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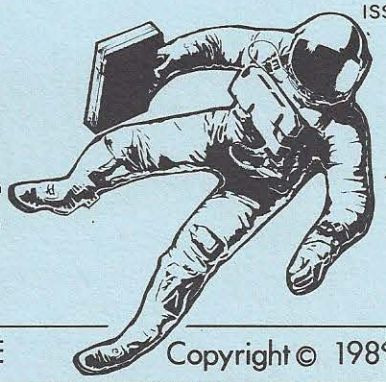
THE COMMERCIAL SPACE REPORT



A MONTHLY NEWSLETTER ON FREE ENTERPRISE IN SPACE

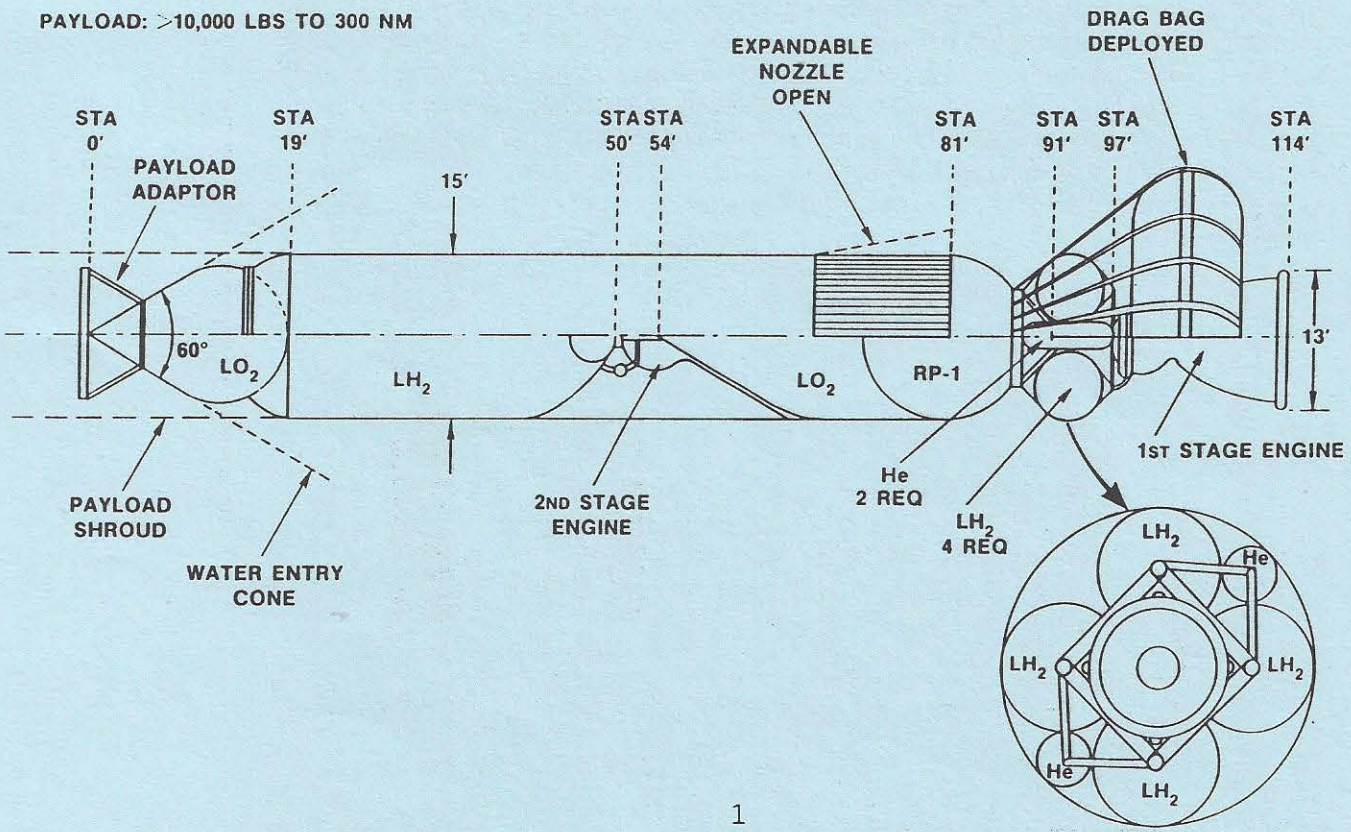
Volume 12, No. 9-10 November-December, 1988

Truax Engineering Sells Test Rocket To Navy

The Naval Center for Space Technology (NCST) has purchased the flight weight model of Truax Engineering's "Enterprise" rocket as part of a program to study sea-launched boosters. The purchase was made as an initial response by the NCST to an extensive three-part proposal made by Truax Engineering and its president, Robert Truax, to develop and build such boosters for the Navy. The purchase price was approximately $750,000.

Truax Engineering, located in Cupertino, Calif., made the proposal in response to a broad agency announcement (BAA) issued by the NCST in August. The NCST was seeking proposals for a concept called "SEALAR" (Sea Launch and Recovery), a two-stage launch vehicle that could be launched from the ocean and place about 10,000 lbs. into a 300-nautical-mile orbit. Both stages would be recovered for reuse by landing them in the ocean. The first stage would be recovered about 400 nautical miles downrange, with its landing speed slowed by an inflatable "drag bag" (see illustration below). The second stage enters orbit with the payload. At a selected time, after the payload is delivered, a retroburn would take place and the second stage would reenter the atmosphere, protected by ablatives. It would land in the ocean, slowed by a drag bag just like the first stage.

NAVAL CENTER FOR SPACE TECHNOLOGY

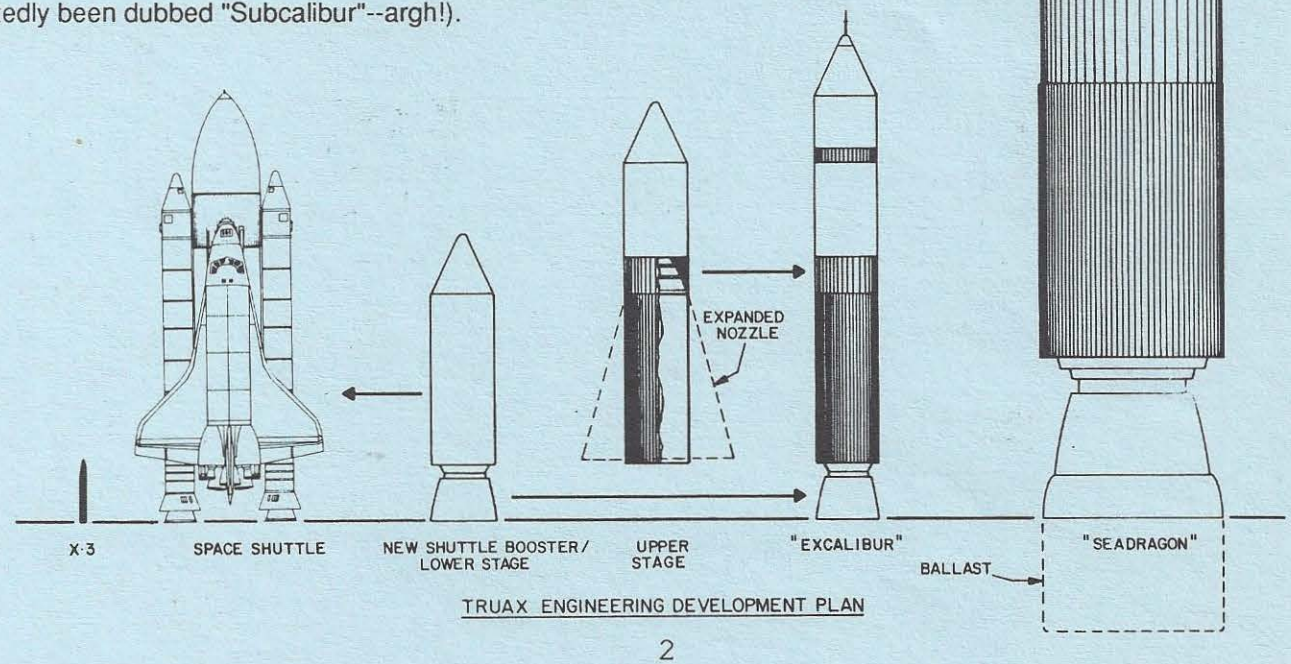


The concept was tailor-made for Truax Engineering, which has been working on developing similar sea-launched and recovered commercial boosters for years. The boosters designed by the company are immense, two-staged, pressure-fed, liquid-fueled vehicles of extremely simple design, capable of carrying enormous payloads to orbit at very low cost. In the early '80s, Truax Engineering was marketing two basic commercial vehicle concepts in this category (see illustration below). The first was the "Excalibur," with a payload to low earth orbit of 100,000 lbs. and a liftoff weight of 3.6 million lbs. Its first stage was also sized to be used as a liquid-fueled, low-cost replacement for the Space Shuttle's solid rocket boosters. The second vehicle was the titanic "Seadragon," 75 feet in diameter and over 500 feet long, with a liftoff weight of 40 million lbs. and a payload to earth orbit of over 1.5 million lbs. Estimated cost per pound to orbit: about $20.00 (for more on Excalibur and Seadragon, see the Sept. 1983 *C.S.R.* along with a correction in the Oct. 1983 issue).

Truax Engineering intended to "bootstrap" development costs by beginning with a small, sub-orbital test vehicle, Project Private Enterprise or the X-3. This vehicle, only 25 feet long, was intended to demonstrate ocean recovery and reuse of a launch vehicle, after which work would proceed on the larger vehicles. Test vehicles, both heavyweight and flight-weight versions (the latter being the one purchased by the Navy), were actually constructed, powered by four 1000-lb. thrust surplus Atlas vernier engines. Static engine test firings were conducted, but no flights have been made.

It was at this point, before the Navy deal, that Truax's development program had stalled--his giant commercial boosters were the right idea at the wrong time. Truax, a rocket pioneer with a professional history in the field stretching back to before World War II, had headed a research project at Aerojet General Corporation in the early 60s. It was from these studies that the Seadragon vehicle emerged, with a payload capability geared toward the far more ambitious space goals that America had at the time. When the early 80's came along, the U.S. space program had shriveled down to a support program for the Space Shuttle. No one in the program could think of anything useful to launch that weighed 1.5 million lbs., or if they did they kept it to themselves. Like other innovative space transportation systems proposed by private entrepreneurs, which promised huge benefits at low cost, Truax's pressure-fed boosters were pointedly ignored by the government space establishment.

But now Truax and his company are working on getting back in the race. If the Navy proceeds with the Truax Engineering proposals, two factors will contribute towards the company's success: The first, of course, is the financial support that further contracts would bring. The second, and more important, would be the concentration of the company's efforts on the launch vehicle sized for the Sealar mission. This vehicle is far smaller than the huge Excalibur, would be cheaper to develop, and has a payload--10,000 lbs.--which is sized to be much more attractive to existing commercial payload customers. Estimated launch costs would still be quite low--about $270/lb. to orbit (the vehicle has reportedly been dubbed "Subcalibur"--argh!).



TRUAX ENGINEERING DEVELOPMENT PLAN

Excalibur and Seadragon should not be counted out quite yet, either. In 1983 President Reagan proposed the Strategic Defense Initiative, a system to defend the U.S. against ballistic missiles. Many of the defensive weapons concepts that have been proposed for SDI would become far more feasible if the existence of a low-cost launch vehicle with immense payloads is assumed. Excalibur and Seadragon could be major assets to the SDI program.

Unfortunately, the U.S. military can normally be relied on to take a great idea and toss it out the window in favor of something completely ludicrous. I fear that low-cost, heavy-lift boosters will fall into this category. The U.S. Air Force has been consolidating a death grip on military launch systems. A knock-down, drag-out fight with the Defense Advanced Research Projects Agency (DARPA) over the Lightsat project ended up with the project under Air Force control (*C.S.R.* July-Aug. 1988, p. 12; Sept.-Oct. 1988, p. 7). Navy launch programs will be next. Add to this the fact that the Air Force is already happily wallowing in a multi-billion dollar program to develop an Advanced Launch Vehicle (ALV) which, if ever built, could launch about 100,000 lbs.--Excalibur's payload--into low earth orbit. Not surprisingly, the Air Force, with the eager encouragement of major aerospace companies, has arrived at the notion that the ALV will require a major technological development effort, and is not likely to look kindly upon 25-year-old designs that can do the same job easier and cheaper.

We can hope for the best. Truax and his crew have worked long and hard over the past years on their ideas--good ideas. They've earned a break and I wish them luck.

* * *

Chinese to Launch U.S. Satellites

An agreement was signed in January between the U.S. and the People's Republic of China that will permit U.S. satellites to be launched on expendable Long March boosters built and flown by the Chinese. The agreement outlines a number of restrictions on the Chinese, intended to insure the security of U.S. satellite technology and to mollify U.S. launch vehicle companies concerned about Chinese competition (Chinese launch prices can range from one-half to one-third of U.S. launch prices for geosynchronous communications satellite missions).

The agreement follows a long and heated debate involving factions within the U.S. government and the U.S. space industry. The debate began last July when the U.S. State Department received requests for export licenses for three communications satellites.

The first request, filed July 12, was from Asiasat, a British/Chinese consortium based in Hong Kong. Asiasat wanted approval to launch the Westar 6 satellite in late 1989. If launched successfully, the Westar 6 would become the first "used" communications satellite ever orbited. The spacecraft was refurbished after being rescued from space by the U.S. Space Shuttle in 1984 when solid rocket motor failures stranded it in the wrong orbit (*C.S.R.*, Nov. 1984). Asiasat bought the satellite from insurance underwriters that financed the rescue mission.

The second request was from the Hughes Aircraft Co., which is selling two of its communications satellites to Aussat, an Australian telecommunications firm (incidentally, Hughes also built the Westar 6). The contract specifies delivery of the satellite on orbit, which makes the low Chinese launch costs a major feature of the Hughes proposal.

In September, the Reagan administration approved the request for the export licenses for the satellites, provided that a formal agreement could be reached between the Chinese and the U.S. covering three major areas: safeguards against technology transfer, third party liability, and restrictions on unfair pricing or trade practices.

The technology transfer issue was based on concerns that launching Western satellites on Chinese boosters would give the Chinese uncontrolled access to advanced Western technology. Recommended measures to prevent this include 24-hour supervision by U.S. personnel over payloads during transportation of the payloads and launch operations, secure payload handling facilities, methods for recovering sensitive debris after any launch accident, and other procedures designed to limit access to sensitive equipment and information.

The third-party liability issue involved the establishment of Chinese liability for any third-party damage claims resulting from an accident.

Agreements on both technology transfer and liability were reached quickly during negotiations in China in October, with the Chinese showing an eager willingness to meet the U.S. requirements. However, the most controversial issue--economic protection of the U.S. launch industry--took longer.

The economic debate began with an immediate split in the U.S. space industry between satellite manufacturers and expendable launch vehicle (ELV) companies. The former were in favor of the export licenses and an open launch market, and the latter were opposed. Their reasons:

U.S. satellite manufacturers (Hughes, for example) stated that restrictions on launch vehicles would severely handicap their marketing efforts. Potential satellite customers are attracted to the low launch prices offered by the Chinese, and would buy satellites from non-U.S. competitors if U.S. satellites were not permitted to be launched on Chinese rockets.

U.S. launch vehicle companies, on the other hand, backed by the U.S. Department of Transportation, felt that opening the satellite launching market to the Chinese would drastically reduce the U.S. companies' ability to compete for payloads. In their view the Chinese, with their low labor costs and non-market economy, could subsidize their launch costs to the point where no market-priced launch company could beat their low prices. At present, the only U.S. ELV companies capable of launching communications satellites into geosynchronous orbit are those which have privatized existing, government-developed launch vehicles (Martin Marietta with the Titan 34D, McDonnell Douglas with the Delta, and General Dynamics with the Atlas/Centaur). Launch prices for these vehicles are currently quite high, and are particularly sensitive to low-priced competitors.

The "trade deficit" issue was raised, with the launch vehicle industry describing the revenues that would be lost if launch business went to China instead of to the U.S. The satellite industry countered by pointing out that overseas satellite sales losses would be even greater if launch restrictions were put into effect. They have a point--estimates on revenues from the export of U.S. satellites over the next five years run as high as $2.5 billion. As a specific example, the Hughes/Aussat deal is worth about $250 million, while the Asiasat deal is worth about $40 million--almost $300 million altogether, or more than three launches would cost on even the most expensive U.S. ELVs (to hammer the point home, both Aussat and Asiasat have stated in no uncertain terms that without the use of a low-cost launch system--in particular the Chinese Long March--the deals would be off and foreign satellite concerns would get the business).

In the end, the satellite exporters and free trade supporters won out, at least partially. A final trade agreement was initialed in December, and signed on January 26. Major features of the agreement:

The Chinese will be permitted to launch up to nine U.S.-manufactured satellites within the next six years (this includes, of course, the Aussat and AsiaSat satellites). The Chinese will be required to spread the launches evenly over this period, to prevent a major competitive stroke by bunching them all up in a short period. In addition, the Chinese agreed to offer launch services, insurance, reflight guarantees, etc. on prices, terms and conditions on a par with those offered by companies in market economies.

The agreement allows enough flexibility to meet unforeseen circumstances. The U.S. and China will meet annually to discuss the agreement. At this time, if the Chinese request it, the limit on the number of Chinese launches of U.S. payloads may be reconsidered, and possibly increased, depending on circumstances. Additionally, the U.S. has the option of reviewing each payload on a case-by-case basis. Naturally, the U.S. satellite industry is happy with the agreement (especially Hughes, whose sudden enthusiasm for free trade seems odd, considering the attitude towards imports taken by Hughes' parent company, General Motors). Even the U.S. launch industry is more or less satisfied.

Now, of course, the Soviets are standing in the wings, with Soviet launch vehicles they also would like to sell to customers who want to launch U.S.-manufactured satellites. They see the conclusion of the U.S.-Chinese agreement as a precedent, and want to know why similar steps are not being taken in their direction. As yet, there has been no official response (more on the Soviet space marketing effort later in this issue).

Quotas or other artificial barriers against imports and exports are rejected by those who believe in free trade as part of an overall free-market approach. Should the Chinese ELV marketing effort fall into this category, being allowed to sell whatever they can for any price they wish, or does the totalitarian Chinese system, supposedly

immune to market forces and able to drastically subsidize prices, fall into a special category which demands protective measures?

The answer is that it's a trick question, incorporating the assumption that the government has the right to interfere with trade and that the only question is when and how much. In fact, the government has no business restricting trade between nations, with the important exception of transactions which involve the transfer of technology or other assistance to potential military adversaries--a proper concern for a government charged with one of a government's few legitimate tasks: defending a free nation. Aside from this circumstance (which, in the case of China, has been settled to the satisfaction of U.S. military authorities), the decision to trade with a country is an economic and moral decision that must be left up to the individual.

In any case, there is little chance that the Chinese, even in an unrestricted market, could end up monopolizing the launch industry. Their government is too poor, and too hungry for Western currency, to heavily subsidize their ELV industry over a long period of time or to charge prices far below their actual costs. The cost of doing business in China is, of course, less than the cost of doing business in the U.S., but this fact does not exactly fall under the category of "predatory" pricing tactics. The Chinese also use a low-cost, low-tech approach to ELV construction and operations (the Long March 2 and 3 ELVs are built in a factory near Shanghai which also manufactures refrigerators) that also helps keep prices down, and also is not an "unfair" marketing technique. Long-time readers of this newsletter know that there are a number of newer ELV companies in the U.S. that are using similar approaches to develop and build low-cost launch systems. These companies will someday be able to offer launches even more cheaply than the Chinese, on vehicles built and operated in the U.S., and without any of the so-called "advantages" of the Chinese in this field. It will be interesting to see what reaction the major ELV companies have to low-cost competition *within* the U.S.

Perhaps the real problem is not that the Chinese prices for their launch vehicles are artificially low, but that the prices for the Atlas, Titan, Delta, and other ELVs built by the established aerospace industry are artificially high.

Soviets Sign Space Marketing Agreement With U.S. Company

Glavcosmos, the Soviet civilian space agency, has signed an agreement with Space Commerce Corp. of Houston, Texas, giving the latter exclusive U.S. marketing rights for Soviet space hardware and services. The agreement was signed by Alexander Dynayev, head of Glavcosmos, and Arthur Dula, president of Space Commerce Corp. Space Commerce has been marketing Soviet Proton launch vehicles for some time, but has been handicapped by U.S. restrictions on the export of U.S.-manufactured satellites to the Soviet Union. The current agreement covers a much wider variety of space services which are not hampered by such restrictions, giving Space Commerce a greater chance of success. The company will be marketing:

- Soviet launch services on the Proton and other expendable boosters. As yet, no commercial use of either the Energia heavy-lift booster or the Soviet space shuttle is planned--the Soviets consider both systems experimental.

- Unmanned recoverable spacecraft for materials processing and other experiments.

- Payload space on the Soviet manned Mir space station. The Soviets are offering a wide variety of areas and equipment on the space station, including compartments both inside and outside the station. Access to materials processing furnaces and electrophoresis facilities will also be available.

- Earth-resources imagery, including digital data from Soviet earth resources satellites, and high-resolution (20-meter and 5-meter) photographs taken from the Mir space station. The 5-meter-resolution images in particular ought to be in great demand--10 meters is currently the maximum resolution available from Western commercial satellite images. However, the Soviet commercial imagery program is apparently still tied tightly to Soviet military interests. For example, the Soviets will not sell any images of the Soviet Union or other East Bloc countries. The quantity and availability of the images they do sell--images of the U.S. and other countries--seems to increase markedly if the area photographed happens to be of military importance, indicating that the Soviets are obtaining at least some data from military reconnaissance satellites. Soviet military interests may even negate the Soviets' main claim to fame: their 5-meter image resolution. An article in the Jan. 30, 1989 issue of *Military Space* quotes researchers at the Carnegie Endowment for International Peace.

Above: Team of American and Soviet space experts in the Proton Booster Assembly Facility at the Soviet Union's main spaceport, the Baikonur Cosmodrome in Central Asia. Space Commerce Corporation president Arthur Dula is eighth from the left. Also shown: Spacehab Inc. founder Bob Citron (fourth from left). The booster in this photo was used to place a geosynchronous satellite into orbit on November 26, 1987.

The researchers claimed that commercial 5-meter-resolution Soviet images they had obtained had apparently been deliberately blurred to conceal the capabilities of the satellite providing the image, rendering the "high-resolution" image no more useful than a more common 10-meter image.

- Data from Soviet communications and navigation satellites.
- Spacecraft hardware and components.

Space Commerce Corp. will be handling all U.S. licensing requirements, and will attempt to deal with the current ban on exporting U.S. payloads to the Soviet Union. Obviously, Space Commerce would like to see the U.S. strike the same sort of deal with the Soviets as it did with China. Like the Chinese, the Soviets say they are willing to comply with procedures to prevent technology transfer--the most critical factor of such an agreement.

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Articles of Interest In Other Publications

The December 1988/January 1989 issue of *Air & Space/Smithsonian* contains two articles of particular interest. Both concern the painful learning process endured by space innovators as they attempt to secure government funding for their projects.

The first article, "The HOTOL Man" by Tom Huntington, is about Alan Bond, the British engineer who designed the exotic RB 545 engine for the HOTOL spaceplane while working as a consultant for Rolls-Royce (for more on HOTOL see the Sept.-Oct. 1987 *C.S.R.*). The article gives some background on Bond, and describes his frustration when the British government ended its support of the HOTOL program after a two-year proof-of concept study ended in 1987. Even more irritating, the British government classified Bond's patent on the RB 545, making it difficult--if not impossible--for Bond to peddle the concept elsewhere. To seal the engine up tighter, Rolls-Royce exercised an option to purchase Bond's patents. This left Bond with a considerable sum of money, and a cordial relationship with Rolls-Royce and British Aerospace (the other company involved in the two-year HOTOL study), but still more or less out of the loop as far as influence on the project goes.

Since this article was written, Bond has continued to support the HOTOL low-cost space transportation concept, and is working on locating private financing to proceed with the HOTOL project. Reported leads in this area have included the Carroll Group, a London-based investment firm, and rumors of money from Saudi Arabia.

The second article, "Space Stations in Lobbyland" is by Eliot Marshall, a Washington reporter for *Science* magazine. The article deals with Space Industries, Inc. and that company's attempt to incorporate its commercially-developed man-tended Industrial Space Facility (ISF) into the U.S. space program. The article describes, in great detail, the ISF's painful contact with the whirling buzzsaw of Washington politics, special interests, turf fights, influence-peddling, and general low dealings. When I last did a comprehensive article on the ISF (in the January, 1988 *C.S.R.*), the ISF looked like it was going to find a firm niche as the official U.S. "Commercially-Developed Space Facility" (CDSF), an interim space platform to fill the need for orbital research and manufacturing space until the advent of the U.S. Space Station. Then, beginning around March of 1988--the Washington buzzsaw began to work. Since then I have been watching with interest, waiting for the blood to stop flying, hoping I could make heads or tails of the horribly complicated process when it was done. Fortunately for me, "Space Stations in Lobbyland" does just that, sorting out the chronology, listing the players, and saving me a great deal of trouble.

Since this article was written, the CDSF (and, by extension, Space Industries) has languished in the dreaded "Congressional Study" limbo. However, the new administration may bring renewed hope, if Space Industries can hang on long enough. New studies are to be completed in the spring, and the subject of the CDSF will be brought up again as part of the 1990 fiscal year.

Air & Space is a relatively new publication put out by the Smithsonian Institution, and is worth subscribing to. As the title suggests, the subject matter covers aviation as well as space, but the aviation articles are usually good enough to interest even readers who normally concentrate exclusively on space-related subjects. Published bimonthly, the magazine is, like its sister publication *Smithsonian*, loaded with photographs and a bargain at $18.00/year U.S. or $24.00/year elsewhere. The subscription price, actually a membership in the National Air and Space Museum, entitles the member to certain special prices and privileges when visiting the Museum itself, but unless you live in or near Washington D.C. this would probably not be a major factor in subscribing. Subscriptions should be addressed to P.O. Box 53261, Boulder, CO 80322-3261.

The December 19/26, 1988 issue of *Aviation Week and Space Technology* contains a special section on commercial space called "Space Business: New Realities". The theme of the various articles is that of a more somber look at commercial space, with more of an emphasis on proven, near-term markets such as communications satellites, satellite applications, and satellite boosters. More "radical" markets such as materials processing are described as much further off than originally thought. As the editorial at the front of the magazine says, it "finds the commercial market poised for a comeback, but stripped of the allure and gold-rush claims pervasive in the early 1980s."

Aviation Week correctly notes that one major problem with markets such as materials processing is the lack of assured, low-cost access to space. No truly low-cost launch systems, private or otherwise, have yet appeared, and the Space Shuttle, the other major route to space in the early '80s, was crippled by the *Challenger* disaster.

Another major problem noted here is the lack of investment support. Ironically, companies attempting to develop the aforementioned low-cost space transportation systems have had little luck in raising money for them. *Aviation Week* cites the reluctance of established venture capital sources to enter a new, untried field as one problem. Also cited is NASA's habit of using its traditional reputation for space expertise to discourage investors unfamiliar with space from financing the private endeavors that NASA would just as soon not compete with. George

Koopman of the American Rocket Company (AMROC) is quoted as saying that NASA routinely told institutional venture capital companies that AMROC's hybrid rocket motor would not work.

Despite the generally sober attitude of this feature, in most articles *Aviation Week's* still comes off as basically optimistic about the future of commercial space. The materials processing market, though more long-term than originally hoped, is showing promise in several areas, such as protein crystal growth for new drugs, or polymers for new types of electronics. The market for commercial satellite launches by established ELV manufacturers is growing, although competition looks like it will be whittling the field down in the next few years. The old, reliable communications satellite market, after a slump, shows an increase in orders. The general gist of the entire series of articles: a slow, steady increase in the fortunes of those involved in commercial space--but be prepared to buckle down for the long haul (as usual, "long hauls" seem to be the hallmark of space endeavors in the U.S. My prescription: inject a $200.00/lb. space transportation system into this "slow, steady market" and stir vigorously with a stick. Exponential growth guaranteed!)

Aviation Week is a somewhat conservative publication, primarily dealing with the established aerospace industries, but the magazine faithfully tracks progress in even the most exotic areas of space technology. If you read *Aviation Week*, you will miss almost nothing going on in the field of space. You will also find out more than you may want to know about other fields, such as the commercial airline industry or military aircraft (on the other hand, if you're into these, then "it's not a bug, it's a feature"). Subscription rates are $58.00/yr. if you can show you are part of the aerospace industry--not too difficult to do. Rates are $70.00/yr. otherwise. For a weekly color magazine of about 100 pages, even $70.00 is not a bad price, but it should be noted here that another thing that makes *Aviation Week's* stand out from the crowd is that it is almost universally available in school or public libraries.

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Some Impressions On The Birthplace of the Space Age

During the months of October and November, I spent much of my time at the Air Force Astronautics Laboratory (AFAL) at Edwards Air Force Base, working with Pacific American on the Liberty rocket engine tests. Mounting a test program at a remote location, far from your company's headquarters, is not easy. This was the first time I have done this sort of "away team" work myself. In the early 1980s, I was part of the design team at GCH, Inc., and helped to design and build that company's Percheron launch vehicle prototype. However, I was not part of the group of people which spent much of its time at Matagorda Island in Texas, setting up and carrying out the Percheron engine test program there, so I could appreciate the difficulties only second hand (for more on Percheron and GCH, see *C.S.R.*, July, Aug., and Sept. 1981).

Mindful of the difficulties of remote site operations, Pacific American designed the Liberty engine test stand to be as self-contained as possible, with most of it being assembled in the plant in Menlo Park, Calif. The idea was to get the system built and checked out, and ship the assembled stand to AFAL, ready for immediate testing. While this approach no doubt saved us months of work at the test site, there was still far more that had to be done at AFAL than was anticipated, and I spent weeks there helping to iron out various scheduling and technical problems.

I had been to Edwards only once before, in college, as part of an Air Force ROTC "field trip." Then, we were flown to the main base in the back of a C-130, and left the same way. Anyone who's ever ridden in the back of a C-130 will realize that I didn't get to see much of the scenery--I saw nothing of the surrounding area except desert.

When I went down there this time, I had a lot more on my mind, and I didn't give a lot of thought to the environs at and around Edwards. While we were there, we were to stay at a motel on the outskirts of Lancaster, a city located, along with the city of Palmdale, near the air base. Like I said, I didn't give it much thought, but somewhere--perhaps from Tom Wolfe's *The Right Stuff*--I had this overwhelming subconscious impression of the entire area as a primitive backwater, with tumbleweeds rolling down Main Street. In the back of my mind I had this vision of the Lancaster motel as a series of bleached white buildings in the middle of nowhere, with screen doors, dark starry nights, and perhaps a coyote or two snuffling around. Perhaps there would be a gas station nearby.

I flew into Burbank Airport and drove towards Lancaster in a rented car as night fell. On the north, Los Angeles is bordered by wide areas of National Forest land. Driving up Highway 14, one passes from the densely

populated L.A. basin almost immediately into a dark, uninhabited zone, dry and sparsely overgrown, that matched my ideas about the Edwards area perfectly. I strained my eyes ahead for the tiny, scattered lights that would indicate Palmdale and Lancaster.

I climbed through dark hills, and then, as I rounded a bend, I saw Palmdale, Lancaster, and the Antelope Valley--a thick, brilliant carpet of lights stretching from horizon to horizon. The "lonely motel" was at the edge of town, true, but less than a mile from a huge complex of shopping centers. So much for romance. I did, at least, see a tumbleweed.

Despite the glut of civilization, once I headed out to Edwards the first thing next morning, I encountered real desert. As far as the eye could see were endless rolling hills covered with a variety of low, scrubby bushes. Sticking up among the scrub were a seemingly infinite number of spiky, twisted Joshua trees--probably one of the ugliest plants on earth (with the possible exception of an ostensibly ornamental plant which occupies one corner of my front yard).

The Air Force Astronautics Laboratory is located several miles east of the main air base at Edwards and the famous flat, dry lake beds used for flight testing and Shuttle landings. As I approached the facility, heading east, the road began to climb. To the left was an immense wall of rock rising out of the desert and extending northwards. Jutting out from the top of this cliff at regular intervals and extending out over the edge were the huge, complex metal skeletons of rocket engine test stands. This is "Thunder Ridge", where the powerful F-1 engines of the Saturn 5 moon rocket first roared to life.

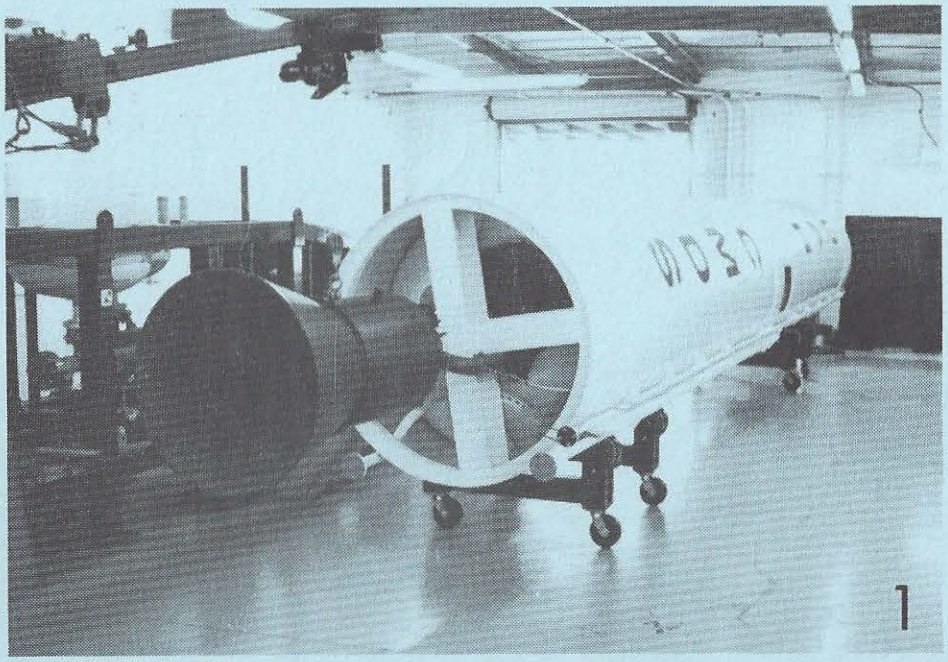
I drove up the hill at the end of the ridge, and around behind it, where I passed through a gate into the laboratory facility itself. Buildings were scattered around the landscape. The land was much higher on this side of Thunder Ridge, so that what was a cliff above the desert floor was only a low hill on this side, with buildings here and there all the way up the hill to the test stands above. There was never much activity at the lab while I was there--some work was going on related to the Strategic Defense Initiative, and one of the huge test stands at the top of the ridge was being modified. All the time I was there I saw no major rocket engine tests conducted by the Air Force.

The test site Pacific American was using was located about four miles further east down a wide, paved road. The existing test facility, not used by AFAL for some time, was a concrete pad with a vertical steel wall at one end, and three test cells, looking like huge sections of corrugated steel pipe, were at the other. About a block away was the control bunker, partially buried in the earth. All around were old tanks, piping, storage areas, and other hardware stripped and left behind when the Air Force finished with this site.

We set up our own test stand on the concrete pad between the steel wall and the test cells. The inside of the control bunker consisted of a series of long rooms, lit by fluorescent lights and full of old, abandoned electronic racks and equipment. We picked a room and set up our own control hardware.

There was wildlife. The control bunker had been largely taken over by mice which, unlike mice I had known elsewhere, thought nothing of trotting out in broad daylight to see if there was anything either worth eating or worth crapping on. Or both. I was surprised they didn't hit us up for spare change. We were assured by the locals that where mice hung out, rattlesnakes would hang out too, and the desert was packed with rattlesnakes. We immediately purchased standard spring mousetraps, and systematically began to purge the bunker of mice. It was a messy business--we had to empty the traps and toss broken mice out on the desert each morning (I eventually located a "live" type of trap in town, which spared a few mice, as well as my queasy nature). I wore high boots, and was careful where I walked, but despite all the dire warnings none of us ever saw a single rattlesnake.

Small lizards were everywhere, along with a type of little rodent that looked to be some type of chipmunk. Twice driving back into town in the evening I saw coyotes in the dusk. The desert floor was thickly pockmarked with burrows of all sizes. I never saw anything either enter or leave one, and still don't know for sure what made them. One fellow on the base claimed that there were mountain lions roaming the area! If so they must be exceedingly rare, but the thought still put a little spring in my step during the long walk from the pad to the bunker after the sun went down.



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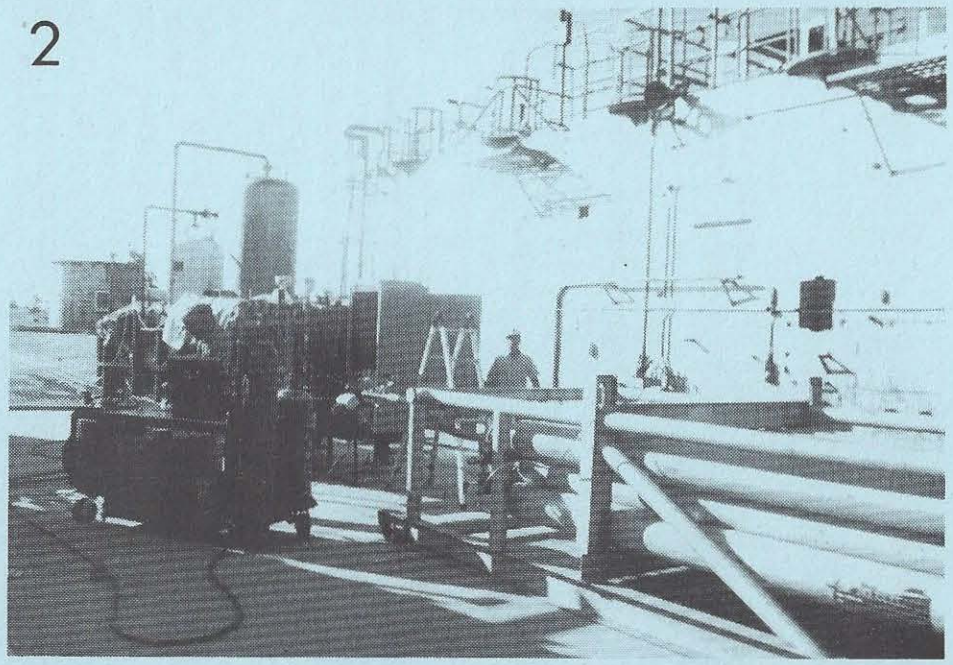

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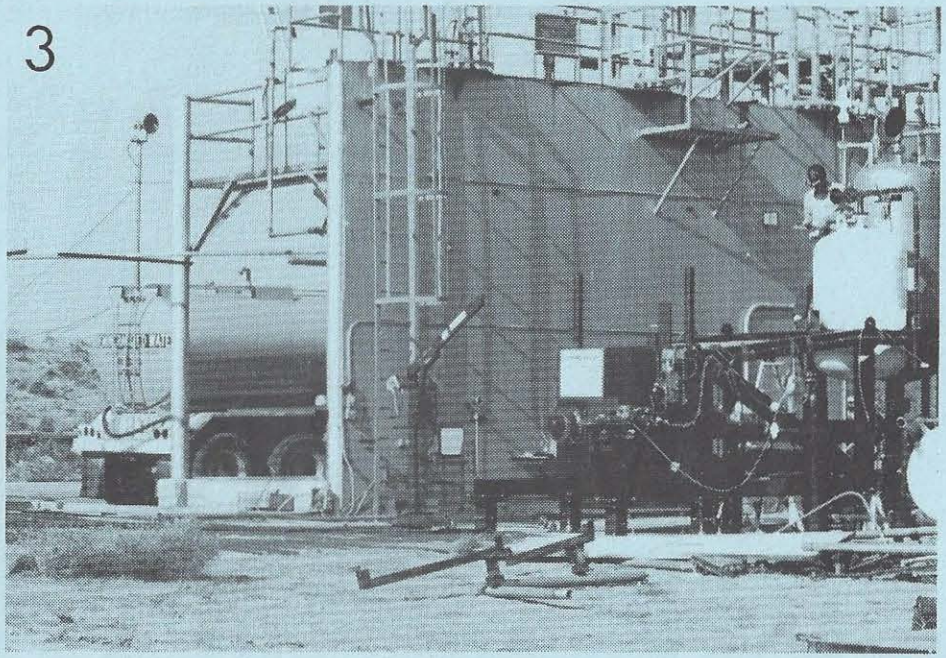

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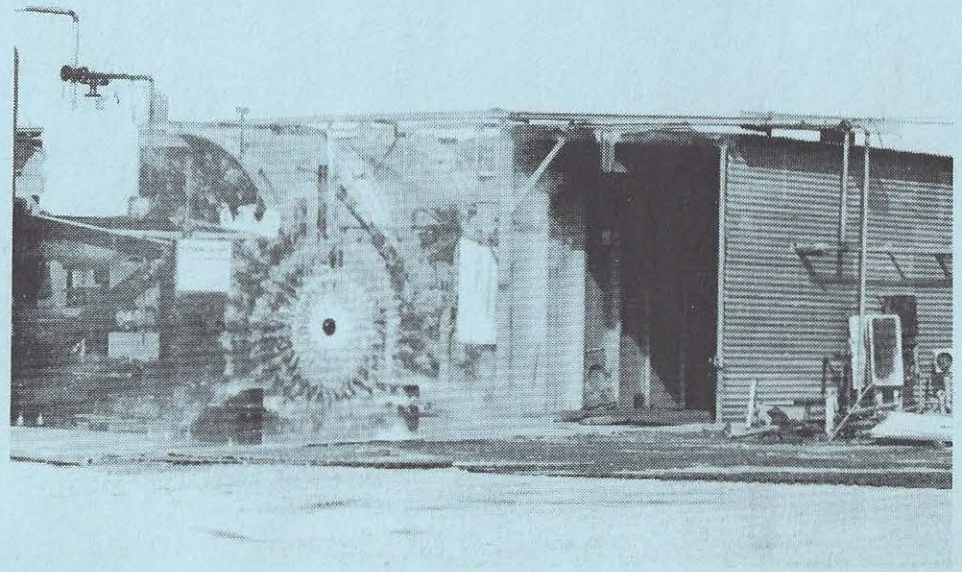

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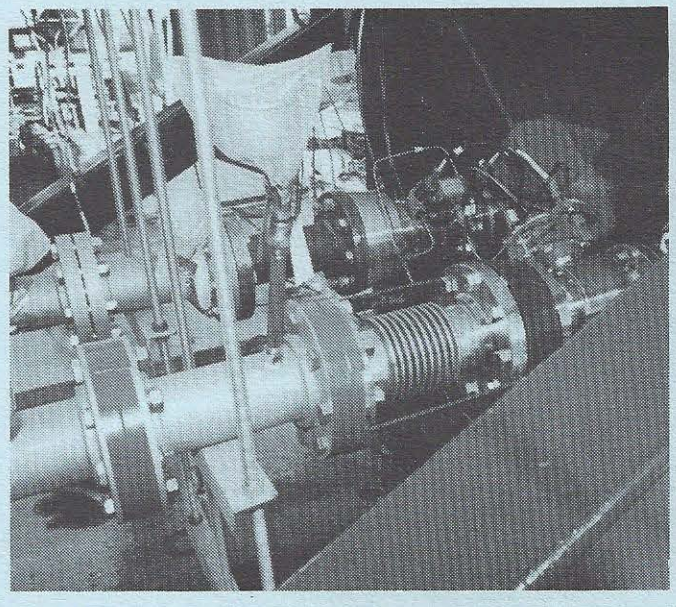

Pacific American Test Program. Above: at left, the propellant valve assemblies for the horizontal test stand. At right, I am shown practicing the fine art of slinging a torque wrench. **Opposite page: (1)** Workshop at Pacific American headquarters in Menlo Park. The test stand is under construction at left. At center is the prototype propellant tank for the Liberty 1 launch vehicle. **(2)** Test site at AFAL. The horizontal test stand is in the background, with the engine facing away. In the foreground is the "cascade," an array of large pressurized nitrogen storage bottles to pressurize the propellant tanks visible on the top of the stand. Behind the stand is the vertical steel wall, behind which earlier users of the site had stored propellant tanks. **(3)** Another view of the stand, showing the injector without the engine bell (just below the white sign on the end of the stand). The test propellant tanks are at the right. Behind the steel wall is parked a water storage truck for water tests of the injector. **(4)** A water test of the pintle injector under way. Shown is the radial spray pattern from the liquid oxygen outlets. A fraction of a second after this photo was taken, water emerged from the fuel outlets along the axis of the injector to impinge on the radial spray to form a fine mist. In the background is an existing storage shack, and part of one of the three steel test cells is just visible behind the spray.

We were having difficulty getting our trash picked up by the base, and bags of garbage were collecting outside. We returned one morning to find trash scattered everywhere. Fresh footprints and other evidence pointed not to coyotes or other normal scavengers, but to a herd of wild burros that cruised the area! I have dealt with dogs, cats, raccoons, and even a bear or two, but I had never figured donkeys to be the can-tipping type. We later saw the burros now and then, usually some distance away in the early evening. There were whole families, including little ones.

We were lucky to have good weather. Like most deserts, it was hot during the day and very cold at night. While we were at Edwards, there were few really hot days. Mostly it was quite mild. Still, the sun is powerful on the high desert, and all of us used double-digit sunscreens. The desert is also famous for its sunsets, and I wasn't disappointed. In the San Francisco Bay area where I live, as the sun goes down, there is a short period sometimes where suddenly all the clouds are lit with brilliant reds, oranges and yellows, and the sky looks like a painting. At home this flareup of colors lasts maybe five minutes before everything fades to dark blue and gray and night falls. At Edwards, when the sun set, the clouds were sometimes lit with brilliant colors for nearly half an hour.

Naturally, aircraft were always in evidence. Sonic booms were a frequent occurrence, and no matter how many you hear you still jump each time. Most spectacular was the low-level flights made by a B-1 bomber, followed by a chase plane. The sleek bomber would roar by us only a couple hundred feet up--fortunately not at supersonic speeds. Many aircraft flew at such high altitudes that they were visible only as contrails. The sonic booms, when they occurred, came from these. One afternoon I watched the contrail of one of these invisible aircraft, as it jigged and turned at what seemed to be impossibly sharp angles at an enormous speed. I have no idea what it was.

Unfortunately, no Shuttle landings took place while I was there. The dry lake bed at Edwards main base where the Shuttle lands is hidden from most of the lab by Thunder Ridge. Even a person who attained a vantage

point on top of the Ridge would have at best a distant view--AFAL is miles from the lake--but he could avoid the crowds packed onto the viewing area on the east side of the lake, and a pair of binoculars might make all the difference. I hope to get a chance to try it out some day.

A couple of miles to the east of our site a small, nearly conical mountain juts out of the middle of the hilly desert. Partway up the north side of this mountain is the engine test site of the American Rocket Company. Because of its location the site is, of course, visible for some distance, and I was fortunate enough to see a couple of tests of AMROC's hybrid rocket while I was there. Neither was a full-duration test, but they were spectacular and surprisingly loud for a small engine at that distance. I can only imagine what the tests of the huge Saturn F-1 engine must have sounded like years ago.

Interestingly, the same test site Pacific American was using had been used earlier by AMROC for testing subscale hybrid engines before they moved to full-scale engines and their new test site on the mountain. The AMROC engine had been enclosed within one of the three steel test cells, facing out into the desert in the opposite direction from the slab where Pacific American's stand was anchored. Where the engine had pointed, the desert was littered with chunks of rubbery hybrid engine fuel and a few shattered chunks of graphite engine throat material--indications that AMROC's initial engine test firings, like most tests involving new engines, were not without incident.

I haven't been to Edwards for a while--the Pacific American test program is on hiatus while design changes are made in the test facility. A new vertical test stand is under construction, and more testing is scheduled for spring. Watch this space.

* * *

Oops.

In the last issue I stated that the first truly commercial rocket launch was "generally conceded to be the flight of the Conestoga I suborbital sounding rocket, launched by Space Services in 1982." Subscriber Ed Regis has gently pointed out to me that the honor of the first commercial flight actually belongs to the suborbital test rocket launched by OTRAG from Zaire in May of 1977.

This is, of course, true. Although it is not the first time (nor, no doubt, the last) that I have been caught in an error, this one is particularly embarrassing considering that the premiere issue of this newsletter, published in September of 1977, featured the OTRAG launch as its "Photo Exclusive" headliner.

Until next time,

Tom Brosz
February 14, 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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