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Update: U.S. Space Shuttle

Problems with the Space Shuttle have pushed the official launch date of STS-26 to August 4, and even this date is beginning to look doubtful. STS-26, the first Shuttle flight since the *Challenger* disaster, was originally scheduled for June, and will be flown by the orbiter *Discovery*.

Hardware problems are the major culprit in the delays. A static test of a redesigned Morton Thiokol Shuttle Solid Rocket Booster (SRB) in December resulted in the failure of the motor's boot ring, part of the aft nozzle assembly. Inspectors found areas in the solid boosters where insulation which helps protect the motors' steel casing from exhaust gases had debonded from the casing. Suspected flaws showed up in the SRB aft skirt structure. Turbopumps in the Space Shuttle Main Engines (SSMEs) were found to contain welding flaws, and critical fasteners in the pumps were suspected of loosening.

NASA is trying hard to solve each problem that comes up while compromising neither safety nor the flight schedule. Thiokol is continuing its comprehensive program of SRB static test burns. NASA will get around the December SRB failure by using an alternate booster design configuration for the STS-26 mission, one that was successfully static-tested in August, 1987. The unbonded insulation areas were inspected, and some rebonded. To avoid some of the time-consuming rebonding procedures, NASA doubled the maximum permissible depth specification for unbonds from 0.050 inches to 0.10 inches, bringing many of them back within official limits. The flawed aft skirt was structurally tested and found acceptable. The SSME pumps were pulled and inspected.

While these problems have not yet pushed the official launch date past August 4, they have used up all of NASA's contingency time for that date. This means that there is no more slack in the schedule for any more unforeseen difficulties. If anything comes up, it would almost certainly push the flight date farther down the road--possibly as far as after the November elections.

The Shuttle flight manifest is running out of room for delays. Payloads are stacking up and some of them cannot easily be postponed any further than they already have. There are other problems, as well--the Hubble Space Telescope eats millions in storage and maintenance costs as it sits on the ground. Space probes like the Magellan Venus probe, the Galileo Jupiter orbiter, or the Ulysses solar probe must be launched during specific "windows" of time, while planets are in a particular configuration. If they miss their scheduled flights, then the next launch windows would not arrive again for up to two years.

Another example: the Long Duration Exposure Facility (LDEF) is a satellite containing numerous experiments to analyze the effects of long-term exposure to space conditions. The LDEF was launched in April, 1984, and was originally scheduled to be picked up by a Shuttle and returned to Earth in March of 1985. Unfortunately, that mission was scrubbed, and another slot for retrieving the massive satellite never opened up (*C.S.R.*, Oct. 1985). Now the LDEF (which should perhaps be renamed the RLDEF--

Really Long Duration Exposure Facility) is slowly decaying out of orbit, jeopardizing those experiments which are not already ruined, and possibly threatening lives and property with those portions of its 11-ton mass which do not burn up in the atmosphere. To save the satellite, NASA opened a slot to retrieve it in July, 1989. If the Shuttle schedule slips any further, there may not be another chance.

Most people agree that another major Shuttle disaster could well mean the end of the Shuttle program. Unlike the airline industry, which can absorb an occasional accident without the destruction of the entire industry, the Shuttle program is not resilient enough to survive the loss of another $2 billion orbiter. Many payload programs now stranded would probably be cancelled permanently, unable either physically or financially to be adapted for launch on unmanned expendable launch vehicles. Worse, the disappointed nation may perceive the end of the Shuttle as the end of U.S. manned space flight, leaving the field entirely to the Soviet Union and, eventually, Europe and Japan.

Yet, another Shuttle disaster is almost inevitable. Roger Boisjoly, the former Thiokol engineer who tried to stop the fatal launch of the *Challenger*, fears another accident is possible, and feels that the design changes to the solid booster joints have been poorly conceived and executed. But even if the SRB flaws have been cured, and even if a host of other potential failure points in the incredibly complex vehicle hold up, the law of averages will catch up to the Shuttle eventually, just as it does for all transportation systems.

Those working on private alternatives to a government manned space program must be ready when this happens. Some commercial space enthusiasts, while not wishing any more tragic accidents on the Shuttle, nevertheless feel that the failure and cancellation of the program would make life easier for private sector manned space systems. This is not necessarily the case. If the Shuttle is scrapped, any private companies proposing alternative manned launch vehicles may have to push much harder to sell their concepts to a bitter nation which will be less than receptive towards high-tech space vehicles. These companies will need to have a very high profile, a solid technical concept, and a level of credibility normally associated only with considerable progress in hardware development. This will be difficult, but this is what it will take to make a firm and favorable impression on skeptical financiers and payload customers, and overcome what will almost certainly be the prevailing viewpoint at that time: that the end of the Shuttle means the end of the U.S. manned space effort.

NASA Selects Design For Crew Escape System

NASA has selected a telescoping pole to be the "escape system" for the crew of the Space Shuttle in case the spacecraft develops difficulty and has to be abandoned. I use the words "escape system" loosely, since the system is useful only under extremely limited conditions--controlled, gliding flight, at the proper altitude, following failures or difficulties during ascent or reentry where landing at a suitable runway cannot be achieved. Previously, procedures for this situation called for ditching into the ocean, until NASA discovered that the Shuttle would not structurally survive a gliding impact with the water (*C.S.R.*, Nov. 1986).

The design of the Shuttle requires the crew to use some form of mechanical assistance to bail out. Simply jumping out of the orbiter hatch while the vehicle glides earthward would result in the crew member being slammed against the forward orbiter wing edge by the slipstream. A mechanism had to be found to carry the astronauts safely beyond the wing where they could then parachute normally to earth.

NASA narrowed the candidate concepts down to two: the tractor rocket extraction system, and the telescoping pole. The tractor rocket system works like this: the orbiter hatch (located on the orbiter's lower deck) is opened, and a folding ramp placed in front of it. Each astronaut, in turn, lies down on the ramp, attaches a cable to his or her harness, and pulls a handle. A 2,000 lb. thrust, solid-fueled rocket motor stored in the cabin next to the hatch (one per crewmember) ignites and, with wondrous alacrity and vigor, sucks the astronaut out the hatch like a fishing fly on its way to that part of the pond where the lunkers hang out. Once clear of the orbiter and its wing, the rocket drops away and the astronaut parachutes down.

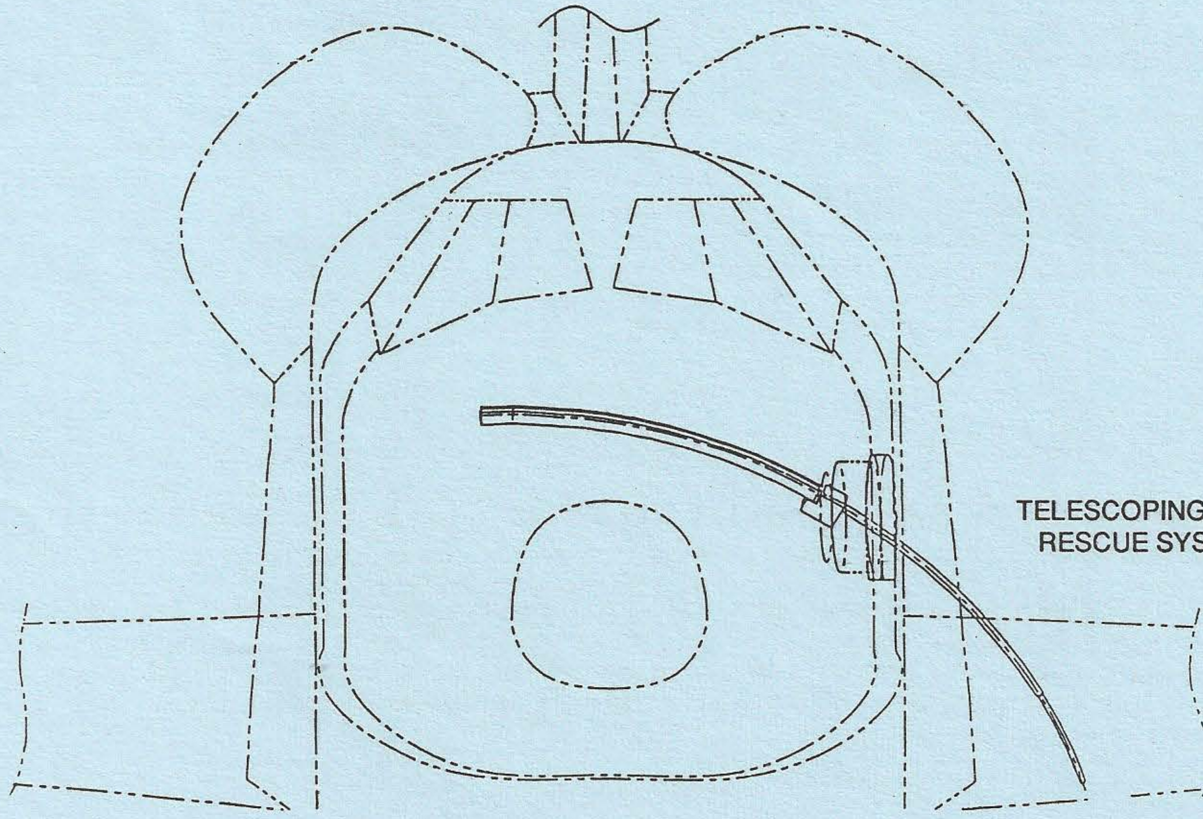
The telescoping pole system works like this: the hatch is opened, and a curved, telescoping pole extends out and downward past the edge of the orbiter wing. The astronauts wear harnesses with a special hoop that loops around the pole, so that as each astronaut bails out he slides down the pole, which guides him along the proper trajectory, and is carried safely past the wing. Once past the wing, and having slid off the end of the pole, the astronaut can then parachute normally.

The telescoping pole was selected over the tractor rockets after a series of entertaining tests involving both dummies and live subjects. Reasons given for the choice: lighter weight, less room taken up, and safety (astronauts took a dim view of storing a rack of solid fuel rockets in their living space).

The escape system is, as mentioned earlier, basically useless. The portion of a controlled glide where the system would be effective lasts, with luck, about two minutes maximum. One former Shuttle astronaut likened it to putting an escape system in an automobile--but one that only works between 29 and 33 miles per hour, at night, on an empty road.

Still, it's about the best NASA can do without shutting down the Shuttle program for about four years to develop a more comprehensive escape system and retrofit it into the Shuttle (such a system was rejected during the Shuttle's design phase--see the Feb. 1986 *C.S.R.*).

It should be noted that the safety refurbishing of the orbiters includes more practical precautions, such as the new hatch, which can be jettisoned quickly, and an inflatable escape slide under the hatchway similar to those used for escaping airlines on the ground in an emergency. These features would be used if there are problems with the orbiter requiring the astronauts to get clear quickly after a landing, a more likely emergency than the "controlled glide" scenario.



TELESCOPING POLE
RESCUE SYSTEM

Project Pathfinder

The Reagan Administration's National Space Policy has many ramifications for commercial space activities, supporting the reduction of NASA's role as a commercial supplier of space transportation and orbital facilities (as described in the previous two issues of this newsletter). However, while these portions of the space policy push NASA out of the commercial picture, another portion of the policy seems to be a gesture by the Administration encouraging NASA to move forward in its traditional role as an agency for science, technology, and exploration.

The Administration is backing a NASA program called Project Pathfinder. Pathfinder is a program of applied research and development, specifically intended to provide new technologies and tools to make a wide variety of future space activities feasible.

As a demonstration of new directions for NASA, Project Pathfinder may seem to some to be largely symbolic. Pathfinder funding for fiscal 1989 is set at $100 million (NASA will seek additional Pathfinder funding over following years, for a total outlay of $1 billion). While $100 million is not exactly chicken feed, it is less than one percent of the $11.5 billion requested by NASA for 1989. And, despite the Administration policy's support of commercialization, NASA is still firmly entrenched in the fields of space transportation and space facilities. The 1989 budget includes almost $1 billion in Space Station funds--$1 billion less than NASA wanted--and over $3 billion for Shuttle development and operations.

Project Pathfinder is divided into four technology development programs: Exploration, Operations, Humans-in-Space, and Transfer Vehicles (a Mission Studies program, to investigate applications of the Pathfinder technologies, is also part of the project). Each of these four programs is further divided into specific areas or elements of study. Following are some details on the programs, along with specifics on some of their more interesting individual elements:

Exploration:

The Exploration portion of the program will provide technologies needed for gathering scientific and engineering data for manned and unmanned missions to the Moon, Mars, and other planets in the Solar System. The Exploration program is broken down further into the study elements Planetary Rover; Sample Acquisition, Analysis, and Preservation; Surface Power; and Optical Communications.

The element on **Planetary Rovers**--mobile robots for exploring the surfaces of other planets--will focus on problems such as compact rover power systems, and the ability to automatically avoid or overcome obstacles in the rover's path. The latter is a critical problem when a rover is operating at such distances from Earth that, even at light speed, a signal can take anywhere from minutes to hours to make the round trip. If a moving rover is operated by remote control from Earth, by the time the operators see a picture of a cliff transmitted from the rover, and send the command "stop" back, the hapless machine may already be a pile of rubble at the cliff's bottom. Without autonomous operation, the rover will either succumb to such accidents, or be forced to operate so slowly, stopping and starting, that little useful work could be done.

The **Surface Power** element will address the technologies needed to provide high-performance, lightweight, reliable solar power to early installations located on the surface of the Moon or Mars. Both photovoltaic and solar dynamic technology will be studied.

The **Optical Communications** element will provide the technology base for the utilization of optical technology to transmit data across space. Communications across space using optical wavelengths instead of radio wavelengths would pack far more data into a given transmission (the same principle is in use on Earth with optical fiber communication networks).

Operations:

The Operations portion of the program will provide technologies needed for Earth-orbit staging and operations, as well as operations at the Moon, Mars, and other planets in the Solar System. The Operations program is divided into five elements: Autonomous Rendezvous and Docking, Resource Processing Plant, In-Space Assembly and Construction, Cryogenic Fluid Depot, and Space Nuclear Power.

The technologies developed by the **Autonomous Rendezvous and Docking** program element will allow unmanned space systems to perform complex docking maneuvers. The docking of space vehicles is a basic feature of almost all large-scale space projects. The assembly of large structures, the transfer of fuel, personnel or supplies from one space vehicle to another, and many other operations require docking procedures. However, many of these operations would not require a human presence if a pilot was not required to execute docking procedures. Affordable autonomous docking systems could make space operations safer and more economical by redirecting personnel resources to more challenging and appropriate tasks.

The **Resource Processing Pilot Plant** element is a wide-ranging program to develop systems for collection, analysis, refinement, and use of Lunar surface resources. Such resources include materials for construction, and materials (such as oxygen) needed for life support and propulsion. Stated project goals include efficient, durable, low-cost systems, with an eye towards automatic and telerobotic operations.

Cryogenic Fluid Depot technologies will enable the design and development of systems to service a broad array of space vehicles in microgravity. The most effective high-energy rocket propellants--liquid hydrogen, liquid oxygen, or liquid fluorine--are cryogenic. Handling and storing these fluids on Earth is routine, but not simple. The ability to store and transfer these propellants in space would greatly enhance the flexibility of many space operations. In fact, reusable space vehicles using these propellants, the Cryogenic Fluid Depot technologies, and the aforementioned Autonomous Docking technologies, would be able to open up much of the Solar System to human exploration and exploitation.

The **Space Nuclear Power** (SP-100) element is directed towards development of nuclear power systems to produce electrical power in the 10 kilowatt to 1 megawatt range. Such systems would be more effective and less massive than solar power systems for many applications, such as certain military and civilian satellites, and Lunar or Mars space stations or bases.

Humans-In-Space Technology

This portion of the program will provide the technology and understanding required for safe and productive missions to the Moon, and to other destinations in the Solar System. The program is comprised of three elements: Extra-Vehicular Activity/Suit, Human Performance, and Closed-Loop Life Support.

The **Extra-Vehicular Activity/Suit** element will develop the space suit technology needed to allow long-duration, high-performance human activity in space. The program will focus on two areas: suit components and systems, and portable life support concepts and systems (a more detailed discussion of new space suit concepts appears later in this issue).

Human Performance involves an investigation of human capabilities and limitations, both physical and psychological, throughout and after long-duration space missions. Stress, confinement, and exposure to unnatural gravitational conditions will all figure prominently in this study.

The **Closed-Loop Life Support** element will study methods and technologies, both chemically-based and plant-life-based (the program will define and test an optimal mix of the two approaches), for recycling materials during long-duration manned missions.

Transfer Vehicle Technology:

This portion of the program will provide critical technologies needed for transportation to, and return from, Lunar and Solar System destinations, as well as for reliable and cost-effective Earth-orbit operations. The program elements are: Chemical Transfer Propulsion, Cargo Vehicle Propulsion, High-Energy Aerobraking, Autonomous Lander, and Fault-Tolerant Systems.

The **Chemical Transfer Propulsion** element will concentrate on development of high-energy, space-based liquid oxygen/liquid hydrogen engines for use in Lunar and Mars landing vehicles, as well as in orbital transfer applications.

The **Cargo Vehicle Propulsion** element will develop very high performance electric propulsion technologies to support a manned Mars mission, and robotic missions to the outer planets. The program will focus on magnetoplasmadynamic (MPD) thrusters, and on establishing feasibility at high power levels.

High-Energy Aerobraking will provide the technology base required to perform high-speed reentry procedures, as well as procedures using aerobraking--skipping into and out of a planetary atmosphere--for orbital velocity changes. Such procedures can result in considerable savings in propellant which would otherwise be required for braking into orbits around Earth, Mars, or other planets with significant atmospheres.

The **Autonomous Lander** element will develop technologies to perform safe landings on planetary surfaces without a human operator. As with Autonomous Docking, this could result in safer and more cost-effective resupply or exploratory missions.

It is obvious that the Pathfinder technology described above could be as valuable for private space endeavors as it would be for future NASA missions. In the past, NASA has tried to justify the agency's large, "showpiece" projects like the Space Shuttle or the Space Station by demonstrating their commercial applications. To date, these applications have generally fallen flat under close examination, and NASA has had to settle for touting the "spin-offs" which have trickled outward from the peripheries of these showpiece programs and into (usually non-space-related) private industries. While these spin-offs have indeed been valuable in many fields, it's still not quite the same as having the space project itself find a profitable place in the private sector. Project Pathfinder could be a breakthrough in this area both for NASA and for commercial space.

Whether or not this turns out to be the case depends on whether NASA comes up with technological solutions that are affordable and practical, or simply comes up with more gold-plated white elephants as the agency has done so often in the past. It will be noted by informed readers that many of the Pathfinder project elements seem to be straightforward extensions of existing technology, which should require little research.

If NASA recognizes the value of existing, off-the-shelf technologies and incorporates them into their Pathfinder programs, developing new systems only when necessary, then Project Pathfinder may turn out to be a valuable, cost-effective technological resource for both government and private sector space endeavors. If not, then these essential technologies will still be developed in due course by free enterprise on its way out into the Solar System.

* * *

NASA Working On High-Pressure Space Suits

Engineers at two NASA facilities will submit competing designs for a space suit that may become the standard work outfit for future astronauts. These space suits are intended to provide crew members aboard the NASA Space Station with a safe, comfortable environment which would allow them to routinely enter and leave the Station, and work outside in space for shifts of up to 8 hours at a stretch.

The two groups, one from the Ames Research Center, the other from the Johnson Space Center, have been working on their respective designs for several years, and have arrived at two different approaches to the design requirements (see illustration on page 8). The life support pack is not included in these designs, and will be developed separately.

Ames is developing a suit called the AX-5, unique in that it is comprised entirely of "hard" metal aluminum elements. In fact, this design is sometimes referred to as a "hard suit." A surprisingly wide range of movement is provided by an ingenious combination of swiveling bearing joints. The current configuration of the AX-5 weighs about 185 lbs. The Ames design team is headed by Vic Vykukal, a scientist with Ames' Aerospace Human Factors Research Division.

Johnson's model, called the Zero Prebreathe Suit (ZPS) Mark 3, combines normal "soft" fabric space suit design with "hard" metal elements. The upper torso, and "brief" are metal, with swiveling bearing joints in the hips. The shoulders and waist use rolling convolute joints, and the arms and legs use modified versions of traditional space suit fabric designs. The ZPS Mk. 3 weighs in at about 150 lbs. The Johnson project is headed by Joseph J. Kosmo, of Johnson's Crew Equipment Branch.

Despite appearances, the two space suit designs have many things in common. Both suits are entered from a hatch in the rear, use wire-and-groove Ortman couplings to attach elements together, allow insertion of sizing rings to adapt to the wearer's body proportions, and incorporate a large, domed helmet for wide visibility. Both design teams have found that one of the most difficult problems is turning out to be the development of effective and flexible high-pressure gloves, and work in this area is still incomplete.

Most important, both suits are "high-pressure" suits, because their internal operating pressure is 8.3 psi, compared to 4.3 psi for existing suits, such as the current Shuttle suits. Developing a space suit technology to handle the pressure increase while maintaining suit flexibility was the greatest challenge the designers faced.

Shuttle suits are pressurized with 4.3 psi of pure oxygen, a technological legacy of times when spacecraft (like the Mercury, Gemini, Apollo, and Skylab) were pressurized with a pure oxygen or oxygen-rich atmosphere at about 5 psi. Leaving one of these spacecraft in a 4.3 psi suit was routine, and presented no problems.

However, the Space Shuttle and Space Station are pressurized with a 14.7 psi oxygen/nitrogen mix (a normal Earth atmosphere at sea level, and considered best for long-term habitation). An astronaut going rapidly from a 14.7 psi oxygen/nitrogen spacecraft to a 4.3 psi oxygen Shuttle suit risks coming down with the "bends," a painful and sometimes lethal condition (familiar to deep sea divers) caused by the expansion of dissolved nitrogen in body tissues. So, current extra-vehicular activities require extensive, three-hour oxygen pre-breathing procedures before the wearer can safely leave the spacecraft (*C.S.R.*, Dec. 1982, Jan. 1983).

Obviously, these procedures are not conducive to routine extravehicular activities and, if anyone develops trouble while outside the spacecraft, these procedures will not permit anyone suiting up quickly to carry out a rescue.

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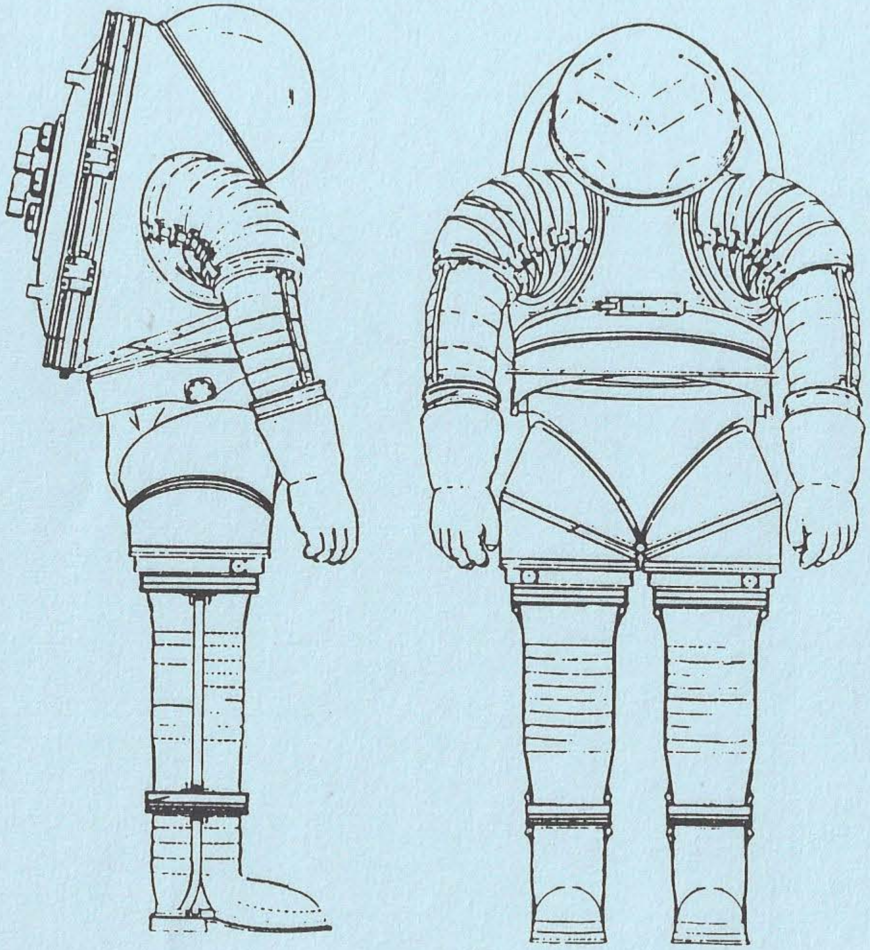
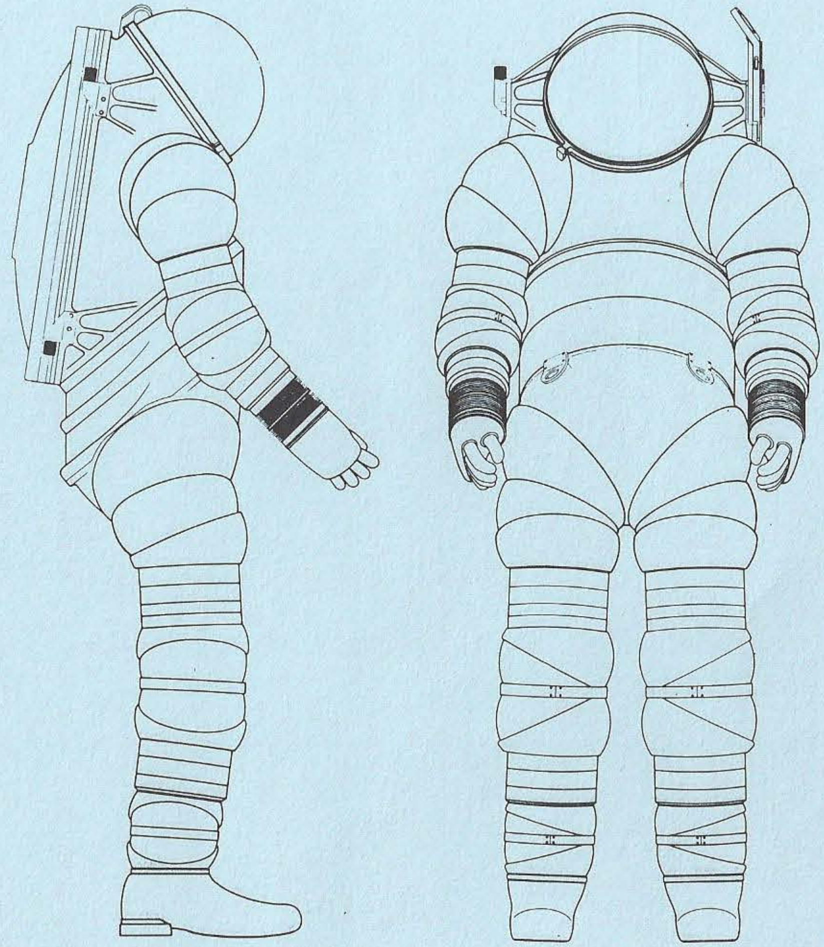


ZPS MARK 3
JOHNSON SPACE CENTER



AX-5
AMES RESEARCH CENTER

The high-pressure suit solves these problems--the difference between the 14.7 psi spacecraft pressure and the 8.3 psi suit pressure is not enough to bring on the bends. But the higher the pressure, the stiffer the suits become. Research to date has shown that the two candidate designs under consideration have excellent flexibility characteristics, but NASA will judge that for itself.

NASA engineers will conduct a number of tests on the two prototypes, primarily concerned with suit flexibility. Astronaut test subjects wearing the suits will perform exercises in front of measuring grids. Later, in the NASA weightless simulation water tanks, astronauts will undergo a series of simulated operations using mock-ups representing portions of the Space Station. The opinions of the astronauts trying out the suits are expected to rank high in the decision-making process.

Still, the final decision may be based more on politics between the two NASA centers than on engineering. Also, NASA may opt to develop a new concept, containing elements from both competing designs. Hopefully, the end product will be simple and reliable, rather than a complex "design-by-committee" engineering nightmare.

I find the Ames AX-5 design to be the most promising of the two. The all-metal construction is better suited to handle hazards such as micrometeoroids and radiation, and lends itself to mass-production techniques. It has fewer moving parts than the ZPS Mk. 3 and, with its single basic joint concept, is more elegant from an engineering point of view.

I must admit that I also find the AX-5 design esthetically appealing as well. Although it gives an astronaut an odd, bulging-jointed appearance similar to one of Larry Niven's alien "Protectors," the smooth, curved, aluminum surfaces of the operational hard suit would be given a microscopically-thin coating of reflective gold as a protection against corrosion and thermal radiation. The resulting appearance of the suit in the brilliant sunlight of space would certainly be nothing less than marvelous, reminiscent of Arthurian knights in their best tournament armor.

* * *

Soviets To Launch Own Shuttle

The Soviet Union plans the first launch of its shuttle vehicle sometime in the next few months. According to Alexandr Dunayev, chairman of Glavkosmos (the Soviet organization charged with providing Soviet commercial space services and overseeing international cooperative space missions), the Soviet shuttle will be launched into orbit on the back of the Soviet Energia booster. This will be the second flight of the Energia. The first flight, which took place on May 15, 1987, was partially successful (*C.S.R.*, May 1987). The upper stage on that flight, a cargo pod carried on the side of the Energia booster, fired its orbital insertion engines in the wrong direction, resulting in the cargo pod falling back to Earth.

The Soviet shuttle will make its first flight unmanned, returning to the Baikonur launch complex in Tyuratam after two orbits, and making an automated landing. The unpiloted reentry and landing are expected to be the most challenging technological hurdles to be overcome in the Soviet shuttle program, and there has been some speculation on the reasons. Crew safety is the obvious reason, but Soviet cosmonaut/pilots themselves have strongly opposed the automated flights and believe that even the first test flights should be piloted (this "Right Stuff" attitude is also prevalent among U.S. astronaut/pilots, and is one reason the U.S. Shuttle is not designed to be flown unmanned). Unmanned shuttle flights would not be needed for cargo flights--the Soviet Energia cargo configuration is capable of handling such missions more easily. The actual reason for the automation may be as simple as the fact that the Soviets prefer to keep ground control over much of its space operations.

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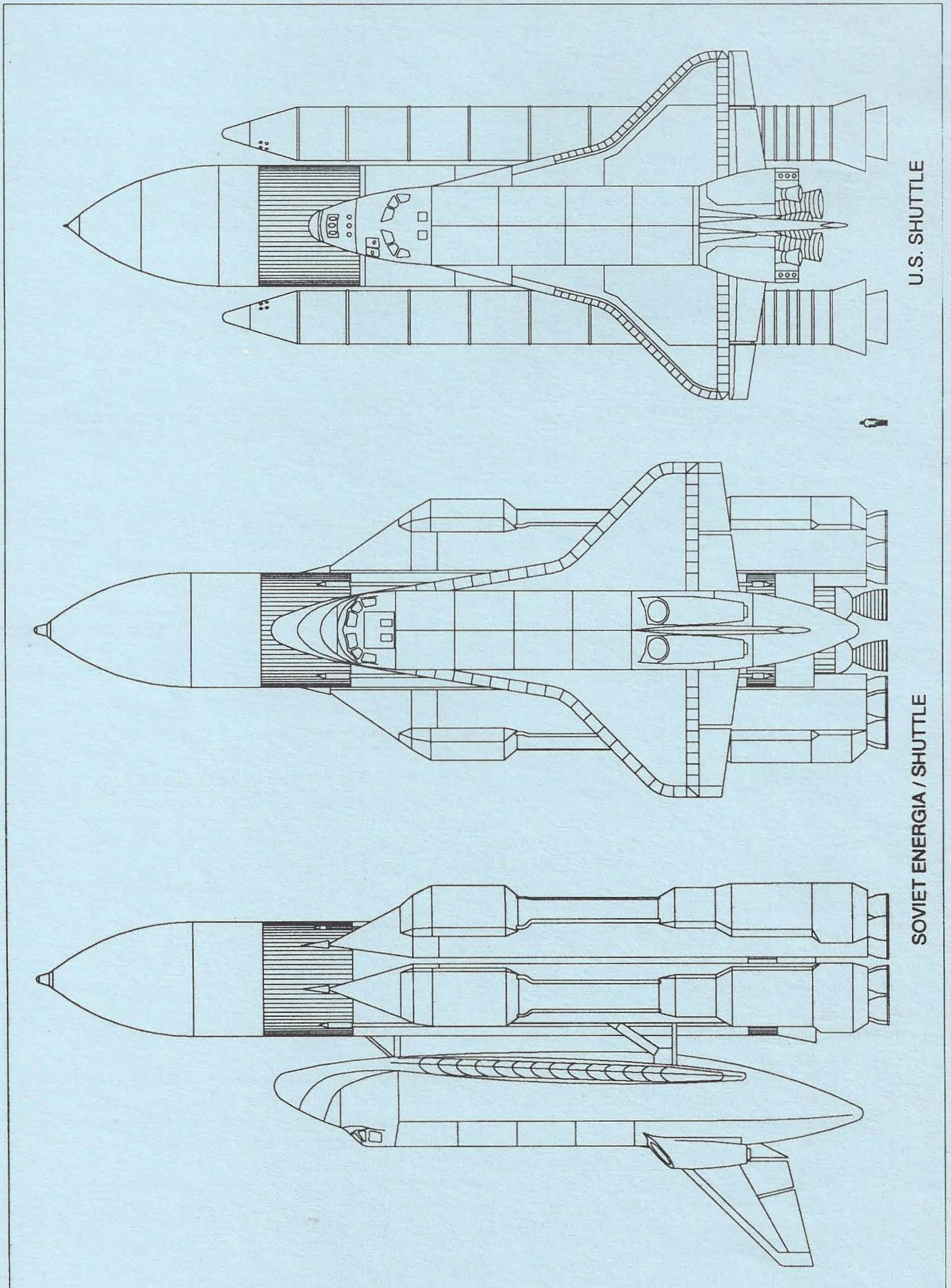
U.S. SHUTTLE
SOVIET ENERGIA / SHUTTLE

The Soviet shuttle design differs from the U.S. Shuttle in several ways, despite the similarities of appearance (see illustration on opposite page). The U.S. Shuttle's main engines are mounted on the orbiter and reused. The Soviet orbiter has no main rocket engines of its own, but relies entirely on the Energia's four oxygen/kerosene boosters and oxygen/hydrogen core to propel it into orbit (the Soviets have claimed that both the Energia boosters and core vehicle can also be recovered for reuse). The Soviet shuttle has two 20,000 lb. thrust jet engines, which allow it to perform powered landings, or to go around if a landing opportunity is missed. The U.S. Shuttle has no such capability. Payload capacity of the Soviet shuttle is estimated to be about 60,000 lbs., compared to the current payload capacity of 50,000 lbs. for the U.S. Shuttle.

Atmospheric flight tests of the Soviet orbiter have already taken place. Unlike the U.S. orbiter *Enterprise*, which was dropped from the back of a 747 aircraft for its approach and landing tests, the Soviet orbiter was able to take off by itself from a runway, using its two onboard jet engines and two additional engines mounted on the orbiter fuselage (the Soviet orbiter can be carried on the back of a Soviet Tu-16 bomber for ferrying operations). These flight tests were carried out with two-man crews on board, riding with ejection seats.

A specific date for the Energia/shuttle launch has not been released, although the month of June has been mentioned. A few sources feel that the launch could be timed to occur on May Day, a Soviet holiday commemorating the Russian Revolution. Under the current policy of *glasnost*, the exact launch date may eventually be revealed prior to the flight, and the flight may even be televised live. That the Soviets have made any public announcement at all in advance of the flight of such an experimental system is a marked contrast to Soviet policy in earlier years, where space flights were not publicized ahead of time, and, in case of failure, sometimes never acknowledged at all.

Soviets Lose Another Proton

On February 17, a Soviet Proton booster failed, resulting in the destruction of three Soviet navigation satellites. The malfunction took place in the separation system between the third and fourth stages, resulting in three advanced Glonass navigation satellites being placed in a very low orbit. The orbit soon decayed and the satellites were burnt up as they entered the atmosphere.

This marks the third Proton malfunction in a little over a year. Earlier failures in January and April of 1987 involved problems with the control computer in the fourth stage (*C.S.R.*, Feb., May 1987). The problem this time, according to the Soviets, was different: a failure of the separation mechanisms between the third and fourth stages.

Proton failures are only one obstacle in the way of Soviet efforts to market the Proton's launch services. Another is the refusal of the U.S. State Department to grant export licenses to American communications satellite manufacturers, the reason being fears that technology transfer would take place (the ban covers satellites anywhere in the world containing American parts). The Soviets have responded by outlining methods which are designed to provide security guarantees against such transfers, but the U.S. government is standing firm. The U.S. position against launching on Soviet vehicles is supported by some U.S. private launch companies as well, who see the heavily subsidized Soviet launch fees (approximately $30 million for a Proton launch placing a 4,000 lb. satellite into geosynchronous orbit--about half what existing U.S. launch companies charge). Not surprisingly, a number of U.S. satellite manufacturing firms, stranded by the Shuttle, have taken the opposite tack. Companies like General Electric and Hughes have been prodding the State Department to take a more moderate view.

U.S. Materials Processing Payload To Fly On Mir

A U.S. company has made arrangements to fly experimental research payloads aboard the Soviet Mir space station. Payload Systems, Inc. (PSI), a consulting firm in

Wellesley, Mass., became the first U.S. firm to win Commerce Department approval to place a research payload aboard the Soviet Mir space station. The contract calls for multiple flights over two years, with PSI acting as broker for a variety of materials processing clients.

Payload Systems was founded in 1984 by Byron Lichtenberg of the Massachusetts Institute of Technology. Lichtenberg was the first payload specialist to fly aboard the Space Shuttle in December, 1983. The company provides support to clients in the field of microgravity technology, and, among other services, currently offers customers access to short-term microgravity flights aboard KC-135 aircraft.

The first Mir payload will be a drug-research experiment involving protein crystallization. Payload Systems will provide the containers, which will be launched to the Mir aboard a Soviet rocket. The experiments will take place in the sealed containers, while Soviet cosmonauts operate simple outside controls. These precautions, taken with the cooperation of the Soviets, are intended to reassure commercial customers that their experiments will remain proprietary.

Unlike the proposals to launch U. S. communications satellites on Protons, PSI's project has received approval from the U. S. government. Apparently, the company's materials processing experiments did not raise the same objections about technology transfer. The deal opens the way for other similar cooperative arrangements between the U.S. commercial customers and the Soviet Union.

The Soviets plan to launch additional Mir modules in the next few years, with such a launch taking place about every five months. The next scheduled module launch will be in late 1988: reportedly a module providing improved quarters for the Mir crews (this will be the first module to be attached radially to the Mir docking unit--until now all docking has been done along the Mir central axis). Later module launches scheduled include: a technology or engineering module in early 1989, a module for remote sensing observations in late 1989, and a scientific research or medical lab module in 1990.

The Mir complex is scheduled to be completed in 1990-1991. The Soviets are making plans for a "Mir II," which would begin operating after 1994-1995. The core module of this new space station would be launched by an Energia booster.

* * *

Note To Readers: As you can see, this is another combined issue. I don't intend to make this a habit, but time got away from me again. Postage prices have gone up, but will not affect subscription rates for the time being.

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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