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Space shuttle commemoration

America's Space Shuttle Program began long before the first launch, April 12, 1981. For ATK, it began in 1974, when the company – then Thiokol – won the contract to build the solid rocket motors for the space shuttle. The contract was for 21 four-segment motors—six flight sets and nine test motors—through 1986. By 1977 we conducted our first static test of the powerful new motor. Seven years of design, development and testing culminated in an unprecedented event—the first space shuttle launch, STS-1, flown by John Young and Bob Crippen. The shuttle's first flight was hailed immediately as a success. It was the first vehicle to go into orbit and return to Earth as an airplane.

Since 1981, the shuttle has flown 135 times with two of ATK's solid rocket boosters powering every single mission. Along with the rocket motor technology, ATK has supplied the titanium hydrazine propellant tanks for the space shuttle auxiliary power units (APU). Three APU tanks house the hydrazine fuel that generates power for the shuttle's hydraulic system. These tanks have provided flawless performance during the shuttle's three decades of operations. Employees at ATK's Beltsville, Maryland, facility have also worked on the Space Shuttle Program, providing a variety of tools used on shuttle missions. For example, ATK provided the crew aids and tools for the STS-125 space shuttle mission to service the Hubble Space Telescope, as well as tools for robotically refueling satellites in orbit, which flew on STS-135.

Countless men and women have dedicated their lives—some have even given their lives—for this magnificent program and the benefits it has brought to the world. This special edition of *Aerospace News* will provide a glimpse into the benefits realized and the tremendous efforts and pride invested in the Space Shuttle Program.

In this issue

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Space Shuttle Program – early beginnings for ATK

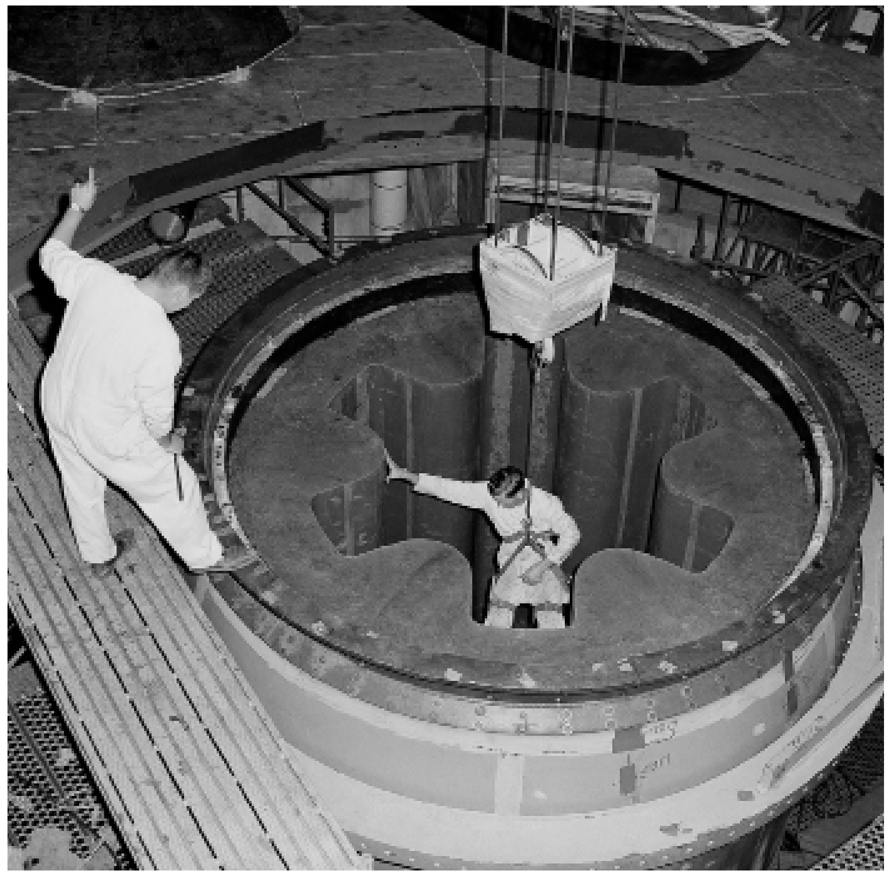
The complex space shuttle design was comprised of four components: the external tank, two solid rocket boosters (SRB), and the orbiter vehicle. Six orbiters were used during the life of the program. In order of introduction into the fleet, they were: *Enterprise* (a test vehicle), *Columbia*, *Challenger*, *Discovery*, *Atlantis* and *Endeavour*. The space shuttle had the unique ability to launch into orbit, perform on-orbit tasks, return to earth and land on a runway. It was an orbiting laboratory, International Space Station crew delivery and supply replenisher, satellite launcher and payload delivery vehicle, all in one.

Except for the external tank, all components of the space shuttle were designed to be reusable for many flights.

ATK's reusable solid rocket motors (RSRM) were designed to be flown, recovered, and the metal components reused 20 times. Following each space shuttle launch, the SRBs would parachute into the ocean and be recovered by the *Liberty Star* and *Freedom Star* recovery ships. The recovered boosters would then be received at the Cape Canaveral Air Force Station Hangar AF facility for disassembly and engineering post-flight evaluation. At Hangar AF, the RSRM field joints were demated and the segments prepared to be returned to Utah by railcar. The segments were then shipped to ATK's facilities in Clearfield for additional evaluation prior to washout, disassembly and refurbishment. Later the refurbished metal components would be transported to ATK's Promontory facilities to begin a new cycle.

ATK's RSRMs were manufactured in Promontory, Utah. During the Space Shuttle Program, ATK supported NASA's Marshall Space Flight Center whose responsibility was for all propulsion elements on the program, including the main engines and solid rocket motors.

On launch day for the space shuttle, ATK's Launch Site Operations employees at Kennedy Space Center (KSC) provided lead engineering support for ground operations and NASA's chief engineer. It was ATK's responsibility to have a representative in Firing Room 2 at KSC in case of potential motor problems. However, the last time ATK was responsible for a space shuttle launch slip was 1989. During launch, engineers were also stationed in Promontory on teleconference with counterparts at KSC in the event their support was required.



A 156-inch motor was used in the development of the space shuttle solid rocket motor.

From left, NASA astronauts John Young and Bob Crippen and Thiokol president Tony Savoca address employees prior to STS-1, the space shuttle's first launch.

Employees work in the weld chamber for the assembly of the space shuttle auxiliary power unit (APU) hydrazine tank. The titanium hydrazine propellant tank is used on the space shuttle APU and is manufactured at ATK's Commerce, California, facility.

After six years of silence, the thunder of human space flight was heard on April 12, 1981. At just seconds past 7 a.m. *Columbia* carried astronauts John Young and Bob Crippen into an Earth orbital mission scheduled to last 54 hours, ending with an unpowered landing at Edwards Air Force Base in California. STS-1 was the first in a series of shuttle missions planned for the Space Transportation System. (NASA photo)

ATK's contributions to the space shuttle program were many

Since the inaugural flight of the space shuttle, ATK and NASA have constantly improved their techniques and processes to increase safety and mission reliability. The solid rocket boosters have undergone countless subscale material characterization tests that tie together complex analyses with hard data. They have also undergone 55 full-scale ground tests, including three successful five-segment static tests.

The solid rocket boosters have showcased ATK's commitment to quality and safety throughout the Space Shuttle Program, and the numerous upgrades and investments ATK and NASA have put into the boosters directly benefit future space exploration programs such as Liberty and the Heavy Lift Vehicle. ATK is preparing to ground test another full-scale development motor (DM-3) this year, as well as complete a 90-percent design review on the five-segment solid rocket motor.

Along with the rocket motor technology, ATK supplied the titanium hydrazine propellant tanks for the space shuttle auxiliary power unit (APU) manufactured at ATK's Commerce, California, facility. Three APU tanks house the hydrazine fuel that generates power for the shuttle's hydraulic system. These tanks have provided flawless performance during the shuttle's three decades of operations.

ATK's Beltsville, Maryland, facility has provided a variety of tools for space shuttle missions. On the final mission, STS-135, *Atlantis* carried the robotic refueling mission (RRM) module that demonstrated technology and tools necessary to refuel existing on-orbit satellites robotically. Under contract to NASA's Goddard Space Flight Center, ATK engineers designed and assisted in building and flight testing the tools that will allow robotic refueling of satellites, even those not designed to be serviced. The four unique RRM tools enabled the station's two-armed robotic system, Dextre, to demonstrate techniques necessary to service satellites. That includes cutting and manipulating protective blankets and wires, unscrewing caps and access valves, transfering fluid and leaving a new cap for future refueling activities. With RRM, NASA can begin the work of confirming the robotic satellite-servicing technologies needed for the development of future robotic servicing spacecraft, whether government or commercial. Robotic refueling has the potential to extend the life of a satellite and result in significant savings for satellite owners and operators.

The STS-1 space shuttle team celebrated a successful liftoff of *Columbia*. The STS-1 mission, known as a shuttle systems test flight, sought to demonstrate safe launch into orbit and safe return of the orbiter and crew and verify the combined performance of the entire shuttle vehicle—orbiter, solid rocket boosters and external tank. (NASA Photo)

The ATK-manufactured robotic refueling mission module that flew on the final space shuttle launch will be used on the International Space Station to service and refuel satellites robotically.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SPACE SHUTTLE 1981-2011
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Employees proud to be part of the space shuttle legacy

Several ATK employees provided their thoughts about how being part of the Space Shuttle Program has affected their lives. To many, it is not simply a program—it is the American dream, and they are honored to be part of it.

While just a few employees are listed here, they represent the feelings of many who work on the program.

For more thoughts from members of the space shuttle family, visit NASA's Marshall Space Flight Center's "What the Space Shuttle Has Meant to Me" website at: http://www.nasa.gov/centers/marshall/shuttle_station/shuttle_memories.html.

Jeff Cook

I began my career with Thiokol/ATK in July 1986 right after graduating from the University of Utah. We were in the middle of the redesign after the *Challenger* incident, and I was assigned to devise tests to see if we could make the new j-leg feature fail. It was an exciting time to work on the Space Shuttle Program.

As the first segments were sent to Florida we had problems with the bondline between the insulation and case. My brother had been hired into the same group as me, and he was supposed to deal with unbonds, but he was unavailable that day so I went to Florida. I had no idea the life changes that trip would make. I fell in love with the launch site.

In February of 1989 the site manager at KSC called to tell me he had a couple of positions open and wanted to know if I was interested. I accepted without hesitation.

Working at the launch site has been an incredible experience. I love working on all the different systems of the RSRM and learning about the other elements. I have seen over 100 space shuttle launches, and I never tire of them. I look forward to working on the future space launch vehicles ATK will provide.

Tim Hess

My impressionable years were influenced by the likes of Buck Rogers, Dick Tracey and Flash Gordon, and events such as Sputnik. I remember watching these programs on the black and white TV thinking this is "pie in the sky." The various NASA programs were Mercury, Gemini and Apollo, but this work was so far distant from Utah, it seemed almost science fiction.

Then Thiokol won the solid rocket motor contract from NASA.

The prime of my life was given to the Space Shuttle Program, and it has been a major part of my career. I was fortunate to have helped build the first test motors and flight set, ship the first flight set to KSC, receive them at KSC, stack the boosters for the *Columbia* flight, watch them launch into space, and perform the postflight investigation on them as they returned to Hanger AF and ship them back to Utah. This program was not science fiction to me anymore, but an awesome reality. The sight of the boosters thundering off the launch pad, carrying the space shuttle into space, was breathtaking.

It is so hard to see this program come to an end, with hardly a vision of what the next generation of flight will be. I hope that a vision and a plan will come to those making the decisions that will once again continue technology, unite Americans, generate the pride that the Space Shuttle Program has and also allow ATK to be a part of the future of space.

Dick Roth

I joined Thiokol as an associate scientist in the R&D Lab Nozzle Process group in the fall of 1974. In the 1976 timeframe I developed the proto-type manufacturing process for the first SRM nozzle plugs, which at that time were of a thin-wall, hemi-spherical geometry constructed from phenolic resin impregnated canvas cloth. Few people probably even remember this plug design since it was used only once in the SRM nozzles on STS-1. The motor ignition breakup characteristics of the material produced such unacceptably high and potentially damaging quantities of on-pad debris that the design was quickly replaced by the friendlier urethane foam configuration still in use today.

I joined the Nozzle Project Engineering group in 1984 and became a manager in June of 1987, about mid-way into the post-*Challenger* redesign effort. The *Challenger* disaster had been an emotionally devastating experience for everyone in the shuttle family, and a life-changing experience for those closest to the problem. I'll never forget the sheer magnitude and intensity of problem solving, redesign and test efforts that occurred from January 1986 through return to flight in the fall of 1988. The learning curve was extraordinarily steep. I found myself right in the middle of all the redesign issues related to the nozzle system—without a doubt some of the most exciting and satisfying times of my career.

Hilda Poole

I started my career at Thiokol working on the space shuttle solid rocket motor (SRM) in late 1976, holding positions in Engineering, Production Control and Program Management. The first thing that comes to mind is how archaic our systems were back then. Engineering documents were typed and drawings were hand drawn, yet we still managed to produce hardware successfully. My first major responsibility was preparing and maintaining all of the SRM engineering bills of materials and procurement data lists.

I remember how exciting it was to watch the first SRM demonstration motor. I have witnessed almost all of the shuttle static test motors since that day, and they have all been just as amazing to watch as the first one.

With the *Challenger* accident in 1986, it was a very emotional time for everyone involved with the program. From adversity, lessons were learned, and everyone involved became even more committed on a personal and professional level. Failure was not an option.

The highlight of my career was when I had the honor to participate in the *Columbia* recovery effort in Palestine, Texas, in 2003. The commitment, hard work, camaraderie, heartfelt concern and desire to do everything possible to support that effort for the sake of the astronauts' families will forever be imbedded in my mind. Remembering that experience still gives me goose bumps even to this very day. I feel very proud to have worked on such a great and successful program.

Space Shuttle Program produces tremendous benefits world-wide

It comes as no surprise to those involved in human spaceflight that there have been innumerable benefits brought to the world by virtue of the Space Shuttle Program. The benefits realized because of the shuttle program improve the quality of our lives on Earth—every single day. Technology needed for spaceflight has "spun off" into improvements for every aspect of human life. The return on investment of these spinoffs is immeasurable.

Gathered from www.nasa.gov, a sampling of these benefits follow:

Medical

- Artifical limbs
- Automatic insulin pumps
- Automated urinalysis
- Blood collection
- Breast biopsy system and cancer diagnosis imaging
- Clean room apparel
- Cochlear implant
- Cool suits
- Corneal refractive therapy
- Dental waterline purification cartridge
- Diamond coatings (artificial hip joints)
- ER infrared ear thermometer
- Eye surgery
- Gait analysis system
- Heart rate monitors
- Heart pumps
- Implantable heart aids, pumps and programmable pacemakers
- Invisible braces
- Laser angioplasty
- Laser technology
- Light emitting diodes
- Medical gas analyzer
- Memory metals (eyewear)
- Precision dialysis pumps and filters
- Portable X-Ray device
- Programmable remapper
- Surgical Robotic arm
- Thermal video imaging
- Ultrasound skin damage assessment
- Ventricular assist device
- Vision trainer
- Vision screening system
- Voice controlled wheelchair

Transportation

- Advanced lubricants
- Airbags
- Aluminum-silicone alloys
- Boat hull riblets
- Car chassis and brake systems
- Cleaner burning cars
- Corrosion-resistant coating
- Crash analysis
- Electro-expulsive aircraft de-icer
- Fabric structures
- Flexible circuits
- High-pressure water-stripping
- Imperfection detection systems
- Improved radial tires
- Induction heating systems
- Metallized materials
- Pressure measurement systems
- Quality control system
- Runway safety grooving
- Standard thermal simulations
- Stirling engine
- Structural analysis
- Vehicle controller for the disabled

Household

- Audio equipment
- Environmentally-safe sewage treatment
- Environmental cleansing
- Enriched baby food
- Freeze dried technology
- Ingestible toothpaste
- Insulated paint
- Portable cordless vacuums
- Temper foam
- Water purification
- Wireless headset

All of the above-listed commercially available systems, processes or services incorporate NASA technology or technical assistance. And that is just a small representation of the many ways humans have benefitted—and continue to benefit—from America's space program.

Timeline of SRM/RSRM Program Events

1974 *Thiokol wins the contract to build the solid rocket booster (SRB) for the space shuttle. The contract was for 21 motors – six flight sets and nine test motors – through 1986*
1977 *The first static test of a space shuttle solid rocket motor, DM-1, is conducted*
1978 *NASA extends contract through 1988 to include 18 additional motors for nine space shuttle flights*
1979 *Thiokol conducts DM-4, QM-1 and QM-2 static tests in one year*
1980 *QM-3, the final motor test before qualification, is completed*
1981 *Launch of STS-1 flown by John Young and Bob Crippen*
1982 *NASA adds six motors to the contract*
1983 *NASA awards the Buy 2 contract to (Morton) Thiokol for 60 additional motors – 23 flight sets and 14 test motors Contract is extended until 1995*
1986 *Challenger accident*
1988 *Return to flight with STS-26 and the Redesigned Solid Rocket Motor*
1988 *Nozzle bonding and assembly building, M-113A, and new X-ray facility, M-197, brought online*
1990 *Space Operations forms work centers to co-locate expertise and resources*
1991 *The Buy 3 contract is awarded for 142 motors – 67 flight sets and eight test motors – extending the period to 2000 Thiokol wins the prestigious George M. Low Trophy for Excellence*
1992 *The new Final Assembly building, M-397, is brought online*
1994 *Propellant premix facility comes online*
1995 *Electronic shop instruction implemented at Space Operations*
1998 *NASA awards the Buy 4 contract for 77 additional motors, extending the contract through 2010*
1999 *The company wins the Low Trophy for a second time*
2000 *The 100th set of flight motors flies on STS-92*
2003 *Columbia accident upon return to Earth from mission STS-117*
2003 *ATK tests the first five-segment solid rocket motor, ETM-3*
2005 *The company wins the Low Trophy for an unprecedented third time*
2009 *The 100th set of reusable solid rocket motors flies on STS-119*
2010 *ATK performs the final ground test of a reusable solid rocket motor*
2011 *Launch of STS-135 marks the end of the Space Shuttle program*

ATK moving forward post-shuttle

By Blake Larson

The end of the space shuttle program is a bittersweet moment for ATK employees and many others, but we are looking forward to the future and continuing on, leveraging the legacy of an incredible three decades. ATK salutes the amazing team that worked on the program. Many individuals have dedicated their entire careers to the shuttle; all of them have sacrificed to ensure the success of the shuttle program.

Recent news articles have discussed NASA's new heavy lift Space Launch System (SLS) that will use ATK's upgraded five-segment solid rocket booster. The company is excited to continue to build on the incredible legacy of the most reliable solid rocket motors in the world.

For the past 30 years, the nation has invested heavily in shuttle and, more recently, Constellation propulsion and hardware technology. By continually advancing this technology, motor performance has greatly increased. Building the SLS on this strong foundation minimizes lifecycle costs and shortens time to operational capability. SLS provides the heavy lift capability needed to send crew to any destinations beyond low-Earth orbit (LEO).

Missions beyond LEO will require mass to LEO many times the weight of the International Space Station for a single mission. This would require tens of Delta IV Heavies or Falcon 9 Heavies. It would be difficult to launch that many missions within the necessary mission window, and mission success probability would be very low with that many launches.

Our country needs to get started with SLS to ensure we can have missions beyond LEO in the foreseeable future and to keep from losing the technical capabilities of people and infrastructure that have been developed over the past 30-plus years.

Given physics, the best launch system incorporates both solids and liquids. The most efficient and economical crew launch vehicle configuration is a two-stage rocket with a powerful first stage that has the high thrust required to get off the ground, combined with a liquid upper stage that inherently operates efficiently in higher altitudes to most economically put the payload into orbit. With few exceptions, heavy lift launch vehicles use liquid cores with solid strap-on boosters, where the boosters provide the power to counteract gravity and drag losses while the liquid core stage provides thrust to deliver the payload to orbit. These vehicles include Titan, Ariane, the space shuttle and Japan's H-II.

While continuing to safely fly the space shuttle, ATK has furthered the development of its upgraded five-segment solid rocket motor. Both the ground test of the third full-scale development motor (DM-3) and a 90 percent design review of the five-segment motor will be completed this year. DM-3 is scheduled for September.

Another big opportunity for ATK is the Liberty launch vehicle. NASA's Participant Evaluation Panel noted that Liberty met or exceeded all goals and objectives on both business and technical ratings during the CCDev 2 competition. While NASA did not select a launch vehicle for CCDev2, they did give Liberty a high probability of success and indicated Liberty's proposal was the best among launch vehicles evaluated. ATK continues to work on Liberty in cooperation with its partners, working toward the preliminary design review scheduled for August.

It is extremely important that we continue to explore our solar system and venture to destinations beyond Earth's orbit. The return on the investment in human spaceflight has been tremendous. It has improved the economy and the quality of life for people across the globe. Exploration is a major contributor to why the U.S. is so great. The westward expansion beyond the Appalachians, the Louisiana Purchase, the efforts of Lewis and Clark, the Alaska purchase, building the transcontinental railroad, the Wright Brothers, the Apollo program and so on, demonstrate how our country has achieved benefits far beyond those originally envisioned. ATK will continue to help our country do so.

The third five segment development motor (DM-3), is shown in the T-97 test bay.

Ares I-X successfully flew in October 2009.

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Kay Anderson, 435.863.3085
kay.anderson@atk.com

Jennifer Bowman, 435.863.4809
jennifer.bowman@atk.com