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AMROC and Space Services Both Fail In Launch Attempts

American Rocket Company:

On October 5, the first attempt of the American Rocket Company (AMROC) to launch a suborbital rocket ended when the rocket failed to generate sufficient thrust to lift off, then collapsed onto the launch pad and burned. The rocket, designated Single Engine Test-1 (SET-1) was going to launch two payloads on a suborbital trajectory. The first payload, from the Massachusetts Institute of Technology (MIT), was a test version of a deployable reentry vehicle. The second payload was a passive experiment for the Strategic Defense Initiative Organization (SDIO) (more details in the June-July 1989 *C.S.R.*)

The AMROC launch attempt had originally been scheduled for September 20, but was postponed until October 5th due to rain and lightning at the launch site at Vandenberg Air Force Base on the coast of California. Scheduling the SET-1 launch was made more difficult because the launch could occur only during a very short period of time when an orbiting military satellite, the Delta Star, was in the proper position to observe the SDIO experiment on board the rocket.

During the launch attempt, the countdown proceeded normally, but when the engine ignited, only about 20% of normal thrust was achieved. The clamps which held the vehicle to the launch pad had already been released, there apparently being no provisions to check for optimal thrust before releasing the rocket. The thrust problem was identified almost immediately, but the rocket had already moved slightly making it impossible to reengage the clamps. The unstable vehicle fell over and broke apart on the concrete pad, separating at the interstage between the solid-fuel engine and the liquid oxygen (LOX) tank.

The rocket then began to burn. Flames from the languidly burning engine had been flowing out of the nozzle and licking up the sides of the rocket, setting fire to part of its composite structure. When the rocket fell over, the bottom skirt and outer engine casing were already burning. Around the nozzle of the rocket engine are a series of thrust vector control (TVC) valves. In a normal flight, these valves would have injected concentrated hydrogen peroxide into the exhaust stream to deflect the stream and change the course of the rocket. Now, as the rocket lay burning, these valves malfunctioned and released hydrogen peroxide (a powerful oxidizer), feeding the flames and adding to the damage.

AMROC designers' claims about the safety of hybrid rocket technology were proven when the fully-fueled rocket--despite catching fire--did not explode. Because of this there was surprisingly little damage to the upper portion of the vehicle which, after breaking loose from the lower portion, lay some distance from the fire. This portion contained the avionics, the liquid oxygen tank, and of course, the payloads.

Initial examinations indicated that the payloads and expensive avionics may have avoided serious damage. The MIT reentry package was not subjected to any loads that it would not have experienced in a normal flight. Struts on the deployable heat shield were bent, and the heat-resistant fabric will need to be replaced. No details are available on the condition of the SDIO payload. The avionics will need to be salvaged and thoroughly tested before their condition is known.

The exact cause of the failure is not known, although a prime suspect is a failure of the LOX valve to open to its full extent. Unfortunately the valve, contained in the broken interstage below the LOX tank, was so badly damaged that analysis is difficult. It is possible that the LOX valve may have iced up and stuck in a half-open condition. The humid conditions of Vandenberg may have created the conditions for such icing. All of AMROC's successful static engine tests have taken place in the dry environment of Edwards Air Force Base in the California desert, and the humidity problem may have been overlooked.

Ironically, a similar problem occurred with another private launch vehicle company in August of 1981. The failure of a frozen LOX valve to open was deemed responsible for the loss of the G.C.H. Inc. Percheron rocket at Matagorda Island, Texas--a project with which I was involved as a design engineer (*C.S.R.*, Sept. 1981). Again, the humidity of the environment may have been a factor. Being liquid-fueled rather than hybrid, the Percheron went up with an impressive explosion that made the national news. But that's another story.

However much physical damage the AMROC launch vehicle avoided, the financial damage to the company may be severe. SDIO would have paid $200,000 for a successful flight of their payload, which will not now be forthcoming. In addition, investors are not likely to put additional funds into AMROC unless more customers are found, and customers may want to see a successful flight first. Add to this the loss of company president George Koopman, killed in an auto accident, whose marketing and fund-raising skills saw AMROC through other tough times. AMROC has furloughed about 60 employees (20 of these would have been furloughed in any case in a planned cutback after the intense effort of the launch).

Though AMROC is operating on a reduced basis, the company still plans to continue with another launch in about a year. However, the vehicle that flies then may be quite different than the SET-1. The basic concept of the hybrid rocket has been proven to AMROC's satisfaction through a long series of successful static tests, and the company is unlikely to abandon this technology. Still, even before the launch failure, AMROC had planned to reexamine the specific designs of the company's hybrid launcher family. Continued market studies and experience gained during the development of AMROC's current vehicle designs might indicate that changes are required. As one example, if market studies show a need for a higher payload capacity (2,000 - 4,000 lbs. to low earth orbit) then the current pressure-fed LOX feed system may be replaced by a higher-pressure pump-fed system.

Space Services, Inc.:

On November 15, the launch of the Consort 2 suborbital research rocket ended with the destruction of the vehicle after an apparent guidance failure. The launch attempt took place at the White Sands Missile Range in New Mexico. The solid-fueled Starfire 1 sounding rocket used for the launch, built by Space Services, Inc. of Houston, Texas, had two stages. The first stage performed properly, but a guidance anomaly during the second stage burn caused the range safety officer to transmit a destruct signal to the vehicle 37 seconds into the flight.

The 1,000 lb. payload, inside a recovery capsule, ejected from the rocket and was recovered in perfect condition. The payload consisted of 12 microgravity experiments provided by a variety of researchers. The Starfire's S19 guidance package, a prime suspect in the incident, was also recovered and will be examined.

The launch was sponsored by the University of Alabama in Huntsville's Consortium for Materials Development in Space (UAH CMDS). The Consortium contracted with Space Services to build the Starfire and provide the launch services. The launch was intended to carry its payload to an altitude of 200 miles and provide 7 to 8 minutes of weightlessness for the experiments.

This was the second Consort launch. The first launch, Consort 1, was carried out successfully on March 29, 1989 (*C.S.R.*, Feb. 1989, p. 5). The UAH CMDS plans a third Consort launch sometime in 1991, and has an option for a fourth. Both launches are contracted to Space Services, and UAH CMDS has not yet indicated that this launch failure will in any way change this program.

* * *

Small Company Promotes Concept For Heavy-Lift Launch Vehicle

The Davis Aerospace Company has been working since 1985 on a design for an unmanned heavy-lift launch system to complement the Space Shuttle's manned capability. The Texas company believes that its vehicle design, called the "Consort," (no relation to the Space Services/University of Alabama Consort suborbital launch program) is a better solution than either the NASA Shuttle C or the NASA/Air Force Advanced Launch System (ALS)--the two heavy-lift launch vehicle programs of the U.S. government.

The Shuttle C and ALS are intended to reduce the costs of flying large payloads into space. It is hoped that costs could be reduced as low as $300/pound to low earth orbit, while providing rapid turnaround and high reliability.

The Shuttle C program is basing its designs on Shuttle technology, which includes the use of Space Shuttle Main Engines (SSMEs) and Shuttle Solid Rocket Boosters (SRBs). Most of the Shuttle C designs being considered are almost identical in their basic configuration to the manned Shuttle (i.e. External Tank with SRBs on the side, and a piggyback cargo carrier). Some designs appear to differ from the manned Shuttle only in that wings and heat tiles have been left off the cargo carrier. Most designs also assume that the SSMEs will be expended with the vehicle instead of reused, and the program is dependent on being able to rework the SSME design into a low-cost, non-reusable version of that engine.

The ALS program is starting from a clean sheet of paper, emphasizing new low-cost expendable engines, improved manufacturing techniques, and more streamlined launch operations. This is a good way to avoid past mistakes, but one which normally increases development costs and time. The ALS program does not give reusability a high priority at this stage, although some ideas have been examined (in particular a winged fly-back booster--not exactly inexpensive to develop).

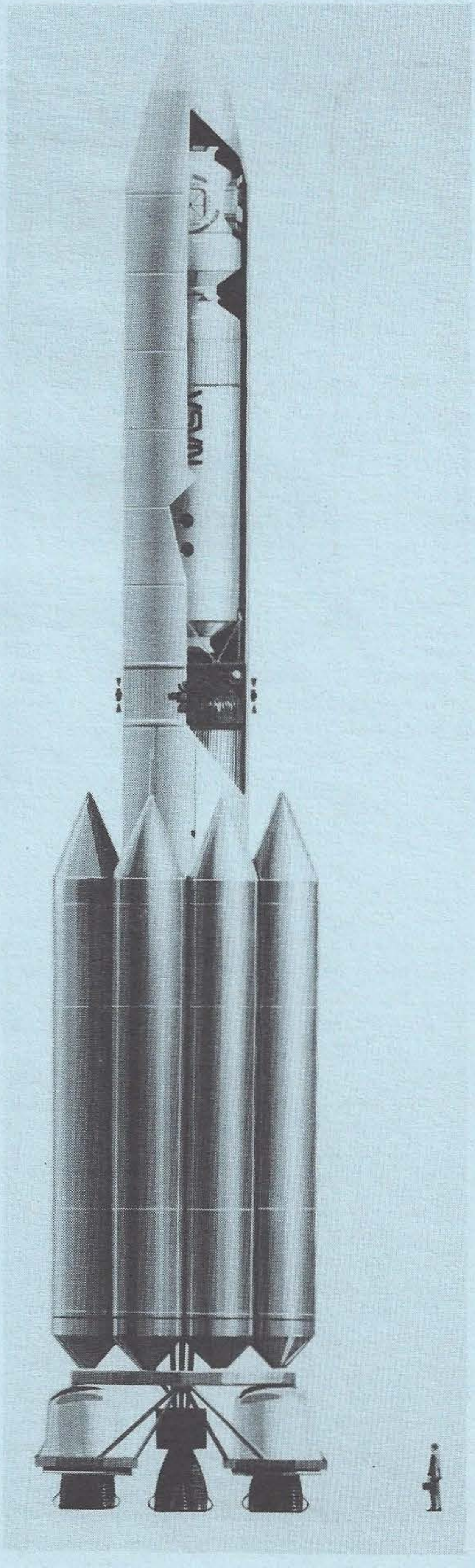
The Consort design combines these approaches, and uses the best features of both. The result is a system that extensively uses off-the-shelf hardware, but also recovers and reuses expensive major components--primarily the engines. The vehicle is intended by its designers to complement and support the existing manned Space Shuttle system. The name "Consort" was selected to convey this intent.

The basic Consort is a two-stage vehicle powered by SSMEs burning liquid oxygen (LOX) and liquid hydrogen (LH2) (see illustration on page 4). The core stage is comprised of a large propellant tank, 7 meters (23 ft.) in diameter, with three SSMEs mounted at the base. The first, or boost stage, consists of a series of outboard propellant tanks, 4.5 meters (14.8 ft.) in diameter, combined with truncated-nozzle SSME boost engines arranged around the base.

Payload capability of the Consort ranges from 32-45 metric tons (71-100,000 lbs.) for the Consort G-6 configuration, to about 100 tons (220,000 lbs.) for the Consort G-11 (these figures are quite conservative--they assume one core engine is out from lift off until main engine cutoff). The variation in payload is accomplished by varying the length of the outboard propellant tanks and the number of outboard boost engines. The number following the G in the configuration designation indicates the total number of SSMEs in the vehicle. These vehicles are shown in the illustration on the opposite page. In the illustration, the two smallest vehicles (G-6 and G-7) are shown with standard Titan 4 fairings, allowing the launch of payloads sized for the Space Shuttle cargo bay. The G-8 and G-9 vehicles are shown with a fairing the same diameter as the propellant tank--7 meters. The G-10 and G-11 vehicles are shown with a "hammerhead" fairing of the same diameter as the current Shuttle External Tank--8.4 meters (27.6 ft.).

The boost engines are each built into individual recovery capsules, to be refurbished and reused after their return to Earth. This feature permits the Consort to utilize the expensive SSMEs, yet keep launch costs low (the relatively inexpensive propellant tanks are expended). The recovery capsules are similar in design to those used to recover film from reconnaissance satellites, although, of course, larger (see illustration at the top of page 6). The capsules are equipped with an ablative nose cap, permitting recovery from near-orbital velocities. When recovered from the lower velocities associated with early boost phases, this insulation may be reused several times. Each capsule houses one SSME, its gimbal actuators, feed lines, and quick-disconnect hardware. The terminal recovery system consists of a conventional drogue parachute deployed at high subsonic velocity, and a "ram-air-inflated" rectangular parachute similar to those used by sports parachutists and military forces around the world. Both drogue and parachute have backups in case of primary chute failure.

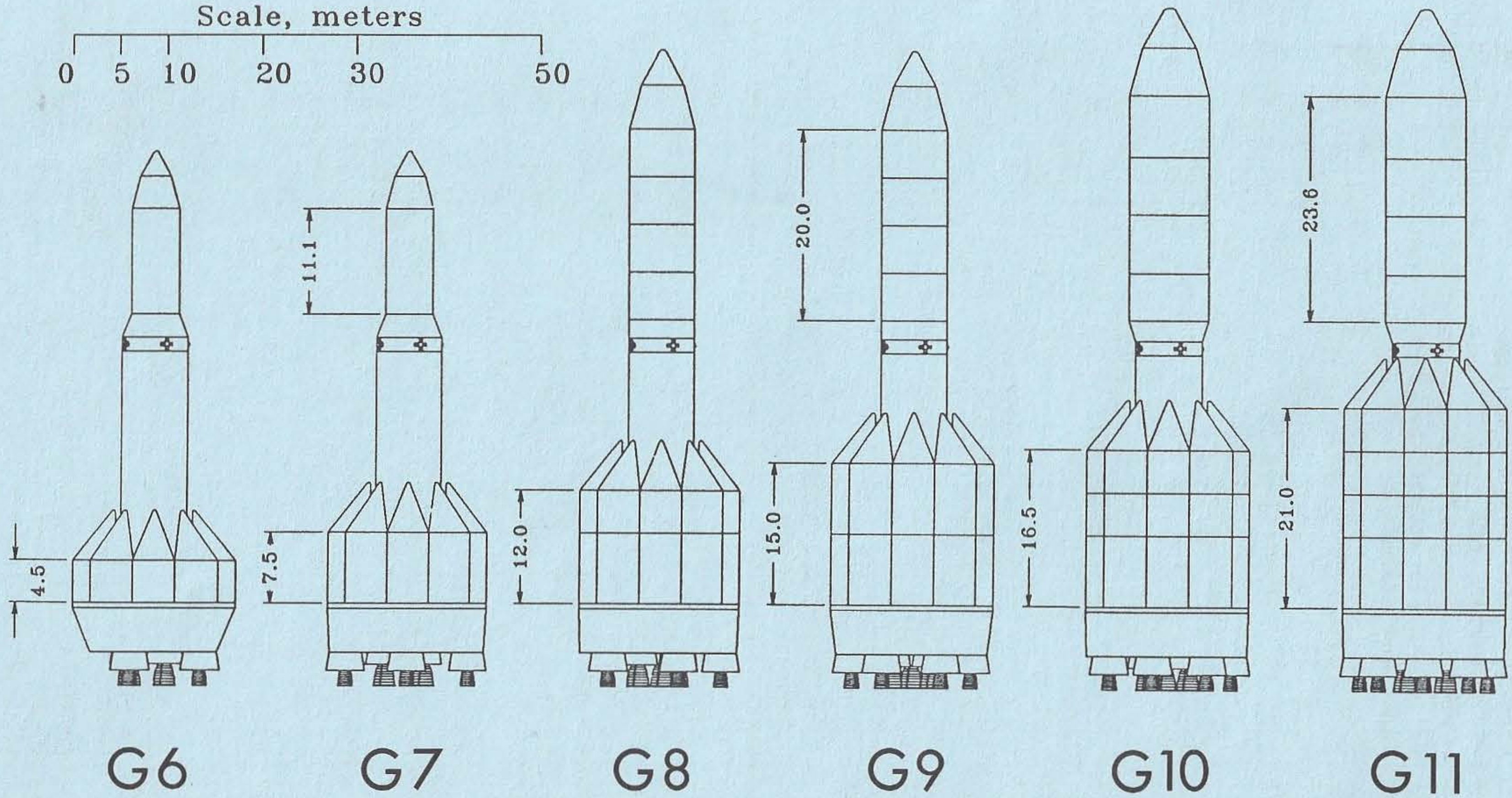
The Consort design assumes that the engines, gliding under their chutes, will be retrieved in mid-air by arresting equipment on the decks of special recovery ships. This allows vehicle operators to avoid costs associated with refurbishing the rocket engines after immersion in sea water. The high maneuvering capability of the ram-air parachute makes it



(TEXT CONTINUED ON PAGE 7)

CONSORT "G" SERIES SLVs

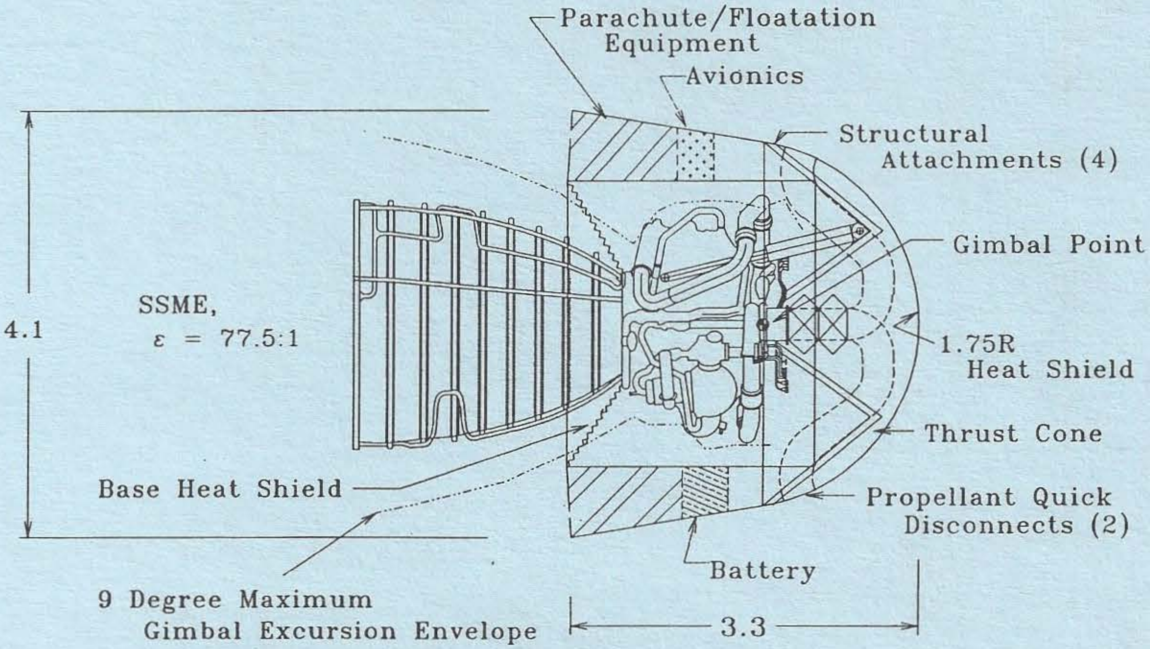
DAVIS AEROSPACE COMPANY
July 19, 1989



ENGINE RECOVERY VEHICLE

DAVIS AEROSPACE COMPANY
July 25, 1989

PROFILE VIEW



RL10 TDV

DAVIS AEROSPACE COMPANY
June 30, 1989

GLOW (MT): 97.0

Payload (MT): 6.7

Core Prop: 41.2

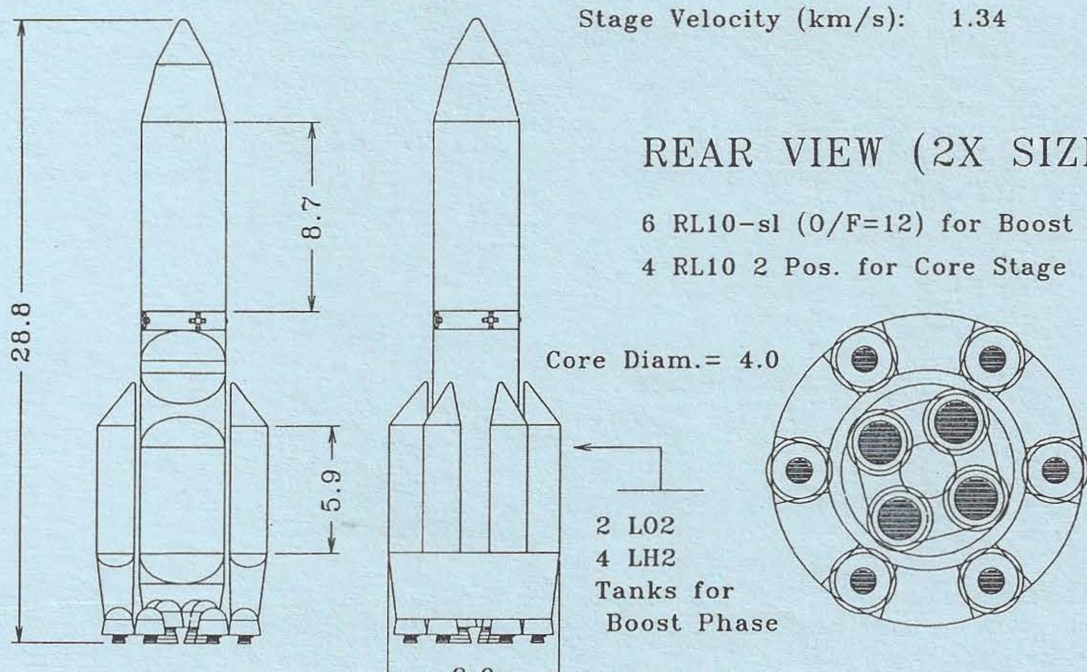
Boost Prop: 39.6

Stage Velocity (km/s): 1.34

REAR VIEW (2X SIZE)

6 RL10-sl (O/F=12) for Boost Stage

4 RL10 2 Pos. for Core Stage



possible for a guidance package to steer the gliding recovery capsules directly into the waiting arresting apparatus with a minimum of maneuvering required by the ship. In case the engine package does miss its intended target and land in the ocean, the recovery capsule is equipped with flotation gear. More extensive and expensive refurbishment of the immersed engine would then, of course, be necessary.

A typical mission goes as follows: a Consort vehicle is launched with all engines running on both the core and the booster stages. During initial boost, propellant for the core engines is transferred from the tanks of the outboard boosters through large propellant manifolds at the base of the vehicle. When the outboard tanks are exhausted, the entire outboard booster assembly slides off the core stage in one piece. After separation of the boost section, the engine recovery capsules of the boosters separate and return to Earth individually for reuse. The tankage and manifold plumbing is expended. Meanwhile, the core stage continues on, with its engines now taking their propellants from the core tank. When orbital velocity is reached, the core engines shut down, separate, and reenter in their recovery capsules. The core stage and its payload are injected into final orbit by two RL-10 LOX/hydrogen engines mounted on the rear of the core stage. After delivery of the payload, the core stage tankage can be either expended or used for other purposes in orbit.

A more recent version of the Consort, called the G-9C, is a modified design that is intended to make even more use of existing Shuttle technology and further reduce Consort's production and recurring costs. The propellant tank of the core stage is widened from 7 meters (23 ft.) to 8.4 meters (27.6 ft.) in diameter, the same as the Shuttle External Tank. This would permit the use of existing ET tooling for Consort production. The outboard booster tanks are also widened, from 4.5 meters (14.8 ft.) to 5.49 meters (18 ft.). This is identical to the tank diameter of a proposed liquid-fueled rocket booster being considered to replace the Space Shuttle's solid boosters. If such a liquid booster is developed, the Consort and the manned Shuttle would have more production tooling in common.

To prove the technologies and design features of the Consort launch system, Davis Aerospace has proposed building a smaller version called the Technology Demonstration Vehicle (TDV). The basic design is identical to the Consort, but smaller (see illustration at the bottom of page 6). Instead of SSMEs, the TDV uses uprated RL-10 engines. Like the Consort, each engine is mounted in its own recovery capsule. The construction of the TDV will allow the demonstration of the launch and recovery features of the Consort with less expenditure of time and money than the full-sized Consort would require. As a bonus, the TDV also has a useful payload: 6.7 metric tons (14,750 lbs.) into low earth orbit.

It is the contention of the chairman of Davis Aerospace, Hubert P. Davis, that the government heavy-lift launch programs will eventually come around to his way of thinking, with reusable versions of existing engines. However, as Davis also realistically points out, that does not mean that the vehicle will be called Consort, or that Davis Aerospace will participate. My own experience tells me that small companies without political connections have a serious handicap when competing for major government aerospace contracts, and it would be easy to edge Davis out of the picture. A factor in Davis' favor: a U.S. patent (No. 4,796,839) on the vehicle design and on the basic feature of recovering individual engines with ship-borne arresting gear.

* * *

Notice to Readers

I am still endeavoring to bring the newsletter issue dates current with the calendar (the recent job change did not help). The last issue, and this one, are double issues. I am planning to make the next issue a triple one--October/November/December--consisting of excerpts from the paper "Alternate Propulsion Energy Sources," prepared by Dr. Robert L. Forward for the Air Force Rocket Propulsion Laboratory in 1983. If I can then get a regular 4 to 6 page issue out before January that will do the trick, and the librarians will get off my case. Now for the bad news:

Beginning with the January, 1990 issue, the price of the *Commercial Space Report* will be increasing to a flat $21.00/year for subscribers in the U.S., Mexico and Canada. The foreign air mail rate will be $30.00/year. This will allow me to absorb anticipated increases in printing and postage costs over the next year, as well as the loss of one of the newsletter's outside income sources: payment for reprint rights from *Claustrophobia*, an excellent technology/biology newsletter which will be ceasing publication at the end of 1990.

All current subscribers can renew their subscriptions at the current 1, 2, and 3-year rates until the January issue--including subscribers whose subscriptions run out months from now. So, renewal cards mailed with this issue and the triple one will still have the old rates. If your subscription expires in January, and you wait until then to renew, the new rates will apply.

For More Information

- American Rocket Company, 847 Flynn Road, Camarillo, CA 93010 Tel.: (805) 987-8970, Fax: (805) 987-5099.

- Space Services, Inc. 7015 Gulf Freeway, Suite 140, Houston, TX 77087 Tel.: (713) 649-1716.

- Davis Aerospace Company, HC-2 Box 296-O, Canyon Lake, TX 78113 Tel.: (512) 935-2743.

Until next time,

Tom Brosz
September 20, 1989

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