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Six Degrees of Freedom from Six Degrees of Separation: The History of Flight Simulators

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SIX DEGREES OF FREEDOM FROM SIX DEGREES OF SEPARATION:

THE HISTORY OF FLIGHT SIMULATORS

READY PLAYER 1

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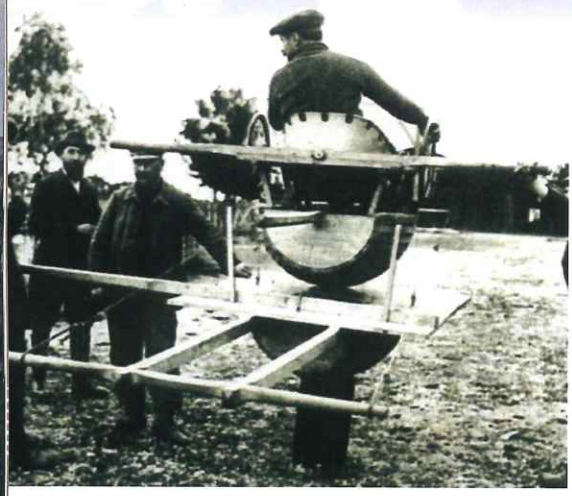
FLIGHT SIMULATORS



Some of today's advanced flight simulators have the capacity to provide pilots with experiences of six degrees of freedom: forward/backward, up/down, or left/right (or pitching, rolling, or yawing in either direction). These incredible devices are the product of over 100 years of design developments that come from a series of technological discoveries and historical events.

Just as we sometimes use the phrase "six degrees of separation" to describe how two human beings can be connected by six or fewer steps, so too can we use this figure of speech as a way of thinking about the interwoven developments that are essential for pilots, aircraft, and simulator designers.

In some ways, devices to simulate flight predate the Wright brothers' flight in 1903. Designers such as the Wrights built models of various forms to try out their designs. It is not too much of a stretch to note that their inventive spirit stems from experiences as bicycle makers and riders. Similarly, the great American fighter ace of World War I, Eddie Rickenbacker, developed the quick reflexes and sure instincts he needed in the skies over Europe as a race car driver.

Two of the earliest aircraft simulators were the Sanders Teacher and the Antoinette trainer. The former was, for the most part, a simple plane attached to a universal joint that could be turned into the wind. Students could use the controls for the rudder, elevator, and aileron to "fly" the plane and make adjustments as required. While the Sanders Teacher depended on the wind to create the forces for the pilot to interact with, the Antoinette trainer was different in that it had pilots struggle to balance their "craft" (a half of a barrel also mounted on a universal joint) against instructors using poles to simulate motion, wind, etc. These two, developed within ten years of the Wright brothers' flight, represent the beginnings of the contraptions we now call flight simulators.

Not too long after, World War I required governments and designers to develop new devices and techniques for flight simulation. The necessity of rapidly preparing hundreds of new pilots to address critical wartime needs meant that effective training tools quickly advanced. The Antoinette models thus became increasingly sophisticated, with the controls of the trainer now moving the vehicle through electrical or mechanical actuators. Simulators also took on the role of helping instructors determine who had the psychological and physiological capability to deal with the stresses of combat. Although such simulators did not do much for preparing prospective pilots for how to deal with specific emergencies in the air, these did help government officials remove unqualified students from programs. In some ways, the ones who failed were the lucky ones – the typical career of a World War I combat pilot lasted only a few weeks.

Although formal simulator training today is mandated by militaries or major airlines, the most important post-World War I simulator was initially marketed as both a "training aid" and as an "amusement device." These trainers, produced by Edwin A. Link, foreshadowed the popularity of computer flight simulator games.

Interestingly, Link used his family's experience with manufacturing player pianos and organs in order to make his own personal trainer. Organ bellows, an electric pump, and a universal joint allowed the trainee to create the sensations of pitch and roll. When twelve Army pilots were killed trying to deliver the US mail because of their lack of experience in flying conditions requiring instruments, the Army contracted with Link to develop simulators for blind flying. This capacity, combined with the more realistic performance of the pneumatic system, meant that Link trainers became the most common simulators of the 1930s.

Such advances in flight simulation helped created a safer environment for flying, but the pilot's identity changed as well. The familiar phrase "to fly by the seat of one's pants" characterizes the spirit of early aviation. However, the widespread use of simulators, instruments, radios, etc. meant that a pilot's identity was increasingly connected to interpretation of data and less connected to the ethos of the free-wheeling barnstormer.

That said, as World War II was to demonstrate, successful combat pilots still needed to improvise in the air and fly by whatever had not been shot away by the enemy. Simulators continued to play a significant role. Pilots of the major air forces of World War II all learned on various models of Link Trainers.

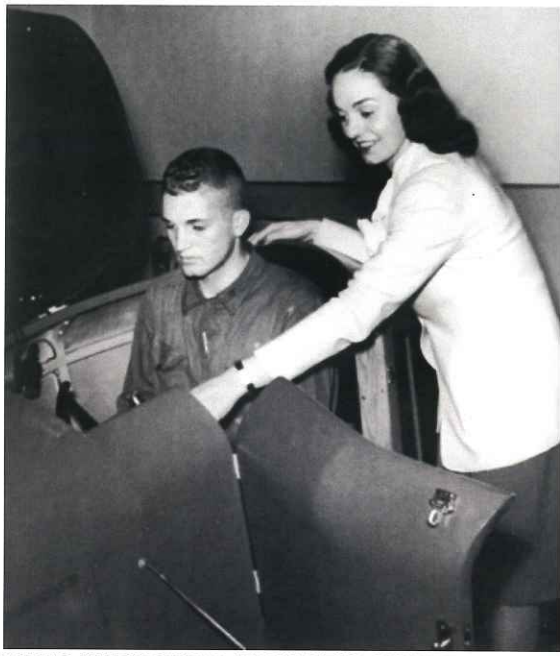


PHOTO: EMBRY-RIDDLE AERONAUTICAL UNIVERSITY ARCH

Even before the United States entered World War II at the end of 1941, a new need for a specific kind of on-the-ground flight training became clear. As early as 1939, the British recognized that they had to prepare their crews ferrying U.S. aircraft across the Atlantic for celestial navigation. Thus, by 1941 the Celestial Trainer was invented. A whole bomber crew could use this large device for various purposes: A pilot flew, the bombardier supplied targeting information, and a navigator used radio aids and a celestial view to guide the pilot. This celestial view consisted of stars that were affixed to the top of a large dome, which would move to correlate the changes in time and longitude and latitude.

The war effort needed more pilots and more complex planes, and the pilots and their crews had to be prepared for accidents, errors, and unexpected needs. The ability to simulate vehicular failures or the results of combat ahead of time prepared pilots and crews for any number of emergency procedures, thereby saving countless lives, as well as enormous sums of money.

Advancements in electronics played an essential role, both in terms of the technical sophistication required of crews and in terms of what simulators were capable of providing. For example, England's Telecommunications Research Establishment (TRE), a research organization working with the Royal Air Force, produced one of the most critical technological advancements during the war: radar. They also designed synthetic radar trainers for all new radars developed during the war. Anti-aircraft directors were computational devices providing ongoing data for shooting at moving vehicles. As they became increasingly complex, the need to prepare crews for using them was met with new simulators.

After the war, steady improvements in visual technology and computers were leading contributors to simulator evolution. There have been many limitations in the various technologies developed for simulator visual systems over the decades. In the 1950s, the shadowgraph, a light source projected upon a panoramic display to create a realistic feeling of flying, was a popular system. Link developed VAMP (variable, anamorphic motion picture projector). This system used film and anamorphic projection to improve the caliber of the image, but the system restricted pilots to the area being displayed on film. The development of closed circuit televisions further improved visual systems. The belt model recorded a moving image on a belt and displayed the image on a screen in front of the cockpit. In 1962, Redifon produced the first color visual system, further increasing the realism of flight simulators. This realism continued with the development of the Rigid Model, where the camera had the ability to move over dioramas of towns and other settings.

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World War II led to crucial advancements in electronics, particularly the ability of analog computers to develop aerodynamic equations and permit an accurate feedback of flight forces. Flight simulators created by Redifon and Curtiss-Wright immediately after World War II used this method, thereby enhancing the realism of ground training. Following these modifications, NASA conducted the majority of the complicated research on motion systems. NASA's research generated a set of motion equations that were then employed by many flight simulator companies. Later, the General Electric Company manufactured the first computer generated imagery (CGI) system for the space program.

Inventors originally developed simulators to prepare those who already had an interest in flying, but within the last several decades, flight simulators for the personal computer have become an important way for young people to develop their passion for the skies. Today's desktop games have their origins in the late 1970 and early 80s, when software developers such as subLOGIC and Microsoft began to produce games such as Microsoft Flight Simulator (MFS) for computers like the Apple II, TRS-80, and the emerging IBM 16-bit personal computer. Initially, the graphics were quite simple, but as computing power progressed, so too have these games continued to evolve. The latest version of MFS is now published as Flight Simulator X: Steam Edition.

Today, the field of flight simulation enjoys a National Center in Orlando, Florida, the abovementioned Hall of Fame, and accepted professional standards for the field. Designers and dreamers continue to develop new ways of providing safe, economical, and reliable training for civilian and military pilots and crews. Just recently at Oshkosh 2017, one-G simulation presented the Torrance 44, "a beta platform representing an R-44 helicopter which uses virtual reality visuals coupled with aerodynamically delivered haptic feedback to create a highly immersive user experience."

The interconnected history discussed here – the links between computers, wars, player pianos, videogames and more – reminds us that the joy of flying in the skies is made possible by hours of safe flying on the ground.

PHOTO: SIMCOM