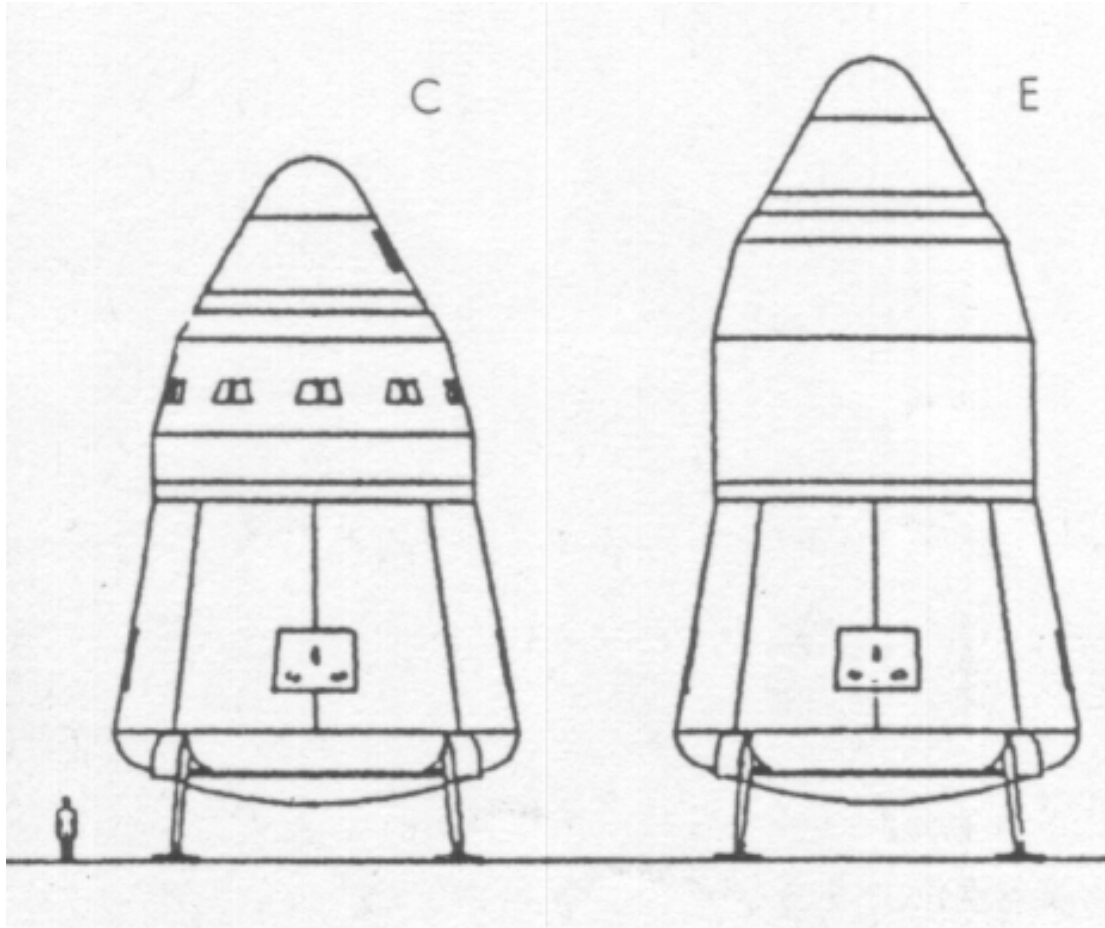
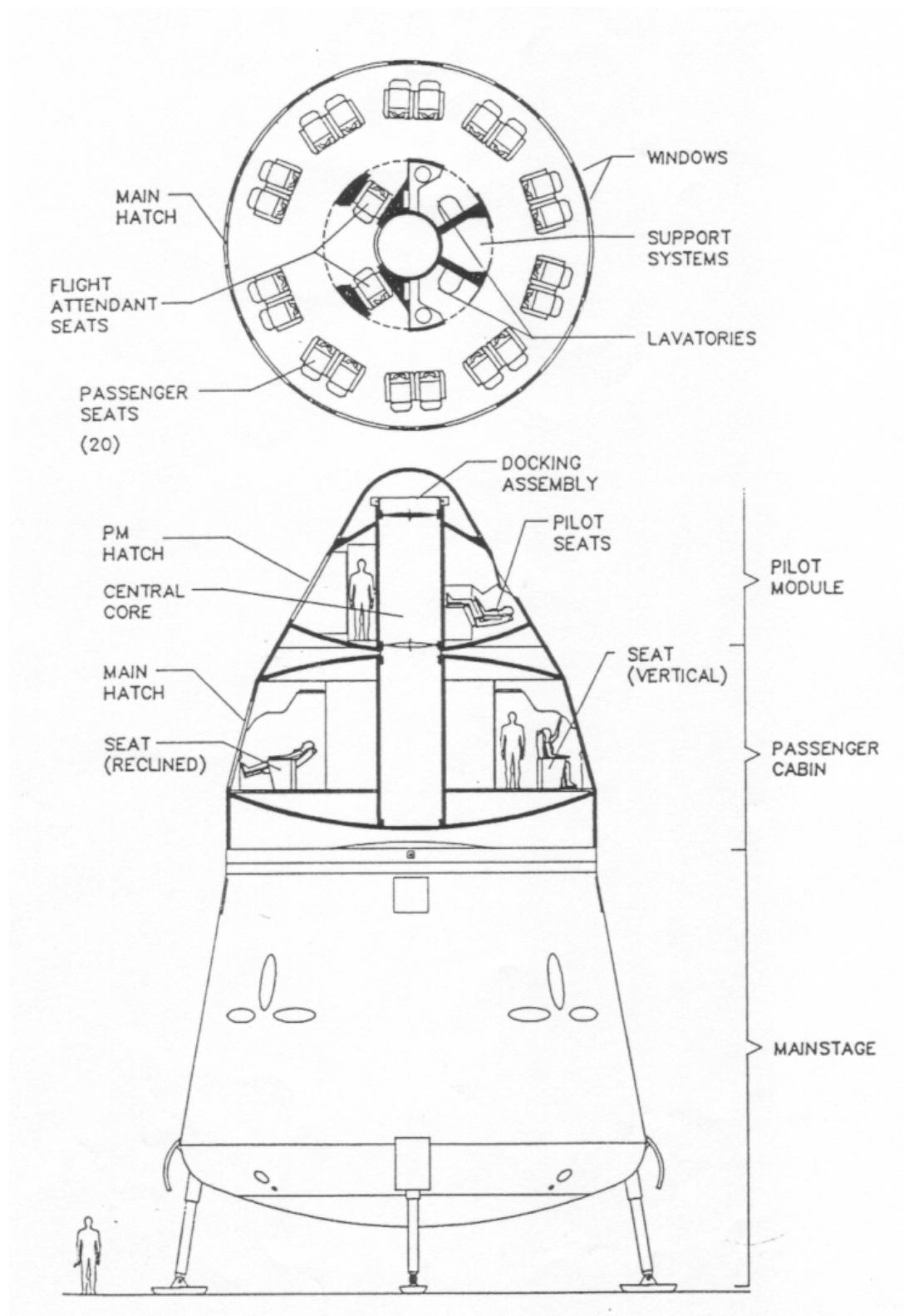


# Phoenix

(the following text was copied from a book called “Spaceships in fact and fantasy”... I think.)

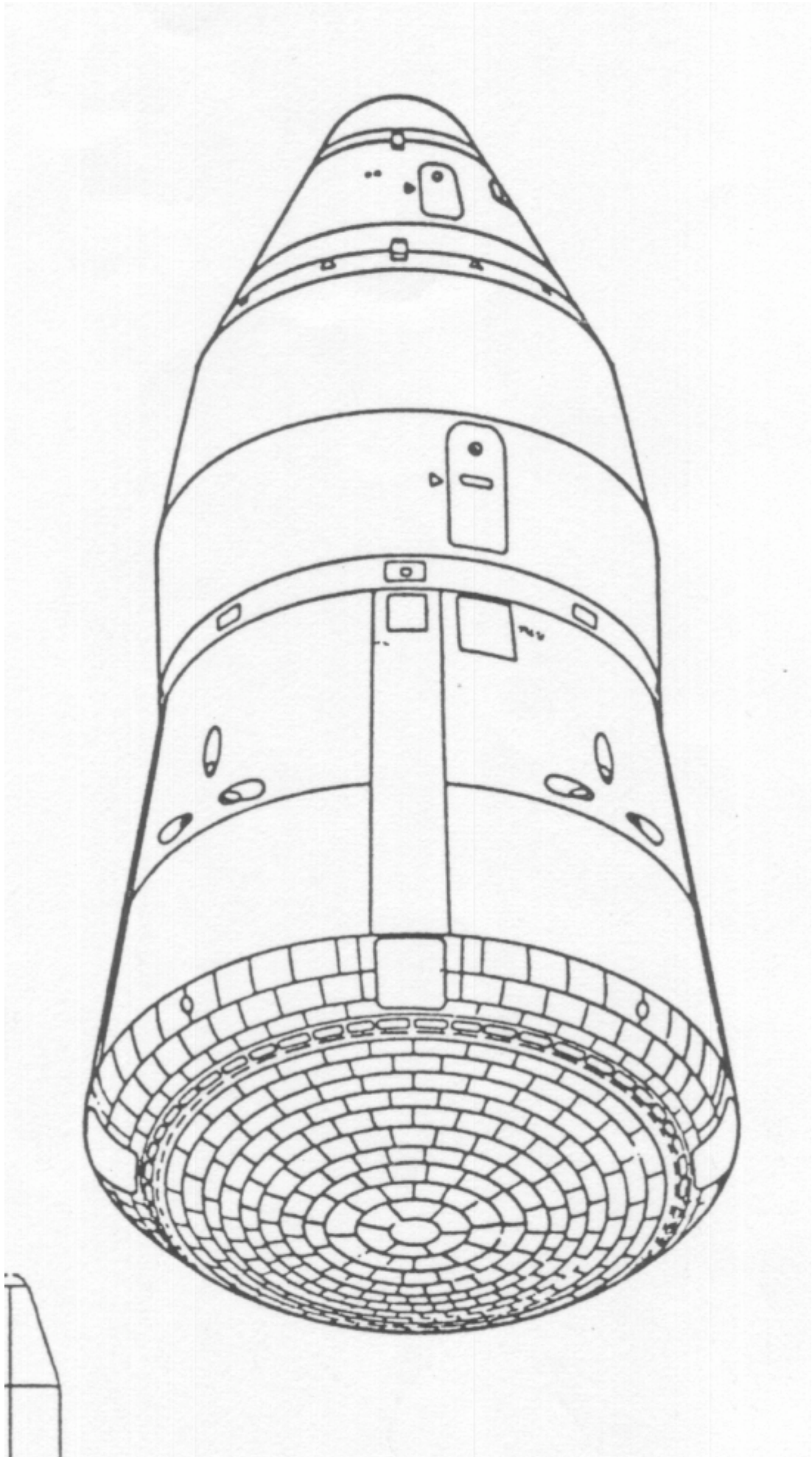


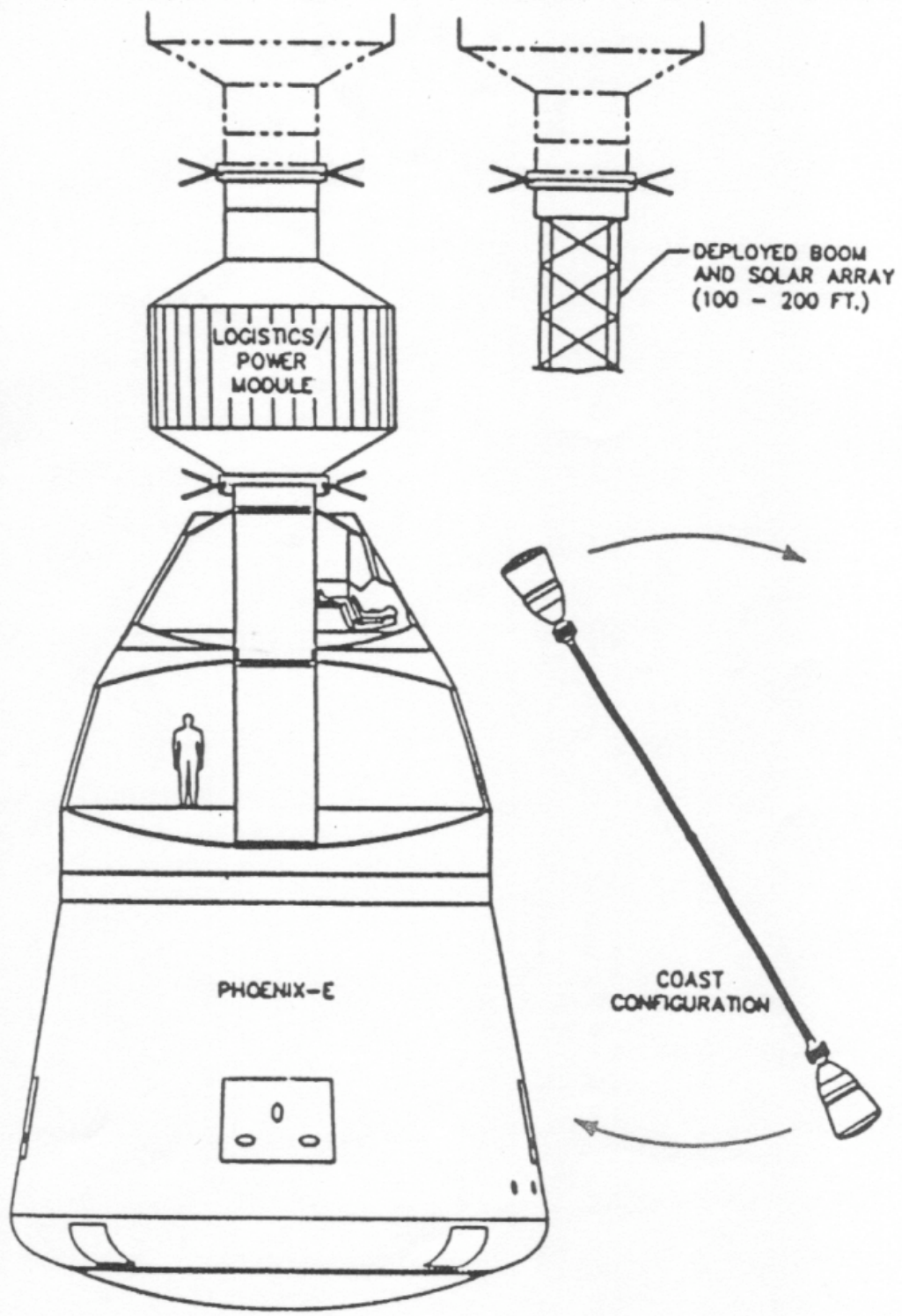
The Phoenix spacecraft has been under development by engineer Gary Hudson since 1982 as a low-cost alternative to the shuttle. A true spaceship that can be refuelled in orbit for orbit-to-orbit capability or for trips to the moon and beyond, it is a squat, cone-shaped vehicle 57 feet tall and 31 feet wide at its base. It somewhat resembles the designs of Philip Bono upon which it is based, though on a much smaller scale. Propelled by a liquid oxygen and liquid hydrogen-fuelled aerospike engine with forty eight combustors, it can be launched by five people in less than 2 hours from hangar to orbit. Cost per pound in low earth orbit can be as low as \$100, which could be reduced to \$20 if there are a large number of flights. There are four versions of the basic design: an all-cargo, unmanned vehicle; a cargo rocket with a crew of two to four; a tanker; and the twenty-passenger, two-crew Society Expeditions version, the Phoenix E. Common to all versions is a main stage that comprises the lower half of the spacecraft, 25 feet in diameter at its top and 32 feet in diameter at the base. The bottom is a spherical segment with a 36-foot radius that acts as a heat shield during reentry. A single, circular aerospike engine comprised of forty eight individual combustors surrounds the base. Maximum sea-level thrust is 640,000 pounds. Propellants are triple-point liquid oxygen and 50 percent slush liquid hydrogen.



Available to be added to the main stage are a payload shroud, pilot module, propellant extension kit (allowing for an additional 250,000 pounds of propellant), and an excursion module capable of carrying up to twenty passengers and two crewmembers.

The Phoenix E is to be 57 feet tall (10 feet shorter than the purely cargo versions). All of the Phoenix spacecraft land on four extendable legs. Twenty adjustable seats are arranged around the cabin's circumference, with a window for each passenger.



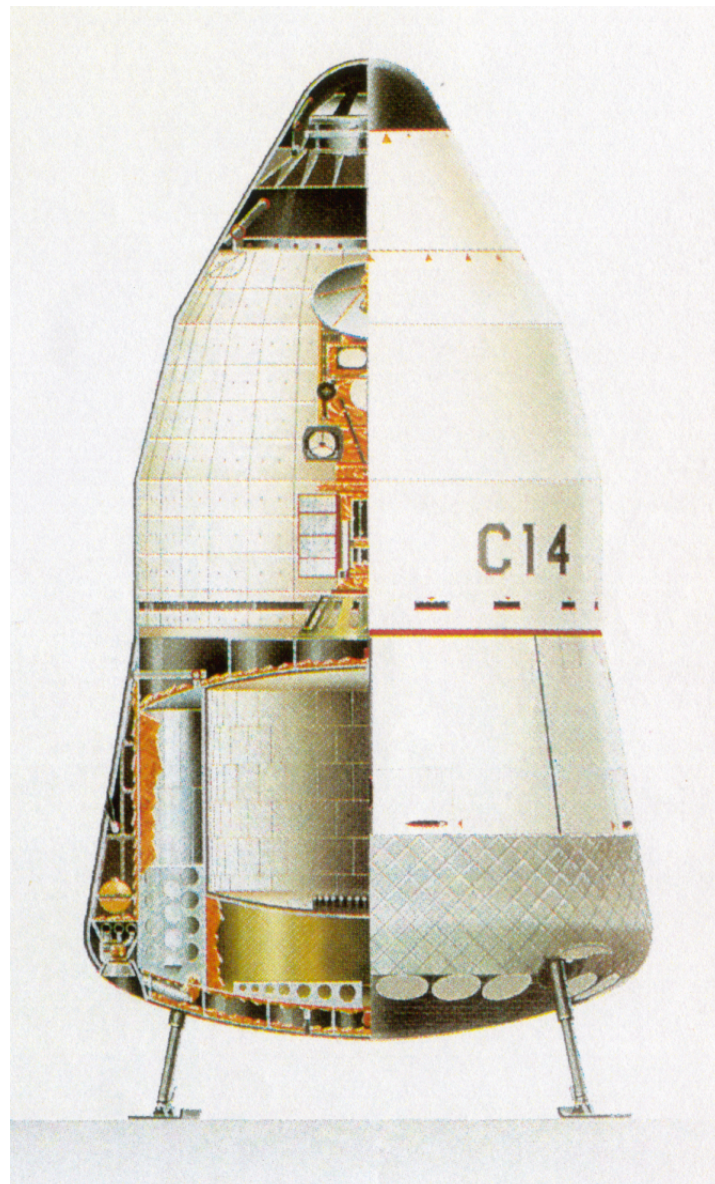


Phoenix-E in Mars mission configuration

In the center are seats for the two flight attendants, lavatories, etc. A central core airlock allows access to the pilot module above. Peak acceleration and deceleration are to be no more than 3 g. Each vehicle will have a life of 1,000 flights.

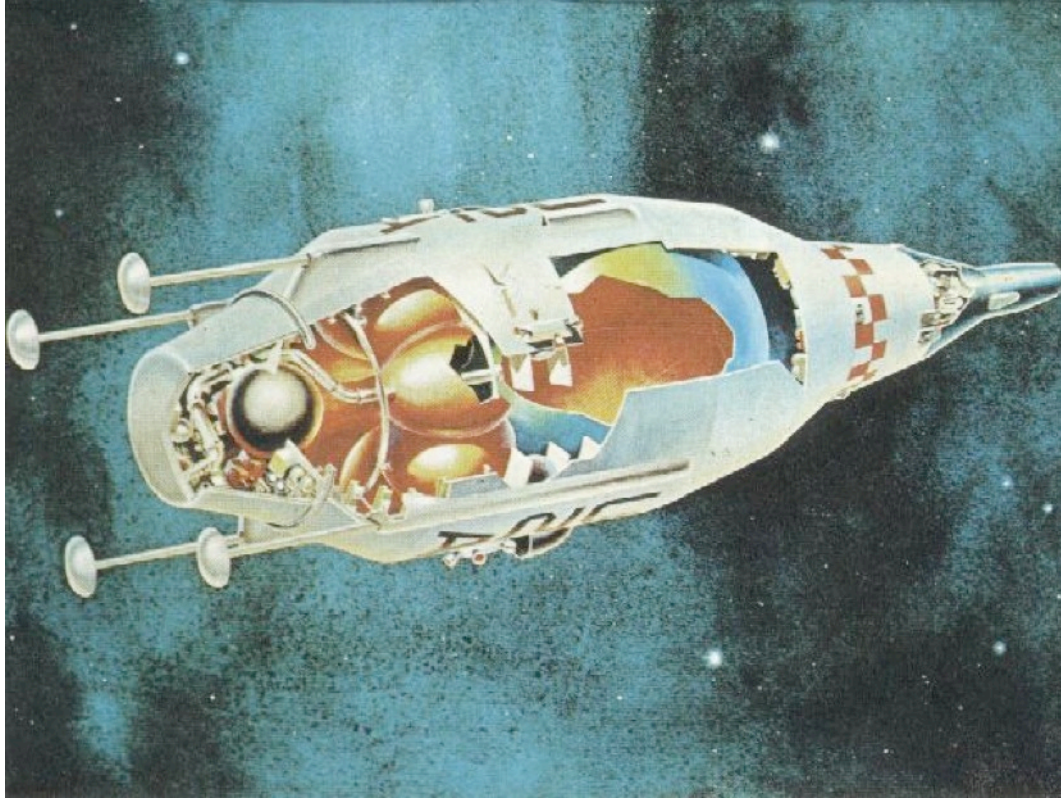
Society Expeditions begins accepting reservations for a \$200 registration fee and a \$5,000 deposit. The first five flights are immediately booked.

Hudson's Phoenix would also provide an inexpensive and reliable means of transporting cargo and human beings to and from lunar settlements (it could carry a 20,000-pound payload to low earth orbit or to the lunar surface after refueling). The Phoenix could place a twelve-person settlement on the moon in 2 years from the start of launches for an estimated median cost of \$54 million (about \$214 per pound to the lunar surface). Hudson concludes that by using the Phoenix a lunar settlement could be established and operated for a year for certainly under \$1 billion and perhaps for as little as \$100 million. Given an effective reusable SSTO vehicle such as the Phoenix, a lunar settlement could be privately built.



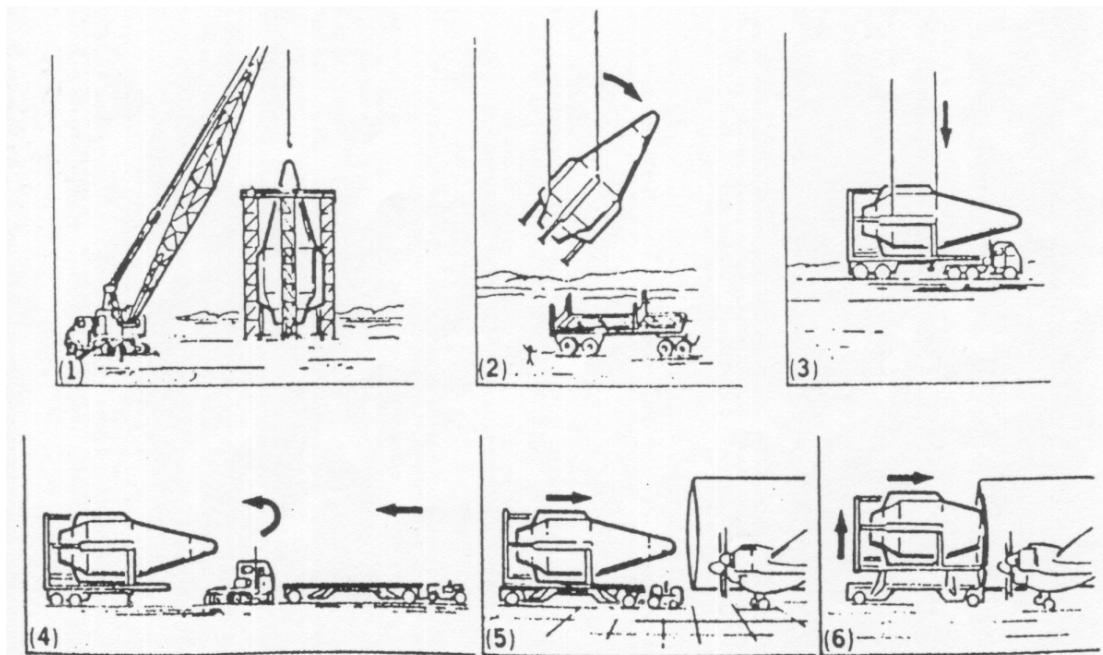
# SASSTO

Phillip Bono's proposal for a first step towards a VTOVL SSTO vehicle – a heavily modified Saturn IVB stage with a plug nozzle engine.



In late 1966, the vertical launch and landing SSTO proponents at Douglas Aircraft Co. carried out a study to determine whether ballistic SSTOs might be cost-competitive vs. winged VTHL TSTO vehicles in the small payload class. Previous NASA and USAF studies had generally assumed ballistic single-stage vehicles might make sense for unmanned heavy-lift payloads but winged TSTOs were invariably chosen for small manned near-term missions. Consequently, Douglas had to define a small VTVL SSTO manned “space taxi” to demonstrate the key elements of the concept (aerospike engine, lightweight structures, ballistic re-entry, vertical landing, actively cooled heatshield, etc.)

The resulting vehicle became known as “Saturn Application Single Stage to Orbit”. Notable design features included an aft-mounted liquid oxygen tank to reduce the difference between vehicle centre of gravity and centre of aerodynamic pressure, and a hydrogen cooling system for the main engine to provide thermal protection during re-entry. Thermal analysis indicated that although the engine itself would be adequately protected by this system, the areas located above the exhaust nozzles would not. Consequently, the designers had to resort to an ablative, expendable material (200 kilograms of Armstrong Insulcork 2760) bonded to the aluminium structure - although it would increase the maintenance cost.



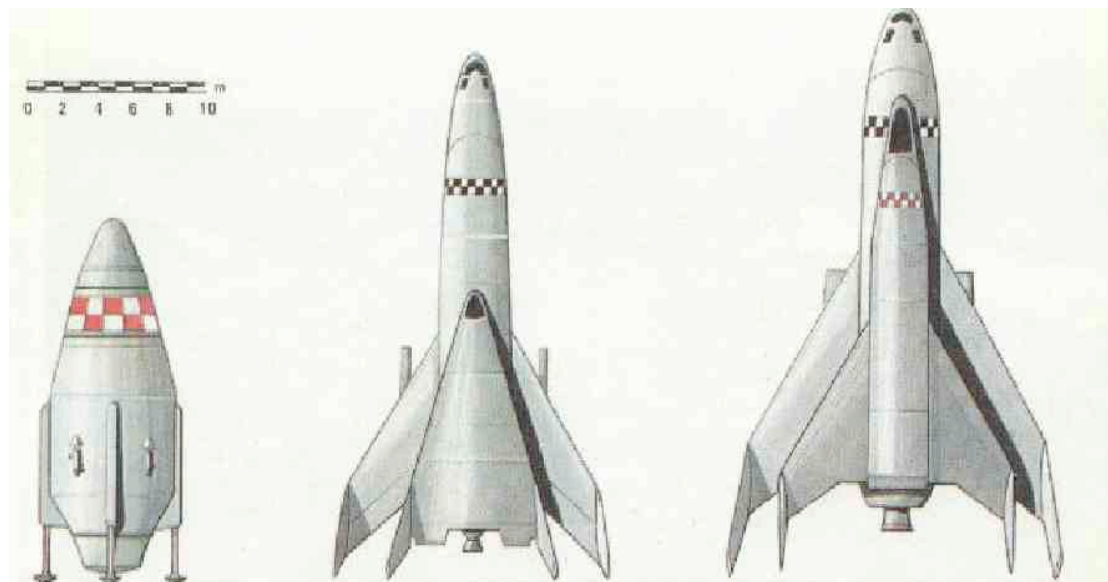
The oxygen/hydrogen mixture ratio was 6:1 rather than 7: 1 since the designers felt a high oxygen ratio would degrade the exhaust velocity and payload capability. 50% hydrogen slush was used to reduce the volume of the fuel tank. The 36-segment plug nozzle propulsion system would have operated at a pressure of 1500psi. It would be used for ascent, orbit insertion, de-orbit and (beginning at an altitude of 760 meters) the final landing burn. The vehicle would carry enough propellant for hovering for 10 seconds before landing at an unprepared site, if necessary. The estimated landing accuracy of 1853 x 3700 m was not regarded as a major concern since the Gemini 6-12 flights achieved an average touchdown dispersion of only 6.85km although the capsule had essentially no manoeuvring capability below 0.5km altitude. The re-entry cross range capability was about 370km, permitting a safe landing at EI Paso, Texas or Wendover Range, Utah after 2-3 orbits from Cape Canaveral. Wendover was the preferred emergency landing site since SASSTO easily could have been returned from nearby Hill AFB to Cape Canaveral in a "Pregnant Guppy" S-IV-B transport aircraft.

SASSTO had a payload capability, of 3,629kg to a 185kin orbit and the standard payload would be a 2-man Gemini spacecraft protected by a jettisonable fairing to reduce drag losses during ascent. This would provide a safe emergency escape system for the test pilots, and the Gemini ejection seats, heatshield, parachutes etc. (1542kg in all) could later be removed as the flight test program increased confidence in SASSTO reliability. Douglas envisioned this vehicle as a "space fighter" capable of satellite inspection missions, or space station resupply flights lasting a maximum of 48 hours. It could also deliver 2.812kg of liquid hydrogen to a spacecraft in Earth orbit.

Since SASSTO was loosely based on the Saturn S-IV-B rocket stage, Douglas also proposed an expendable version for use as a more capable upper stage with the Saturn IB and Saturn V launch vehicles. The expendable SASSTO stage would have had a burnout mass of 7,400kg and carried 85,729kg of oxygen+hydrogen propellant. The stage was thus of a much more lightweight construction than the standard S-IV-B (12,949kg + 104,326kg LOX/LH2) and the new aerospike engine would have been more efficient as well (464s specific impulse vs. 426s for the J-2 engine).

	SATURN IB		SATURN V		
	S-IVB DATA (LB)		SASSTO DATA EXPENDABLE (LB)		REUSABLE (LB)
*INCL. IN THE BURNOUT WEIGHT	78,549 (INCL. I.U.)		16,370 (INCL. GUID.)		19,000 (INCL. GUID.)
*INCL. INTERSTAGE STRUCT.	230,000		189,800		189,000 GUID.
BURNOUT WEIGHT	3,495		2,680		(2,255)*
PROPELLANT WEIGHT	7,000 (INTERSTAGE)		(1,300)*		(1,725)*
WT LOSS IN 4-1/2 HOURS PARKING ORBIT	262,044		208,000		208,000
ADDITIONAL STRUCTURE *					
GROSS WT. LESS PAYLOAD **					
USABLE PAYLOADS					
100 NMN ORBIT	35,000	261,000	57,000	286,000	52,500
ESCAPE	NONE	98,000	16,000	117,000	---
SYNCHRONOUS ORBIT	NONE	72,000	11,500	90,000	---

Consequently, the Saturn V's payload capability to low Earth orbit would have been boosted by 10 metric-tons as well. The Saturn IB's basic 15,876 kilogram payload capability, to a 185km orbit would have increased to 23,814-25,855kg depending on whether SASSTO would be flown in expendable or reusable mode. The latter version was known as SARRA (Saturn Application Retrieval and Rescue Apparatus) and was intended for returning stranded Apollo crews from the lunar surface.



Finally, the Douglas design team also compared the cost of SASSTO with two different all-rocket VTHL TSTOs: a winged 1st stage plus lifting-body 2nd stage (centre) and winged first and second stages (right). All three vehicles were designed for a 2,812-kilogram payload although the lifting-body TSTO only was able to carry 2,086kg due to centre of gravity problems. No attempt was made to estimate the marginal launch cost since there were too many unknown factors.

VTVL SSTO would however be expected to yield a significant operational advantage since only a single vehicle must be maintained and the VTVL SSTO does not require a landing runway. SASSTO was expected to cost \$1.1 billion to develop (= \$5.88B at 1999 rates). The winged VTHL TSTO would cost 2.2 times as much to develop as SASSTO while the smaller lifting-body TSTO variant would be 50% more expensive. The winged and lifting-body 1st unit production costs would be 4 and 2.7 times higher than the SASSTO 1st unit cost respectively.

The general conclusion was that the complex winged or lifting-body TSTO shapes result in added lift-off and manufactured weights of a more expensive construction than ballistic wingless SSTOs. For example, the lifting-body TSTO dry mass (12,274kg + 2,086kg payload) is 2.4 times higher, and the winged TSTO weighs 3.6 times as much (18,176kg+2,812kg P/L) as SASSTO at touchdown. The gross lift-off weights bear the relationships of 1.0 (SASSTO.. 97,887kg GLOW). 1.25 (lifting body orbiter TSTO. 122,245kg GLOW) and 1.91 (wing-body orbiter TSTO. 187,020kg GLOW). In that case, is the combination of lower re-entry g-loads, better manoeuvrability (landing go-around with jet engines) and improved cross range really worth the cost of carrying wings ... ?

Although TSTO thus appears to be uncompetitive vs. ballistic single-stage RLVs for small payloads, the authors admit that requirements for higher payloads (22-45t) may yield rapid increases in propellant mass fraction for winged two-stage vehicles, making TSTO more performance/cost effective.

Specifications:

LEO Payload: 2,812 kg. to.. 185 km Orbit. at 28.0 degrees. Liftoff Thrust: 125,647 kgf. Total Mass.. 97,887 kg. Core Diameter: 6.7 m. Total Length: 21.0 m. Development Cost S.. 1,100.00 million. in 1968 average dollars. Launch Price S: 0.03 million. in 1968 price dollars. FYawaY Unit Cost S.. 16.10 million. in 1968 unit dollars. Cost comments: Cost is as calculated by Bono for production run of 50.

Stage Number: 1. 1 x SAS STO Gross Allmass: 97,976 kg. Emp~v Mass: 6,668 kg. Thrust (vac):

158,882 kgf. Isp: 464 sec. Burn time.. 300 sec. Isp(sl): 367 sec. Diameter: 6.6 m. Span: 6.6 m. Length: 18.8 m. Propellants: Lox/Slush LH2 No Engines: 1. Plug-Nozzle SASSTO