

The Links to the Desk

Research paper for the Delta Flight Museum
Jim Daigneau / June, 2018©

Visitors to the Delta Flight Museum have seen “simulator corner”, which maintains the theme of “then and now” in Hangar 2. The commanding machine on the hydraulic legs is the operational, full flight B737-200 simulator. Used for pilot training and certification by Delta until 2003, it continued to train pilots from other air lines until its retirement in 2014. Although not certified for training now, it still provides a high fidelity flight and visual experience of modern jet flight for museum visitors. ([Check the Museum website for details.](#))



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In front of the 737, at floor level, is the Museum’s [AN-T-18 Link trainer](#). Recently, through the efforts of Exhibits Manager Tim Frilingos, Maintenance Manager Mark Cook and others, the display has been completed with the addition of the instructor’s desk, accompanying control and indicator panels, and the recording unit or “crab”. The charts on the desk are reproductions of actual simulator charts on which the crab would trace the pilot’s flight.

The trainer is a single pilot cockpit with basic flight controls and flight instruments. When most of these simulators were built in the 1930s and early 1940s, flying by instruments was called “blind flying”: hardly a reassuring term to the traveling public. The Link trainer allowed pilots to practice the critical skills of instrument flying in a safe, academic environment where good performance was immediately acknowledged and poor performance was immediately corrected.



Delta Flight Museum

The addition of the instructor desk completes the display. Every Link trainer, whether built for military or civilian customers, included the cockpit mounted on the motion base and the instructor’s desk with all of the control panels and instruments to run the simulator. Some simulators had more features than others, but they were essentially the same. The instructor had to “run” the simulator while simultaneously instructing the student: it was a job at least as challenging as flying the simulator itself. The instructor had to manipulate multiple controls to allow the student to see the correct

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instrument indications and hear the correct aural cues at the appropriate time. A poorly run simulation would be negative training and very confusing to the student.

Instructors were required to have complete knowledge of the pilot's job as well as the air regulations, air traffic control procedures and technical knowledge to maintain proper simulator operation. [Delta's own Pat "Mother" Malone](#)¹ was one of those early Link instructors. [An interesting personal story is posted at the "Friends and Neighbors" website](#). Like Pat, Mary Daggett Kessel was a U.S. Navy instrument and navigation simulator instructor. Thousands of women were brought into the work force and non-combat military jobs to allow more men to head to combat. Women were employed in nearly all jobs done by men prior to the war. Mary's story is interesting: she had been working in an aircraft factory but knew nothing about flying when she volunteered to become a Link instructor in the Navy. Intense and concentrated training for six weeks at Naval Air Station Atlanta (current day Peachtree-DeKalb Airport) started her on her way to instructing in the Links. It is a story worth reading.

Mr. Link's History

The history of Edwin A. Link and his "pilot trainer" is a fascinating story of ingenuity and technical expertise that rivals any in the aviation industry. There is a short biography at the [National Aviation Hall of Fame](#) website, but his life and accomplishments have been widely documented, most notably in Lloyd Kelly's book *The Pilot Maker*. "Edwin Albert Link, an unusual pioneer of aviation, was dissatisfied when he took his first flying lesson in 1920, as the instructor didn't even allow him to touch the controls for his hard-earned fifty dollars."² Wow! That would be \$649 in 2018 dollars, and he didn't even touch the controls! It is little wonder that Edwin looked for a pathway to more economical flight training. He came by his engineering skills honestly: his father owned the Link Piano and Organ Company. Mr. Link's company produced automatic organs and player pianos. Edwin readily adapted that technology to his flight simulators. He also came by his enthusiasm for flight honestly: like so many people during the pioneering days of aviation (Delta founder [Mr. C.E. Woolman](#) being one of them), the sight, sound, feel and potential freedom of the "aeroplane" was too much to resist.

Edwin worked on improving his simulator through the 1920's and early 30's. His first big break came in 1934 with a contract to build six trainers for the Army Air Corps. This was not a random request. President Roosevelt canceled the civil air mail contracts in January that year. The AAC was assigned the task of flying the air mail: a mission the service was neither qualified nor equipped to fly. The results were disastrous in aviators' lives and Army equipment. The AAC realized that they needed to train their pilots in blind and night flying, and Edwin's "pilot trainer" was the perfect device to get that training underway.



Edwin Link, [Wiki](#)

As World War 2 approached, the military knew it would need to train a huge number of pilots as quickly as possible. The War Department placed orders for thousands of pilot trainers. Edwin Link

¹ Delta Flight Museum "From the Hangars" Blog: [Delta Stories. Patricia "Mother" Malone](#)

² [National Aviation Hall of Fame, Edwin Albert Link](#)

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delivered those trainers and even developed a [simulator to help train navigators in celestial navigation](#).³ A star filled “sky” moved over the flight deck and accurate land was moved under the flight deck. Navigators could take “star shots” with a sextant and bombardiers could practice bomb runs with the Norden bomb sight they would use in their actual aircraft.

Mr. Link eventually sold his simulator company to pursue other endeavors, but his impact on pilot training and safety will never be forgotten. The “Blue Box” and the 737 simulator in the Delta Museum are directly “linked” in history through the vision of Edwin Link.

Delta’s Link History

“Delta’s Link Trainer Training Program began in late 1941, ‘to improve the instrument flying of already qualified Captains; to prepare First Officers for qualification as Captains; to bring Captains and First Officers up-to-date regarding procedures to be used on instrument flying.’ Chief Pilot memo, Nov. 7, 1941.”⁴ Note the date: one month prior to Pearl Harbor. By that time, many of the nation’s political leaders, industrialists and military leaders knew that war was near. They did not know exactly what would happen, but they knew America’s involvement in the European theater was imminent and that the Pacific theater was on a short fuse.

Also, by November, 1941, Delta had had a very busy year. The company transferred headquarters from Monroe, Louisiana to Atlanta Municipal Airport in May. Routes to Cincinnati and New Orleans were approved early in the year, with an additional award of Air Mail Route 54 from Cincinnati to Savannah in July. The four DC-2s Delta had been operating were sold to the British in advance of the Lend-Lease Act. With the expansion of service and the award of AM 54, the Lockheed 10s and new DC-3s were flying more hours per day, so the time available for pilot training was not enough to cover the requirements. Unlike airline pilots today, new airline pilots learned mostly by OJT, “on the job training.” The training for instrument flight and approach procedures was especially time consuming. The noisy, dynamic flight deck of a DC-3 was an expensive and uncomfortable classroom. The instrument training done in the “Blue Box” helped the new pilot understand the procedures before trying them in the airplane. It also helped experienced pilots brush up on procedures that were infrequently flown and to introduce new airport and route procedures.



Ed Schattle, August 2001, (Steve Edwards)

The restoration of Delta’s Link trainer was completed by retired Delta employee Mr. Ed Schattle. Ed “joined Delta in May 1946, as System Chief - Link Trainer. When the jets arrived, and Link Trainers were phased out, he started a side business selling and servicing Link Trainers.”⁵ His company was a family business appropriately called Link Trainer Sales & Service, Inc. in College Park. He registered his company in February, 1966 and finally dissolved it in 2001. Through those years, he helped

³ [Bookworm History website](#), Daniel Thurber web host, October 19, 2017

⁴ Delta Flight Museum Online Collections, [Link Trainer Model AN-T-18 Flight Simulator - 1941](#)

⁵ Ibid.

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many individuals restore and maintain their pilot trainers. As you read the next section, “People behind the Desk”, you will meet one of those individuals, Mr. Steve Edwards of Orange, California. Steve remembers: “A search for Link Trainer parts lead me to meet a retired Delta Employee by the name of Edmund (Ed) Schattle. In late August of 2001 I visited Ed at his home in College Park GA to purchase some Link Trainer Parts”.

People behind the desk

Art Arace, the previous Delta Flight Museum Maintenance Manager, crafted a wheeled frame for the desk to rest on. Being built from 1940s wood, the desk was a bit rickety. The frame allowed the desk to be moved without fear of damage. Art retired as an aircraft mechanic from Delta’s Tech Ops Center in 2006, and then retired again in 2017 as the Museum’s Maintenance Manager.

From an array of parts and pieces, Mark Cook assembled the best looking panels, instruments and accessories to make up a complete instructor desk. He cleaned and repaired each item as required to make them presentable for display. He also performed a surface cleanup of the desk but kept the original paint to preserve the “period” look. Mark retired as an aircraft mechanic from Delta’s Tech Ops Center in 2017, and is the current Delta Flight Museum Maintenance Manager.

Tim Frilingos, the Museum’s Exhibits Manager, was responsible for authorizing incorporation of the desk into the floor display. Tim has overall responsibility for all displays in the Museum hangars as well as the B747. His biggest project to date was the Delta 747 Experience, featuring Ship 6301, the first-built Boeing 747-400. He had to turn the airplane, designed to fly, into a building that would be securely anchored to the ground. The 747 is a “must see” attraction and proudly shows Delta’s colors at the East Gate entrance to the Museum.

Malcolm Lelliott is on the staff of the [Commemorative Air Force Dixie Wing](#), based at Falcon Field in Peachtree City, GA. Malcolm and other volunteers are restoring a Link trainer to flying condition. He shared his time and a small treasure trove of documents about Link trainers. The Dixie Wing is a very active organization that maintains and flies such rare warbirds as the North American P-51 Mustang, Goodyear FG-1 Corsair, Douglas SBD Dauntless and the very rare Bell P-63 Kingcobra.

Ron Ewart of Protobox LLC, [aka Blue Box Driver](#), provided background history and knowledge that greatly assisted in assembling a historically accurate desk. Additionally, he provided scans of actual charts that were used on the desk to trace a pilot’s flight and to assist the instructor after the flight. The charts were essential in that they provided a visual record of the flight and allowed the instructor a place to make notes at critical phases of flight. Ron also forwarded an electronic copy of an amazing 1948 Pan-American Navigation Service “Link Instructor Manual” which gives detailed insight to the complex knowledge base and tasks that were required of Link instructors. Ron and his group are restoring an ANT-18 Link trainer in their facility in Dayton, Ohio, not far from the [USAF museum](#). (Note: take the time to visit [BlueBoxDriver.com](#): they have detailed some very interesting history and pictures of their restoration effort.)

Steve Edwards of Orange, California, also provided a great amount of knowledge, chart scans and history to help create an accurate exhibit. Steve, a mechanical and electrical engineer, has worked for several commercial and aerospace companies including his own consulting business prior to joining Boeing in 2004. Being a tinkerer and craftsman by nature and upbringing, Steve spent five

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years restoring a C-3 Link trainer to “flying” condition, complete with a fully functional instructor desk in his home shop. His website is Linktrainer.net.



Captain Jim Daigneau getting a cockpit check from Steve Edwards. (A Swartz)

Finally, having spent many years working as a flight instructor with flight simulators during my military and civilian career, I saw the instructor desk as a way to make a complete display. A Link trainer on a pedestal is, literally, only about a third of the story. The instructor desk and the stories of the instructors who operated them and of the pilots who spent many hours training in those Blue Boxes paint a complete picture of this important invention and its impact on our aviation heritage.

Link Trainer Operations

This link takes you to [a video of Delta First Officer Andrew Swartz](#) demonstrating a stall-spin recovery in Steve’s Link. The noise is from the powerful vacuum motor that provides the simulator motion as well as providing suction for the vacuum instruments. The simulator aerodynamically “stalls” at 60 to 70 MPH and spins in a random direction. The pilot would recover by lowering the nose, applying correct rudder opposite the spin and adding throttle. While not quite as violent or dynamic as a real airplane, the feature allowed the student to learn to correctly interpret the instrument indications and apply the correct recovery controls. It could still be a very “sweat inducing” event for a new pilot.



Steve Edwards' Link instructor desk (JMD)

Steve offers an interesting anecdote about his visit with Ed Schattle. “Ed explained that he had obtained most of his Link parts from various military and government surplus sales ... We talked late into the evening as he told me about his time in the military and at Delta Airlines. He commented on some modifications made to the Link trainers while at Delta to accommodate some of the heavier pilots that involved adding a second vacuum turbine to have enough power to operate the motion base properly.”⁶ Those pilots must have been enjoying a little too much of that great airplane food!

⁶ Steve Edwards email to Jim Daigneau, 27 February, 2018,

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All Link trainer instrument panels had basic “blind flying” instruments. The picture to the right is Steve Edwards’ panel which shows a typical arrangement. From left to right, the top row shows the compass correction card, wet compass, stabilized gyro compass and attitude indicator. The next row is the altimeter, airspeed indicator, turn and bank indicator, vertical speed indicator and engine tachometer. The bottom row has the clock (very important instrument), ILS indicator, radio compass and fuel quantity. Lighting for night flying was typically red incandescent lights or ultra-violet lighting using luminescent nomenclature and needles in the instruments themselves. This allowed a completely dark cockpit to enable the best night vision outside. Steve cleverly simulates this lighting using black-light LEDs, which creates an amazing “night flying” effect.

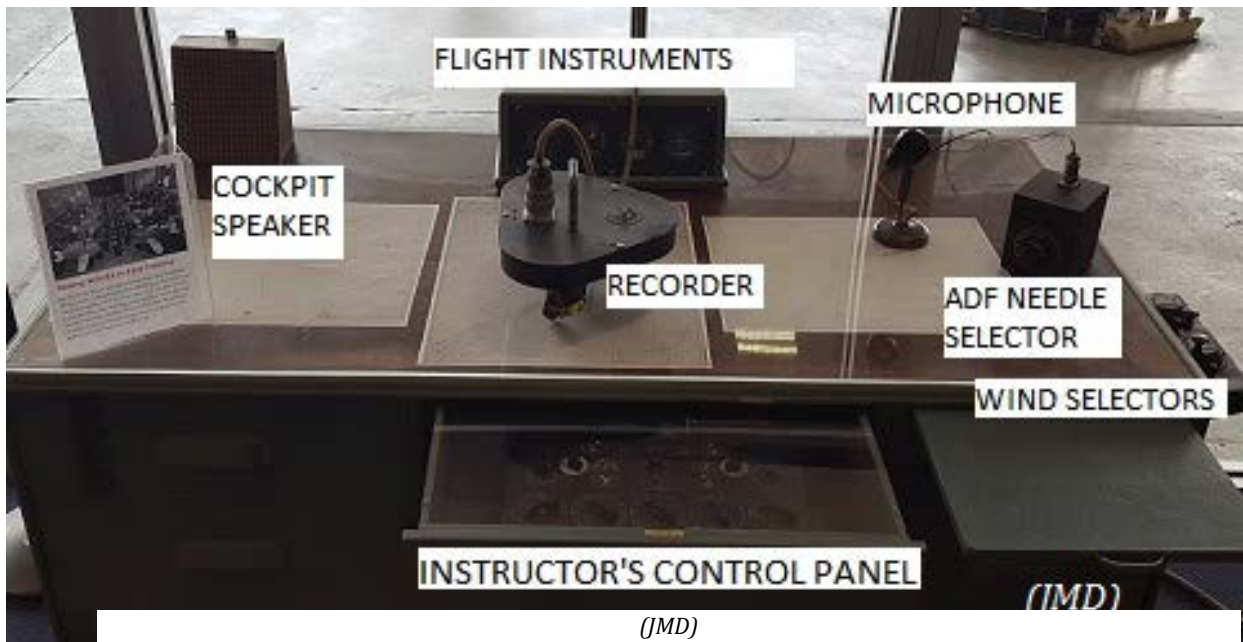


Steve Edwards' Link instrument panel (JMD)

Ron, Malcolm, Steve and many un-named volunteers demonstrate a true love of technology and history by spending countless man-hours to restore and preserve these rare treasures of aviation.

On the Desk

The instruments and panels are the “brains” of the Link. The knobs, dials and switches control most of what the student sees and hears in the cockpit. The photo below denotes the major components of the instructor desk. The charts are reproductions of actual Link trainer charts used to record a student’s flight. The speaker and microphone allowed voice communications between the instructor and pilot. Remember that the instructor was acting both as instructor and air traffic controller so clear voice communication was critical to a successful simulator session.



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This is Steve Edward's beautifully restored control panel. Notice the vacuum tubes. All the switches and selectors are functional and provide input to the trainer. The selector in the lower right corner controls the volume of the airway signal. In the United States, the quadrants of [the four course ranges](#) were identified with the aural Morse code letters "A" (dit dah) and "N" (dah dit). When the pilot was on course or "on the beam", the signals would merge



(JMD)

into a continuous tone, marked by the "0" on the selector. In the United Kingdom, the quadrants were identified with "E" and "T". The mechanical wheels on the upper right of the panel would send out an aural "station identification" every thirty seconds, so the pilot could confirm he was listening to the correct station.

The yellow and blue selector in the middle of the panel controls the approach localizer display. This could be used alone or with the "Glide Path" selector in the upper right corner if a full Instrument Landing System was being simulated. [ILSs \(Instrument Landing System\)](#), [VORs \(Very High Frequency Omni Range\)](#) and [DME \(Distance Measuring Equipment\)](#) were slowly introduced after WW2 and many airplanes did not have the necessary radios installed until late into the 1950s and early 1960s. The introduction of these technologies made navigation much more precise but also introduced new training requirements for pilots and instructors.

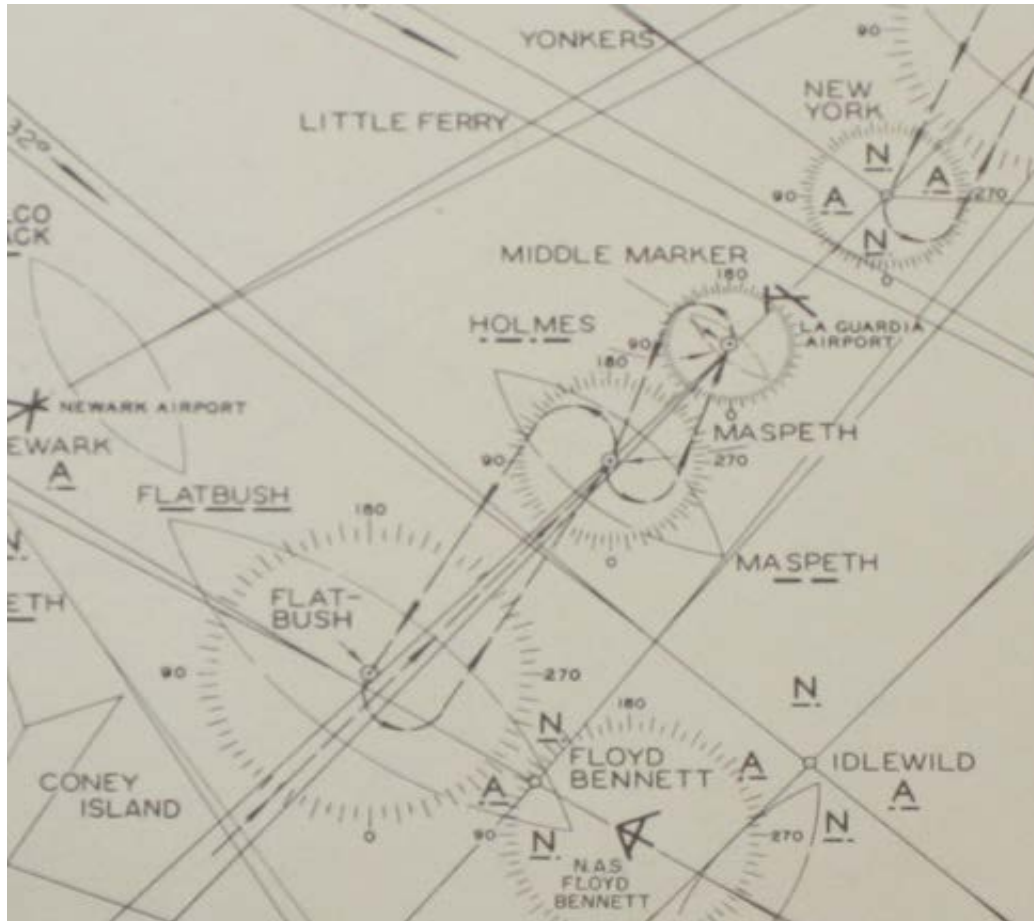
This illustrates a wonderful feature of the Link trainer. Although the instrument panel is rather small, it could be modified to account for new technology. Simulator "techs" like Ed Schattle, could move or install new instruments and make the necessary changes and additions to the instructor desk. Thus the trainer enjoyed a long and useful life improving piloting skills.

The Link trainer's limitation was that it was only a good simulator for propeller airplanes. It could not adapt to the more dynamic and complex environment of the first jets like the Douglas DC-8 and Boeing 707. The flight regime was more dynamic and the airplanes required two pilots and a flight engineer, working together, in a relatively large cockpit. The Link Company continued to make simulators for the jet age, but the end of the era of the "blue box" had arrived.

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The Charts

The example below shows a section of a Link trainer chart. It is a very busy New York area chart, created by the TWA Cartography shop in 1949. Note the LaGuardia and Newark runway patterns. The IDLEWILD range station is now JFK airport. Although Idlewild Airport opened to airlines in 1948, the cartographers chose not to show the runways. Floyd Bennett field was a very busy airport at the time. It served as a Naval Air Station, a Coast Guard Station and a delivery facility for new naval aircraft and sea planes. "NATS (Naval Air Transport Service) set up a terminal used by Pan American Airlines-Atlantic Division under contract with the Navy. Pan Am operated the Boeing 314 and PB2Y in this role".⁷



(JMD)

Other charts might show a single, generic radio facility for basic orientation maneuvers like course reversals and holding. Other specific airport charts might only show a few specific radio stations for specific procedure training. The charts provided the instructor an important tool for the accurate and complete review of a student's flight.

Hopefully this paper has provided useful and interesting background about Edwin Link's great invention. The following appendix contains web links to other Link trainer history.

⁷ M.E. Shettle, Jr., *United States Naval Air Stations of World War II, Vol 1*, (Schaertel Publishing, Georgia, 1995)

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Appendix

Note: the following links are a sample of those available on the internet.

Websites:

[Edwin Albert Link: Inventor of the First Flight Simulator](#)

[NAS Ft Lauderdale Museum](#)

[Norfolk and Suffolk Aviation Museum](#) (United Kingdom)

[Canadian Museum of Flight](#)

[Link Trainer wiki page](#)

[WIKIMEDIA COMMONS page](#)

[Western Museum of Flight](#)

Videos:

[Syracuse University College of Engineering](#) (news story video)

[San Diego Air & Space Museum / Ryan Aeronautical](#) (silent video, recorder operation at 8:00)

[Army Air Corps Link trainer video](#)

[Veterans Affairs Canada, "Heroes Remember"](#) (video)