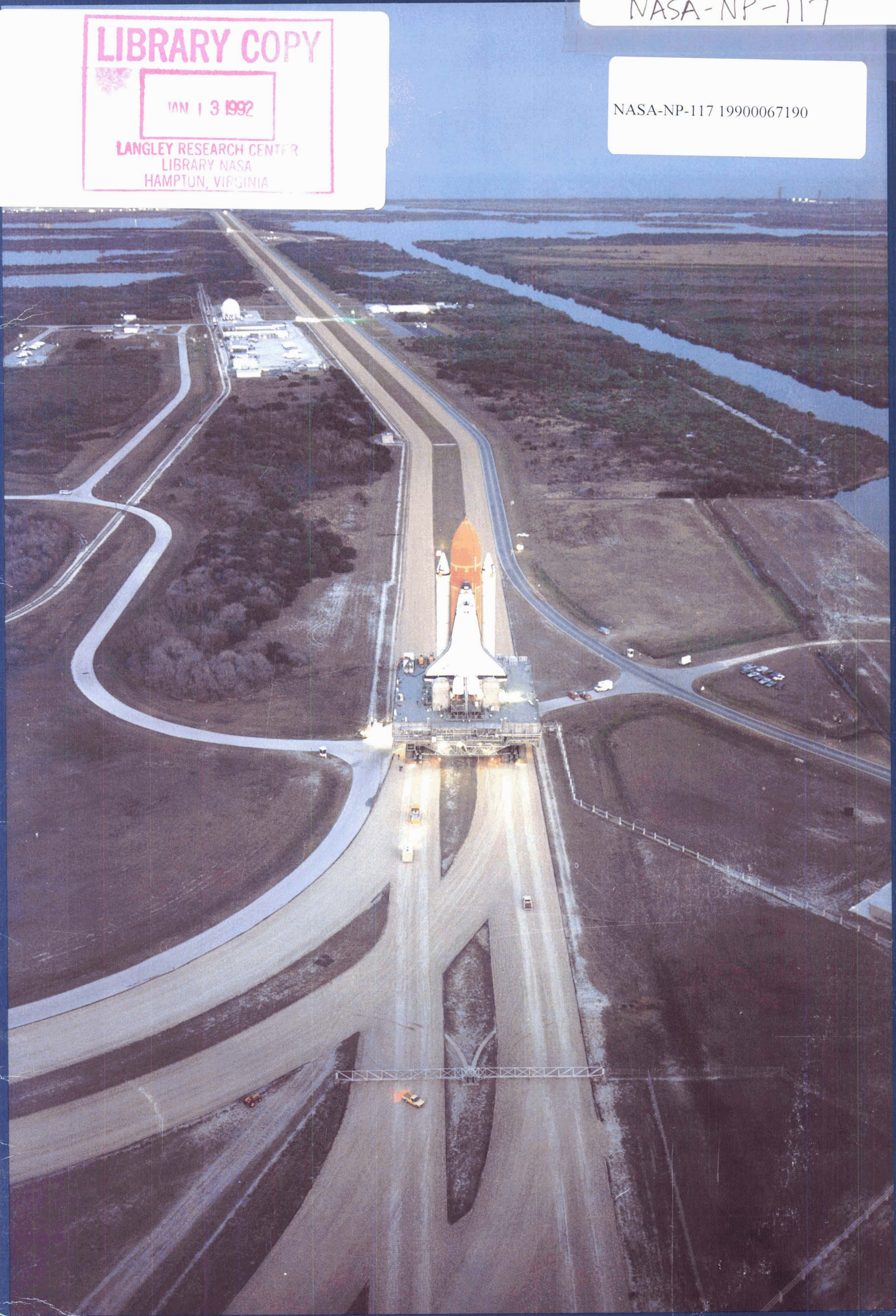
SPACE SHUTTLE

The Journey Continues





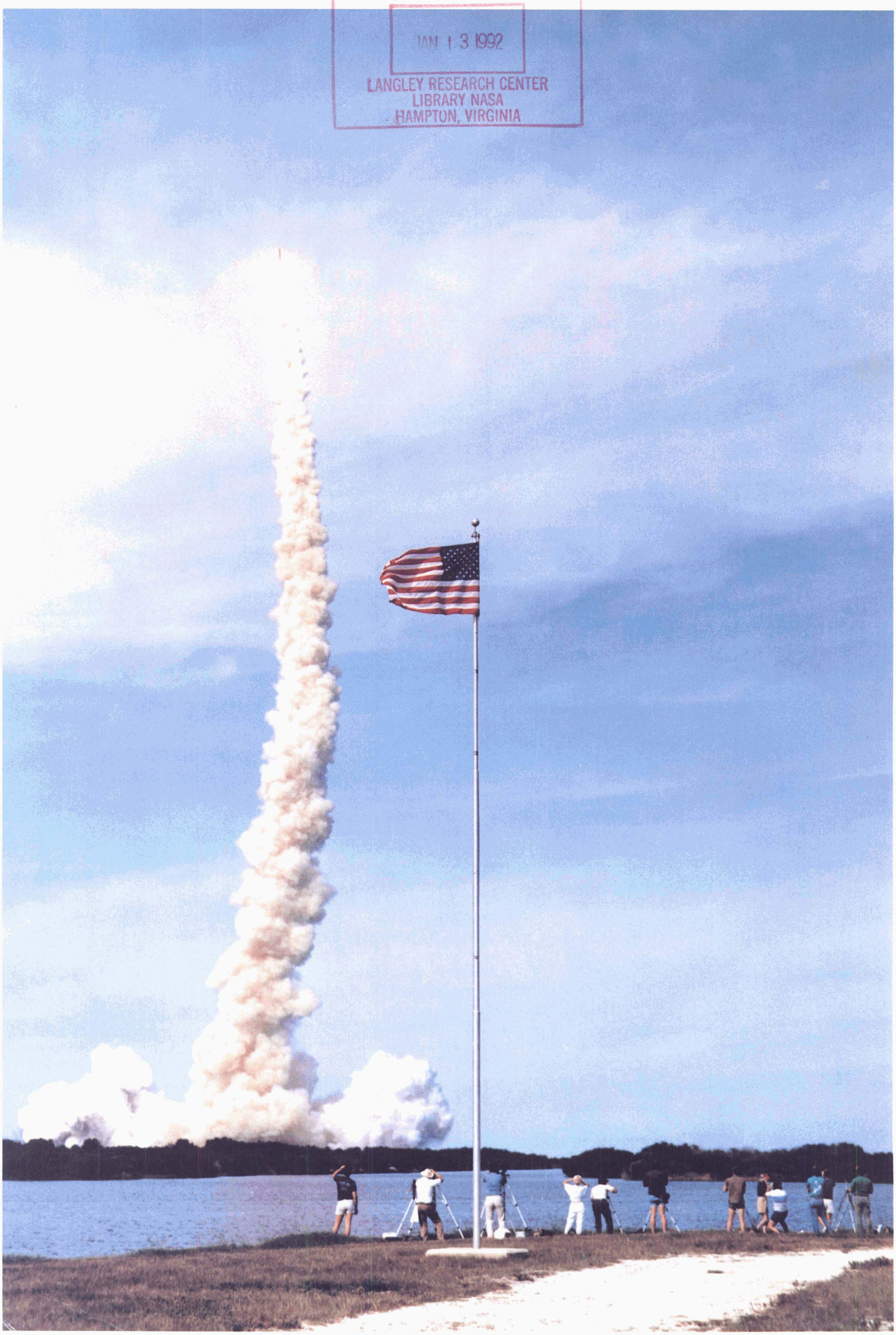
RADM Richard H. Truly, USN

NASA National Aeronautics and Space Administration

We risk great peril if we kill off the spirit of adventure, for we cannot predict how and in what seemingly unrelated fields it will manifest itself. A nation which loses its forward thrust is in danger, and one of the most effective ways to retain that thrust is to keep exploring possibilities. The sense of exploration is intimately bound up with human resolve, and for a nation to believe that it is still committed to forward motion is to ensure its continuance.

James A. Michener
February 1, 1979

Richard H. Truly is the NASA Associate Administrator for Space Flight. A Rear Admiral in the United States Navy, Admiral Truly was previously the first Commander of the Naval Space Command. An astronaut, he piloted the second Space Shuttle flight in 1981 and commanded the Challenger in 1983 during the eighth flight of the Shuttle.



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NASA National Aeronautics and Space Administration

The Space Shuttle is important because space transportation and manned space flight are now essential to the well being of the United States.

Space has become a place where extremely useful and worthwhile activities occur, and space transportation is always the first step. Some of these activities can be done only in space. Some can be done better in space than on Earth. No longer limited to high adventure and occasional spectaculars, space provides practical benefits we now take for granted. It also provides opportunities for science, commerce, and international cooperation.

The practical benefits are many. Communications, navigation, and weather prediction are all now space dependent. Remote sensing spacecraft aid a host of other activities including agriculture, petroleum exploration, map making, environmental protection, and urban planning. In truth, our society has come to rely upon the now everyday capability of modern space systems.

Science also benefits from space. Space provides such a rich environment for the advancement of knowledge that science and technology now have a core dimension rooted in space. Research in space is remarkably diverse. It examines near-term concerns such as ozone depletion that may affect the atmosphere's ability to shield us from harmful radiation. It seeks ultrapure pharmaceuticals, uniform semiconductor crystals, and new glasses and alloys from the microgravity environment of space. With a longer focus, it looks at the Sun and the planets to learn more about life and the one planet in the solar system that supports it. And, with incredibly sophisticated orbiting observatories, space research peers across the electromagnetic spectrum into distant galaxies in search of answers to fundamental questions about human and physical existence.

Yet space is more than a laboratory for science or a source of practical applications. It is also a place of business. Private companies conduct extensive activities focusing upon space. Some build space hardware; some sell support equipment and services. Some simply utilize the capabilities provided by spacecraft. Newspapers, for example, rely upon space systems for printing. Space is a place of profit and of competition.

This competition is not simply commercial in character. In the decade of the 1980's, the space programs of Europe have matured and challenge our own. Japan and China are becoming major spacefaring nations. The Soviet Union is accelerating its already impressive space program. These countries understand that profit, productivity, prestige, and power are the products of investments in space. U.S. leadership among spacefaring nations has eroded. The implications of this affect not only our science, technology, and commerce, but also our national security. As importantly, it affects the confidence with which Americans face the future.

While competition in space flourishes, so does international cooperation. At the same time that we compete, we conduct cooperative activities. Through NASA, the United States has engaged in a large number of highly successful space missions with allies and friends. These missions are usually scientific in character. While they support our foreign policy objectives, they more directly add to our storehouse of knowledge. And they demonstrate the peaceful use of space for the benefit of all.

## PAYLOADS AND PEOPLE TO ORBIT

To realize the vast potential of space and to achieve the benefit from space in science, technology and commerce, you must first get there. Transportation, as always, is critical. Payloads must be placed in orbit. The Space Shuttle is important because it carries these payloads into space. The Shuttle is a heavy lift launch vehicle. The United States relies on the Shuttle to transport a variety of spacecraft to where they need to go. If the destination is low Earth orbit, the Space Shuttle brings them up. If the objective is geosynchronous orbit or another planet, the Shuttle brings the payload to about 250 miles above the Earth from where it is propelled to its destination. Despite its technical complexity and sophistication, the Space Shuttle is conceptually simple. It is a truck to transport things into space. During the first period of Shuttle operations, from 1981-1986, it hauled a vast amount of cargo. Four orbiters, in 24 flights, carried numerous payloads aloft, as shown on page 6. The future looks equally busy. The Space Shuttle's manifest continues to be booked out to the horizon of our planning. I have no doubt the Shuttle will be flying throughout the first decade of the twenty-first century, lifting payloads into orbit and demonstrating its value as a national space launch vehicle.

But the Space Shuttle is much more than simply a launch vehicle. What makes it unique, what marks it as a resource of extraordinary value to the United States, is that it carries more than heavy cargo. It transports men and women into space. It enables them to live and work on orbit and then returns them safely to Earth. Moreover, the Shuttle is reusable—the first such craft in the world. The Space Shuttle works in four distinct regimes: it is a launch vehicle bringing people and payloads to and from space. As a versatile spacecraft circling the Earth, it provides time on orbit for human beings. It is a reentry vehicle gliding safely through the atmosphere at such high speed that the molecules of air have difficulty getting out of the way. And then, at the end of its flight profile, the Shuttle is an aerodynamic vehicle—a glider that is flown to land upon a runway.

The fundamental purpose of the Space Shuttle is to place human beings into space, then return them safely and lift them aloft once again.


By bringing payloads and people back from space, the Space Shuttle provides a capability of enormous significance. It is the world's first reusable spacecraft and will haul crew and cargo to and from space well into the twenty-first century.

## Space Shuttle Flights 1981-1986

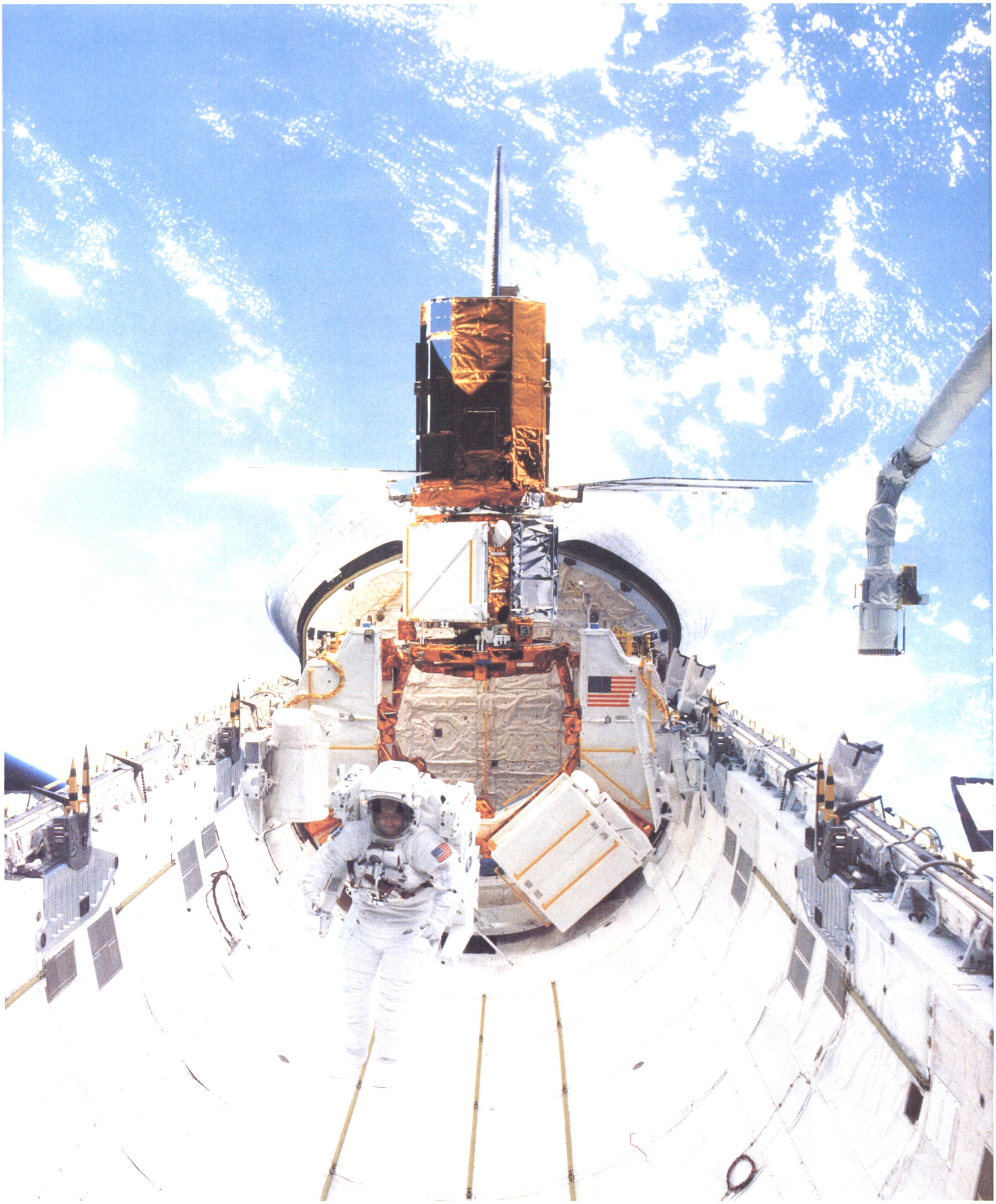
| ORBITER | DATE | PAYLOAD |
| --- | --- | --- |
| 1. Columbia | April 12, 1981 | Flight Instrumentation |
| 2. Columbia | November 12, 1981 | OSTA-1, First RMS, Flight Instrumentation |
| 3. Columbia | March 22, 1982 | OSS-1, Flight Instrumentation |
| 4. Columbia | June 27, 1982 | DOD, Flight Instrumentation |
| 5. Columbia | November 11, 1982 | SBS-C, Telesat E |
| 6. Challenger | April 4, 1983 | TDRS A |
| 7. Challenger | June 18, 1983 | SPAS-01, OSTA-2, Telesat F, Palapa B-1 |
| 8. Challenger | August 30, 1983 | PDRS/PFTA, OIM, INSAT 1-B |
| 9. Columbia | November 28, 1983 | Spacelab 1 |
| 10. Challenger | February 3, 1984 | SPAS-01A, Palapa B-2, Westar 6 |
| 11. Challenger | April 6, 1984 | LDEF, SMM Repair |
| 12. Discovery | August 30, 1984 | OAST-1, SBS-D, Telestar 3-C, Syncom IV-2 |
| 13. Challenger | October 5, 1984 | OSTA-3, ERBS, LFC/ORS |
| 14. Discovery | November 8, 1984 | HS-376 RETV(2), Telesat H, Syncom IV-1 |
| 15. Discovery | January 24, 1985 | DOD |
| 16. Discovery | April 12, 1985 | Telesat I, Syncom IV-3 |
| 17. Challenger | April 29, 1985 | Spacelab 3 |
| 18. Discovery | June 17, 1985 | Spartan, Morelos A, Arabsat 1-B, Telestar 3-D |
| 19. Challenger | July 29, 1985 | Spacelab 2 |
| 20. Discovery | August 27, 1985 | Aussat 1, ASC-1, Syncom IV-4 |
| 21. Altantis | October 3, 1985 | DOD |
| 22. Challenger | October 30, 1985 | Spacelab D-1 |
| 23. Atlantis | November 26, 1985 | EASE/ACCESS, Morelos B, Satcom KU-2, Aussat 2 |
| 24. Columbia | January 12, 1986 | MSL-2, Satcom KU-1, Gas Bridge |
| 25. Challenger | January 28, 1986 | TDRS B |

## MEN AND WOMEN IN SPACE

The rationale for having men and women in space rests upon utility as much as anything else. While there is an emotional, intangible dimension to the human presence in space, there is, decidedly, a compelling practical value as well.

The presence of astronauts significantly enhances the utility of spacecraft. The output, the results and the benefits derived are far greater when humans are present. After all, human beings are the most sophisticated machines of all. Their creativity, their dexterity, their ability to perceive, their interaction with instruments and each other, and their ability to respond to the unexpected are unmatched. Whether piloting the Shuttle, controlling its Remote Manipulator System (the Shuttle's Canadian developed high-tech crane), or conducting scientific experiments in Spacelab (the European laboratory module that sits in the payload bay), the presence of a crew brings unique and extraordinary capabilities to space. Humans can fix things. They can redirect or reprogram their activities. As Neil Armstrong showed during the Apollo 11 descent to the lunar surface, they can steer clear of unexpected obstacles. They also can do what machines simply cannot. They can act upon hunches and they can channel intuition. Although requiring extensive life support systems, humans in space bring expertise and imagination to the cockpit and to the laboratory. Their presence increases immeasurably our orbital capabilities.

Space science traditionally has been best served by a balance of manned and unmanned missions. The crew's influence on the three Spacelab flights and in the conduct of numerous middeck experiments has demonstrated great benefits. Having scientists in the laboratory is hardly revolutionary. We do it all the time on Earth. On Earth the scientist prepares the experiment, monitors its progress, and shuts it down when necessary. The scientist in space interacts with the experiment in the same way. He or she reads the data and makes realtime adjustments. The scientist is there to interpret, to react, to fix, and to do it again. When we have the capability to place scientists in an orbiting laboratory, as we do now with Shuttle and will be able to do so more extensively in the future with the Space Station, we do so. When simply not possible, as in a mission to the outer planets, we do not. We then rely upon sophisticated unmanned spacecraft. Each approach is valid. Each brings rewards. In a balanced approach to space exploration, NASA conducts both unmanned research and manned space flight. Each has its place. And neither is independent of the other. The unmanned scientific expedition requires the guiding hand of the flight director and the flexible mind of the principal investigator (they just happen not to be onboard). And when the astronauts are conducting experiments in Spacelab or on the middeck, they are completely dependent upon automated systems that sense, calculate, and switch at speeds and reliability no human can match. Manned space flight requires the technology of unmanned systems. Unmanned scientific spacecraft require the presence of men and women. A balanced U.S. space program needs and will continue to need both.



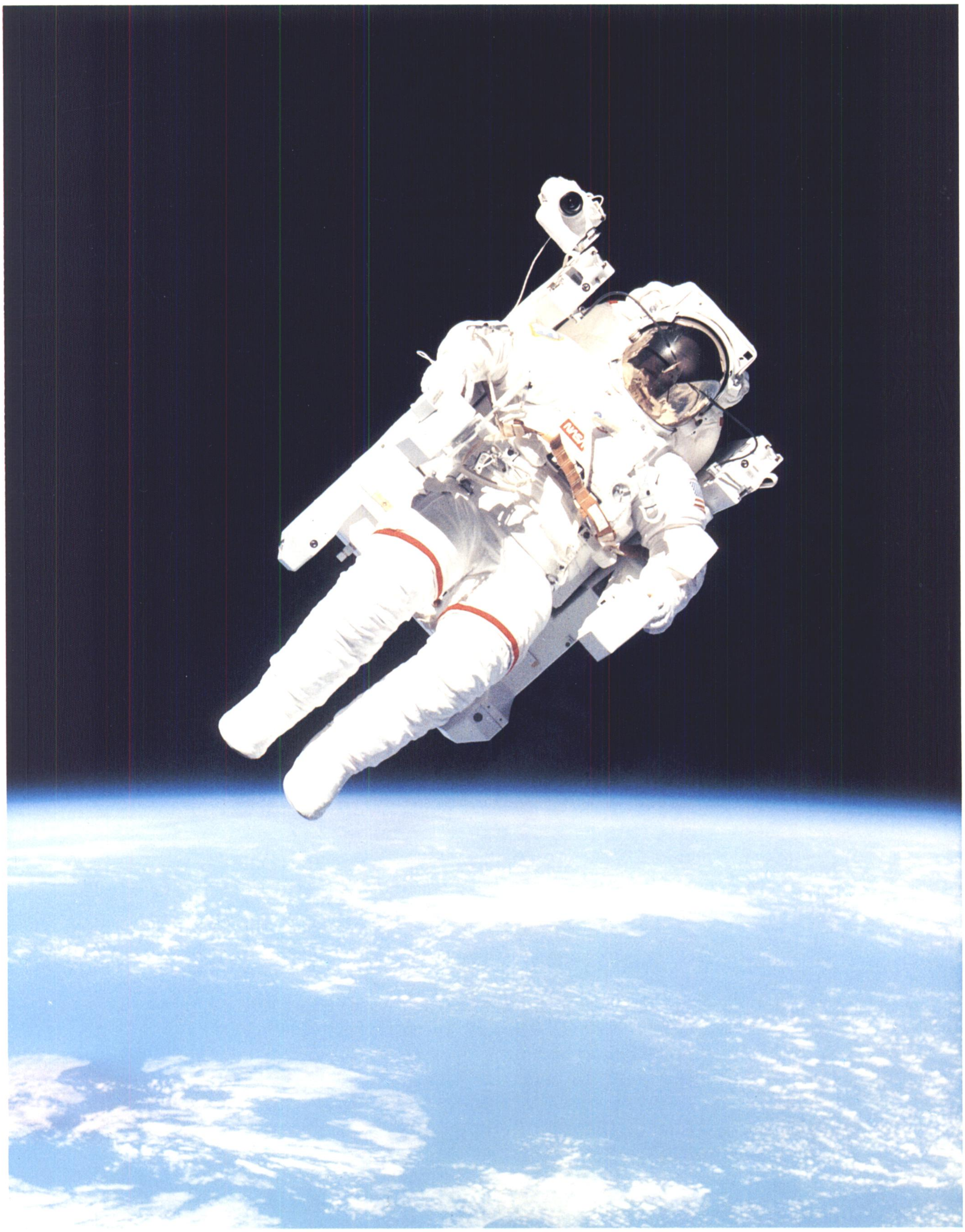
The retrieval, repair and redeployment of the Solar Max scientific satellite by astronauts in April, 1984 demonstrated the feasibility of using the Space Shuttle as a maintenance and repair depot in space. Future satellites, such as the Hubble Space Telescope, will benefit greatly from Space Shuttle servicing. Solar Max was a satellite that focused upon the Sun, examining solar flares over a wide range of wavelengths.

## HUMAN EXPLORATION

Along with the utility of having humans in space lies the emotional value and intellectual dimension of human exploration. To deny these ignores a fundamental dimension of life.

Consider first the emotional value of space flight. People are human. They react with their heart as well as their mind. The excitement of space flight has thrilled people well before Uri Gagarin and the Mercury astronauts pioneered manned flight around the Earth. The adventure of space exploration by men and women, the purview no longer of fiction but of engineering, continues to fascinate people here in the United States and around the globe. No one who has witnessed the launch of a Saturn V rocket with Apollo astronauts on board or seen the Space Shuttle lift off from Cape Canaveral can fail to experience the excitement. An adventure has begun. Despite the display of technology, the adventure is intensely personal. Being there, seeing it and hearing it, compels you to wish the astronauts God Speed as they are hurtled into space. A Shuttle launch leads to a binding, an awareness of a common trait shared with the crew and with the people who are there. We are all human beings. Our lives are intertwined. Our future is one. Their success is our success. In times of triumph and, as we learned with the loss of Challenger, in times of tragedy, space exploration expresses a profound sense of brotherhood.

The intellectual character of manned space flight is no less real than its emotional dimension. We place men and women into orbit in order to learn. Learning is not the only reason, but it is an important reason. Exploration is a human imperative laced with a sense of adventure, buttressed by a need to know. Being there in person enables us to know more. Astronauts (and cosmonauts) can see and measure and look further still. They question and think and question again. Until we are physically there, we will not fully understand. This need to know has driven human exploration throughout the ages. It drove Vasco de Gama to the Cape of Good Hope. It sent seaman such as Cabot and Frosbisher to Canadian waters in quest of a Northwest Passage. It sent Lewis and Clark up the Mississippi River. It drove the great navigators Cook and deBougainville to the Southwest Pacific. Of course, it was not just a pure desire to explore that propelled these astronauts of their day. Nationalism, the scent of profit and what Daniel Boone called "Elbow Room," contributed, but the necessity of learning played a key part. Men and women are more than economic creatures and patriots. They are seekers of knowledge, inquisitive types, who are borne with a desire to learn. Curiosity motivates human behavior. The exploration of space by men and women reflects this. It adds to our understanding. It stimulates our minds. It enables us to question further and to delve deeper.





The United States space program utilizes both unmanned spacecraft and manned space flight. Each mode is beneficial and each has its place in NASA's overall strategy. Human beings enormously enhance a spacecraft's capabilities. After all, human beings are the most sophisticated machines of all. Their creativity, their dexterity, their ability to perceive, their interaction with instruments and each other, and their ability to respond to the unexpected are unmatched.

## NATIONAL SPACE POLICY

Human exploration of space is not just a mission of NASA or simply the dreams of a few visionaries. It is an objective of the United States government and is reflected in our national space policy. Adopted in early 1988, this space policy sets forth a set of goals and objectives to direct U.S. efforts in space for the future. The policy, manifested through a Presidential directive, reaffirms the national commitment to the exploration and use of space. It sets, as a long-term goal, human expansion beyond Earth orbit. It acknowledges that U.S. space activities are conducted by three separate and distinct (though interactive) sectors: civil, national security, and commercial. Most importantly, the directive states that a fundamental objective guiding U.S. activities in space has been, and continues to be, leadership in space.

The policy directs NASA to conduct a balanced program of manned and unmanned space exploration. Preeminence in critical aspects of manned space flight is mandated. The policy sees efforts to improve Space Shuttle performance and to develop the Space Station as intended to ensure such preeminence. Indeed, I believe these efforts are vital. A robust Shuttle fleet and a permanently manned Station are essential to the United States. Without them, the 1990's and the first decade of the twenty-first century would be a time when our abdication of space leadership becomes evident.



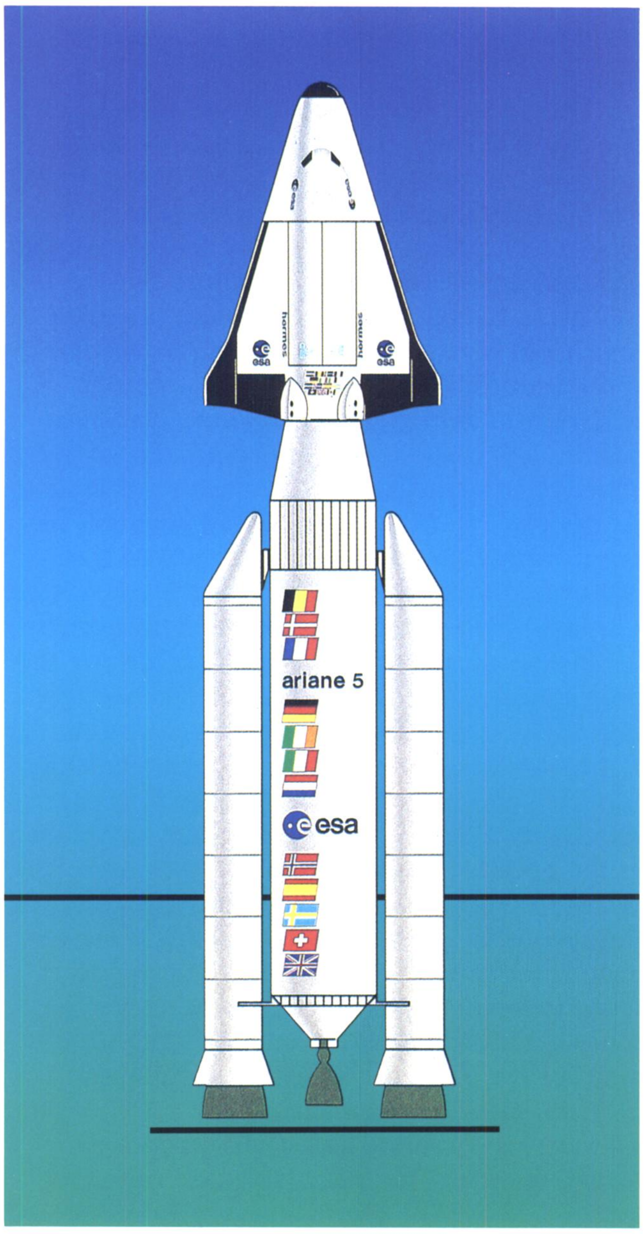
Our national space policy speaks directly to the subject of space transportation. It recognizes the link between transportation and the benefits of space. The policy calls for assured access to space and for transportation capabilities in space. It states the U.S. space transportation systems must provide a balanced, robust and flexible capability. The system must be sufficiently resilient to allow continued operations despite failures in any single system. The policy further states that we will exploit the unique attributes of both manned and unmanned launch systems. It encourages the development of private sector space transportation systems. It sets as a goal the reduction of space transportation costs.

# COMPETITION IN SPACE FLIGHT

The Space Shuttle is a unique space launch system. It is "man-rated" and reusable and has carried a vast amount of cargo into space. It also has carried cargo back from space. The Soviet Union will soon be flying a Shuttle-like reusable craft to carry cosmonauts and cargo into space and back. In the 1990's, the Soviet Shuttle no doubt will be a regular caller at MIR, the Soviet space station. Mated to the Energia launch vehicle, the world's largest rocket, the Soviet Shuttle will comprise an impressive capability. The Soviet record in space is already impressive. At the end of 1987, of the 1,736 payloads in orbit, more than half (1,045) belong to the Soviet Union. The Soviets are totally committed to space. They recognize fully its many benefits.

However, the two superpowers are not the only countries in the business of manned space flight. The countries of Europe, organized as the European Space Agency (ESA), have built the Spacelab and have established a small corps of astronauts. Some of these astronauts have flown in the Shuttle. Spacelab is a highly capable laboratory in space whose development enabled the Europeans to gain manned space flight experience at bargain prices. Europe's stated goal in space is autonomous manned capabilities. To achieve this, ESA has begun development planning for the Ariane V launch vehicle and the Hermes manned space plane. The former is an advanced technology heavy lift expendable launch vehicle. The latter is a small reusable space plane whose first manned flight is targeted for 1999. An illustration of the Hermes craft atop an Ariane V is shown on page 14.

Competition among nations in expendable launch vehicles is substantial. While manned space flight at present is dominated by the United States and the Soviet Union, a number of countries build and market unmanned expendable vehicles. One of the most successful vehicles is Ariane. Built by the Europeans, and marketed commercially by a private company, Ariane has placed in orbit both communications satellites and scientific spacecraft. Launched from the ESA facilities in Kourou, Guiana, Ariane has flown 23 times since 1979. Nineteen of these flights have been successful, four have failed. China too is now in the expendable launch vehicle business. Its Long March vehicle has flown successfully and is offered for sale on the world market. Japan is also building launch




**Both the Ariane V launch vehicle and the Hermes manned space plane (both illustrated here) are under development in Europe.**

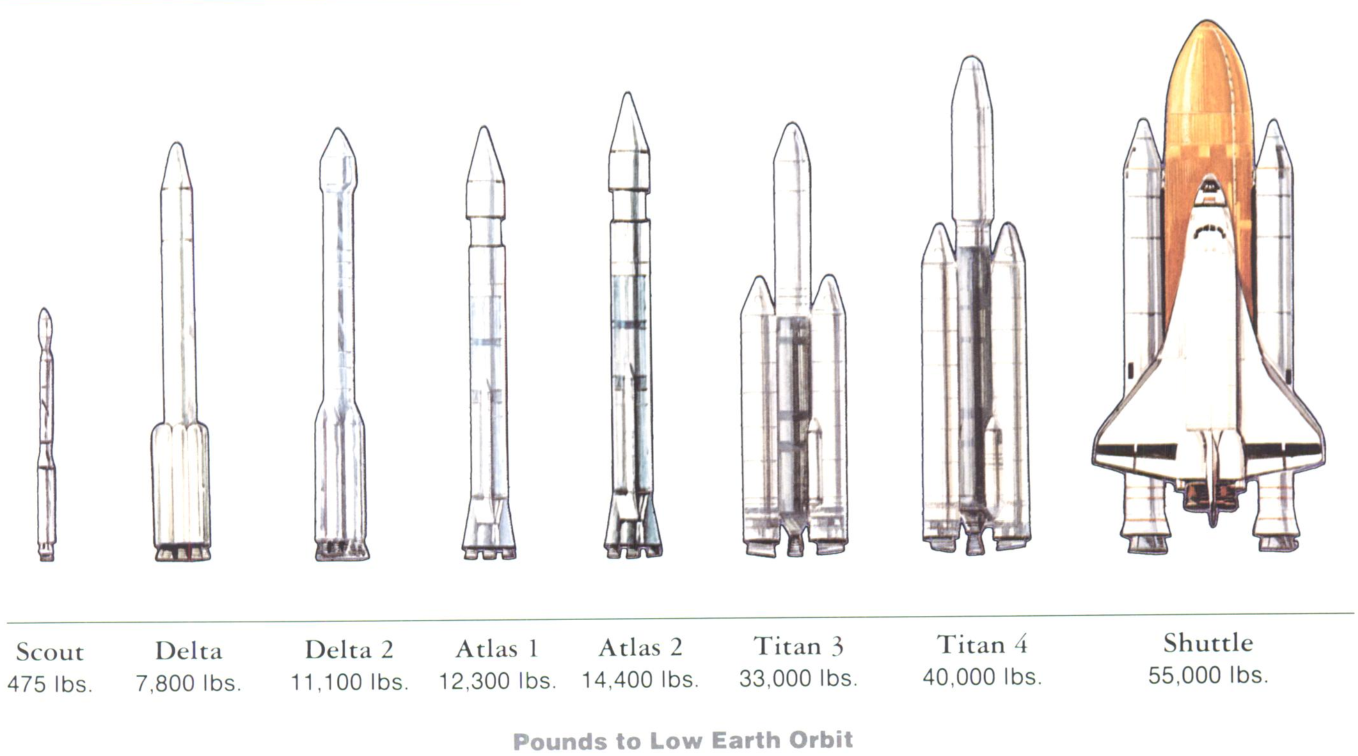
vehicles. Its H-I rocket, based on U.S technology, has carried Japanese scientific spacecraft into orbit. Now in development is the H-II. This three-stage heavy lift vehicle will have an advanced liquid hydrogen-oxygen engine. Developed solely by the Japanese, the H-II is scheduled to become operational in the early 1990's. No doubt, it will make its presence felt. The Soviet Union also flies unmanned vehicles. The Proton rocket is the workhorse of the Soviet rocket fleet and recently has been offered commercially. Difficulties with utilizing Proton exist, but the Soviets are making a concerted effort to market the vehicle.

International competition in expendable launch vehicles is stiff. Europe, China, Japan, and the Soviet Union are flying vehicles now that compete with U.S. expendable launch vehicles. Moreover, they are developing more advanced rockets that will compete in the future. The extent of the competition reflects the maturity and availability of rocket technology. It also reflects the heavy demand for launch services which itself demonstrates the commercial and scientific value of space.

U.S. expendable launch vehicles, however, constitute an impressive capability. Given a level playing field, they can more than hold their own. With demand fostered by NASA and the Department of Defense, U.S. industry has supplied a variety of reliable vehicles to meet a diverse set of requirements. The Scout vehicle,

**U.S. Launch Vehicles**

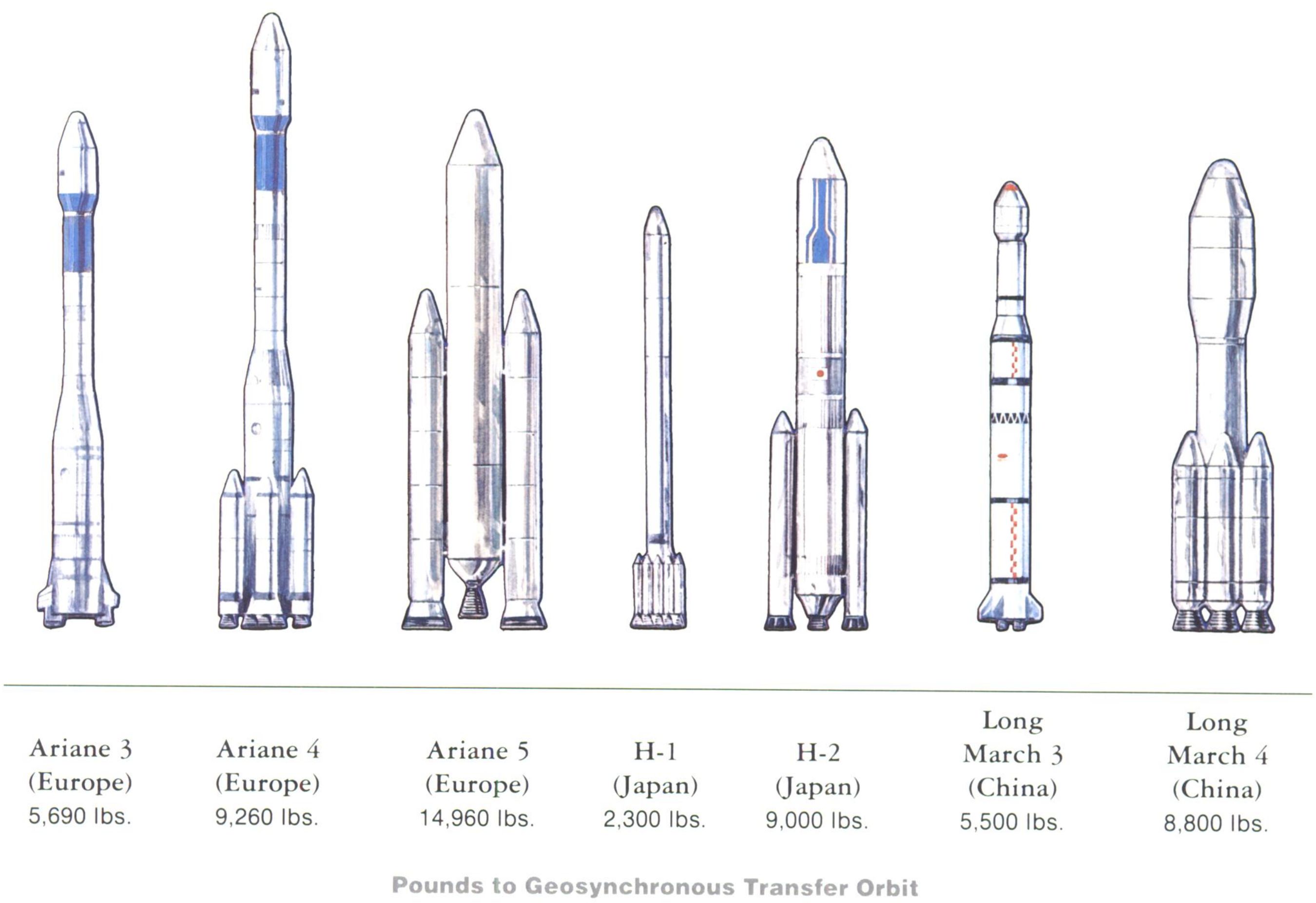




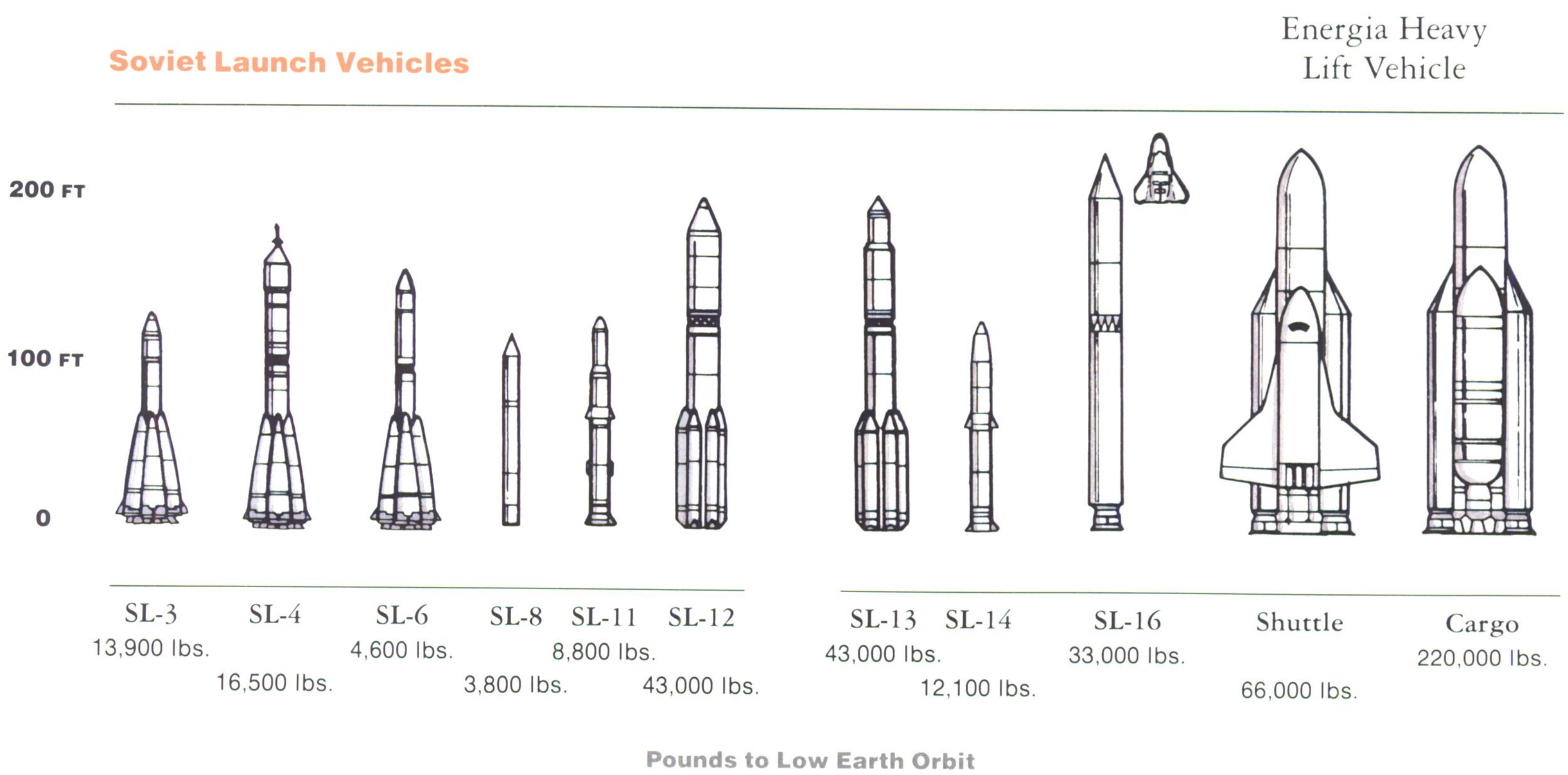

built by the LTV Corporation, lifts small payloads into orbit. The Delta launch vehicle, manufactured by McDonnell Douglas, carries medium-sized payloads aloft and is a mainstay of the fleet. The Atlas vehicle, built by General Dynamics, lifts larger, intermediate payloads into orbit while Martin Marietta's Titan launch vehicle places heavy payloads into their orbital positions. These expendable launch vehicles are illustrated here as are foreign vehicles.

The national space policy directs NASA to procure expendable launch services from the commercial space sector. The commercial launch services industry is now a reality. The U.S. space policy is intended to enhance the competitive posture of the American expendable launch vehicle industry.

## Launch Vehicles of Europe, Japan and China




## Soviet Launch Vehicles

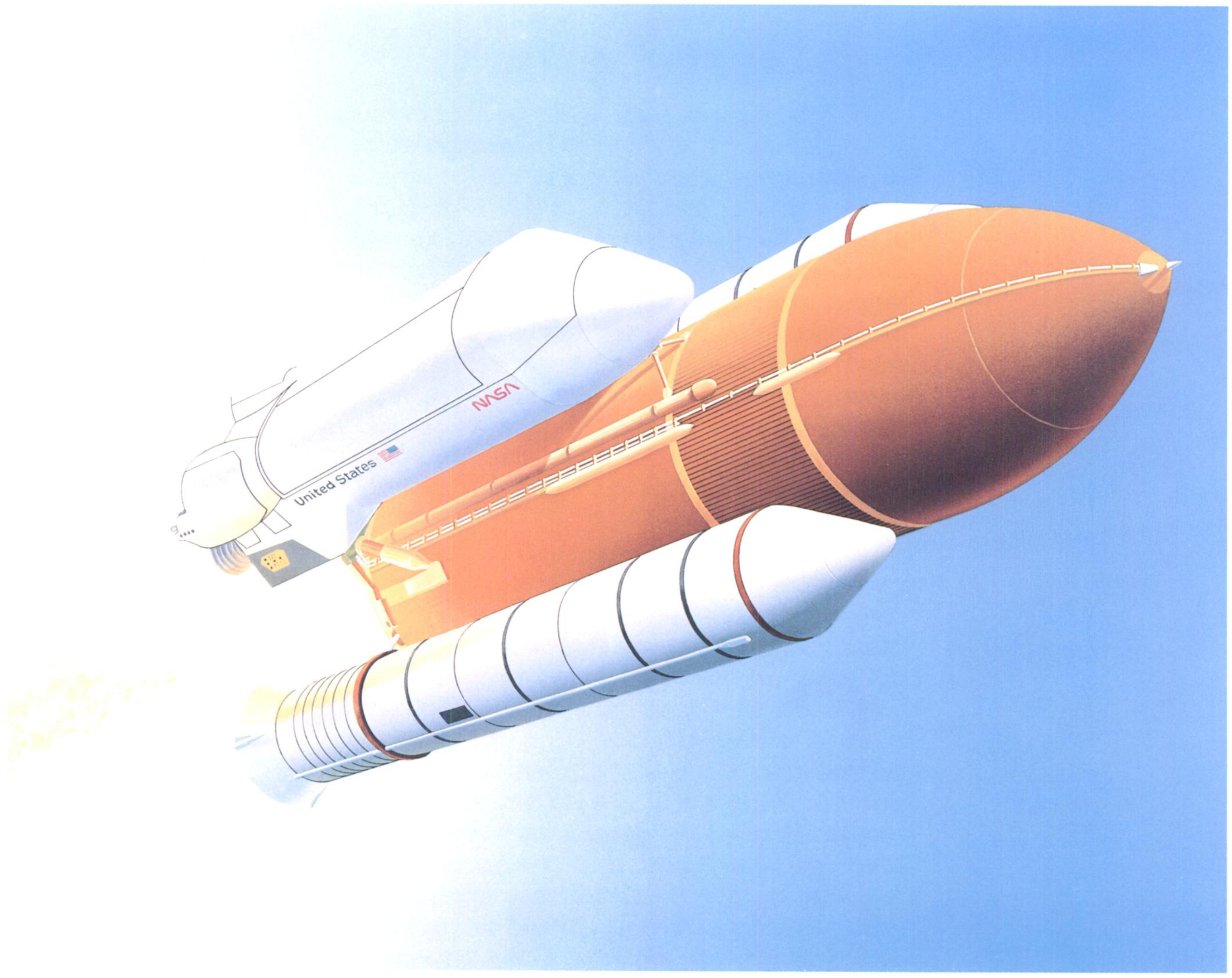


# TOMORROW'S LAUNCH VEHICLES

The U.S. expendable launch vehicle industry is developing advanced versions of current expendable vehicles. Most noteworthy are the Titan 4, Atlas 2 and Delta 2 vehicles of Martin Marietta, General Dynamics, and McDonnell Douglas, respectively. They reflect not only new requirements but the inevitable tendency in aerospace to upgrade performance through steady improvement. These new vehicles will ensure a competitive expendable launch vehicle fleet in the early 1990's, although the competition is clearly intent upon reducing the United States' market share of the launch business.

Despite the relative strength of the U.S. expendable launch fleet, there is cause for concern. Space transportation is an expensive proposition, and the vehicles we now have or are designing cannot lift the heavy payloads we will have in the next century. Reducing the cost of access to orbit is essential. So is increasing the performance of the next generation of launch vehicles. What is required are new technologies and, in effect, an advanced launch system. We need new launch vehicles that carry more and cost less. High performance, simple systems, large payload volume and robust and resilient design margins are required. Manufacturing and operational characteristics that emphasize automation, simplicity and reliability are also required.

NASA and the Air Force have a joint program to develop such an advanced launch system. It focuses upon technology and an end-to-end manufacturing system necessary to sustain an efficient production capability. The joint program has gotten off to a strong start. The advanced launch system is a research activity which will lead to a development effort. I believe it will result in a new family of launch vehicles that will carry us into the twenty-first century. It is an essential national investment.






**Utilizing Shuttle hardware and experience, NASA could develop an unmanned version of the Space Shuttle that substitutes a large cargo carrier for the manned orbiter. Shuttle-C, as this concept is termed, is an attractive option providing an interim heavy lift capability at reduced expense. Shuttle-C is currently being defined by NASA and U.S. industry. Companies involved include McDonnell Douglas Astronautics, Rockwell International, and Martin Marietta which provided this illustration.**

One heavy lift launch vehicle we might develop would be based upon the Space Shuttle. Utilizing Shuttle hardware, and experience, NASA could develop an unmanned version that substitutes a large cargo carrier for the manned orbiter. Shuttle-C (C for Cargo), as this concept is termed, is an attractive option. It would provide an interim heavy lift capability without the expense of building an entirely new system. It would take advantage of Shuttle technology, hardware, and flight experience. The Shuttle-C concept is illustrated above. NASA has conducted preliminary analysis establishing the feasibility of Shuttle-C. It would be a sound investment.

## SHUTTLE RECOVERY AND IMPROVEMENT

The time when the Space Shuttle did not fly was time well spent by NASA. When we look back at 1986-1988, we will see it as a time when NASA and the country took an unwanted, but necessary, breather in the space program. During this time, we took a hard look at ourselves and at what we hoped to accomplish in space. What we saw was solid. Some things needed changing and changes were made. It was a time of introspection, not without pain, but mostly it was a time when we recharted our course and rededicated ourselves to space exploration. The shock and grief of Challenger never affected our determination to rebuild and fly again.

Policy issues were reexamined and, from the debate, a new space policy emerged. Requirements for launch vehicles were analyzed, and the concept of a mixed fleet was adopted. From this concept will come expendable launch vehicles for today and an advanced launch system for tomorrow. The role of the Space Shuttle was looked at too. The result was a recommitment to manned space flight, declared not just by words but by the decision to build a replacement orbiter. The Shuttle fleet will be brought back up to four. In 1991, a new orbiter will join Columbia, Discovery, and Atlantis.

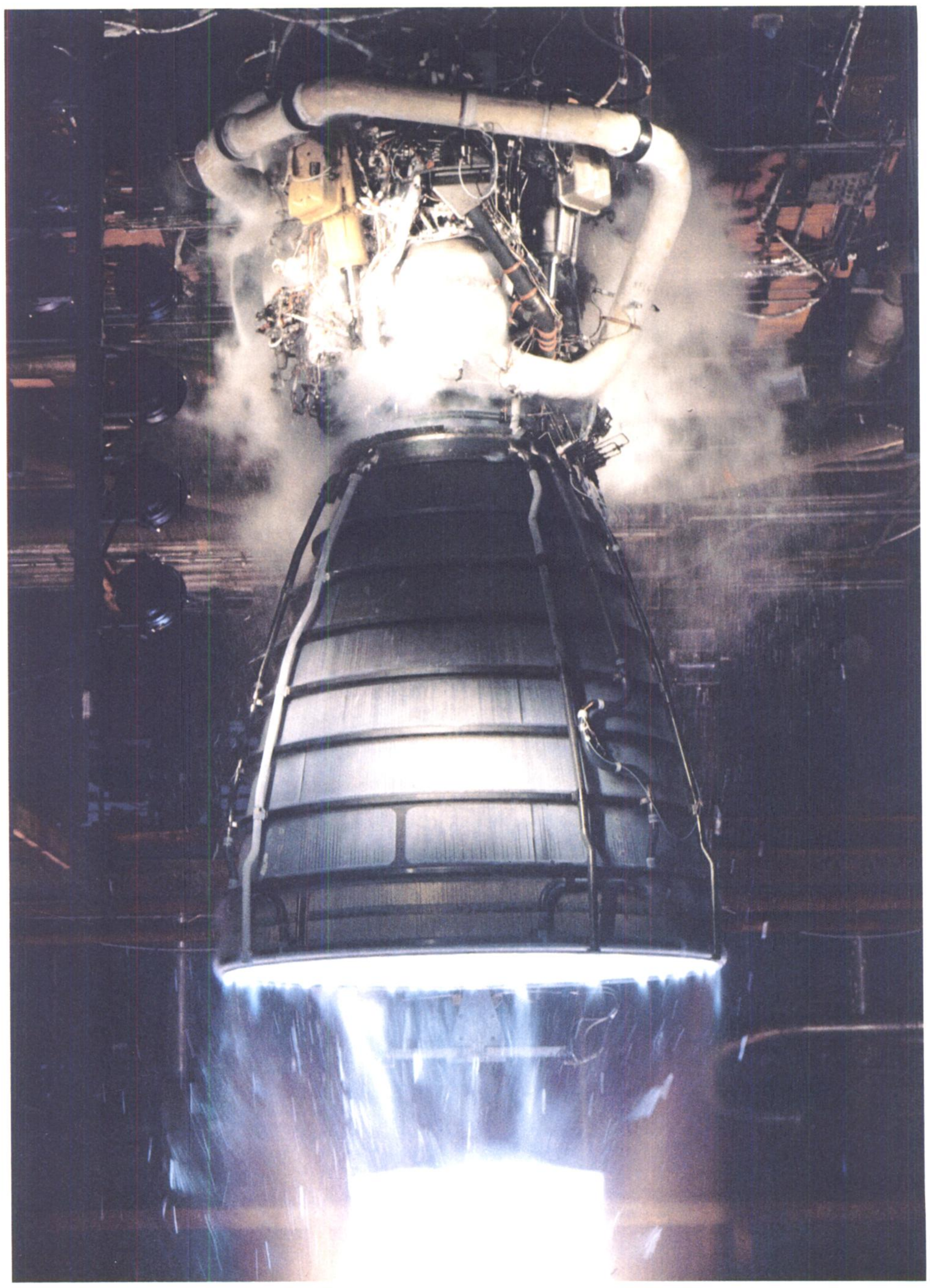
The Shuttle system itself was thoroughly reexamined. A Failure Mode Effects Analysis, Hazard Analysis, and Criticality Review were performed on virtually every aspect of the program, extending to both ground and flight operations. The certification process for each item of hardware was examined in detail. Attention was devoted to areas that directly influence flight safety and mission success. An audit panel appointed by the National Research Council (NRC) verified the adequacy of the review effort. The NASA committees in the Senate and the House of Representatives conducted oversight hearings to monitor the effort. The review resulted in many redesigns that improved the Space Shuttle system. The process was scrutinized at each step of design and testing by the NRC, which reported its findings to Congress and to the Administrator.

Solid Rocket Booster (SRB) field joints, case-to-nozzle joints, and nozzle assemblies were redesigned and verified in extensive testing which included five full-scale motor firings. The redesigned joints performed flawlessly—so well, in fact, that deliberate flaws had to be introduced into test articles to assess their redundant characteristics. The Space Shuttle Main Engines (SSME) underwent more testing since the Challenger accident than than they did prior to the first Shuttle flight. One engine underwent testing to the equivalent of 80 flights. The design limit is 10 flights. Improvements were made to valves, plumbing, and engine subsystems. New inspection techniques were developed to detect flaws in welds and structural integrity. Such scrutiny was not restricted to hardware.

Management issues received comparable attention. The launch decision making process was reviewed and improvements were made in training, definition of responsibilities, and communications. Safety issues received renewed emphasis, and an Associate Administrator for Safety, Reliability, Maintainability and Quality Assurance was established. The Space Shuttle office was extensively restructured. The "lead center" concept—under which particular field centers exercised control over certain programs—was abolished, and in its place a strong central authority was created at the Headquarters level. A safety reporting program was established, modeled after a system used by the Federal Aviation Agency.



Concurrent with the recovery program, NASA continued to look at ways to improve the Shuttle's overall performance. A good flying machine is one that lends itself to incremental improvements over time. The Shuttle is such a machine. Two such improvements are under way. One deals with reaching space, the other with time on orbit. The first change is to the booster rocket. A new Advanced Solid Rocket Motor (ASRM) will be built to replace the booster we are now using. Safer and more reliable, the ASRM also will enhance performance. ASRM is scheduled to fly in 1994. The second improvement is called the Extended Duration Orbiter (EDO). Not a new vehicle, but rather a kit to be carried in the Shuttle's payload bay, the EDO will enable the orbiter to remain in space for longer periods of time. Carrying the necessary consumables, it will extend the astronaut's stay from 8 days in space to approximately 16 days. More time on orbit will enable men and women to better utilize the Shuttle as a platform for science, commerce, and technology. While no substitute for a permanently manned presence in space, the EDO is an important, interim step.



The Space Shuttle Main Engine (SSME). The world's most advanced liquid rocket engine, the SSME is reusable and delivers more thrust per pound than any engine in the world. Three such engines are part of the Shuttle system along with two Solid Rocket Boosters. Together, the three SSME's develop 37 million horsepower.

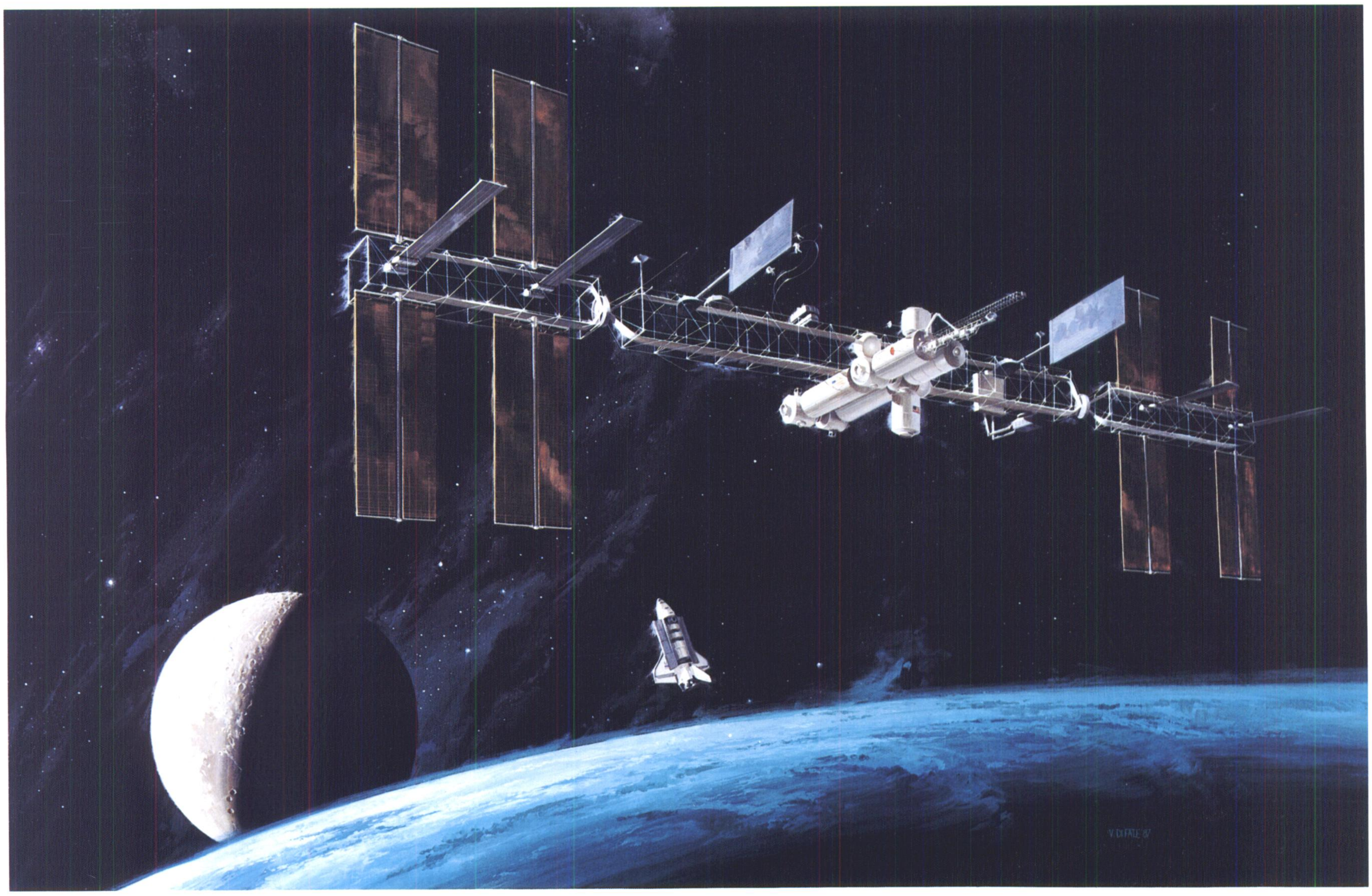
# A NEW SHUTTLE FOR THE NEW CENTURY

The Space Shuttle will fly into the next century. The first orbiter, Columbia, first flew in 1981. I have no doubt it will still be flying in the year 2005. As we build up to a steady flight rate of 12-14 Shuttle flights a year, these remarkable vehicles will be hauling payloads and people into and back from orbit. Complemented by expendable launch vehicles, they will remain the backbone of our space transportation system.

Yet it is not too soon to begin thinking about what vehicle will follow our present Space Shuttle. Though durable, Columbia, Discovery, Atlantis, and the replacement orbiter will not fly forever. A few years into the twenty-first century, we should be building the first of the new reusable, man-rated spacecraft.

The next century may seem far away. It's not. Moreover, concept definition and preliminary design of the new craft will take 3-4 years; technology development will require more. Actually building the vehicle will take 4-5 years, and test and checkout will add another year or two. Like any major space flight development effort, the program will need about 10 years. So it is appropriate for us now to start considering what the new Shuttle should be like. Once the development cycle of the Space Station is behind us, in the early 1990's, NASA will be in a position to initiate the effort.

It is imperative that by the year 2005 or 2010, the United States has the new Shuttle operational. In the new century, space will continue to be a place for the advancement of science, the conduct of business and the development of technology. The practical benefits of space will increase, as will our everyday dependency upon spacecraft. Human exploration will continue too. The imperative to explore will place men and women in space. If not Americans, then the Russians, the Europeans, or the Japanese will push the space frontiers of adventure and knowledge. The new Space Shuttle will ensure that the United States will continue to lead the way.



**With the Space Station, the United States will establish a permanently manned presence in space. No longer will we visit space, we will be there. An orbiting laboratory for science, technology and commerce, the Space Station will become operational in the mid-1990's and assure for the United States a position of leadership. The Space Shuttle will carry Station elements into orbit, help assemble the Station and then with five flights a year sustain Space Station operations. Unmanned lauch vehicles will probably complement the Shuttle in providing operational support.**

## WE CAN BE WHAT WE WANT TO BE

The space program of the United States is extraordinary. Technologically superb, intellectually rewarding, rich in heritage, witness to tragedy yet filled with triumph, the space program is a reflection of our country at its best. It is a success story of which we all can all be proud.

Today, our space program is at a crossroads. The Challenger loss is behind us and the Space Shuttle is returning to flight.

So we must now decide what our future in space will be. 1988 and 1989, and perhaps a year or two beyond, will set the course of NASA and America's space program for the next two decades. We have the technology and the experience to be the best. We must decide if the twenty-first century will see the United States as the preeminent spacefaring nation or simply one of several nations in space. We have the capability to be what we want to be. We can lead as we have done in the past, or we can simply remain a principal player. The choice is ours.

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