Technology Advances Flight Training Field

by Matt Thurber

Flight simulators have advanced rapidly with the advent of improved electronics technology, and now there is a broad base of simulator types available for many types of training. From free and inexpensive desktop computer simulators such as the free open-source FlightGear and low-cost X-Plane and Microsoft Flight Simulator X to inexpensive motion-based training devices from Redbird and full-flight simulators from the big flight-training providers, simulation has had a profound effect on pilot training, and new technology promises even more advances in coming years.
Specific training for business aviation

TRU Simulation + Training, the simulator manufacturing and training company owned by Textron, has adopted many of the pioneering efforts launched by ProFlight, which it purchased in 2014. ProFlight’s Citation CJ3 training and now TRU’s business jet training revolves around two key devices: a full-flight Level-D simulator and a fixed-based cockpit with full avionics and most systems functionality, using real displays, knobs, buttons and switches. Complementing these tools is TRU’s interactive, online recurrent ground school. ProFlight was also the first full flight simulator training provider to offer PilotEdge live ATC services to its customers (see Training Tools on page 5).

TRU’s Integra fixed-base cockpits are designed to help students transition into the CJ3 while spending less time in the more expensive Level-D simulator. During an initial CJ3 course, students spend about an hour in the Integra for every two hours in the simulator, according to David Smith, vice president of training centers. Integra devices have visual displays, so the student can practice flying while learning the systems and avionics.

ProFlight developed an interactive online recurrent ground school, which is FAA approved to replace the ground portion of the recurrent event. The ground school covers systems and provides detailed animations of systems operation and freeplay options for students to observe how systems work under varying conditions. Students can sign up for systems questions to be emailed regularly, to help keep their knowledge...
fresh. “The thing that falls off the most after you go through a training event is systems knowledge,” Smith said.

While TRU is adding simulators for Textron Aviation airplanes to the online ground school program, so far the 525B Citations and King Air 350 with Pro Line Fusion avionics are available, with the King Air 250 and 90 series to follow, then more Citations. TRU plans to seek partial approval for online training for initial clients.

All of the TRU training for business jet pilots can be wrapped into its Current365 program, in which “two training events per year bookend a year-long currency model,” he explained. This provides year-round access to the Integra devices at TRU’s training facilities in Carlsbad, Calif. and Tampa, Fla. and the online ground school.

TRU is adding aircraft types, among them the new Cessna Denali single-engine turboprop and Citation Hemisphere large-cabin jet as well as new Citations currently on the assembly line. “We see some major opportunities that will improve safety dramatically in the coming three to five years,” Smith said. “There is a lot of technology coming that we’re bringing to bear, a lot of research on how to maximize learning of highly sophisticated processes.”

At flight training and simulator manufacturer FlightSafety International, technology is a key driver of improvements in simulator and training tool quality to help improve customers’ training experiences. The company recently introduced simulator-based upset training, improved simulator ground handling, display system upgrades and training tool development.

FlightSafety was the first training provider to reprogram simulators with enhanced aerodynamics and to offer upset prevention and recovery training (UPRT) in simulators that replicate the full stall regime. The first simulator to be so qualified was the G550, and FlightSafety has added many other models since, offering a one-day advanced course in UPRT taught by specially trained instructors in the qualified simulators. For the G550 qualification, said Dan Littmann, manager of flight dynamics at FlightSafety, “We had a lot of data to sort through to see how the aircraft behaves up and into the aerodynamic stall in a variety of conditions. This allowed us to model the threshold accurately, to the point where it would stall, and the surrounding conditions that would affect it.”

A new regulation governing simulators requires improved touchdown dynamics to reflect more accurately what happens during a bounced landing and gusty crosswinds. FlightSafety has developed new ground-reaction modeling software that better replicates ground handling, and this has also improved the feel of taxi operations. Making this possible depended on improving the motion system.

FlightSafety’s sim cueing takes the evaluation of simulator motion from a subjective standpoint where a pilot comments on the quality of the motion to a system that measures motion cues in the simulator and compares them precisely against motion in the real aircraft. The result is a much improved feel, according to FlightSafety, given the limited amount of motion that is available in the six axes in which a simulator moves. “It’s an exercise in the physics and excursions allowed by motion,” said director of engineering Dr. Nidal Sammur. “We have six axes, and with that limitation we try to zoom in and give the best performance and cues.” Simulators with electric motion systems are best suited for sim cueing, as they offer more frequency response than hydraulic motion systems, he explained.

FlightSafety vice president of simulation John
Van Maren, who is a pilot, has flight-tested the new sim cueing system. “From the standpoint of feeling like the aircraft, it’s a night and day difference,” he said. “This is going to improve the fidelity and quality of training.”

The company’s Airbus A320 simulator uses sim cueing, as do some of its helicopter simulators, the Phenom 300, Falcon 8X and other newer aircraft types.

On the display side, FlightSafety is adding more glass-mirror technology to visual displays, upgrading from the more traditional mylar-type mirrors, which tend to lose fidelity over time as they accumulate dust and grime. Easily cleanable glass mirrors offer a wider field of view, currently at 240 degrees horizontal by 60 vertical, but they can go up to 300 degrees horizontal. Glass is brighter and delivers better sun- and moonlight attenuation, atmospheric scatter, shadows and runway light glimmer. FlightSafety is adding more realistic scene detail on the ground, with buildings and roadways replicated more accurately. FlightSafety helicopter simulators have used glass mirrors for five years and now they are being deployed on new fixed-wing simulators.

Pilots at FlightSafety learning centers will find new tools, such as upgraded graphical flightdeck simulators (GFS) and new iFlightDeck training modules available on the iPads that each student receives as part of the training program. The new Gulfstream G500 GFS will replicate the multi-touch features of the real airplane’s touchscreen-based cockpit. One of the first iFlightDeck modules available is FlightSafety’s CPDLC training software, which replicates the FMS button-pushing needed during a typical Atlantic crossing. “The whole idea is to make sure the transfer of training is specific and timely, so they don’t waste a lot of time with the simulator,” said Tom Montgomery, director of programs at FlightSafety’s Savannah learning center. “We’re trying to make advances in interactive publications and where to put training, whether in the simulator, GFS or iFlightDeck.”

“Everything is physics-based,” concluded Van Maren. “With today’s computing power we’re not limited like we were 20 years ago. Realism is much greater, and the pilot sees that in more accurate simulation of aircraft.”

Simcom Aviation Training recently deployed a new King Air B200 simulator equipped with Garmin G600 displays and GTN 750 com/navgator, “to address glass conversions in the King Air market,” according to the company. The next new simulator will be a Daher TBM 930 with Garmin G3000 touchscreen-controlled avionics, supplemented with a standalone desktop G3000 trainer. Simcom has also added a recurrent training format with progressive checking, “with optional training modules designed to allow customers to tailor training to their needs,” the company said.

CAE, which also manufactures simulators and provides pilot training, is designing a new training program that uses data collection and analysis to provide a more objective approach to training. The company’s next-generation training system (NGTS) is one of a number of initiatives that CAE has under way, along with upset recovery training and sims for more aircraft models.

The NGTS, which is installed on a simulator, enables the customer to gather data about pilot performance and compare that with safety data. The idea is to develop objective means of evaluating pilots, using modern data and analytics tools, instead of traditional, more subjective methods of pilot assessment.
Training tools for the present... and the future

Even as long ago as the early 1980s, companies offered desktop simulation devices to help pilots learn and practice IFR procedures, the ATC-610 being a prime example. ATC Flight Simulator is still manufacturing aviation training devices for multi-engine piston and turboprop, helicopter and firefighting simulators.

The advent of more powerful computing has greatly benefitted the pilot community, not only allowing companies such as ATC to improve their products and new companies like Redbird to launch but also encouraging developers to come up with training tools that play on generic computers instead of dedicated devices.

One of the best places to learn about computer-based simulation is the annual FlightSimCon show, held in Bradley, Conn., each June (this year’s show is scheduled for June 10 and 11). During the show, visitors can try out all sorts of simulation devices and programs, but the simulator enthusiast group Boston Virtual ARTCC (BVA) setup offers a different way to fly a simulator. Volunteers from BVA set up computers running flight simulators and invite people to learn about flying or hone their skills, explained BVA training administrator Evan Reiter.

“We put on a live demo of online flying,” he said, with pilots handling the flight controls and nearby volunteer air traffic controllers acting as a live ATC network using the free Virtual Air Traffic Simulation Network (Vatsim).

BVA is a regional member of the worldwide Vatsim network, offering a realistic flying experience for flight simming pilots in the Boston ARTCC encompassing most of New England.
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(but not New York City). Membership in BVA is free, and what makes this organization unique among Vatsim members is that it allows pilots to join as well. (Vatsim’s free ATC services, run by volunteers, are accessible worldwide.)

The benefit of working with live controllers while flying a desktop simulator is that it makes for a more realistic experience, Reiter explained. Practicing a maneuver in a simulator is useful, but adding ATC to the mix is even better, because the pilot has to heed controller instructions, warnings about other traffic, obtain clearances and so on. Anyone can join BVA and Vatsim, and BVA provides detailed instructions on how to participate.

For simulator pilots looking for a more formal ATC experience, PilotEdge offers real-time ATC services seven days a week. Controllers are mostly those who have retired from jobs in ATC, and flying while using PilotEdge is extremely realistic; controllers are strict about proper phraseology and procedures.

PilotEdge launched in the Los Angeles ARTCC but has now expanded to the western U.S., covering the Seattle, Oakland, Salt Lake City, Denver and Albuquerque ARTCCs. Unlike the Los Angeles coverage, which treats all airports within the ARTCC normally, the new western coverage offers full ATC services only at seven major airports, and on a two-week rotating basis 10 more airports are available.

Other towered airports within those ARTCCs are treated as non-towered. The idea for the expansion was to offer simulator pilots flying transport-category airplanes longer routes suitable for faster airplanes.

As a commercial operation, PilotEdge is easier to incorporate into existing simulator operations. For example, the Simulator Training Center in Camarillo, Calif., offers PilotEdge during training sessions in a Redbird training device. TRU Training + Simulation offers customers access to PilotEdge during simulator training. To add even more realism to desktop simulation, two pilots can simulate flying the same airplane together as a crew. PilotEdge also offers remote coaching via Skype from an experienced flight instructor.

PilotEdge can even save manufacturers money on certification programs. Gulfstream, for example, used PilotEdge for crew workload and human factors tests on the G650 program, saving hours of hugely expensive real-airplane flight-test time, and it is doing the same for the G500/G600 program.

One area where desktop simulators can help pilots of all stripes is in learning new avionics. In the simulator environment, many actual avionics systems are replicated, although with varying degrees of fidelity. In X-Plane, for example, Garmin’s GNS 430/530 com/navigators are fully modeled, while the G1000 system has not yet been given full functionality by any developers in the simulation community. China-based Simionic has accurately replicated the G1000 system on the iPad, a remarkable accomplishment given that this was done without input from Garmin.

Avionics functionality is even better with certain aircraft models and in the Microsoft Flight Simulator X (FSX) environment (currently offered for commercial users by Lockheed Martin as Prepar3D and on Dovetail Games’ Steam platform for home users). Flight1Software offers an add-on version of Garmin’s GTN 650/750 com/navigator and an Avidyne Entegra panel, both available for Prepar3D/FSX users. Developers Carenado and Alabeo have replicated a huge variety of aircraft, many with stunningly accurate avionics, including FMS. Boeing is among the most progressive of major manufacturers, having licensed its intellectual property for multiple airplane types with a remarkable level of fidelity.

BVAs Reiter, who plans to become an airline pilot, sees a major benefit with the airliner replications that equip pilots, especially light-airplane pilots who have never been exposed to an FMS, to learn how to program the FMS without access to a full flight simulator or real airplane. “I’ve been in a real 737,” he said, “and using only what I knew from the simulator, I was able to program the FMS.”

—M.T.
Low costs bring sim tech to wider market

by Curt Epstein

Flight simulators have come a long way since the primitive Link trainer helped the U.S. military churn out tens of thousands of pilots during World War II. The device, a collection of pneumatic tubes and vacuum pumps indicative of its inventor’s background as a pipe organ manufacturer, moved a student pilot seated in a miniature airplane, depending on his control inputs. It was used to teach instrument flying, and had an opaque hood that closed over the top, isolating the trainee and forcing him to concentrate on their illuminated instruments, while a linked writing device plotted his course on a nearby map table. Some 10,000 of the “blue boxes” were produced during the war years.

The airlines began using simulators in the 1950s, and the devices have continued expanding in utility and complexity ever since, with an explosion of development over the past decade. As they improve they are becoming a more central tool for training new pilots. “The simulators are better, specifically because they are visual systems; they’re more appropriate for ab initio training,” said Carl Suttle, joint CEO of simulator manufacturer FlyThisSim. “In the old days when flight simulators didn’t have a visual, they were useful only for instrument training.”

Today, flight simulators run the gamut of price and complexity, from continually upgraded computer software such as Microsoft’s Flight Simulator and X-Plane, to desktop aviation training devices, to larger static systems mounted in aircraft cockpit representations, all the way up to the monolithic Level D full-motion simulators that reside in specially designed buildings and are operated by the likes of training providers such as CAE and FlightSafety.

At approximately $1,000 an hour to operate,
they are generally reserved for the most experienced pilots. “The guys who are using those Level D simulators are the guys who need it the least,” observed Jerry Gregoire, founder and owner of Texas-based Redbird Flight Simulations. “After you have flown 25,000 hours in airplanes, being in a motion simulator does almost nothing for you, and yet these are the guys that the FAA insists have motion systems. We knew it was important for the primary student.”

His company was one of the first to bring motion to simulators aimed at new pilots. “We knew that motion was a key factor in training new pilots, and nobody had a motion system that anybody could afford,” he told AIN. “There were motion systems, but they required a lot of money, and they required special facilities and special rooms and special electricity, so when we began engineering 10 years ago, one of the key design features we needed to accomplish was a motion system that could be carried through a regular size door, set up in a classroom and plugged into a wall outlet, which we did.”

Other companies soon followed suit with similar smaller, more manageable training devices. Affordability was also a driving force. While Level D simulators can cost many millions of dollars, the smaller simulators such as those produced by Redbird cost a fraction of that price, topping out at several hundred thousand dollars, making them more attractive to flight schools and university training programs.

“Today we can teach stick-and-rudder skills and a muscle memory built on reacting to motion cues that you could never claim before except in an airplane, so things have gotten a lot better for the primary student,” said Gregoire.

**BENEFITS OF VIDEO GAMES**

Even the static training devices have made vast strides of late, according to Suttle, who noted that the current level of realism allows them to be used for other forms of training. “It’s massive improvement in the visuals, which are both geospecific—meaning you can use them for pilotage—and faster in terms of their refresh rates. The result is more realistic because graphics cards are so mind-bogglingly powerful now.”

“When these devices were first approved 10 to 15 years ago, they were used mostly for IFR procedural training and the outside graphics weren’t that great,” noted John Dixon, president and CEO of Elite Simulation Solutions. “With the much nicer graphics that we can do now for outside visuals, more and more people are seeing the value in ab initio or for entry-level training.”

Suttle explained that the visual systems that now accompany flight simulators have been driven by the recent advancements in three-dimensional video game graphics. “Even though that technology itself was born from flight simulation, it’s really the gamers who have produced such power, and now that’s being fed back into flight simulation,” he said.

“Your multimillion-dollar flight simulators are tasked only with having accuracy around the airport environment, so if you flew over San Francisco, you would probably see some kind of low-resolution image of the city. Gamers won’t put up with that, and if you fly around San Francisco in X-Plane, you’ll see a good 3-D representation of the Golden Gate Bridge, the TransAmerica Building, automobiles and trains.”

Another big boost to current simulators is the widespread integration of GPS, which has allowed manufacturers to imbue them with extraordinary mapping accuracy. “Add the two together with some clever programmers and we’ve got awesome geospecific graphic systems for flight simulators,” added Suttle.

This accuracy lets users fly approaches at different airports whenever they wish and in all sorts of simulated weather. “You can do 10 approaches in
an hour in a simulator. You can do perhaps two in the aircraft, so you get more repetition [in the sim],” explained Suttle. “Because of the extra power we have available in the computers we can now do good representations of the instrument automation, so [the user has] good autopilots, good GPS navigators, moving maps and all of those other things that you need to be able to practice.”

Suttle’s company builds static simulator devices primarily for the private pilot home market. He saved on manufacturing costs by eschewing real avionics, opting instead for graphic representations of cockpit instrumentation on a touchscreen. He also credits a confluence of technological advances for making the system more affordable. “We’ve got the computer power now, we’ve got the graphics power now, we’ve got the large TV screens at a ridiculously low cost now and we’ve got touchscreens at low cost.”

**SPEEDY FAMILIARIZATION**

Cost is certainly a major concern for the general aviation training market as well, since any expenditures will be passed along to the students. “Let’s say you have a flight school with two airplanes sitting on the flight line,” said Dixon, whose Florida-based company produces training devices from desktop to six-degree-of-freedom motion simulators ranging in price from $10,000 to $300,000, and caters largely to the flight school market.

For the highest-level simulators, manufacturers must use air data handling packages from the airframer that will verify the simulator’s performance. “Since we’re not in that category we don’t have to have the aircraft manufacturer’s data,” Dixon told AIN. “What we do is rent the aircraft, and we have pilots on staff who go out and take measurements ourselves. It’s more the bottom end of the training device [scale], but that doesn’t discount the capabilities for training.”

The devices Dixon’s company makes can use real avionics or digital representations, depending on customer needs, for training devices for aircraft as large as a King Air 200 or as complex as an Airbus Helicopters AS355. “We also use electronic actuators that will give you motion cueing, so that with a high-definition visual system, your brain is interpreting motion through the cueing, and with that motion cueing we can give a good motion-based trainer at an affordable price.”

“If you had a good sim that felt and flew the same way as the aircraft and a good visual system, you can kind of go through that familiarization and orientation process in the device, which has a far lower operating cost for you, so that way when you get to the aircraft, essentially all you are doing now is starting to work on becoming proficient,” said Randy Gawenda, manager of business development for Frasca, which produces training products up to Level D simulators, starting at $100,000.

Frasca recently introduced a new program to assist new pilots in its simulators, known as SimAssist. “It’s almost like an automated stability augmentation system for the sim, so that way when they first get in there, and they’re not particularly good with muscle memory, they’re needing to learn those things,” said Gawenda. “SimAssist can help in much the same way the instructor follows through on the controls. You can either set a particular fix level or it is automatically adaptable, depending on the pilot’s control inputs.”

Aviation training devices have also found new niches as well. “All kinds of new technologies were designed specifically to teach the primary student the skills that you used to have to burn gas to do,” said Gregoire. “These are the skills and muscle memory trainers that get students good at doing something before they actually go out and do it in the airplane.” As an example, Redbird produces a generic crosswind landing trainer. “It’s a bit of a one-trick pony, said Gregoire, “but it’s a really important trick.” The company also produced a program called Parrot, which can provide practice on radio skills, a subject Gregoire calls the second
hardest to learn in aviation.

“It behaves exactly like ATC. The simulation knows where it is, what radio frequency it should be receiving because we have the entire world’s database in this simulator so students coming out of school using Parrot in their Redbirds are already proficient on the radio before they go out and fly around.”

Likewise, he believes aviation fuel should not be wasted learning how to use electronic flight bag (EFB) applications such as ForeFlight; therefore, his company developed a software package called Cygnus and integrated it into its products. “If the simulator is sitting in Seattle, ForeFlight is always going to think it’s in Seattle, no matter what you are doing with the simulator,” Gregoire explained. “Our simulators spoof the location service layer in Apple’s operating system so when you climb into one of our simulators, your device thinks it’s wherever the simulation is taking place. This is how you use technology for primary training and make it so much safer.”

The use of simulators allows students to experience many scenarios that would be too dangerous otherwise. “There are certainly situations and emergencies that I can do in the simulator, but in the aircraft I can only simulate it because I need to make sure we walk away from it and we don’t bend any metal,” said Gawenda.

Likewise, Dixon recalled how during his student pilot days instructors were not permitted to pull circuit breakers to simulate an emergency in bad weather. “I loved to take checkrides in bad weather because I knew the instructor couldn’t screw with me, but in the simulator, the instructors can run these kids through any kind of scenario imaginable, and nobody gets hurt if they mess it up.”

For rotorcraft training, autorotation is one of the most challenging skills to teach. Yet Elite offers this ability in its Robinson R22 trainer. “A lot of schools have stopped doing touchdown autorotations because it’s a great risk to property damage and it’s a very high risk to life, because it’s dangerous,” said Dixon. “With a simulator we can give the exact same environment and the exact same procedures to do touchdown autorotations, and to me that’s a tremendous benefit.”

Beyond safety concerns, mastering such skills before entering the cockpit can provide considerable savings to the student. “Even an R22 is going to cost more than $300 an hour to operate,” noted Gregoire. “The paybacks are so fast because it costs about $1.50 an hour to run one of our simulators. If you’re good at hovering in our simulator, the real helicopter is a non-issue.”