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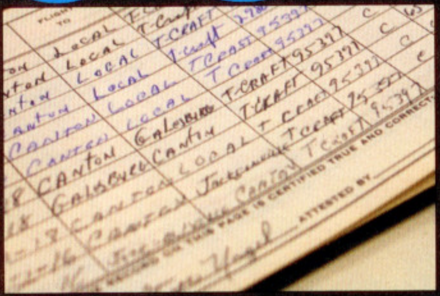

SPACE

The last space shuttle pilots take the basics with them **BY JASON PAUR**

"Houston, *Atlantis* is in the roll."

Space shuttle Commander Ken Ham announces that the orbiter, *Atlantis*, has just started its trademark maneuver, made during every space shuttle launch shortly after leaving the launch pad. And just a second later he utters the word that spells trouble for him and his crew for the next several minutes: "Helium."

PHOTOGRAPHY BY THE AUTHOR


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"Roger, roll," comes the call from mission control. "You have a go to work the helium leak on the right engine."

It's only been 18 seconds since liftoff. Everyone on the flight deck flips through the three-inch-thick emergency checklist used during the ascent stage.

Helium is critical to the main propulsion system on the orbiter. It's used to operate valves that control the flow of fuel and, perhaps more important, it is used as a seal to purge the area between the hot and cold sides of the turbine in the high-pressure oxidizer turbopump. Losing helium in the shuttle is analogous to losing oil in a piston engine. You might be OK for a little while, but if it can't be fixed you're eventually going to shut down an engine.

Like any multiengine aircraft, the shuttle has its limits in the event of an engine loss. If the crew loses one of the three main engines, they can still make it to orbit, although it might not be the orbit they initially planned. Lose a second engine early during the ascent and it's time to start looking for alternative landing sites.

Dominic "Tony" Antonelli is the pilot on the STS-132 crew. Sitting in right seat, one of his many, many jobs is to execute the workaround being developed to help the leaking engine. Soon the plan is relayed from mission control to share some helium from the center engine with the leaking right engine. As the workaround is started, another alarm goes off in the cockpit.

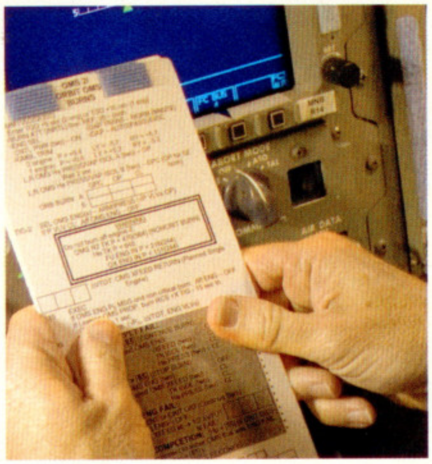
"Engine down!"

Ham sees that the left engine has shut down completely. *Atlantis* is now limping along on one and one-half engines. Granted, with 375,000 pounds of thrust apiece, it's a pretty strong limp, but the crew knows they're not making it to orbit.

"TAL pages, everybody," says Ham, referring to the transoceanic abort landing instructions.

The crew of STS-132 has nothing to worry about. They are lying on their backs inside the full-motion simulator, which is tilted back 90 degrees to replicate the feeling of launch. The simulator is located at the Johnson Space Center inside historic Building Five, where astronauts have trained for missions to space and the moon for decades. The four-person flight deck crew is going through its final ascent simulations before their mission to the International Space Station.

Immediately after the TAL instruction from Ham, Antonelli, along with mission specialists Garrett Reisman and Michael



An orbital maneuvering system checklist (above); Ken Ham, Garrett Reisman, Dominic Antonelli, and Michael Good outside the simulator (above right). Instructor pilot Steve Nagel (right); Antonelli works on the helium leak during launch simulation (below); overhead panel in the simulator (far right).

Good, flip through the massive ascent emergency checklist again and start preparing for a landing. *Atlantis* is on the border of being able to make a TAL site and with the loss of a second engine likely imminent, the team decides to follow the east coast.

"*Atlantis,* we're looking at site 16."

The team will be practicing some old-fashioned flying skills as they prepare to slow down from Mach 10 and shoot an approach into Otis Air National Guard Base in Massachusetts. And control tells Ham—whom everyone refers to by his Navy call sign, "Hock"—that it's going to be a challenge.

"Hock, we're a bit short on energy, might try closing the speed brake," control says. "Our preliminary result puts us about 20 miles short."

Winding down

After more than 30 years, NASA's space shuttle program will come to an end with the final mission of *Endeavor,* scheduled to launch in February 2011. The Space Transportation System flights began with STS-1 in April 1981. Since then, there have been 132 missions to space—the most recent being STS-132, the final scheduled mission of *Atlantis.* In addition to *Endeavor* in February, *Discovery* is scheduled for its final mission on November 1. Those two final flights will mark the end of U.S. manned spacecraft flights for the foreseeable future. There are no plans to replace the space shuttle with any kind of winged, piloted vehicle.

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For the astronauts, especially the commanders and pilots who fly the orbiter, the end of the program is the end of an era where actual stick-and-rudder piloting skills are as important as the massive systems management skills everybody must learn. Despite the fact that guidance computers and autopilots control most of the launch and reentry, like other professional pilots, the crews train to hand-fly almost the entire mission should the need arise.

"After 90 seconds [after liftoff], you're trained to fly all the way to orbit," says Ham. During a *nominal,* or normal, ascent everything is automated from the main engine start to main engine cutoff. But the crews train extensively on how to deal with just about every conceivable emergency that could occur during the mission. And this is especially true of ascent abort procedures.

Ham, like the entire flight deck crew, was preparing for his second mission to space. He's followed a long path that even he didn't dream of when he first soloed a Cessna 150 at Kupper Airport, now called Central Jersey Airport, just outside Manville, New Jersey. He got his pilot certificate at age 17.

Soon he became a midshipman at the U.S. Naval Academy. After graduating in the middle of the "*Top Gun* glut" in the

A converted Gulfstream II serves as the shuttle training aircraft (left); the STS-132 flight deck crew debriefs the simulation training crew after spending several hours in the full-motion simulator (above); inside the fixed-base shuttle simulator (right).

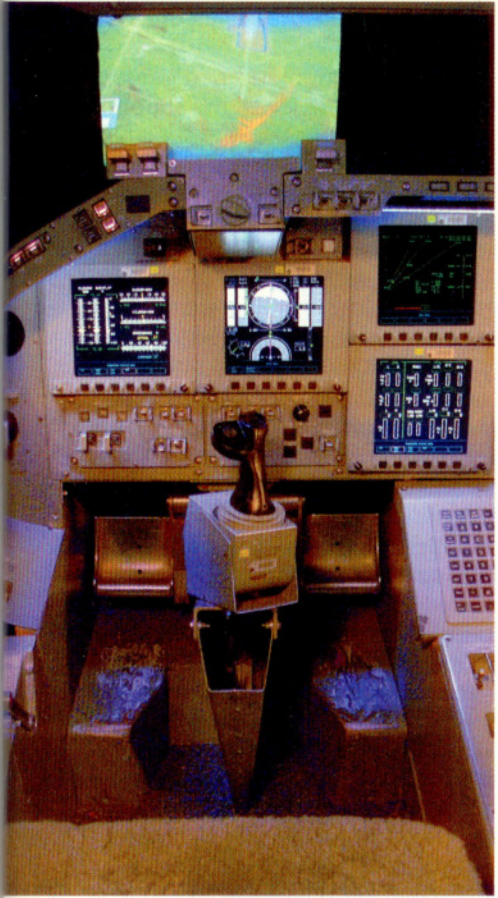
late 1980s, Ham eventually learned to fly F/A–18s and attended test pilot school as well as engineering graduate school. After what he calls a lot of luck and good timing, Ham was accepted to the astronaut corps on his second try in 1998. As with any new flying job, he attended a lot of ground school.

All of the NASA astronauts preparing for a mission must fly a certain amount of time each month in the Northrop T–38s. The twin-engine supersonic trainers are used by commanders and pilots to keep flying skills sharp. Mission specialists also fly in the T–38s as a way to gain situational awareness skills and to train on systems management and other attention-saturating tasks.

Reisman and Good also are pilots. Good is a former U.S. Air Force pilot who has logged more than 2,650 hours and Reisman is a CFI who learned to fly the civilian route attending graduate school at the California Institute of Technology.

"The most complicated thing I had flown before coming here was a Bonanza," Reisman says, laughing. "The first time I got to hop in the T–38 was unbelievably cool, because going from a Bonanza to a T–38, it's a big difference." These days Reisman is a partner in a Grumman Tiger. "That's different than flying in the T–38 and the shuttle," he says. "I'm PIC in the Tiger."

Mission specialists fly with either an instructor pilot, a commander, or pilot



astronaut during their T–38 training. Space shuttle commanders and pilots can fly PIC in the T–38s; they also undergo regular checkrides with the instructors.

Steve Nagel is a NASA instructor pilot at Ellington Field in Houston, a few miles north of the Johnson Space Center. "I soloed in a T-Craft, flew in the Air Force, four shuttle flights, and now an instructor in the T–38 and STA [shuttle training aircraft]," he says quickly.

Nagel's dad owned a Cub, which he sold when Nagel was 13. The Cub was traded for the Taylorcraft that Nagel soloed on his sixteenth birthday. He earned his private a year later and had more than 800 hours under his belt before joining the U.S. Air Force. From there he joined NASA as part of the first space shuttle astronaut class in 1978 and flew on the shuttle four times, twice as commander. Since leaving the active astronaut corps, he's logged more than 5,700 hours in the T–38.

But the main training aircraft used by shuttle commanders and pilots is the shuttle training aircraft or STA (see "Shuttle Training Aircraft," March 1997 *AOPA Pilot*). A highly modified Gulfstream II, the STA has been reconfigured with a replica of the space shuttle left seat with the small center stick and headsup display. On training flights, the instructor pilot flies the STA to about 35,000 feet, closes the throttles, and pushes three buttons on the panel that engage the simulation computer, the autopilot, and the autothrottles. Then the controls are turned over to the astronaut sitting in left seat. Now the once-analog Gulfstream II has become the fly-by-wire STA.

Astronauts practice about 10 approaches per flight. With the main landing gear and thrust reversers deployed, the once-slippery business jet can be pointed downhill for a 20-degree descent while maintaining the same airspeed as the orbiter during approach (270 to 300 KTAS during most of the approach, with touchdown at around 200). Although the STA doesn't actually touch down at these speeds, it simulates a landing with the main gear about 20 feet above the runway, which provides the same eye height in the cockpit as the orbiter. The whole approach from 35,000 feet takes about two and a half minutes.

"We can't simulate a lot of the system malfunctions the way the ground-based simulators can, but we do fly to real runways with a real visual scene out the front," says Nagel.

"The sight picture is a lot different," says Ham.

With the extremely good guidance displayed on the HUD, the simplified version of landing the shuttle is to just keep the flight path marker on the guidance diamond. That is, until the flare. "It's a pretty easy task for an experienced pilot to make a safe landing," says Ham, a one-time Bellanca Viking owner. "It's basically just like flying an ILS, just a different presentation that's going to take you on a 20-degree glideslope—which, as you can imagine, you almost have to put your hand on the glareshield to keep from falling forward."

There is one unusual thing about the shuttle's stick. It pivots roughly in the middle of the palm for pitch. This is so during launch it won't accidentally be pulled back while the commander and pilot are lying on their backs.

After the de-orbit burn slows the shuttle enough that it begins to fall back toward Earth, the guidance computer rolls the orbiter to help dump some of the energy and avoid skipping off the top of the atmosphere. "You roll in 90 [degrees], or maybe a little bit more," Ham says. "It's a forward slip, of sorts."

Saying "you'd be crazy" if you didn't look outside during the reentry, Ham says on his STS-124 flight he first noticed the speed they were traveling (still hypersonic) when they were low enough to start seeing some of the weather below.

"I looked out the window and whole thunderstorms are going by like they're wispy little clouds [from] in your Cessna."

Once the orbiter slows down below Mach 1, the commander takes over control from the guidance computer. At around 50,000 feet the orbiter is approaching the *heading alignment cone*, or HAC. The HAC is a virtual circular guidance device that is located near the end of the runway, off of the centerline. Turning around the HAC, the orbiter continues on its 18- to 20-degree glideslope as it lines up with the runway.

On final, a pair of triangles begins to rise from the bottom of the HUD. These are the indicators that tell the pilot when to flare. Still flying nearly 300 knots, the flare begins when the triangles reach the flight path marker, which happens at 2,000 feet agl. The speed is down to 220 knots as it crosses over the numbers. Holding the nose up, speed bleeds off as the descent rate drops ideally to just under three feet per second. This is where one of the unusual aerodynamic characteristics of the orbiter might bite somebody not used to flying a delta-wing aircraft with elevons: The center of rotation is not anywhere close to the center of gravity. Instead, the orbiter rotates around a point near its nose—so a small pitch input near the ground, to try and extend the glide, will result in just the opposite. "You never want to put in a positive pitch impulse on this thing close to the runway, you will drive the main gear into the ground," warns Ham.

As the airspeed slows down to just under 200 knots, the main gear touch down on the runway and, after the drag chute is deployed, the nosegear makes its dramatic drop to the ground and the orbiter rolls to a stop.

On final

Unfortunately for the STS-132 crew, site 16 at Otis doesn't have any of the navigation aids. As *Atlantis* passes through Mach 5, the decision is made to fly a TACAN approach. With some help from the crew at mission control, Ham has closed the split-rudder speed brake on the tail to stretch the glide and is now looking good for making the airport.

"Runway 32 is 9,000 feet," says Reisman.

"That puts us at short field, right?" Ham asks.

The runway at Kennedy Space Center is 15,000 feet. There are special techniques and procedures for this type of a "short field" landing. Just as Ham is going to make his call for the straight-in approach, proud of his crew's work, the instruments reset. The simulation is ended.

Less than a month later, on May 14, the crew of STS-132 and *Atlantis* would successfully launch from the Kennedy Space Center. After eight and a half minutes of trouble-free ascent, the crew reached main engines cutoff and continued on to the International Space Station. After four successful space walks and nearly 12 days in orbit, Ham returned his crew safely to Runway 33 at the Shuttle Landing Facility at KSC with a perfect landing. After 12 years at NASA, he plans on returning to active duty with the Navy. And after two shuttle flights, the desire to fly is still as strong as ever.

"I'm hoping to find a job with a cockpit," he said. AOPA

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