Space is becoming big business . . .

Most serious investors today, even those who have profited greatly from high tech industries, would regard investing in outer space as falling somewhere between buying the Brooklyn Bridge and investing in wild-cat oil, with the possibility for a reasonable return for a reasonable risk lying in the far distant future. This is an overly pessimistic appraisal.

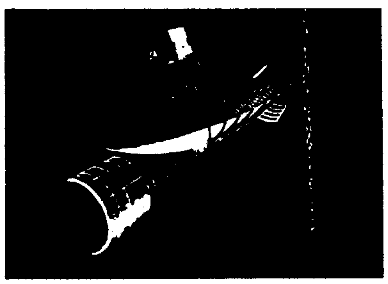
As a matter of fact, the present investment in commercial space activities exceeds $4 billion, is paying off at a handsome rate, and is growing by leaps and bounds.

The four NASA space shuttles, in their projected lifetimes, are expected to lift some twenty-six million pounds into low orbit. At least half of this payload capacity will be allocated to commercial satellites. Revenue from the sale of transportation for these satellites is expected to be in the neighborhood of $13 billion. At least one firm, William Sword, Inc. believes the capacity of four shuttles will be insufficient to meet the demand and is willing to invest one billion dollars to buy a fifth.

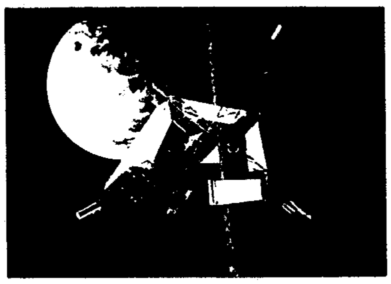
In the book, *Space Industrialization,* (CRC Press, 1982) the most authoritative report of commercial space activities available to date, the revenue from all commercial activities in space is predicted to exceed $15 billion per year by the year 2000 (which is only 16 years away).

Whether any of these forecasts are correct remains to be seen; however, the expansion of activity in space to date has exceeded the predictions of even its most enthusiastic proponents. Our first satellite weighed only a few pounds and there were serious arguments as to whether more than a hundred pounds or so would ever be justified, or even possible.

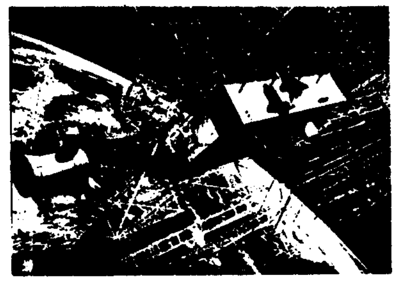
A scant ten years later the Apollo launch vehicle (Saturn V) was capable of carrying 250,000 lbs. to low orbit, and our shuttles, at 65,000 lbs. payload per flight, are booked solid for several years to come. Both the demand and the capacity have grown enormously. There is every reason to expect this growth to continue.



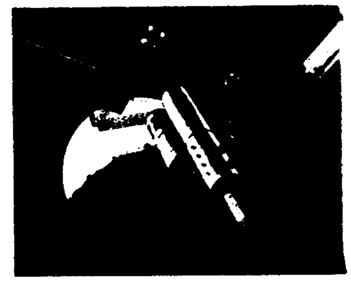
Communications



Power Systems

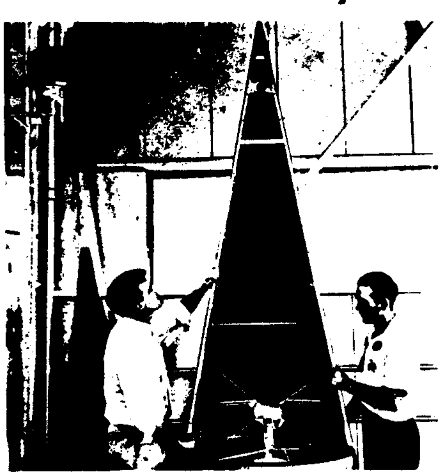


Manufacturing

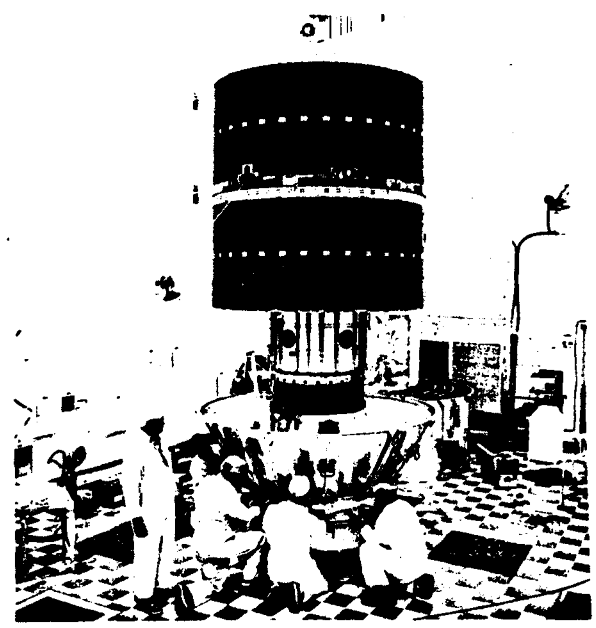


Space Colonies

1958: 6.4 lb. First Payload



1980's: Payloads in the tons



The Shuttle: not cost effective . . .

Despite its nearly flawless technical performance, the NASA shuttle, from a cost-effectiveness point of view, is an incredibly bad design. The system is very heavily penalized 1.) by the use of wings to land the orbiter, 2.) by the fact that the orbiter is manned, 3.) by throwing away the main propellant tank and 4.) by the use of solid propellants for the boosters.

The airplane-like features of the shuttle, and the extra heat protection required to bring this awkward shape back through the "thermal thicket" requires a weight investment nearly twice that of the payload itself. In fact, most of the weight of the orbiter is devoted to recovering the recovery provisions! This means that the shuttle would be at a 3 to 1 price disadvantage compared with a design using lighter recovery methods, other things being equal. Furthermore, other things are not equal. . . they make the picture even worse! For example, the airplane-like features lead to enormous complexity: fins, rudders, ailerons, controls, complex hydraulic and electric systems, hundreds of instruments, thousands of switches and buttons, innumerable ribs and stringers and millions of rivets.

The direct cost to launch an expendable (Saturn V) type rocket is shown on page 3. It may be seen that about half of the total cost is associated with launch preparations. These costs are directly related to the complexity of the vehicle. The other half of the cost is for propulsion hardware. Reducing this latter cost is the sole reason for developing a reusable vehicle such as the shuttle. The increased complexity of the shuttle attributable to winged recovery, by increasing the cost of launch preparations, largely nullifies the cost saving resulting from reusability.

The decision to make the shuttle a manned vehicle further added to its complexity. The high reliability required for manned vehicles leads to the use of series-parallel redundancy, which in turn increases the complexity several fold wherever used. It also increases development, manufacturing and launch costs. For 90% of the forseeable missions, there is no need to have men on board.

Reusability is vital to reducing the cost of propulsion hardware, but the shuttle is only partially reusable. The "external" tank, the largest component of the shuttle, is jettisoned and burns up on re-entry into the atmosphere. These tanks cost about 10 million dollars each and contribute significantly to the total transportation cost.

Orbiter Weight Penalty

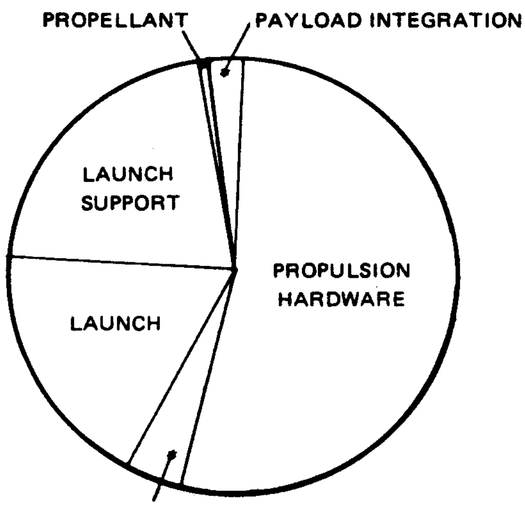
WEIGHT ITEM	AMOUNT	ATTRIBUTABLE TO AIRPLANE
WING STRUCTURE	15,717	15,717
TAIL STRUCTURE	2,911	2,911
BODY STRUCTURE	42,938	36,000
INDUCED ENVIRONMENTAL PROTECTION	19,837	15,000
LANDING AND AUXILIARY SYSTEMS	7,909	7,100
PROPULSION, MAIN ASCENT	28,224	0
PROPULSION, RCS AND OMS	5,619	0
PRIME POWER	2,944	2,500
ELECTRICAL CONVERSION AND DISTRIBUTION	7,106	6,000
HYDRAULIC CONVERSION AND DISTRIBUTION	1,979	1,400
SURFACE CONTROLS	2,761	2,761
AVIONICS	5,949	5,000
ENVIRONMENTAL CONTROLS	5,250	5,250
PERSONNEL PROVISIONS	1,094	1,094
PAYLOAD PROVISIONS	607	607
PERSONNEL	2,644	2,644
TOTALS	153,489	103,984

Overall ratio, lift-off weight/payload weight = 68/1 (present design)
Possible ratio, airplane-like provisions eliminated = 26/1
Same ratio for Saturn V Apollo launch vehicle = 25/1 (for comparison)

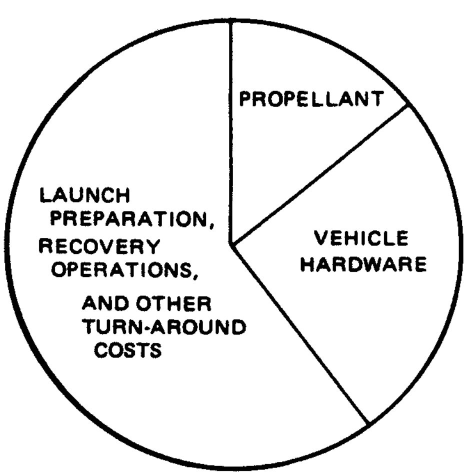
The Shuttle: not cost effective . . .

Solid propellants cost $3 - 6 dollars per pound, and each shuttle launch consumes over two million pounds, for a total of $6 - 12 million dollars per launch. Furthermore, the solid boosters are difficult to refurbish, raising some doubt as to whether recovery and reuse of these is really economic. Total refurbishment cost has been reported to be $8 million each, for a total of $16 million per launch. Comparable liquid propellants cost only a few cents per pound, and refurbishment of this type of rocket, primarily refueling, can be done at the launch site in a few hours.

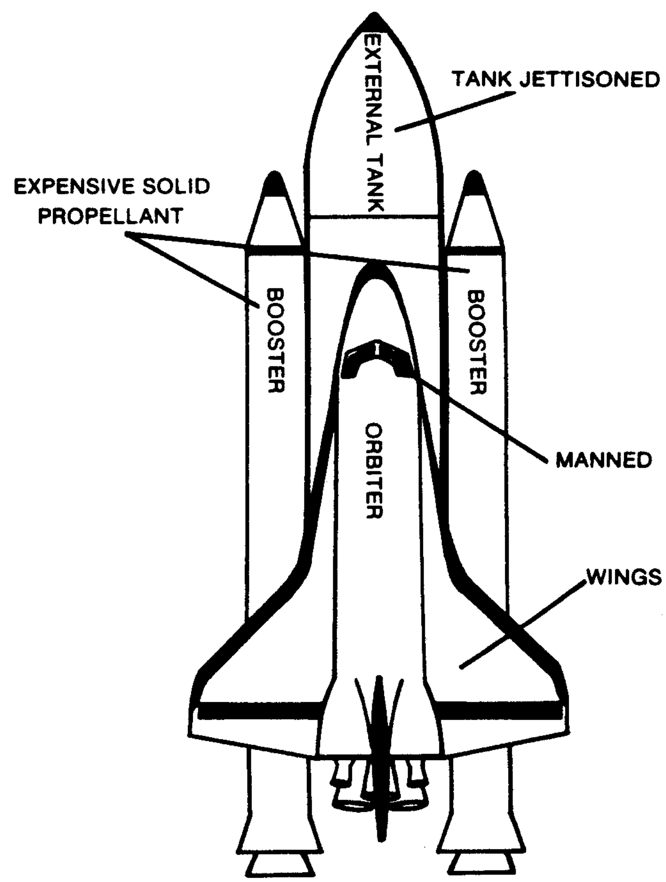
Granted the truth of these drawbacks to the NASA shuttle concept, are they none-the-less necessary to achieving the reusability so important to bringing down the cost of propulsion hardware? Is there really an alternative that eliminates these drawbacks without encountering others that are more serious? We think that there is.



COST BREAKDOWN FOR LARGE EXPENDABLE LAUNCH VEHICLE (Saturn V)



COST BREAKDOWN FOR LARGE SEMI-REUSABLE LAUNCH VEHICLE (Space Shuttle)



UNECONOMIC FEATURES

SHUTTLE DATA

Payload:	65,000 Lbs.
Lift-off Wgt:	4.4 Million Lbs.
Solid Boosters (2)	3. Million Lbs.
External Tank	1.15 Million Lbs.
Orbiter (Partially Reusable)	.25 Million Lbs.

An alternative to the Shuttle: Excalibur

Our concept stresses reusability and simplicity to attain low cost. Excalibur, our first operational vehicle, is a two-stage-to-orbit vehicle, both stages of which are recovered by parachute in the ocean. Typically such recovery systems weigh only a few percent of the weight recovered.

Liquid oxygen and kerosene are used in the first stage, liquid oxygen and liquid hydrogen in the second. Both stages are pressure fed, without pumps, turbines or gas generators. There is only one engine per stage, and the operating conditions are very relaxed. Instead of the fantastic combustion pressure of 3,000 p.s.i. used on the shuttle, Excalibur uses only 300 p.s.i. on the first stage and 75 p.s.i. on the second stage.

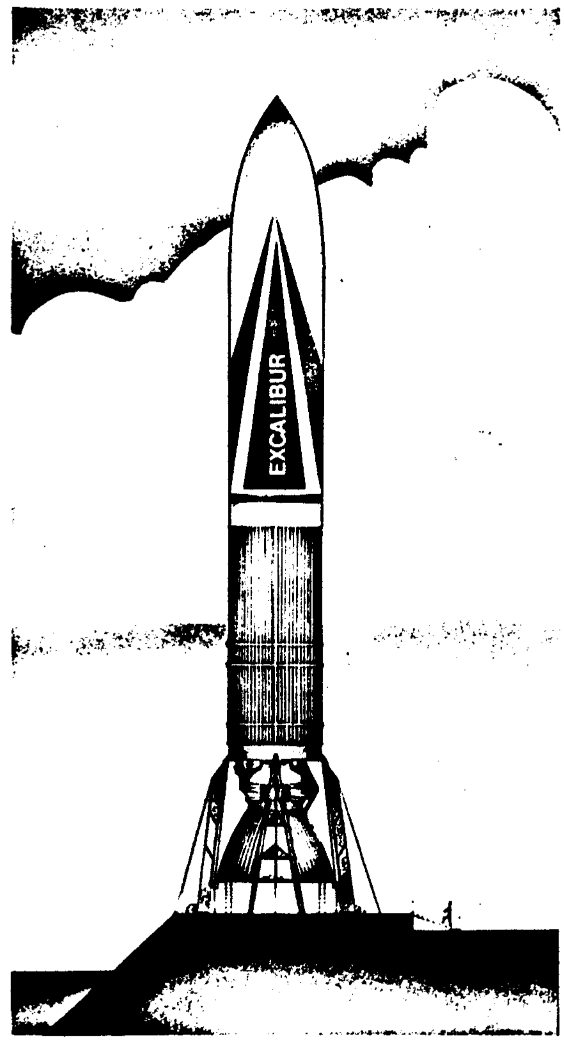
Although the use of pressure fed engines on Excalibur leads to a weight penalty, the saving in launch cost, development cost and manufacturing cost is very large. Tankage for a pressure fed system would be made of relatively heavy gauge steel, rather than thin aluminum. The saving in recovery system weight far overbalances the added weight of the pressure fed propulsion. The resulting ratio of payload to lift-off weight for our relatively simple Excalibur is twice as good as the shuttle.

In view of its better payload-to-weight ratio, cheaper propellants, full recoverability and greatly reduced complexity, we believe that it can carry payload to orbit for under $100 per pound.

The Excalibur design is based on studies made by the Aerojet General Corporation in the early sixties. These studies, made under the direction of R. C. Truax, were aimed at achieving the lowest possible payload transportation cost to support a manned mission to Mars and a lunar base. The vehicle designed was called Sea Dragon. Excalibur is a scaled down version of Sea Dragon. Over one million dollars was spent on the design and supporting cost studies. The final transportation cost was predicted to be $20./lb. (direct operating cost, 1983 dollars). TRW (then STL) was given a NASA contract to verify or refute the Aerojet's cost predictions. They confirmed Aerojet's figure within a few percent.

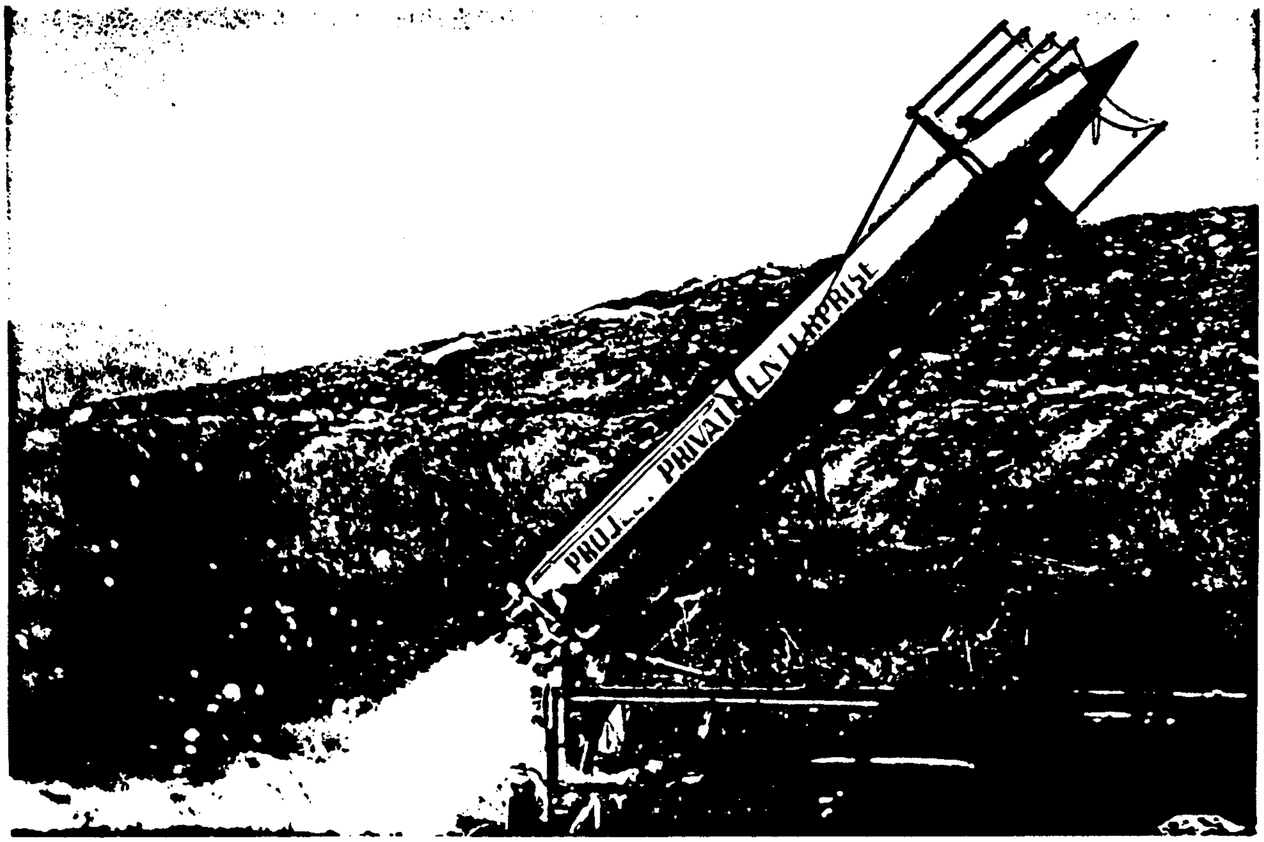
Despite this confirmation, NASA refused to believe the costing, contending that the use of pressure fed propulsion made the approach "technically uninteresting" and that ocean recovery would lead to refurbishment costs much larger than predicted by Aerojet or STL.

Although two experimental programs, "Sea Horse", and "Sea Bee" were carried out by Aerojet in an attempt to resolve this issue, the question of cost-efficiency became irrelevant during the late sixties because of reductions in the NASA budget and loss of interest in any new launch vehicles. When interest in reusable vehicles revived a few years later, the Sea Dragon studies were conveniently forgotten by NASA and an airplane-oriented industry. No attempt was made to verify further the conclusions of the Sea Dragon, Sea Bee, and Sea Horse programs.



Excalibur Payload: 100,000 lbs.
Lift-off Wt.: 3.6 million lbs.

What we are doing now . . .



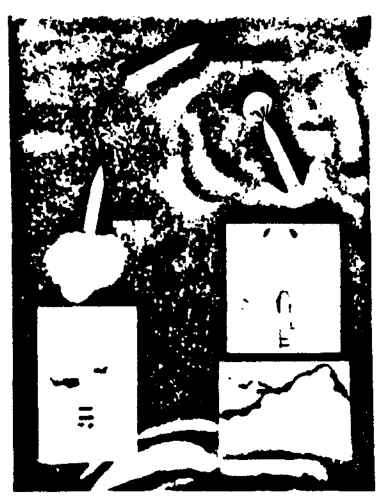
Captive Test Firing of Enterprise rocket

Truax Engineering is now attempting to prove the principle of Excalibur and Sea Dragon through its Phase I program; multiple launch and recoveries of a small scale prototype called "Enterprise".

The designer of the "Enterprise" is R. C. Truax. He is a pioneer in the rocket, missile and space fields. A detailed resume of R. C. Truax is on pg. 12.

Fell Peters R. C. Truax

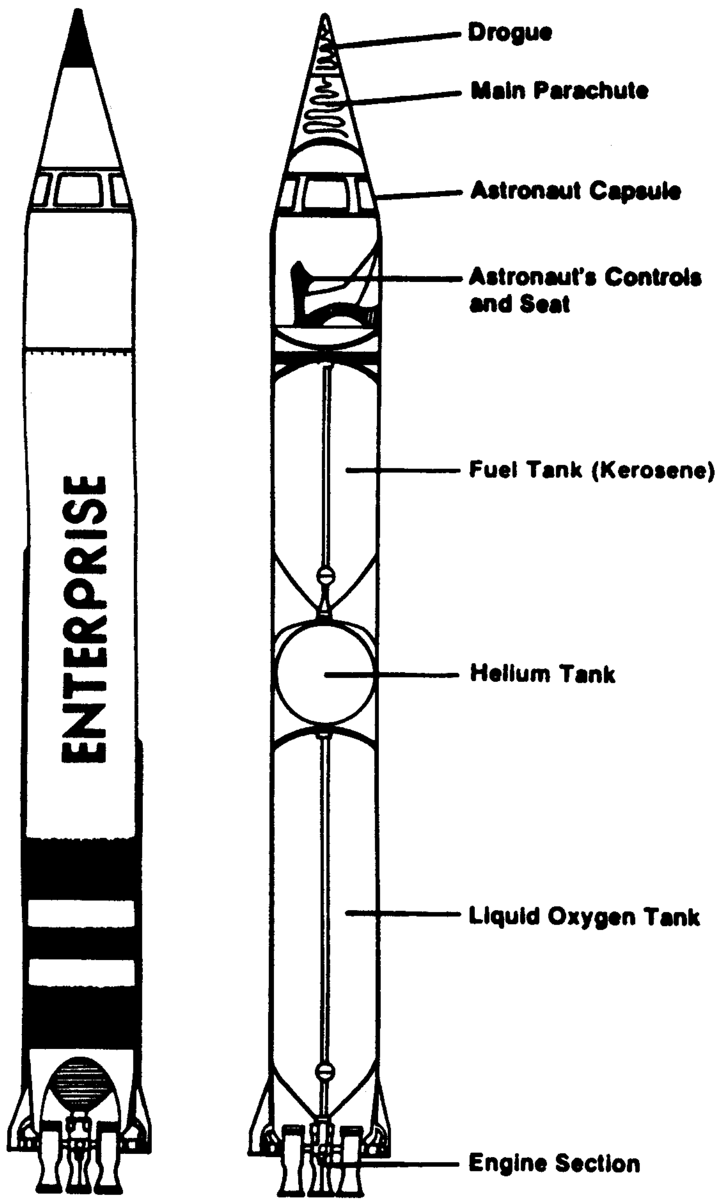
Flight Plan



Project Private Enterprise

The Phase I flight test will be sub-orbital in nature. The "Enterprise" rocket is 25 feet long, 25 inches in diameter and weighs 3,000 lbs. at liftoff. It uses liquid oxygen and kerosene as propellants. It is designed to fly a near-vertical trajectory, and pass the offical lower limit of outer space, which has been set at 100 kilometers. The speed of the rocket will be about 2,700 miles per hour. Descending by its parachute, the rocket will splash down some ten miles from its launch point. A helicopter will pick up the rocket and return it, ~~with the astronaut still inside~~, to the launch site. The rocket will be reserviced and relaunched many times.

These flights will duplicate most of the events the first stage of a two-stage-to-orbit vehicle would encounter. We will pay most serious attention to the recovery and preparation for re-launch, since these are crucial to the economic viability of the concept. Accurate track will be kept of the parts replaced or repaired, and the operational man hours involved in turn-around. It is expected that once any initial design faults have been corrected, only the most minor refurbishment will be required between flights, and that over one hundred flights will be possible without a major overhaul. If this result can be accomplished, the concept will be proven, and we can proceed with confidence to construct Excalibur.



FLIGHT ROCKET CUT-AWAY

Our final goal . . .

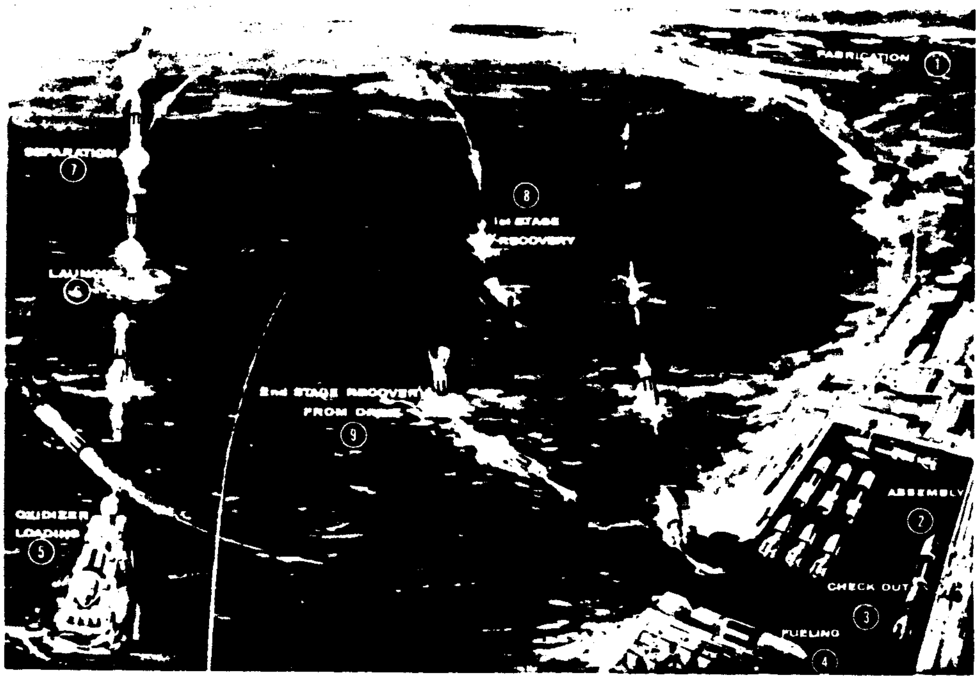
After Enterprise (Phase 1) and Excalibur (Phase II) comes our ultimate goal: Sea Dragon.

Sea Dragon will essentially be as designed in 1963, with some use of better materials and updated electronics. The exact size will depend on the economic climate existing at the time. With the decrease in operating costs attributed to Excalibur, payload requirements are expected to grow both in unit size and in annual totals. Sea Dragon's original 20,000 ton lift-off weight and 1,000 ton payload capability seem in the proper range for the time frame 1995 - 2010.

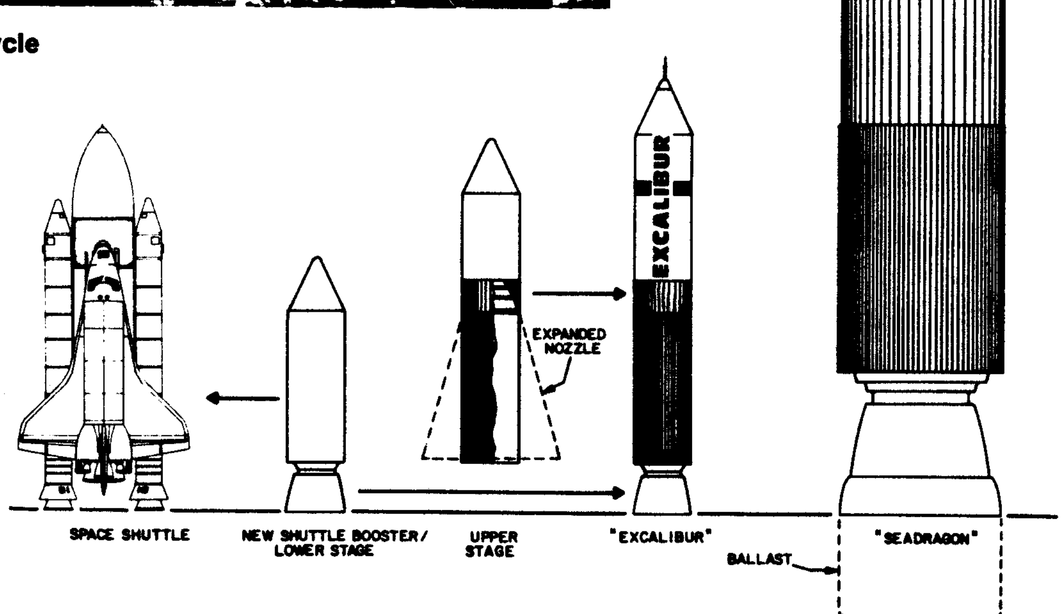
Because of its very large size, Sea Dragon will be treated more like a ship than an airplane. It will be built in a dry dock, floated like a ship, towed to its launch site and fueled from tankers. It will then be erected to a launch attitude by flooding a ballast unit and launched directly out of the water. Use of sea-going techniques completely eliminate any constraints on size imposed by handling requirements.

Excalibur is small enough to be launched from land, yet large enough to profit from sea launch. It could serve as a test vehicle to develop the sea launch technique. Once sea launch has been perfected, both Excalibur and Sea Dragon could use this technique to gain launch site flexibility and reduce real estate costs.

A small fleet of Sea Dragons, operating on a realistic turn-around schedule, could put in orbit a yearly total of one million tons, and do so at a cost of $20/lb.



Sea Dragon Operational Cycle



Present and Future Launch Vehicles