Simulators

Airplanes are not like automobiles. They travel at a high rate of speed and move forward and backward and also from side to side and up and down. They are difficult to operate and require hundreds of hours of training. They are also a threat both to their occupants and people on the ground if they experience problems in the air. Because of this, innovators and engineers have long sought ways of training people to operate an airplane without actually having to fly one. They have developed machines called flight simulators that today are highly sophisticated and important tools, useful for training, learning safety procedures, and even for aircraft design and development.

Aviation simulators generally serve three major functions. First, they are used to train pilots in many of the basic operating procedures. Their primary advantage is that they are relatively cheap to operate compared to flying an actual airplane. Second, they are used for advanced training, particularly in emergency procedures. Numerous emergency procedures cannot be practiced in the air, either because they would be too dangerous or because there is no way to recreate the emergency. Finally, simulators are used in the design process for new aircraft.

The Wright brothers experimented with a primitive form of a simulator to teach their aviation students to fly. They used the center section of an old plane on a mount, which someone on the ground would move based on the student's actions with the controls. But the first true simulator was designed by Edwin A. Link. While learning to fly airplanes in 1927, Link learned about a French training technique called the "penguin system" that had been used during World War I to train many U.S. pilots. In this system, the novice pilot would taxi a plane on the runway, gaining some limited feel for the controls. Link wondered if it was possible to build a training system that would simulate the feel of an aircraft's controls. He began designing a machine that used forced air to exert pressure on a control stick and rudder pedals, and in April 1929 filed a patent for his pilot training device, called the Link Aviation Trainer. His early trainers came complete with fake wings sticking out of either side. He also established a ground school classroom in the basement of his Link Piano and Organ Company. Link managed to sell a few of the trainers to the military. But the onset of the Depression led to hard times and Link ended up marketing his trainers to amusement parks as rides.

Over the next several years, Link improved his trainers, adding instruments that responded to the control inputs. The Link Model 45 was a fully integrated trainer where the movements and instruments worked together; if the pilot pulled back on the control stick, the attitude indicator would show that the plane was climbing as the speed indicator showed that the plane was decelerating. The fuel gauge would eventually go to empty, and the engine noise would become erratic if the engine temperature rose. By World War II, Link was selling thousands of basic pilot trainers to the Army Air Forces and U.S. Navy.

Gradually trainers became more sophisticated and other companies, such as the Curtiss-Wright Corporation, entered the business. Motion trainers, which moved the trainee in response to control inputs, fell out of favor as the military sought to train students to rely on instruments. Analog computers were also incorporated into trainers and over time, people started to refer to these training devices as "simulators." In 1944, the Massachusetts Institute of Technology (MIT) started work on one of the most important early computer projects, known as Whirlwind. Whirlwind was a computerized flight simulator. It was the first interactive computer that responded immediately to inputs from the user. Later, its features were incorporated into other flight simulators.

Starting in World War II, trainers were also developed for aviation purposes other than simply teaching flying as gunnery, radar, and navigation trainers were also built. By the early 1950s, Link produced the C-11B jet flight trainer, the first basic jet simulator for all branches of the military.

Link also began developing simulators for specific aircraft. The B-47B flight simulator was the first simulator for a modern jet bomber. The F-4C Weapon System Trainer allowed an F-4 Phantom crew to learn how to operate its missiles and radar system. Virtually all new American military aircraft and helicopters soon had dedicated simulators. The military operated simulators for everything from fighters to bombers to helicopters to cargo transports.

The military was the primary customer driving the demand for new and more capable simulators. Because military aircraft often operate at the edge of their performance envelope and include many sophisticated systems, it is easier, cheaper, and safer for pilots and aircrew to gain experience on the ground, where they can "crash" a plane repeatedly while learning. Link and other companies also continued to build simpler simulators for the general aviation market, primarily for basic flight training.
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undergoes T-1A flight simulator training at Vance AFB, Okla. The T-1A Jayhawk is a medium-range, twin-engine jet trainer. It is used by the U.S. Air Force’s Air Education and Training Command to train student pilots to fly airlift or tanker aircraft.

The X-15 research aircraft, which first flew in 1959, also marked an important milestone in the development of flight simulators. The X-15 was the first aircraft where a simulator was used to practice flight maneuvers before they were tried in the aircraft, whereas previous simulators had been developed only after the plane’s flying characteristics were already known. There were two simulators developed for the X-15. The first was used to prove its reaction control system, which used jets to change the attitude of the aircraft. The second simulator was more sophisticated and enabled a pilot to gain a sense of how the aircraft would respond as it was made to do things that had not been accomplished before.

During the 1960s, aircraft designers became much more interested in seeking ways to improve an airplane’s performance. They began studying the best ways to present information to the pilot and to design controls so that an aircrew could use them effectively. This resulted in the creation of engineering simulators used in aircraft design. The one major problem with such simulators is that they are only as good as the data provided to them. For a new aircraft that has not flown yet, data on how it will perform is limited and could be flawed.

Simulators also played a major role in training astronauts. The Apollo Mission Simulator allowed astronauts to simulate the operation of what was then the most sophisticated vehicle ever built, the Apollo spacecraft. In the late 1970s, Link also developed a Space Shuttle Mission Simulator that simulated launch and landing of the Shuttle.

In some cases, aircraft companies added simulators to aircraft themselves to improve the quality of the simulations. First done in the 1950s, it was then the only way to provide realistic visual and motion inputs to a pilot. Sometimes the pilot in the in-flight simulator had no control over the aircraft. In other cases, the simulator had some degree of control over the aircraft, although a backup set of flight controls and a second pilot were always included. A pilot working in a conventional cockpit could take the aircraft to a predetermined point and then let someone in the simulator take over, testing new control systems and information displays. In-flight simulators were used in the development of the F-16, F-18, A-10, B-1 airplanes and the Space Shuttle. During the mid-1980s, Sikorsky Aircraft equipped an S-76 helicopter with an additional “evaluation cockpit” that protruded in front of the nose of the helicopter and was equipped with various display and control systems to help develop advanced technologies for other helicopters.

Today it is rare for any major aircraft to enter production before designers build a cockpit simulator. The plane is “flown” hundreds of times before it ever leaves the ground, allowing designers to rearrange cockpit instruments and improve information displays, as well as providing them with some sense of the aircraft’s handling qualities. This saves money by avoiding design mistakes that might normally become apparent only after the equipment has been built.

Finally, a major advance in simulation came during the 1980s with the appearance of commercially available flight simulator software for personal computers. Programs such as Flight Simulator were initially marketed as home entertainment. But as they gained in sophistication, they became useful tools for private pilots, who could practice flying and also purchase software depicting specific airports that they intended to fly to. Today, some of these programs are used in actual pilot training programs and can be very sophisticated, complete with air traffic control systems and simulations of different weather conditions. They allow the private pilot to use a sophisticated training device that was previously available only to militaries and large commercial airlines.

--Dwayne A. Day

Sources and Further Reading

Link Training Systems (information brochure), 1980.


http://www.centennialofflight.gov/essay/Evolution_of_Technology/simu...
Second Lt. James S. Ferguson of the National Air Intelligence Center, Wright-Patterson Air Force Base, Ohio, works the controls of a fighter aircraft flight simulator at a display booth representing Aeronautical Systems Center's Simulation Analysis Facility, also at Wright-Patterson.


