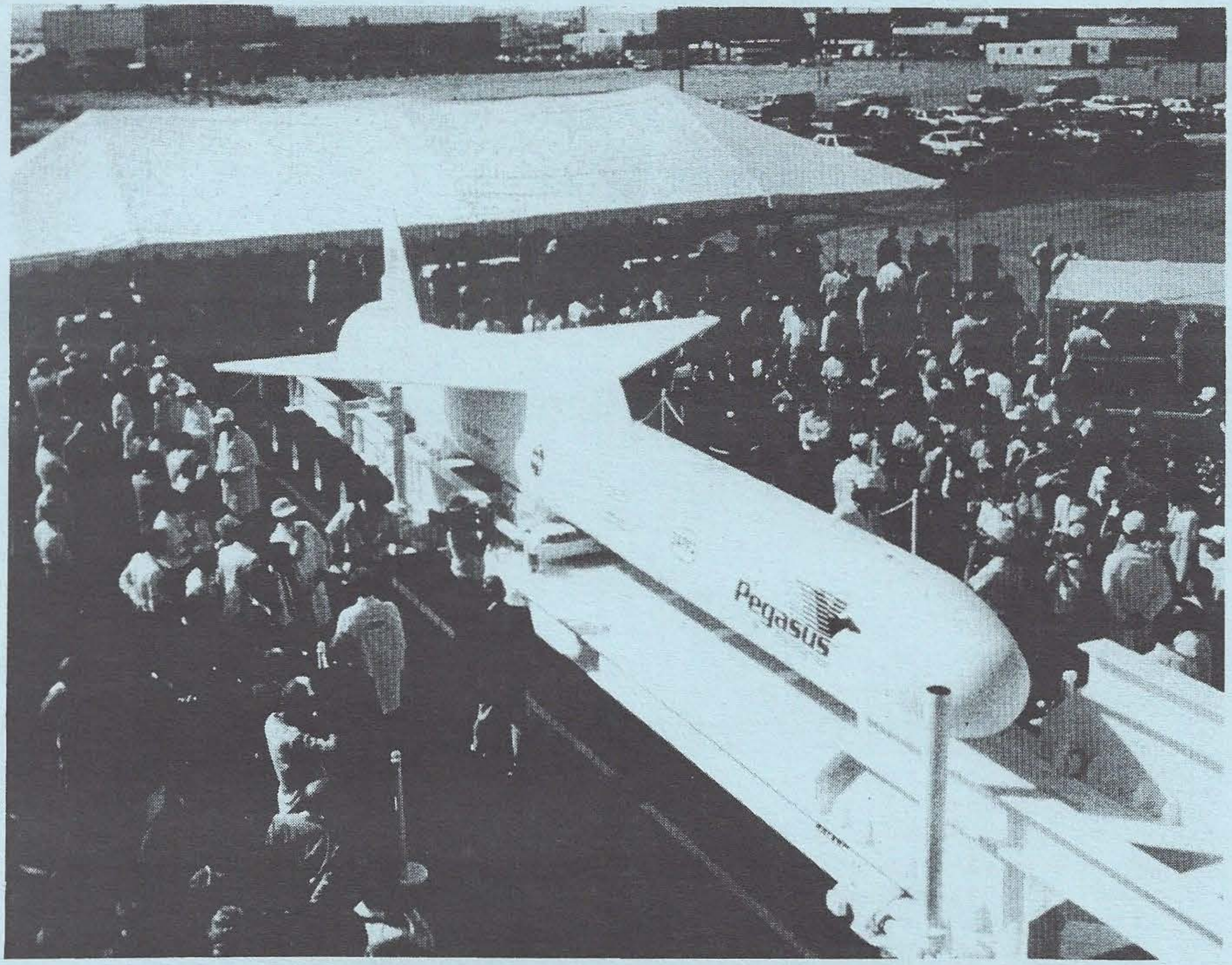
The *Skidbladnir* test heat shield fits inside the nose of the AMROC booster, furled around a payload capsule. It is 40 inches in diameter undeployed, and expands to 102 inches upon deployment--a nearly seven-fold increase in area. The capsule and heat shield together weigh about 350 lbs., resulting in a low 6.2 lbs. per square foot aerodynamic loading on the heat shield's projected area. No impact attenuation system is installed for this flight, and the vehicle will splash down in the ocean at its terminal velocity of about 45 miles per hour.

The purpose of this flight is to gather data to validate analytical models and to test mechanisms. *Skidbladnir* is instrumented with still and video cameras, as well as with a variety of other instruments. Data will be stored on board and recovered with the payload.

In addition to a launch fee for flying the *Skidbladnir* experiment, AMROC will receive some rights to use the ParaShield technology. The ParaShield payload return system should prove quite useful as part of AMROC's plans to market sounding rocket flights to other customers.

MIT is also examining the use of ParaShield technology as part of a crew escape system for the U.S. Space Station. Space Station program managers see a need for a simple, inexpensive "lifeboat" vehicle permanently docked to the Station and capable of quickly returning astronauts to Earth in an emergency. Some form of space capsule using ParaShield technology could fill this need.

AMROC will fly another suborbital test flight before attempting an orbital launch in about a year.



Orbital Sciences Corporation:

OSC also had a rollout of a new launch vehicle in August, with the company's Pegasus air-launched space booster making its first public appearance on August 10. The Pegasus (seen above at the rollout) is a three-stage, solid-fueled launch vehicle about 50 feet long and 50 inches in diameter. Its first stage is winged, with a wingspan of about 22 feet. The Pegasus is launched from underneath the wing of a B-52 bomber or other large aircraft. During first stage boost, the Pegasus flies along a roughly horizontal trajectory, using the lift from its wings while still in the atmosphere to assist its flight. After the first stage burns out, the second and third stages ignite in sequence, and follow a more typical rocket trajectory into orbit (*C.S.R.*, May 1988). The Pegasus can put a payload of about 1,000 lbs. into low earth orbit.

The first flight of the Pegasus, originally scheduled for August, has been postponed until at least the end of October. Company officials cited problems with the pylon that mates the Pegasus to the wing of the B-52 aircraft as the main reason for the delay. The first flight will carry a 450-lb. payload into a 320-nautical-mile circular polar orbit.

The payload for the first Pegasus flight is called PEGSAT. The payload was developed by NASA's Goddard Space Flight Center, and will perform three functions. The first package is the instrumentation that will analyze the flight of the Pegasus vehicle, including instruments to measure vibration, temperature, pressure, and structural loading. The second package is a small Navy experimental communications relay satellite that will be deployed in orbit. The third package is a barium-release experiment that will allow researchers to observe characteristics of the Earth's magnetic and electrical fields.

The Pegasus is scheduled for two "carry flight" tests before the vehicle's maiden flight. These tests will check out the Pegasus vehicle while it is attached to the wing of its B-52 carry plane in flight.

DARPA Awards SSLV Contract to Space Data

The Defense Advanced Research Projects Agency (DARPA) has awarded Space Data Corp. a contract to develop and demonstrate a Standard Small Launch Vehicle, or SSLV. The contract calls for up to five orbital flights of this new vehicle, with the first taking place from Vandenberg Air Force Base in 1991. Space Data is being paid $10.9 million for this first flight.

The contract represents another score for Orbital Sciences Corporation, which acquired Space Data as a wholly-owned subsidiary last year. Once both the air-launched Pegasus and the new ground-launched Space Data SSLV become operational, OSC will possess a commanding lead in both government and commercial small launch vehicle markets.

The configuration of the proposed SSLV is essentially a wingless Pegasus stacked on top of a Thiokol MX "Peacekeeper" solid-fueled first stage booster for a total of four stages (see illustration on opposite page). The resulting vehicle has an impressive performance, with the capacity of placing more than 3,000 lbs. into low earth orbit, or 800 lbs. into geosynchronous transfer orbit. Aside from its high performance, this configuration has the added advantage of combining the already-existing Peacekeeper first stage motor with the now-completed Pegasus propulsion and guidance package. This will permit Space Data to field the new SSLV very quickly and with a minimum of integration work.

One feature of the SSLV contract was a requirement for mobility of the launch vehicle. An important characteristic of the SSLV would be its ability to respond in a military emergency when access to more conventional launch sites might be impaired. The SSLV and its launch support systems are required to be fully transportable by conventional over-the-road trucks, and capable of launch within 72 hours of call-up starting only with an unprepared concrete pad.

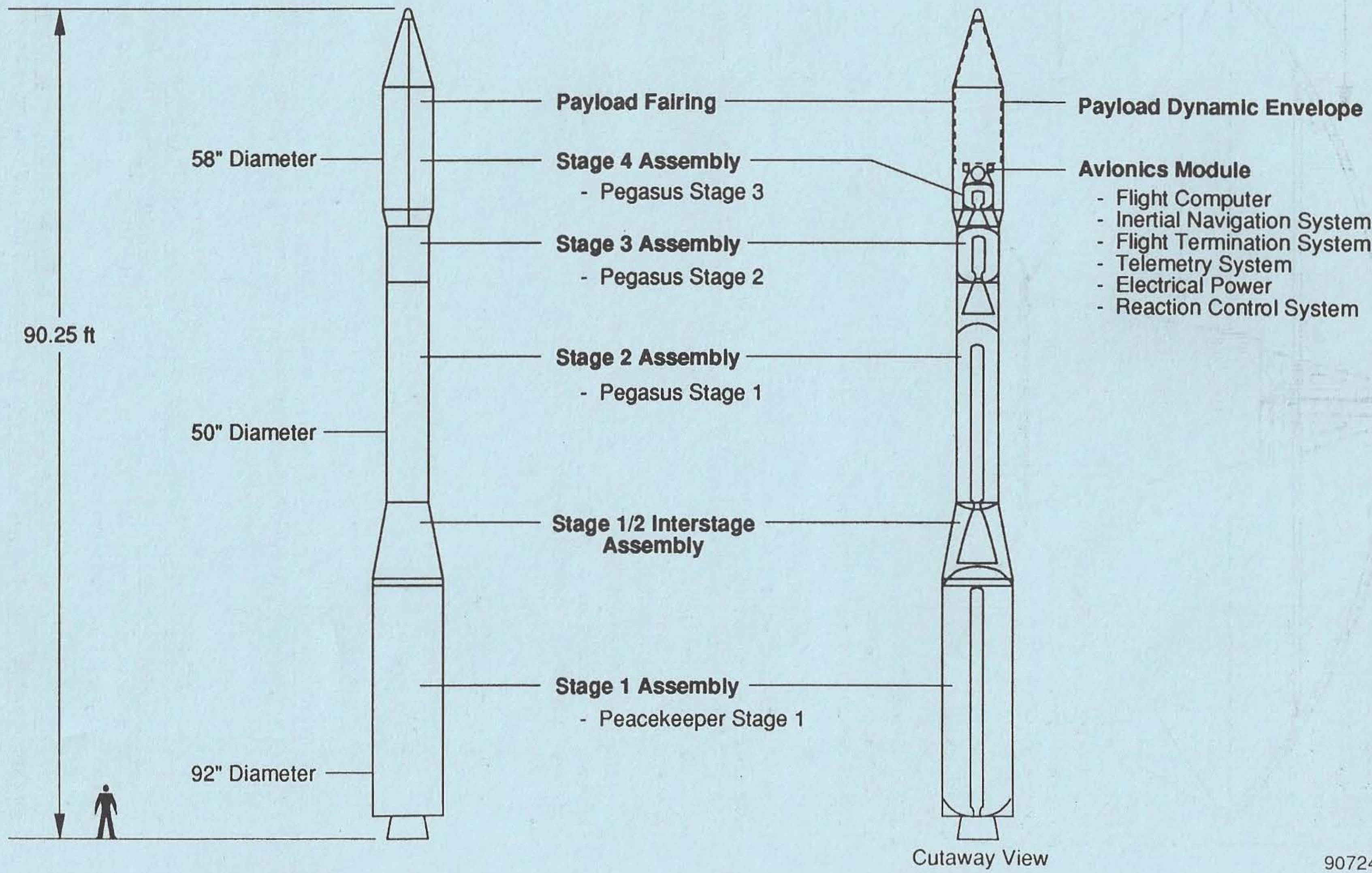
Mobility of the Space Data SSLV is feasible, but it won't be simple. The Peacekeeper first stage weighs about 92,000 lbs., and the Pegasus weighs in at about 41,000 lbs. (the Pegasus wings and fins will be deleted of course, but adding a larger payload shroud should balance out the weight estimation). This, plus a 3,000 lb. payload, totals out to 136,000 lbs. or 68 tons. To deliver this vehicle and its support equipment in sections to a launch site will take 12 semi-trailer trucks.

The selection of Space Data has caused considerable controversy in the private launch vehicle industry. In 1987, DARPA began investigating the potential of small (600-1,500 lb.) satellites, or "lightsats." Small launch vehicle companies responded eagerly, and were encouraged by DARPA to participate (*C.S.R.*, Nov. 1987). After a competition between nine bidders, four $300,000 cost-plus-fixed fee contracts were awarded to Lockheed, TRW, LTV, and Space Services, Inc. (SSI). One of these companies was to be selected for further development of the Lightsat launcher (*C.S.R.*, May 1988).

Later in 1988, DARPA and Lightsat came under attack by the Air Force (primarily in the person of then-Air Force Secretary Edward Aldridge), which saw the DARPA program as a threat to the Air Force monopoly on military space launch operations.

SSLV Vehicle Configuration

Orbital Sciences Corporation OSC



Funding for the program was threatened. The problem was apparently solved to the satisfaction of all concerned when an agreement between DARPA and the Air Force placed the Lightsat launch vehicle program under the control of the Air Force. DARPA was told to concentrate on satellites. Meanwhile, the four "winning" contractors continued their work.

Then in April of this year, DARPA issued a new request for proposals (RFP) for the SSLV, with less-stringent requirements than the old bid (i.e. a payload of 1,000 lbs. to polar orbit instead of 1,500). Interestingly, DARPA announced that all bidders on the new RFP would be on "a level playing field," that is, no special consideration would be given to the winners of the four $300,000 contracts. Three bidders responded: Space Services, Inc. (again); E-Prime Aerospace Corp., a small launch vehicle company in Titusville, Fla.; and Space Data. Details on the SSI and E-Prime proposals have not been made available, but their bids were reportedly competitive.

It is not known why only SSI, out of the original four Lightsat bidders, chose to bid again on the new RFP. Some sources theorize that the other three companies, all large organizations, felt that there was no real government market for the SSLV's capabilities despite the fact that Lightsat funding requests have been doing quite well in Congress. Another theory is that these big three knew that the choice of the winner was a foregone conclusion.

It is no secret that OSC and the Pegasus have become very popular with the Air Force. After the first two Pegasus flights for DARPA, the Air Force will be taking over as the prime customer for the launch vehicle, and Air Force support has been strong for the Pegasus project from the beginning. With the Air Force currently pulling DARPA's launch operations strings, it would not be surprising if there was a strong tendency for DARPA to lean towards Space Data/OSC's proposal.

Space Data/OSC has plans to market the SSLV commercially. OSC has mentioned prices in the range of $12 to 17 million per launch--a competitive price in the current market. Fortunately, unlike the military version, the commercial version will not need to be "portable."

McDonnell Douglas Delta Accomplishes First U.S. Commercial Orbital Launch

On August 27, a McDonnell Douglas 4925 Delta made its first official flight as a privately-owned expendable launch vehicle (ELV), and became the first U.S. private ELV to place a payload into orbit (U.S. private launch vehicles have made suborbital flights in the past, and the European Ariane, privately owned--by a somewhat loose definition of "private"--has flown a number of payloads into orbit). This Delta was identical to many others that have been successfully flown in the past, but this time the vehicle was marketed and flown entirely by McDonnell Douglas, the company that has built Deltas for NASA and the Department of Defense for many years.

The payload was a TV broadcasting satellite for a company called British Satellite Broadcasting Ltd. The Delta placed the satellite, called Marcopolo 1, into a geosynchronous transfer orbit. The satellite was successfully inserted into geosynchronous orbit on August 29, and is now being checked out before beginning operations.

The British company is paying Hughes Aircraft $300 million to build and launch two satellites. Hughes built the HS 376 satellites, and then contracted with McDonnell Douglas to launch them into orbit for about $25 million each. The second satellite is scheduled to be launched, also on a Delta, in 1990.

The Delta was launched from Pad 17B at the Air Force launch facility at Cape Canaveral. McDonnell Douglas is paying the Air Force about $1 million per launch for the use of the facility.

McDonnell Douglas' commercial Delta program currently has nine confirmed orders for satellite launches through 1991.

Other companies which are privatizing existing ELVs are ready for their first all-commercial launches. Hard on the heels of McDonnell Douglas are the other two mainstream U.S. launch companies: General Dynamics, with the Atlas/Centaur, and Martin Marietta with the Titan.

General Dynamics:

General Dynamics will launch its first payload on a commercial Atlas around June of 1990. The payload will be the NASA Combined Release and Radiation Effects Satellite (CRRES).

General Dynamics currently has 25 commercial launches planned--7 firm orders and 18 options (this does not include a number of military launches which will still be under the control of the Air Force). Customers include the European Telecommunications Satellite Organization (Eutelsat), the National Oceanic and Atmospheric Administration (NOAA), and Intelsat. Eutelsat has contracted to launch the Eutelsat 2 communications satellite in the 3rd or 4th quarter of 1990. NOAA will use the Atlas to launch three badly-needed new geosynchronous weather satellites--GOES I, J and K. The first of these, GOES I, is scheduled to fly in the 4th quarter of 1990. Intelsat will use the new, more powerful Atlas IIAS to fly two Intelsat VII communications satellites into orbit.

Martin Marietta:

Martin Marietta is scheduling its first privately-operated Titan 3 launch for November of 1989. The rocket will carry two satellites into orbit: the Japanese JCSAT-2 communications satellite (contracted through Hughes), and the British Skynet 4A military communications satellite.

Martin Marietta has two more firm contracts for commercial launches, both for Intelsat. The Titan 3 will be used to fly two Intelsat VI satellites into orbit, one in the 1st quarter of 1990, and one in mid-1990. Another contract, for the NASA Mars Observer, was in the process of being completed at this writing. In addition to these contracts, Martin has options on at least 19 more launches for General Electric and others.

These first commercial launches of formerly government-owned vehicles represent significant milestones for the companies involved and for the U.S. space industry as a whole. They herald the welcome move of launch services away from the government and toward the private sector, and the recovery of the U.S. expendable launch vehicle industry after NASA attempted to shut it down in the mid-1970s. This last stupid maneuver was an attempt by NASA to force all U.S. payloads, commercial or otherwise, to use the Shuttle for launch services while production of U.S. ELVs was deliberately phased out. The inevitable result was the complete paralysis of the U.S. launch industry for over two years when the Shuttle *Challenger* was destroyed, and the associated growth of Europe's launch industry, represented by Arianespace. We only are now at the point where the U.S. can continue on with a space program based on a mixed fleet of ELVs and the Shuttle--where we should have been in the first place.

However, the privatization of existing ELVs is not enough to revolutionize space transportation. The Atlas, Titan and Delta vehicles (or the French Ariane for that matter) are still far too expensive to allow any major expansion of private space endeavors beyond the existing market for the launch of costly satellites.

The industry is still waiting for someone to develop the low-cost, reliable space transportation that will bring about a real revolution in the exploitation of space.

Pacific American Launch Systems Closes Manufacturing Plant

Pacific American Launch Systems, Inc. (PacAm) has closed its Menlo Park manufacturing facility due to lack of funds. Anticipated investment funding from the Rockefeller Foundation in New York failed to materialize, and the company was forced to close up shop and furlough a majority of its employees. At the time of the closing, PacAm was in the process of developing the Liberty low-cost liquid-fueled expendable launch system.

For More Information

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- Orbital Sciences Corporation, 12500 Fair Lakes Circle, Fairfax, VA 22033 Tel.: (703) 631-3600
- McDonnell Douglas Astronautics, Box 516, St. Louis, MO 63166 Tel.: (314) 232-5911
- General Dynamics, Commercial Launch Services, P.O. Box 85911, San Diego, CA 92138-5911 Tel.: (619) 496-4010. R. E. (Bob) Dupuis, Director of Business Management.
- Martin Marietta, Commercial Titan Inc., P.O. Box 179, Denver, CO 80201 Tel: (303) 977-3000

A personal note: as an employee of Pacific American, I got furloughed along with the rest. At this time, I am under contract with the Gravity Probe B project, a joint effort of NASA and Stanford University. The objective is the launch of a satellite in about 1995 to test fundamental predictions of Einstein's general theory of relativity. To do this, the satellite will contain four tiny gyroscopes of an accuracy unprecedented in gyro technology (for those interested: an absolute drift rate of less than 10^{-11} degrees/hour and the capability of detecting changes in spin angle of less than 1 milliarc-second--the width of a human hair as seen from ten miles away). So far, the engineering work is fascinating (although a lot of the physics is over my head), and best of all, I'm still in the space biz.

Until next time,

Tom Brosz
September 12, 1989

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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