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Update: Phoenix Launch System

Gary C. Hudson, President of Pacific American Launch Systems, Inc. of Redwood City, Ca., is continuing basic design work on the "Phoenix," a vertical take-off, vertical landing, fully reusable launch vehicle. The company is still seeking sufficient start-up funds to finalize detail design and move into initial hardware development and procurement of long lead items.

The goal of Pacific American is to make space transportation low in cost, reliable, available, and flexible, similar to the characteristics of aircraft operation. The development of the Phoenix is seen by Pacific American as the key to this goal (C.S.R., Nov. 1982, pp. 3-4; Jan. 1983, pp. 2-3)

Low cost is Phoenix's most intriguing feature. Development costs of the basic, unmanned Phoenix C (Cargo) launch vehicle (Figure 1) are estimated to be about $100 to $200 million (less than the cost of a single Shuttle flight). Once development costs have been amortized, the sales price of the Phoenix C is projected to be between $40 and $60 million. The baseline Phoenix C is designed to carry a payload of about 13,600 lbs. into low earth orbit (LEO), and, if Pacific American's design and production goals are met, it could do it for as little as $20.00 per pound. This compares favorably, to say the least, with present costs-per-pound of $1000 to $5000 on the Shuttle and expendable launch vehicles.

Reliability of the Phoenix is derived from a maximum use of existing technology, a production philosophy based more on the aircraft industry rather than the exotic NASA-type space industry, and simplicity of design. As an example of simplicity, the basic structure of the Phoenix is composed of radially symmetrical shapes, such as cylinders, cones, and spherical sections. Such shapes lend themselves to much easier structural and aerodynamic analysis than more complex winged systems. As examples of utilizing proven technologies, initial Phoenix designs are based on off-the-shelf structural methods using materials like aluminum, and propulsion systems are based on existing designs for engines and pumps.

Availability will depend on short (1-2 day) turnaround times, and a large fleet of launch vehicles to work from. A Phoenix transport could be dedicated to a single customer's mission for an extended period of time without decreasing other customers' access to Phoenix's capabilities.

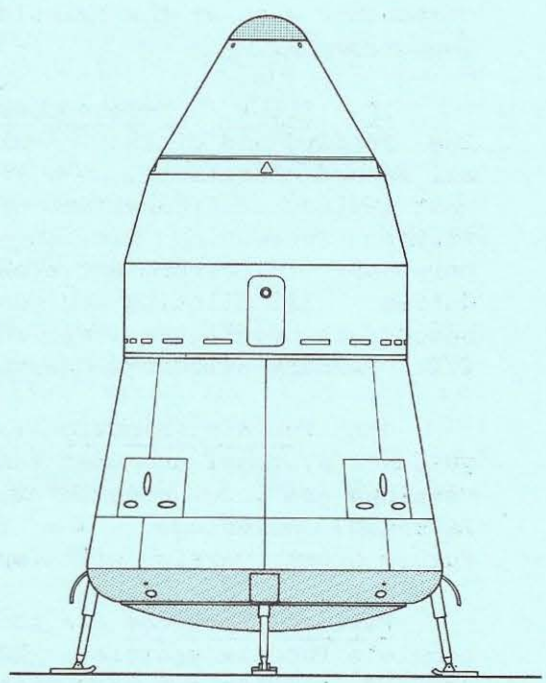

Figure 1

Flexibility is built into the Phoenix design. The basic Phoenix is modular, with the propulsion section, or "Mainstage," structurally and functionally separate and independent from the forward payload section. This allows the same Phoenix Mainstage to accommodate a variety of payloads and payload enclosures. It also allows mission planners to modify payload sections without tying up the more valuable Phoenix Mainstage during the process.

Flexibility is further enhanced by a standardized "hermaphroditic" docking system included in almost all Phoenix configurations. The nose-mounted docking assembly performs (in manned configurations) the normal function of creating a pressure-tight passage for personnel transfer between spacecraft. However, it also includes a system of cryogenic refueling connectors, which permit the transfer of propellant between spacecraft. Such a refueling capability permits the Phoenix to engage in missions beyond the standard launch to LEO.

Some examples: If refueling propellant is carried into orbit by a Phoenix C tanker (rather than being obtained from another source, or launched aboard a larger vehicle), then each flight could carry 13,600 lbs. of propellant. Under these circumstances, the propellant needed to place the mission vehicle into a geosynchronous transfer orbit (GEO transfer) would require 3 refueling flights. Inserting the vehicle into geosynchronous orbit (GEO) would require 9 flights, and a lunar landing or asteroid rendezvous would require 22 flights (all of these assume a return to earth or LEO using aerobraking techniques). Although 22 refueling flights may sound like a lot, it is not that onerous in a scenario containing numerous Phoenix launch vehicles and short turnaround times wherein flights could possibly take off several times a day. Also, if one assumes a cost of about $300,000 per flight, the total mission cost attributable to Phoenix operations is less than $7 million, surely a reasonable price for bringing six tons of payload to the moon and back.

Some changes have been incorporated into the Phoenix concept since the January, 1983 C.S.R. article was written. A major change involves the shelving of the miniature "Phoenix LP" design in favor of concentrating on the larger vehicle.

The modular nature of the Phoenix has been enhanced. A new component has been added: an optional pressurized Pilot Module for manned operations. Other major components such as the Mainstage and various payload sections have undergone design improvements.

The Pilot, or Personnel Module (PM) is a pressurized capsule which fits onto the forward end of the Phoenix launch vehicle, and acts as the crew cockpit during all manned operations. The PM is a self-contained system and can easily be added to most payload configurations without any major modifications to the payload section, further increasing mission flexibility. A central airlock inside the PM allows personnel to perform extravehicular activities for payload deployment or assembly duties. All piloting and control activities are handled from the PM, even in those spacecraft configurations which include a larger manned area such as the Phoenix C/E. Primary avionics, however, would still be located in the Mainstage.

The Phoenix Mainstage (shown in Figure 2) contains all of the propulsion and guidance systems, and operates independently of the other parts of the vehicle. Two versions are under consideration: the Phoenix C Mainstage and the Phoenix CX (Cargo, Extended) Mainstage. The former is the baseline design, while the latter is a future growth version with improved engines and increased fuel capacity.

Payload sections are mounted onto the forward end of the Mainstage to form the complete Phoenix vehicle. Within certain structural and aerodynamic guidelines, a payload section can vary greatly in size and function. Figure 3 (page 4) shows a variety of Phoenix C and CX configurations incorporating different payload sections. (numbers underneath show estimated weights associated with each version).

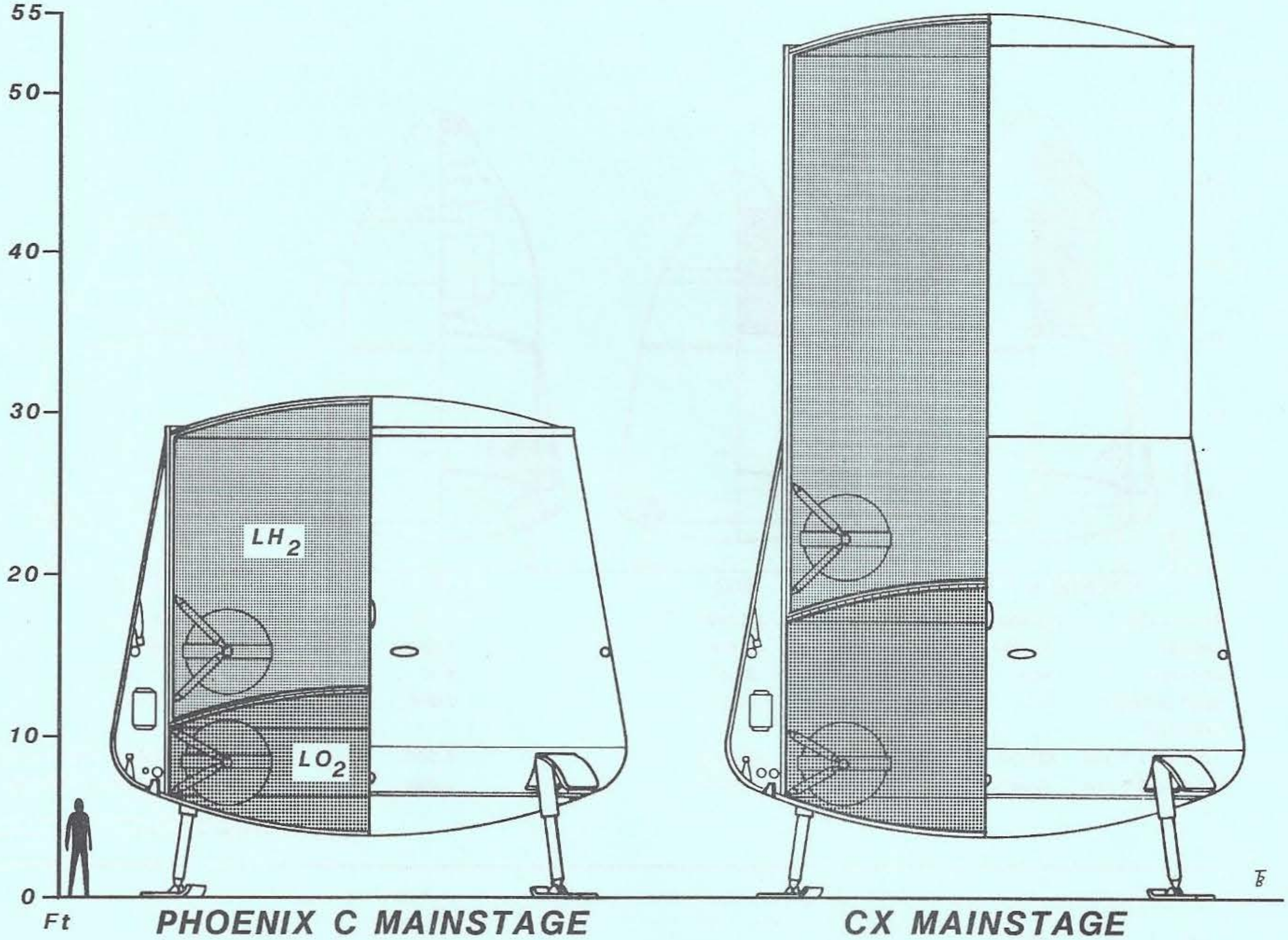

Figure 2

The basic Phoenix C (or CX) utilizes a large, unpressurized payload shroud for LEO payloads up to 18 feet in diameter. In most cases, the shroud remains attached to the Mainstage, while the payload is ejected through the swing-open nose hatch. However, the Mainstage would be capable of reentry without a forward shroud, permitting ejection of a shroud if necessary, or utilization of the payload enclosure itself as the basic structure of a factory module or space station segment.

The Phoenix S/C ("Short"/Cargo) is designed to carry a smaller, heavier payload into LEO. The S/C shown contains a geosynchronous payload along with the PAM-D-type orbital transfer stage which is required to place the payload into GEO transfer (the S/CX can carry a payload directly into GEO transfer).

The Phoenix C' (C-prime) incorporates the manned PM. The version shown here also includes a pressurized cargo or experiment cannister accessible to the PM crew through a short tunnel.

The Phoenix S/C' (or S/CX') carries only the PM, mounted on a short adapter. These versions, being lighter in weight than some of the others, have the option of attaining low earth orbit with a quantity of fuel left in the propellant tanks. This fuel permits a considerable amount of on-orbit maneuvering by the crew, such as that required for satellite rendezvous or repair missions.

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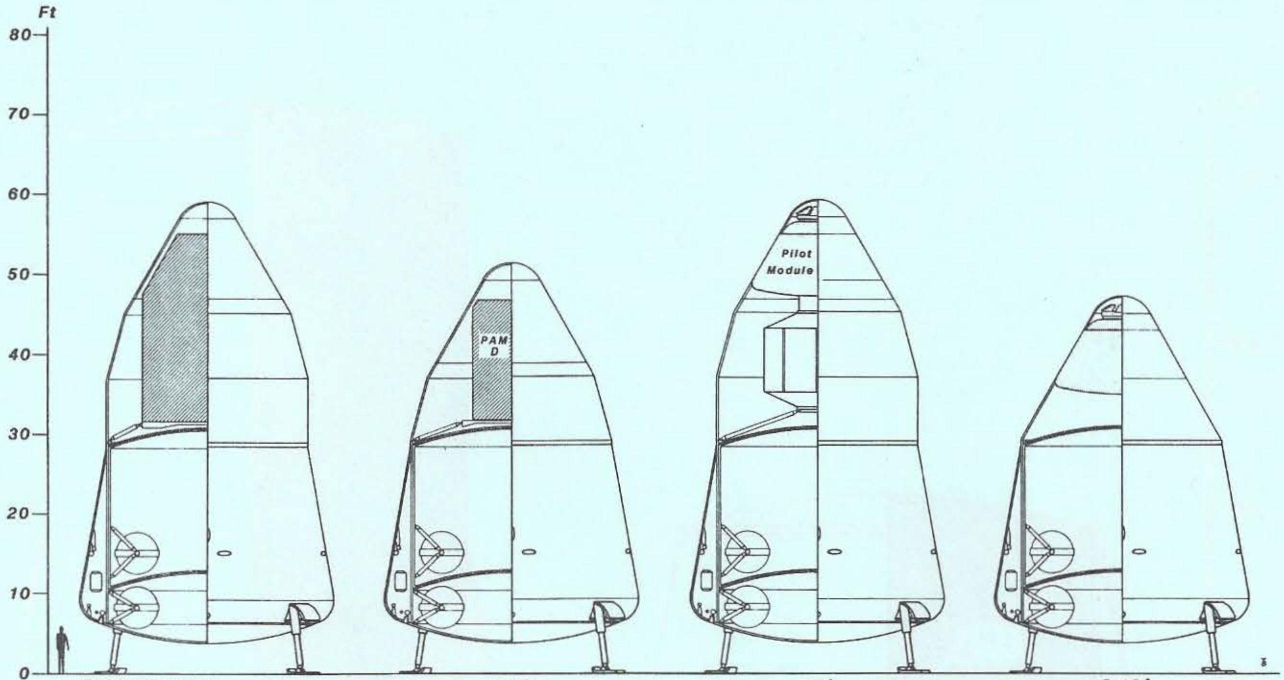
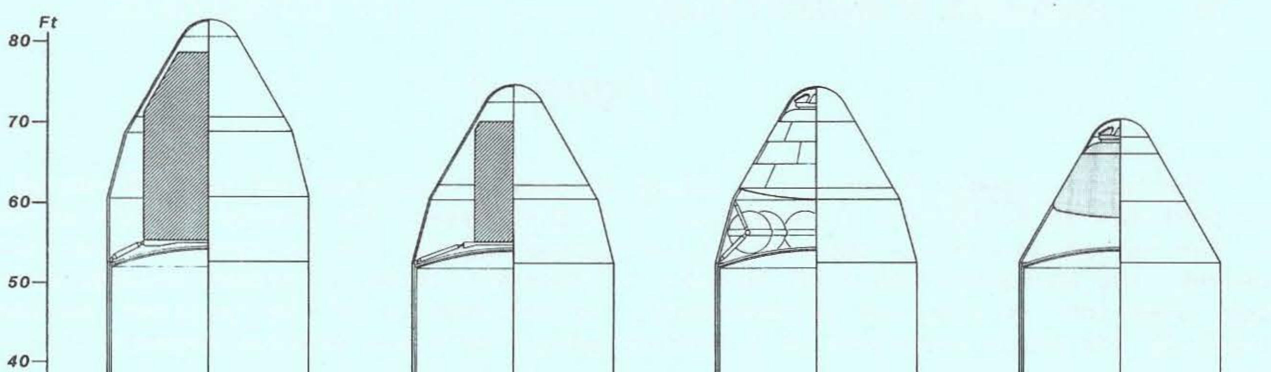


	PHOENIX: C	S/C	C'	S/C'
MAINSTAGE	27,500 lbs.	27,500	27,500	27,500
SHROUD	3,900	1,500	3,000	N/A
ADAPTER	N/A	N/A	N/A	1,500
PILOT MODULE	N/A	N/A	8,000	8,000
PAYLOAD:				
ΔV 29.3 K fps	13,600	16,000	6,500	8,000 (2,900 fps)*
ΔV 31.0 K fps	8,660	11,000	1,500	3,000 (1,150 fps)

*Indicates additional velocity available to spacecraft if payload is carried in the form of extra propellant



	PHOENIX: CX	S/CX	CX/T (TANKER)	S/CX'
MAINSTAGE	34,500	34,500	34,500	34,500
SHROUD	3,900	1,500	1,500	N/A
ADAPTER	N/A	N/A	2,400 (Tankage)	1,500
PILOT MODULE	N/A	N/A	N/A	8,000
PAYLOAD:				
ΔV 29.3 K fps	51,600	-	51,600	46,000 (10,600 fps)
ΔV 31.0 K fps	41,600	-	41,600	36,000 (8,850 fps)
ΔV 38.8 K fps (GTO)	-	7,600	-	-

Figure 3

The Phoenix CX/T is specifically designed as a tanker. This configuration is capable of lifting 51,600 lbs. of propellant into LEO with one flight. This allows Phoenix C operations which require refueling to be made faster and more efficient since the CX/T can orbit a given amount of fuel with only about one-fourth as many flights. For example, a Phoenix C mission to the moon and back would require only six refueling flights if a Phoenix CX/T were used instead of the 22 flights required by a Phoenix C tanker.

Other, more advanced versions of the Phoenix C include the Phoenix C/E (Cargo/Excursion), in which the entire payload section is a two-level pressurized cabin accommodating personnel, instruments, or manufacturing equipment. This configuration is not shown in Figure 3, but would be somewhat similar to the Phoenix C/E configuration illustrated in the Jan. 1983 C.S.R., except for the addition of a Pilot Module on the nose forward of the cabin (which would replace the piloting station shown on the lower level).

The Phoenix propulsion system has been improved. The major improvement is the option of utilizing conventional cryogenic propulsion instead of the advanced mixed-mode propulsion described in the January article.

Conventional cryogenic propulsion uses liquid oxygen (LOX) and liquid hydrogen (LH) as the propellants, a combination which provides very high engine performance, a must for single-stage-to-orbit vehicles (early designs for such vehicles developed by Hudson in the 1970's were all based on LOX/LH propulsion). On the negative side, because of the hydrogen, vehicles using these propellants have to deal with a very low total average fuel density which results in much larger propellant tanks and more structure weight.

Mixed mode propulsion utilizes three propellants, LOX, LH and liquid propane. By replacing some of the LH with denser propane, this combination has the advantage of increasing total average fuel density, resulting in smaller propellant tanks and lighter vehicle structure weight, without a significant drop in engine performance. However, a mixed-mode system requires three propellant tanks and either two different sets of conventional engines and pumps, or advanced engines capable of burning two very different kinds of fuel.

A compromise which keeps the simplicity of a LOX/LH vehicle while offsetting to some degree the problem of low fuel density involves lowering the liquid hydrogen to a temperature which will partially freeze it into a denser, "slush" form. Similarly, the temperature of the liquid oxygen can be lowered to its triple point, increasing its density as well. In addition, average fuel density can be increased by raising the mix ratio of oxygen to hydrogen. These measures have the potential of increasing average fuel density by almost 75% over standard LOX/LH systems (although this is still less than the densities possible in a mixed-mode system).

Another propulsion improvement involves replacing the multiple bell-nozzle engines (which utilized pivoting nozzles for attitude control) by an annular, multiple-combustor "ring" nozzle (which utilizes differential throttling for attitude control). This eliminates the actuators associated with pivoting the engines, and, since the ring nozzle is mounted flush with the external skin of the spacecraft and is resistant to reentry heating, it also eliminates the engine cover doors and their associated actuation systems.

* * *

Starstruck Under New Management

Starstruck, Inc. of Redwood City, Ca. has largely completed the reorganization begun after the first flight of the company's Dolphin rocket in August (C.S.R., Aug.

1984, pp. 1-2). The old board of directors was removed, including investors Dan Fylstra and Michael Scott (Scott also resigned as President and CEO). A new board was then elected, chaired by George Koopman and including Tucker Thompson (replacing Scott as President/CEO), Bevin McKinney, Jess Millikan, and Phillip Salin. This change in personnel (apparently by friendly mutual agreement of those involved) reflects a return to top positions of some of the company's early leaders (McKinney and Salin were among the original founders back in 1981--Thompson joined soon after the company was officially incorporated).

Starstruck is still proceeding with the intention of continuing its launch vehicle production program. However, financing is a problem--funding is running low. A number of the present personnel are working on a volunteer basis, and steps are being taken to reduce the company's overhead.

People's Republic of China Offers Commercial Launch Vehicle

The People's Republic of China intends to make their new three-stage geosynchronous launch vehicle available to commercial customers. The 140-foot launch vehicle incorporates a LOX/LH third stage, and successfully launched an experimental communications satellite into GEO last April. The cryogenic stage was stacked on top of an operational launch vehicle called the Fengbao FB-1 (Storm 1) by the Chinese (the FB-1, which uses storable propellants, is a modified intercontinental ballistic missile and can place about 2,600 lbs. into LEO).

The payload capacity of the Chinese rocket is a little over 900 lbs. into GEO. Launch prices have not yet been set, but are likely to be quite low. The closest competing launch system in the United States is the McDonnell Douglas Delta family of rockets presently being marketed by Transpace Carriers, Inc. of Greenbelt, Md. The Delta has a payload capacity of up to 1,550 lbs. into GEO, and a price in the $20-30 million range. Whether or not the Chinese can become serious competitors depends on the satellite customers. It remains to be seen whether China's anticipated bargain prices can offset the proven record and greater payload capacity of the Delta.

Shuttle Satellite Rescue Ready To Go

Space Shuttle mission 51-A, scheduled for launch Nov. 7, will attempt the rescue of two communications satellites "lost" in the wrong orbits--Westar 6 and Palapa B-2 (C.S.R., May 1984, pp. 1-3). NASA is charging the satellites' various insurance underwriters a total of $5.5 million for the retrieval. The underwriters plan to refurbish the satellites and sell them, thereby claiming the honor of becoming the world's first official Used Satellite Dealers.

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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