



Becker Helicopter's virtual reality sim safely immerses AW139 crewmembers in realistic training situations.



BECKER/OFF PLANET SIMULATION

Simulator technology takes helicopter training into the future

by Kim Rosenlof

In the past, some helicopter pilots and even governing agencies have dismissed simulators as not realistic enough to provide effective training. Sitting in a fixed-base simulator, some pilots experience vertigo from the disconnect between what their eyes are seeing and what their ears and butts are experiencing. But the newest wave of helicopter-specific flight simulators use a combination of multi-axis motion actuators, high-definition graphics, and advanced computer programming to achieve realistic and effective training for helicopter pilots and crews. Some companies are even incorporating virtual reality (VR) and night-vision-goggle (NVG) simulators into their training curriculum.



FlightSafety's level-D sims like this Sikorsky S-76D use a glass mirror display for brighter and sharper images.

FLIGHTSAFETY

FlightSafety's Crew View Brightens Level-D Displays

While many pilots recognize FlightSafety International for its simulator-based flight training at more than 40 locations worldwide, they might be surprised to learn that the Flushing, New York-based company has been manufacturing its own simulators since approximately 1978. That's when FlightSafety purchased Atkins Merrill, a flight simulator manufacturing company located in Broken Arrow, Oklahoma. It then purchased the visual systems division of McDonnell Douglas in St. Louis, Missouri, shortly thereafter.

These little-known simulator and visual systems divisions of FlightSafety work together to manufacture state-of-the-art full flight simulators (FFS) not only for the flight training giant, but also for offsite military and commercial customers as well. In addition to recently installing new FS1000 level-D FFSs for the Airbus AS350, Airbus EC130, and Bell 407 at its Denver learning center, FlightSafety has delivered 28 (soon to be 32) Airbus UH-72A Lakota simulators—including 10 cockpit procedures trainers and 18 instrument and operational flight trainers based on the FS1000 FFS—to the U.S. Army's helicopter training center Flight School XXI at Fort Rucker, Alabama.

"The helicopter training segment is very important to FlightSafety," said a FlightSafety International spokesman. "We've invested a lot in helicopter training in the past few years,



and we're very pleased that the industry realizes how important it is to train in level-D qualified simulators. It's a good thing for our customers and for the industry, as well."

The latest simulator configuration in FlightSafety's simulator arsenal, the FS1000 introduced in 2014, provides the six-axis motion and separate vibration platform cues expected from a large motion base level-D FFS. It also incorporates the company's Vital 1100 visual image generation and display system, which supports FLIR, ColorTV, low-level light TV/electro-optical, all level light TV, visual threat recognition and avoidance trainer, and digital video output sensors, and is compatible with NVG, HUD, and EVS systems.

One of the big differentiators between the FS1000 and other level-D simulators is the CrewView rigid glass mirror used to display the simulator visuals. Combined with the Vital 1100 visual system, the CrewView display provides a more realistic image than simulator systems that use Mylar canvas, according to Scott Goodwin, general manager of simulation at the FlightSafety's Broken Arrow facility.

"Because it's a fabric stretched over a frame, [with Mylar] there are distortions and imperfections in the surface," said Goodwin. "The glass mirror has no distortions and no imperfections. It's a true spherical surface that is brighter and provides more contrast, resulting in a much sharper image. And when you're talking about helicopters where you have training tasks like maneuvering in close proximity to buildings, landing on an oil rig, or other things that require high visual acuity, the glass mirror is a perfect fit for a helicopter simulator."

FlightSafety has also begun adding chin windows to its helicopter simulators using separate displays correlated to the main windscreen. "If you're looking down the runway, then you look down beneath you, it's the same scale, the same coloration. It looks like a continuous image. All of our helicopter simulators are coming with the chin window displays now," said Goodwin.

He added that correlated eyebrow window displays are next, with introduction on the FFS being produced in conjunction with Sikorsky for the HH-60W Combat Rescue Helicopter Black Hawk variant. The HH-60W simulator will be an upgraded version of the HH-60G simulator produced by FlightSafety in 2012 and in service at Kirtland Air Force Base, New Mexico, that contains coordinated crew and pilot training stations. The HH-60G level-D simulator includes two side gunner stations equipped with simulated mini-gun and .50 caliber machine guns to provide training for the flight engineer and gunner. The simulated weapons contain active recoil and aerodynamic torque system programming to provide realistic recoil and aircraft slipstream feedback to the gunner crew positions.

"It's a trend we're seeing in government and getting more prevalent in the commercial industry: wanting to integrate training of mission crewmembers—the people in the back—on the same platform with the pilots, all together in one simulator," said Goodwin. "The combat rescue



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helicopter will have separate visual systems, one on each side, with gunner positions. It will look like a seamless continuous image from front to back, but you will be looking out the side doors of the helicopter and be able to fire the guns.”

CAE Special-mission Training

CAE has been manufacturing simulators for a variety of aircraft for many years, including full flight simulators for medium and larger helicopters, but the company’s CAE 3000 series flight and mission simulator offers a lower-cost package designed to help train pilots for any special-mission helicopter operation. These include not only simulating the way the helicopter flies, but also the environments in which operators spend most of their time flying.

For example, offshore operators can train pilots in the CAE 3000 with databases supporting highly realistic oil-and-gas platforms populated with objects and even random people, while wind-driven whitecaps adorn waves on the ocean below the rig. EMS operators can practice confined-area landings in rural areas or densely populated cities, surrounded by emergency vehicles and personnel and even EMS first-responders pushing a stretcher. According to CAE, the 3000 series is the first simulator for the civil helicopter training market to provide realistic human form and moving vehicle dynamic simulation driven by artificial intelligence technology.



Other scenarios in the CAE 3000 include all types of emergencies, such as engine failure, hydraulic system failure, tailrotor problems, and even a stuck tailrotor control.

The CAE 3000 meets global standards for helicopter flight training simulation training devices, including for FAA level 7 flight training device (FTD) credits, but it isn't just a fixed-base device. A three-degree-of-vibration motion platform helps pilots experience more realistic helicopter simulation, without the expense of a full-motion system.

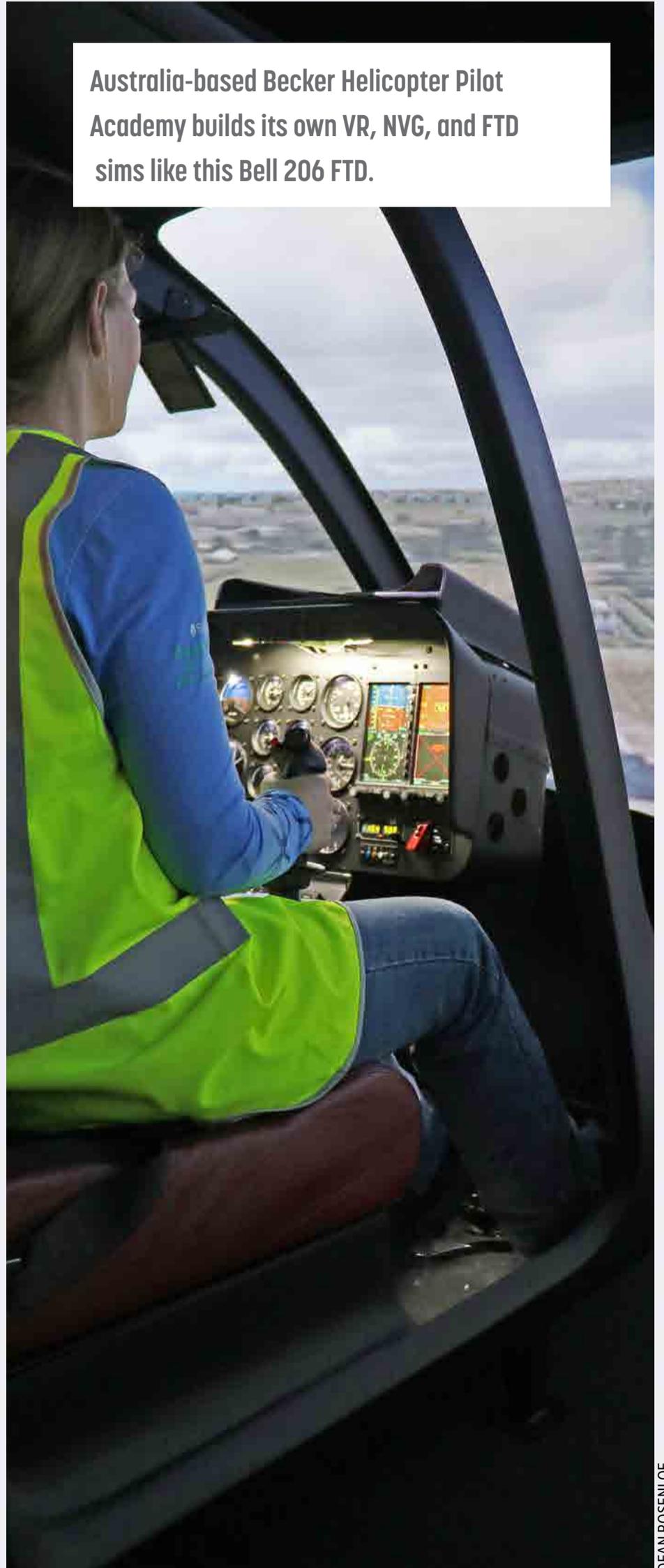
The visual system is CAE's Tropos-6000, which uses projectors to deliver imagery to a 220-degree horizontal by 80-degree vertical field-of-view director projection dome. Pilots can look down and see the expected view through simulated chin window coverage.

Dose Of (Virtual) Reality At Becker Helicopters

Responding to the requirement to provide state-of-the-art training for crewmembers in the back, Queensland, Australia-based Becker Helicopter Pilot Academy recently built a VR simulator to conduct crew training in a Leonardo AW139 rear cabin.

"Currently we're using the virtual reality trainer for basic crewman control procedures, including standard communications and phraseology for guiding the pilot," said Becker's director of maintenance Michael

Australia-based Becker Helicopter Pilot Academy builds its own VR, NVG, and FTD sims like this Bell 206 FTD.



DEAN ROSENLOF

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Yip. As director of maintenance, Yip oversees not only the maintenance of the 20-plus helicopter fleet but also the engineering, development, and maintenance of fixed-base FTDs, VR, and NVG simulators, all developed and built in-house. “The benefit of virtual reality is that you can put a person in a place that you can’t put him in with any other simulator. It’s like when you’re in a game. As soon as you put the virtual reality goggles on, you have to do whatever the virtual reality situation is.”

Founded by Mike and Jan Becker in 1995, Becker Helicopters employs more than 30 instructors providing approximately 15,000 training hours per year to both pilots and crewmembers. The company has developed and built four traditional fixed-based FTDs in house, all certified to Australian CASA level B standards (approximately applicable to FAA FTD level 7) for pilot training and recurrency requirements. Having completed the VR sim in mid-2017, Becker has already conducted two crewmember classes in it.

For crewmembers receiving the VR training at Becker, the realism starts before the goggles go on. The simulator is the size, shape, and essential configuration of a Leonardo AW139 rear cabin with the doors off. Dressed in their duty flight suits, helmets and protective gear, crewmembers must attach themselves to the cabin harness just as if they were going flying. Only then will the instructor start the program. When the student puts the VR goggles on, the student can see the entire helicopter, including main and tail rotor, plus all outside graphics encompassing the scenario including underneath the aircraft.

“To immerse the student in the VR world, we make sure the VR aircraft is the same as the real aircraft,” said David Betts, an instructor who teaches crewman training at Becker. “For example, the door handles and the ceiling rings are in the same position. Then if you start by putting your harness on before you put your VR goggles on, your brain starts to think in the same mind[set] as when you walk out to the aircraft. When you can then reach your finger through a ring on a hard point on the roof, your brain believes that you’re in the aircraft...That’s what we’re trying to do: immerse the student in the aircraft by first making it look like the real aircraft, and then take the same level of seriousness. If you do that, it works well. If you just walk out to a chair in a room and put the goggles on, you’re going to get sick very quickly.”

One of the biggest benefits of VR training is that the instructor can see not only what the student is doing in the cabin, but also what the student is looking at through the VR goggles. “We want to make sure that when the guys say they are looking at the rotor system, we physically see them looking at the rotor system,” said Yip. “When you’re brand new, you spend time looking all over the place. When you get more experienced, your situational awareness becomes a lot better.”



Yip says that it was not a big jump to go from development of the existing flight simulators to the VR simulator, partially because Becker developed an NVG simulator in between. While NVGs can be used in the Becker FTDs for training normal NVG operations, the NVG simulator is a special set of goggles synced to the flight simulator that projects images onto the goggle lenses to train crewmembers to deal with failures of the goggles themselves.

“We can simulate the defects on the night vision goggles, such as a tube failure, ‘chicken-wiring’ [an irregular pattern of dark lines, sometimes hexagonal or square-wave shaped], edge glow, dark spots or white spots. You can simulate all of that on each goggle, or you can simulate a complete failure to practice emergency procedures such as handing over to the next pilot, changing the battery pack, etc.”

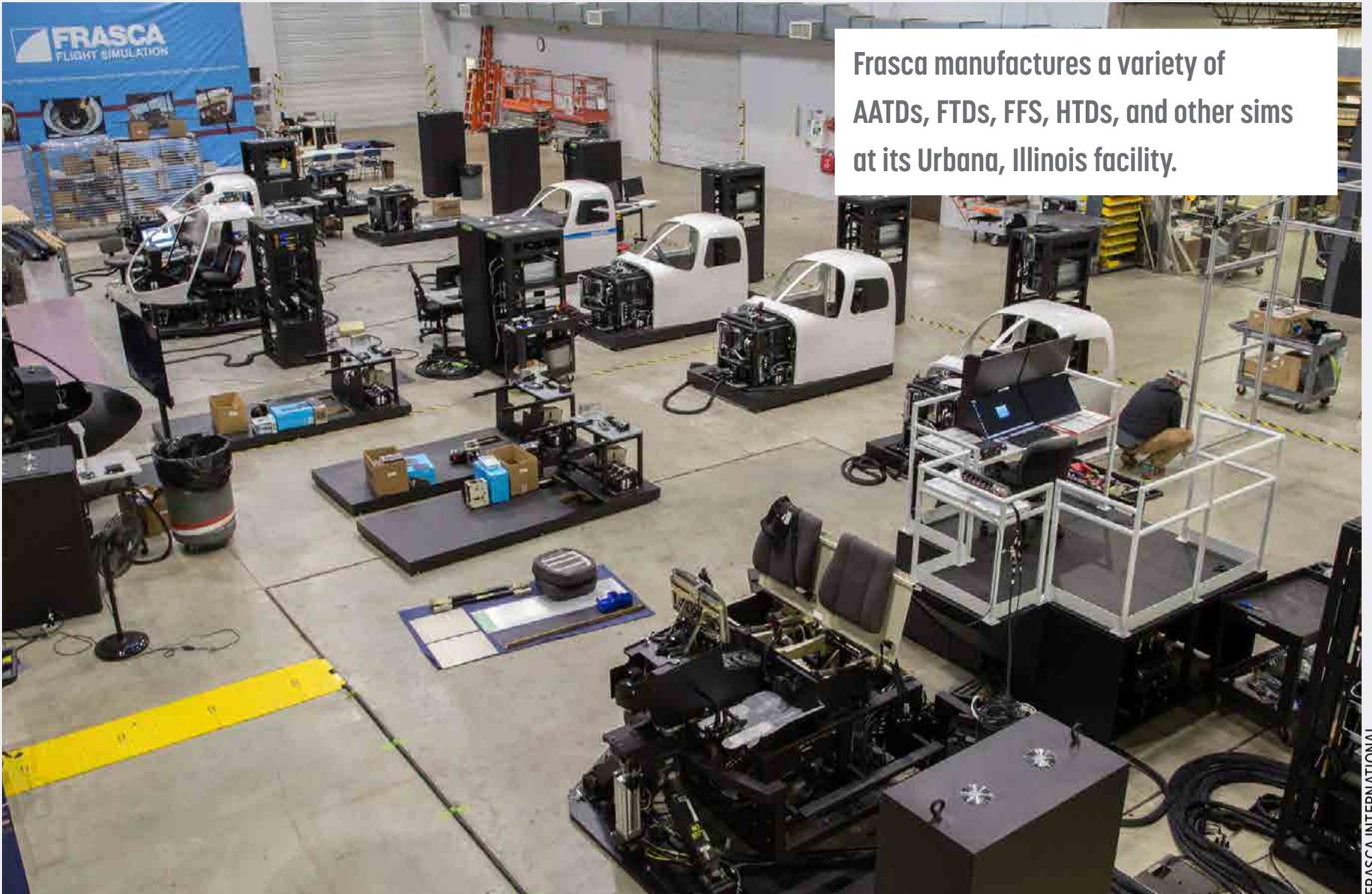
At Frasca, Bigger Isn't Always Better

Urbana, Illinois-based Frasca International turns 60 this year, but its simulator technology is not only keeping up with the times, it's making breakthroughs. Based on decades of research in building simulators and training devices of all types for both airplanes and helicopters, CEO John Frasca, son of founder Rudy Frasca, is convinced that when it comes to helicopter simulators, short strokes are better.

“Big motion bases have existed for years, and we've built them with up to 60-inch stroke legs,” said John Frasca. “The large simulators move so much in response to the pilot inputs, when they wash that motion out, it imparts a negative cue.” Frasca used the classic cues of a sustained bank—when after several seconds the vestibular system equalizes to make the pilot feel as if he's straight and level even though instruments still show the aircraft turning—as an example. “The way we do that with motion bases is that [the actuators] move to put the initial bank in, and then as the pilot sustains the turn, [the actuators] wash out so that the motion base is sitting level even though the visual still shows the turn. When you do that with a large motion base, it means that you have a large negative cue in the wash out.”

Frasca said that small motion bases using six-inch stroke actuators, such as Frasca's Motion Cueing System (MCS), as opposed to the 60-inch strokes normally used on Level D FFSs, can feel more like the actual aircraft—especially when training in small helicopters.

“With the small motion base we're seeing pilots adapt to the simulator more quickly, and their workload is more comparable to what they encounter in the aircraft. And it may be more prevalent in small helicopters where the cues are felt sooner. That's the market we're really after with this,” said Frasca.



Frasca manufactures a variety of AATDs, FTDs, FFS, HTDs, and other sims at its Urbana, Illinois facility.

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The MCS uses six six-inch actuators with brushless electric motors and three pneumatic assist cylinders to provide six degrees of freedom (6DOF) motion plus vibration cues. The company began offering the MCS on its custom FFSs and as an option to fixed-base FTDs about two years ago, delivering one of the first instances on a Bell 206L level-7 FTD delivered to EMS operator Air Evac in December 2015. According to a testimonial on the Frasca website given by Air Evac instructor Stephen Sullivan, “It took about four weeks for the FAA to approve it and our instructors to become familiar with [the] capabilities before it was ‘ready for training’ on January 27, 2016...With Frasca’s new cueing system a pilot really senses motion with the vestibular apparatus [in the inner ear] and the proprioceptive sensors [the body].”

In 2017, Frasca introduced the Helicopter Training Device (HTD), a new product aimed at the small helicopter operator or flight school. Essentially an off-the-shelf fixed-base AATD using Frasca’s level-D helicopter mission simulation database, the HTD can be ordered in one of four models: Bell 206, Bell 407, Robinson R44, and Airbus AS350. Avionics include a choice of analog or Garmin G500H primary instruments and Garmin GTN 650 or 750. With no motion or vibration cues, the HTD is essentially an advanced procedures trainer



with some beefy software upgrades, including the same aerodynamic modeling as used in Frasca's level-D FFS, and a helicopter mission database designed to provide IFR training scenarios.

"With the HTD, we really focused on one training task: inadvertent IMC," said Frasca. "Pilots were getting into the clouds without being current. This device is designed around getting them current and keeping them current."

The HTD also comes standard with Frasca's SimAssist adaptive training software module introduced in 2015. Developed to measure the pilot's task proficiency in real-time and provide variable assistance to optimize training, SimAssist is useful for pilots learning new tasks but can also help experienced pilots adapt more quickly to a fixed-base FTD. Currently only programmed to activate during hover, SimAssist reduces aggressive inputs and assists in the hover when the student is first learning. As the student gets better at hovering, the SimAssist program gradually adapts to the student's capability and returns the sim to the full realism of the aircraft.

"It's like a variable augmentation system," said Frasca. "Instructors often have to hold on to the cyclic or pressure the control one way or another to keep the helicopter stable when the student is flying poorly. With SimAssist, the software is doing it so the student can find it easier to fly. As he starts coordinating and muscle memory begins to develop, the system slowly reduces the amount of assistance provided."

Although the technology is still in its infancy, Frasca sees the adaptive SimAssist technology expanding beyond single maneuvers like hovering and autorotation to encompass entire lessons. Since the system essentially assesses when the student is ready to fly certain maneuvers without assistance, SimAssist or its future incarnations may allow students to learn the basics of helicopter flying without a human instructor.

"I think teaching hover with the SimAssist is more effective than the instructor fighting [the student] or turning him loose by himself," Frasca said. "As you get into more complex maneuvers, we still have to develop the software to be able to replace the instructor. But it's only a matter of time until the student will take an entire flight lesson without an instructor."

TRU Provides Small/Large Motion Base

Determining that two motion bases are better than one, South Carolina-based TRU Simulation + Training, a subsidiary of Textron formed in 2014, recently introduced its Odyssey H helicopter-specific platform, which incorporates a large-motion-base FFS exterior with a separate small-motion base under the interior cockpit. Both motion bases provide 6DOF



TRU Simulation's Odyssey H sim employs a roll-on/roll-off cockpit configuration to allow training for different helicopters in one sim.



cues, but are independent to allow the small secondary motion base to provide essentially a seventh axis, such as a yaw kick simulating an engine failure during a turn.

“You can almost think of the secondary [motion base] as providing the ‘seat of the pants’ cues and the large primary [motion base] providing the sustained g’s that you would feel in the aircraft,” said Troy Fey, TRU v-p of technology. “They have to be synced together to make it seamless and prevent any negative abnormal effects that the brain could pick up.”

According to an example provided by Fey, the primary motion base with its 60.5-inch actuators can pitch down 33 degrees from horizontal. The secondary motion system can separately pitch an additional 9.5 degrees down, for a net down pitch attitude of 42.5 degrees. The secondary motion system also provides vibration cues.

“[The secondary motion system] will also give you very good cues for vibration, which is important for various failures on the aircraft,” said David Smith, TRU v-p of training centers. “When you drive really strong vibrations from that secondary motion system, you can then use the full motion to drive the aircraft cues, so it just gives a higher fidelity.”

The Odyssey H platform includes a 10-projector, 41-megapixel visual system consisting of a 240-degree horizontal by 80-degree vertical field of view display, with an 11th projector for the chin window. Both the Bell 429 level-D FFS certified at the Bell Helicopter Training Academy in Valencia, Spain, early last year, and the Bell 525 FFS soon to be certified at Bell’s Fort Worth facility use the Odyssey H platform, which also encompasses a roll-on/roll-off cockpit configuration.

“[The 525 FFS] is nearly identical to the 429 [FFS at Valencia],” Smith said. “You could take a 429 cockpit and roll it into the 525 mothership and use that same visual system to do both.



That's not been the current plan, because they think the 525 will be busy enough to stay in 525 configuration all the time. But the Odyssey H gives us the ability to have one fixed expensive asset and then swap out lower cost cockpits to keep the biggest, most expensive part running round the clock. The projectors, the actuators all stay the same, but one day you can park a Bell 429 cockpit in the slot and then the next day you could slide a Bell 412 cockpit into the slot.”

In July 2017, TRU delivered an Airbus H145 level-D FFS to Helsinki, Finland-based Coptersafety using the Odyssey H platform. The FFS earned EASA level-D certification in October 2017, one month after the German Federal Aviation Office certified the “world's first H145 FFS” at Airbus Helicopters Training Academy in Germany. TRU is scheduled to deliver four more level-D FFSs to Coptersafety this year representing Airbus H125 and Leonardo AW139, AW169, and AW189 airframes. ■

Helicopter Simulator Terminology

While any device that represents or reproduces a real-life scenario can be called a simulator, the FAA and other certification agencies rigorously categorize various types of helicopter simulators for flight training.

Flight Simulator Training Device (FSTD): generic term used to designate any level of flight simulator in FAA or EASA documentation.

Aviation Training Device (ATD): An open flight deck or enclosed cockpit containing a replica of aircraft instruments, equipment, panels and controls with the hardware and software necessary to represent a category and class of aircraft in ground and flight conditions. May use a mixture of physical and virtual controls.

Advanced Aviation Training Device (AATD): An ATD that represents a specific model aircraft cockpit using physical knobs, controls, switches, and panels in the proper position and distance from the pilot's seated position. An AATD must include a digital avionics panel, GPS navigator with moving map display, two-axis autopilot (not required for helicopter), an independent visual system, panel or screen, and a separate instructor station.

Flight Training Device (FTD): Fixed-base simulator containing a full-size replica of a specific aircraft type cockpit and controls with equipment and software capable of representing the aircraft in ground and flight conditions. Most FTDs also contain an out-of-cockpit visual system but lower level FTDs do not need one. No motion or vibration cueing actuators are necessary to be considered an FTD, but motion can be added without bumping up to FFS levels. Designated by numerical levels based on fidelity of simulator operation, visuals, programming, etc. FAA levels 1-7 with 7 as highest; EASA Helicopter FTD levels 1-3 with 3 as highest (Note: EASA only categorizes Aeroplane FTDs into levels 1 and 2).

Full-flight Simulator (FFS): Full-motion simulator with out-of-cockpit visual system and large-base force cueing system providing three to six degrees of freedom and special effects cues such as buffet due to translational lift, vortex ring, turbulence, and high speed and retreating blade stall. Must contain full-size replica of specific aircraft cockpit and controls, including control force feedback replicating helicopter feedback under the same conditions. Designated by lettered levels A-D for both FAA and EASA with level-D the highest. Type ratings may be performed in level-D FFSs. **K.R.**