

Shuttle to Orion: First steps back to orbit

The day of your first spaceflight, experiences come tumbling at you with ever-increasing pace and intensity. One of the most memorable is riding the elevator up the gantry to your own spaceship. That first leg skyward, no matter how many times you've ascended to the White Room, alerts every fiber of your being. As I ascended Launch Pad 39A for my first launch, not even John Young or Bob Crippen on STS-1 could have been charged with more adrenaline.

Riding up Pad 39A's gantry, I recalled its spectacular history. Apollo 11 and seven other missions to the Moon had departed Earth from this very site. I was following in some very big footsteps. But the thrill of riding the same elevator that had carried Neil Armstrong, Buzz Aldrin, and Mike Collins quickly succumbed to facts: The old Apollo 11 launch umbilical tower and elevator had been struck down from each of the Kennedy Space Center's mobile launch platforms (MLPs). Pieces of the old towers were rusting on a back lot behind the Operations and Checkout (O&C) building a few miles south. No, my elevator was taking me up Pad 39A's fixed service structure, an amalgam of old and new steel built in the late 1970s to support space shuttle operations.

Okay, so it wasn't Apollo 11's elevator. But it was the same pad, the same predawn morning breeze, the same lofty view of the cape. And it was my rocket. What it was was damn exciting!

Today, NASA uses Launch Pad 39A to dispatch its remaining three shuttles to the ISS. The next launch, STS-120, is due later this month, with Atlantis taking the critical Node 2 docking module to the station, enabling the installation of laboratory modules from Europe and Japan.

Since August's STS-118 mission sustained worrisome tile damage near Endeavour's right main landing gear door

from external tank foam impact, NASA has wrestled with another round of possible fixes. X-rays revealed cracks in foam insulation covering liquid oxygen feedline brackets, the source of the debris; a proposed fix would eliminate a denser cork layer there and reapply lightweight foam.

The options for modifying the foam applied to a liquid oxygen feedline bracket, the source of the debris, have been considered. Engineers may also shorten the time that the fully fueled, chilled external tank sits on the pad during launch count, vulnerable to ice and frost growth that could liberate foam during ascent. Shuttle managers are optimistic that repairs would not delay this month's upcoming launch.

Even if this foam fix works, NASA will soon end shuttle operations at Pads 39A and 39B. The space shuttle will exit its Florida stage in less than three years. More than a quarter century of space shuttle drama and history have played out on these two pads since they were rebuilt after Apollo's heyday, but soon they must metamorphose again.

NASA will recreate these launch pads for their original mission: launching astronauts to the Moon.

Constellation planning

In designing NASA's next generation of rockets, Constellation managers will leverage three decades of shuttle experience to achieve safety, reliability, and re-



The Ares I-X flight vehicle towers above the shuttle facilities on Pad 39B in April 2009. The pad's shuttle service structures are still in place, and the Ares vehicle uses the shuttle's mobile launch platform.

duced operations costs. The shuttle's components—the external tank and solid rocket boosters—are proven technologies that currently enable the system to orbit 100 metric tons on each mission. Those well-understood elements (reconfigured to preclude the shuttle's chronic insulation loss and debris problems) will roll forward into the Ares family of boosters.

The Ares I is the next-generation lifter for U.S. astronauts. Its two stages will carry the crew exploration vehicle, Orion, into low Earth orbit, first to the ISS. On lunar missions, Ares I will carry Orion to a rendezvous with a separately launched Earth departure stage, which will then rocket the combined Orion crew module and lunar lander to the Moon.

Ares V, still in very early development, will build on Ares I flight heritage to achieve the heavy cargo-lifting capacity needed for lunar missions. Using a core stage derived from the shuttle's external tank and two strap-on solid rocket boosters (derived from the Ares I first stage), Ares V will inject the fully fueled Earth departure stage and Orion lunar lander into LEO. At more than 360 ft, Ares V will rival the stature of Apollo's Saturn V.

Although a "clean sheet" design might have produced a more economical or higher performance system for long-term use, NASA argues that limited development funding and the political realities of transitioning the shuttle workforce drive the decision to use shuttle-derived components for Ares. This evolutionary approach will use 85% of the facilities already built or in use by the shuttle.

NASA is using shuttle components only where they make good performance or fiscal sense. Where necessary, the agency has rejected shuttle heritage, as in the choice of engines for the Ares I upper and the Ares V core stages; it selected the proven J-2 and RS-68 engines over the space shuttle main engine to realize lower development and operations costs.

This sequenced development, from shuttle to Ares I to Ares V, means that the Ares I investment is a direct down payment on the later production of the heavy-lift Ares V. In this respect, the Ares



NASA has an ambitious flight test program ahead to prove the components of its Ares I launcher. (Courtesy ATK.)

sequence is reminiscent of the Saturn family, which progressed from Saturn I to IB to Saturn V, each rocket incorporating elements of the previous model even as performance and size jumped significantly.

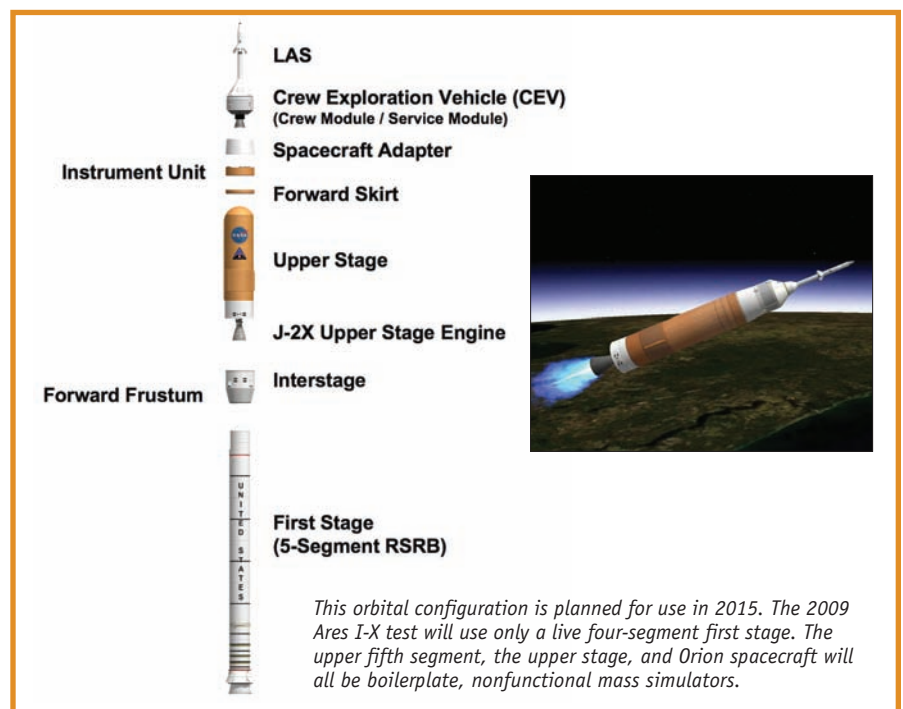
Transition

In early 1977, I visited Kennedy Space Center as an Air Force Academy cadet and astronautics student. The cape was quiet. Apollo-Soyuz had flown 18 months earlier to end the Moon race era; the shuttle was still four long years away. Apollo-

Saturn launch umbilical towers gathered rust outdoors; a Saturn IB pedestal stood silent in the Vehicle Assembly Building (VAB), awaiting demolition. The twin pads at Launch Complex 39 were already being modified for shuttle service, with a permanent service structure rising alongside each firebrick-lined flame trench. Apollo's glory days were receding rapidly, but the first shuttle, Enterprise, had not yet ridden aloft on its 747 carrier.

Something of that same anticipatory mood is in the air now at Kennedy, even as launch teams ready the three orbiters for the remaining ISS missions.

The Constellation program had hoped to have Pad 39B (host to Apollo 10 and my third mission, STS-80, among many others) released from shuttle service by now and undergoing modification for Ares test flights. But Atlantis' planned Hubble servicing mission in September 2008 will require a shuttle standing by on 39B for a possible rescue. The launch-on-need mission prevents Constellation from doing anything to the pad that precludes shuttle use. In the interim, Kennedy engi-



neers will do preliminary work for Ares until the rescue shuttle, cleared from that role, rolls back from Pad 39B, into the VAB for processing, and out to 39A for its ISS launch. Only a few modifications will be needed for the first Ares test launch, scheduled barely six months later, in April 2009.

Ares I-X

That first Ares flight test is Ares I-X, an unmanned demonstration of the new vehicle's first-stage flight performance and dynamics. Only a few umbilical arms will reach across from the existing shuttle fixed service structure to the slim, free-standing Ares stack, keeping pad changes to a minimum for this suborbital launch. The four-segment solid rocket first stage, transferred from the shuttle program, will lift off from hold-down posts over one of the two booster exhaust openings in the mobil launch platform.

Only the first stage of Ares I-X will be live; the uppermost fifth booster segment will be a mass simulator only, carrying no propellant. Both the upper stage and the Orion crew exploration vehicle will be inert, boilerplate articles, accurate in shape and mass but having no func-

tional capability. At liftoff, the stack will weigh about 2 million lb.

The I-X flight test will check out launch, flight control, stage separation, motor reentry, parachute deployment, and ocean recovery of the first stage, taller and heavier than the shuttle's solid rocket booster. Engineers hope to show the Ares I configuration has ample control and structural margins as it experiences maximum dynamic loads imposed in the lower atmosphere. Demonstrating adequate roll control on the single-nozzle solid rocket motor is a high priority to validate the Ares I design.

Kennedy ground operations

With the early milestone of Ares I-X complete, Constellation planners will shift rapidly toward the new ground operations concept for Ares and Orion. The most obvious changes will be to the launch pads. NASA examined several combinations of launch facilities to handle Ares I and Ares V, even considering modifying Pad 40, the old Air Force Titan complex, for the new systems. But the development and modification costs proved to be far more expensive than revamping launch complex 39. Ares I will use Pad

39B, and after shuttle, 39A will be dedicated to Ares V, an appropriately historic departure point for the new Moon rocket.

For Ares I use, Pad 39B will be stripped of its fixed and rotating space shuttle service structures. This "clean pad" will leave the immense concrete foundation and flame trench empty of any superstructure, save for a surrounding set of lightning protection masts that will be similar to those at Titan's Complex 40. A new mobile launch platform, to be carried atop the Apollo and shuttle crawler-transporter, will bear both a permanent service umbilical tower and the Ares I stack, a throwback to the Apollo-Saturn V configuration.

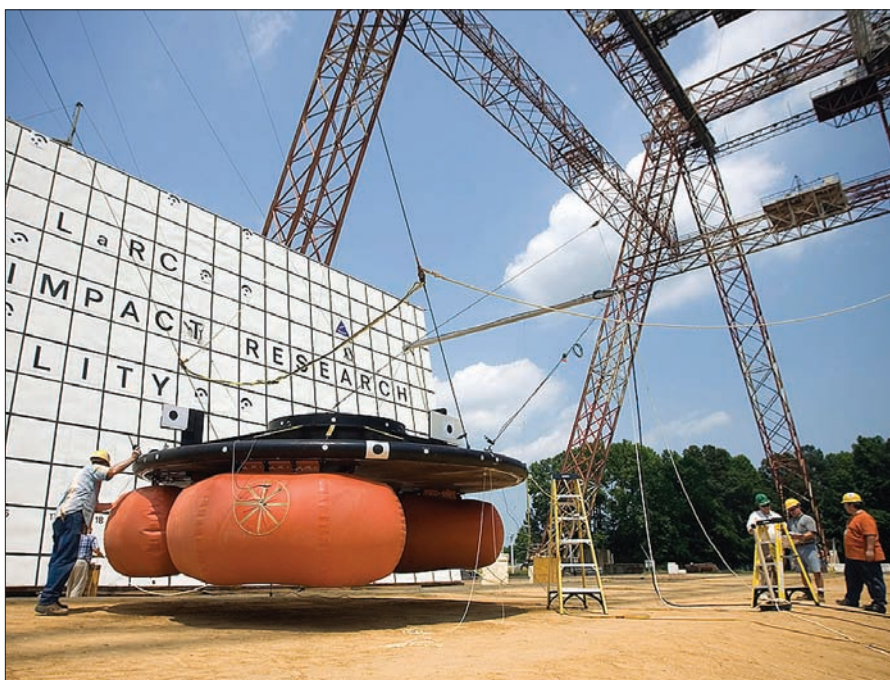
For astronauts, the new MLP and umbilical tower will add a thrilling new dimension to launch pad escape. Today, shuttle crews fleeing a launch pad emergency exit the orbiter through the White Room swing arm on the 195-ft level and move swiftly to a set of escape slide baskets. Up to three astronauts can ride in each cable-borne basket, which takes them on an eye-watering, 55-mph descent to a blast-resistant bunker a quarter mile away.

The old Apollo system was just as exciting. Crews took a high-speed elevator from the White Room to the base of the MLP, then slid down a teflon-lined chute deep into the concrete recesses of the pad. The hurtling astronauts were deposited into the so-called "rubber room," where they strapped into shock-mounted couches to ride out the overhead blast of a detonating Saturn and await rescue. The locked slide entrance remains on each pad surface today.

Plans for the new Ares pad dispense with the chutes and slide wires and incorporate instead a "tower of terror" drop sled that plummets crewmembers down the side of the umbilical tower, accelerates them through a 90-degree pullout, and shoots them on rails across the grass and sand to the blast bunker. Sign me up for that test program.

Stacking Ares

A complex choreography will bring the Ares components together at the cape. Lockheed Martin plans to perform final assembly of the Orion spacecraft in the O&C Building in the KSC industrial area (also home to astronaut crew quarters).



Engineers at NASA Langley's Landing and Impact Research Facility prepare for an airbag drop test of the Orion crew exploration vehicle. These tests, in parallel with abort and launch vehicle trials, are aimed at providing a robust crew escape and survival capability to the Ares design. (NASA/Sean Smith.)

The completed crew module will be checked out next door in the vacated Space Station Processing Facility (unused after ISS completion in 2010). Orion then moves to the VAB for stacking atop Ares.

The Ares first-stage, solid motor segments arrive via the cape's booster processing facilities, converted from shuttle use. As with shuttle, motor stacking takes place in the VAB. In the VAB high bay, the upper stage and Orion vehicle are lowered atop the first-stage motor. The mobile launcher drives beneath the stacking platform as the Ares/Orion undergoes integrated testing and final ordnance installation. The vehicle is now nearly launch-ready, much more so than a shuttle leaving the VAB.

A crawler-transporter carries the MLP and Ares stack to 39B. Once these are "hard down" at the pad, only ground power and servicing connections need be mated. Final propellant loading and ordnance arming take place during the countdown. The goal is to go from rollout to launch within one week.

NASA is planning Kennedy ground operations both to leverage the investment already made in shuttle and ISS facilities, and to ensure that Ares and Orion design and manufacturing plans will minimize ground operations costs. The agency also hopes to reduce manpower costs significantly compared to the existing shuttle launch flow. Given the 30-year operational life planned for Ares and Orion, the high priority given to ground operations planning is vital.

Ares testing

Administrator Mike Griffin has publicly lamented, most recently after STS-118 in August, the five-year gap in U.S. human spaceflight launches that will follow shuttle retirement. Griffin termed it "unseemly" for the world's premier spacefaring nation to deliberately forgo access to orbit for so long.

To minimize the gap, Constellation will have to move smartly through its flight test program. Pad tests of the Orion's launch abort system (LAS) are due to begin in autumn 2008, followed by the Ares I-X flight and more suborbital abort tests in 2010-2011. The LAS trials will all use boilerplate Orion capsules and small, cheap boosters analogous to the Apollo-era "Little Joe" rockets.

Production versions of the Ares/Orion stack begin flying in late 2012 with Ares I-Y, a high-altitude abort test. The unmanned Orion 1, the first orbital shakedown of the booster and spacecraft, was planned for the first half of 2013. Funding shortfalls resulting from the Congress' continuing freeze of NASA funding at FY06 levels will force delays. The first piloted Ares/Orion launch, Orion 2, will now slide into 2015. An Orion vehicle carrying astronauts to the ISS will not launch until the latter half of 2015 (or later, if NASA's budget line remains flat).

A lengthening gap

Robert Bigelow, CEO of Bigelow Aerospace, which has launched two inflatable Genesis modules to orbit, announced plans in August for flight-testing a three-person orbital spacecraft, Sundancer, in late 2010. Few believe that U.S. astronauts will be able to buy tickets to the ISS on Sundancer or a commercial competitor soon enough to bridge the shuttle-Orion gap, but we can hope.

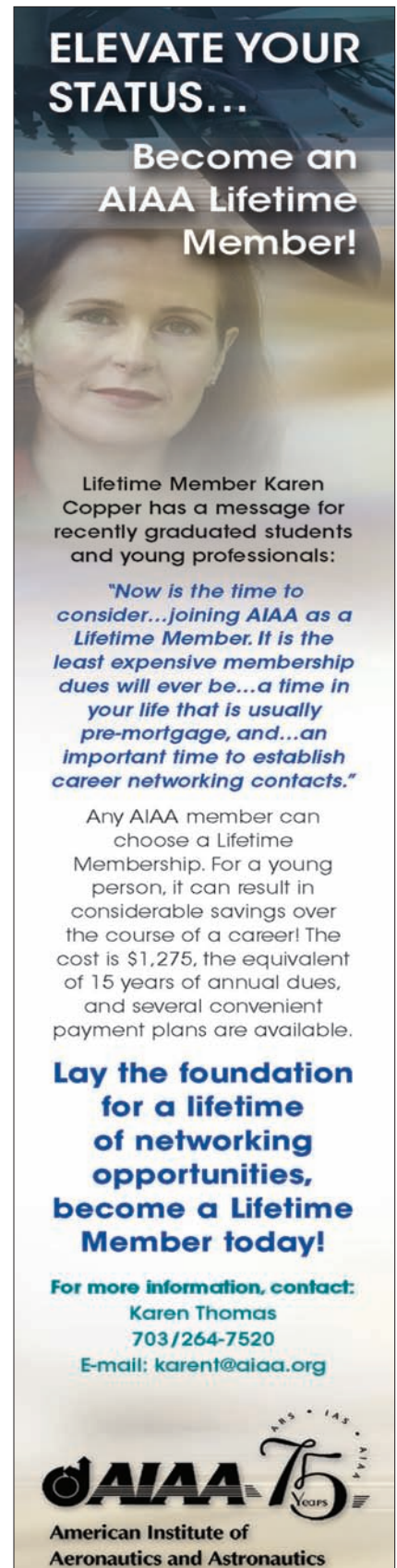
Russia's Soyuz and China's Shenzhou will no doubt be flying frequently during the gap, but Americans are unlikely to be aboard either. NASA currently has no authority to buy Soyuz services from Russia after 2011, even if it wanted to spend \$25 million and up per seat. The president and Congress will be able to look into the evening sky at a completed space station, funded and built mainly by U.S. taxpayers, which may host no American occupants for an extended, politically painful period.

For astronauts flying the versatile yet fragile shuttle, its looming retirement evokes mixed emotions. At last, chronic problems with external tank debris shedding and damaged heat shields will be a thing of the past. The new Orion should be immune to such worries, providing astronauts with a robust escape capability over its full flight regime.

Yet the end of the shuttle era will put the spaceflight ambitions of many on hold. Astronaut Story Musgrave, my crewmate on STS-80, waited 17 years for his first trip to orbit. For NASA, the wait for Orion will not be as lengthy, but it may be far more frustrating to endure.

Thomas D. Jones

skywalking@comcast.net
www.AstronautTomJones.com



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