Flight Inspection History

Written by Scott Thompson - Sacramento Flight Inspection Office (May 2008)

Through the brief but brilliant span of aviation history, the United States has been at the leading edge of advancing technology, from airframe and engines to navigation aids and avionics. One key component of American aviation progress has always been the airway and navigation system that today makes all-weather transcontinental flight unremarkable and routine. From the initial, tentative efforts aimed at supporting the infant air mail service of the early 1920s and the establishment of the airline industry in the 1930s and 1940s, air navigation later guided aviation into the jet age and now looks to satellite technology for direction. Today, the U.S. Federal Aviation Administration (FAA) provides, as one of many services, the management and maintenance of the American airway system. A little-seen but still important element of that maintenance process is airborne flight inspection.

Flight inspection has long been a vital part of providing a safe air transportation system. The concept is almost as old as the airways themselves. The first flight inspectors flew war surplus open-cockpit biplanes, bouncing around with airmail pilots and watching over a steadily growing airway system predicated on airway light beacons to provide navigational guidance. The advent of radio navigation brought an increased importance to the flight inspector, as his was the only platform that could evaluate the radio transmitters from where they were used: in the air. With the development of the Instrument Landing System (ILS) and the Very High Frequency Omni-directional Range (VOR), flight inspection became an essential element to verify the accuracy of the system. In the modern airspace system, GPS satellites now provide the basis for air navigation and signals further changes to aviation. Flight inspection has been there all along, quiet and meticulous, changing and developing through various government agencies charged with air safety: the Aeronautics Branch, Bureau of Air Commerce, the Civil Aeronautics Agency, through to the modern FAA. With continued growth of air transportation, and new technologies to support that growth, the essential means of flight inspection also changed, but its foundation, that of ensuring aviation safety, still remains the same.

American flight inspection began in function, if not yet in form, with the development of an airway system in the early 1920s. The infant airways were created at the behest of the U.S. Air Mail Service operated by the Post Office Department. The Post Office developed the concept of the airway to provide a reliable means of safely transporting the mail by airplanes on predetermined routes and schedules. The Post Office initially sought to establish a coast-to-coast mail route from New York to San Francisco, and the Air Mail Service laid out a route that followed a line from New York to Cleveland to Chicago to Omaha to Cheyenne to Salt Lake City to San Francisco. By 1920 air mail was flown from New York to Chicago in one day on the new airway.

However, in the early days, the term "airway" was very loosely construed, as there was no actual route specified, nor were there any means of aerial navigation provided. There were no aeronautical charts, no terrain or obstruction information, and no radio capability for weather, communication, or navigation, much less anything resembling air traffic control. There was no civil aviation authority at either the state or federal level. There were neither flight rules nor, at that point, a real need for them. Airplanes and pilots were unlicensed and anyone with a self-perceived skill could build his own version of a flying machine and sell it to anyone who wanted an airplane. But this romantic idea of ultimate aeronautical freedom was heavily mortgaged with the prospect that aviation, without the ability to provide a safe, reliable, and productive means of transport, would remain relegated to the circus sideshow as a venue for daredevils. And, with the lack of effective aeronautical navigation, operations were limited to daytime flights in good weather, obviating most of the advantages held by the airplane as a transportation medium. The mid-1920s saw the beginning of federal navigational aids as efforts were made to provide lighted airway beacons along the airways to allow safe nighttime navigational assistance.

Drawing upon the methods of marine navigation, airway beacons were developed by the Post Office. The earliest lighting consisted both of rotating beacons and fixed course lights. The beacons were placed 10 miles apart and the 1,000-watt lamps were amplified by 24-inch parabolic mirrors into a beam exceeding one million candlepower. They were mounted onto 51-foot towers anchored on 70-foot long concrete-slab arrows, painted black with yellow outline for daytime identification and pointing along the airway. Course lights were also mounted on the light towers, projecting a 100,000 candlepower searchlight beam along the airway course and flashing a Morse-code number between one and nine that identified the individual beacon along a hundred mile segment of airway. Intermediate landing fields were spaced every 30 miles along an airway. These fields were primarily used for emergencies during poor weather or for mechanical difficulties. Pilots could locate these intermediate fields at night by green flashing lights installed on the nearest airway beacon.

The transcontinental segment between Chicago and Cheyenne was equipped with the beacons and nighttime service was begun on July 1, 1924. Additional segments were lit both east and west and the entire route east of Rock Springs, Wyoming, was lit by July 1925. Work continued to complete the lighting of the entire route, and the segment between Rock Springs and Salt Lake City was lit in 1926. The last segment over the California Sierras, with the most difficult terrain, was not completed until 1929 and was done by the new Aeronautics Branch of the Department of Commerce. As the airway was lit, the movement of airmail became a viable service. Even with only the eastern two-thirds of the route available for night flying, the mail could still move from San Francisco to New York in 29 hours, versus 72 hours for the routine rail service. By the mid-1920s, airmail was the greatest success story of commercial aviation and became the foundation upon which the passenger airlines were built.

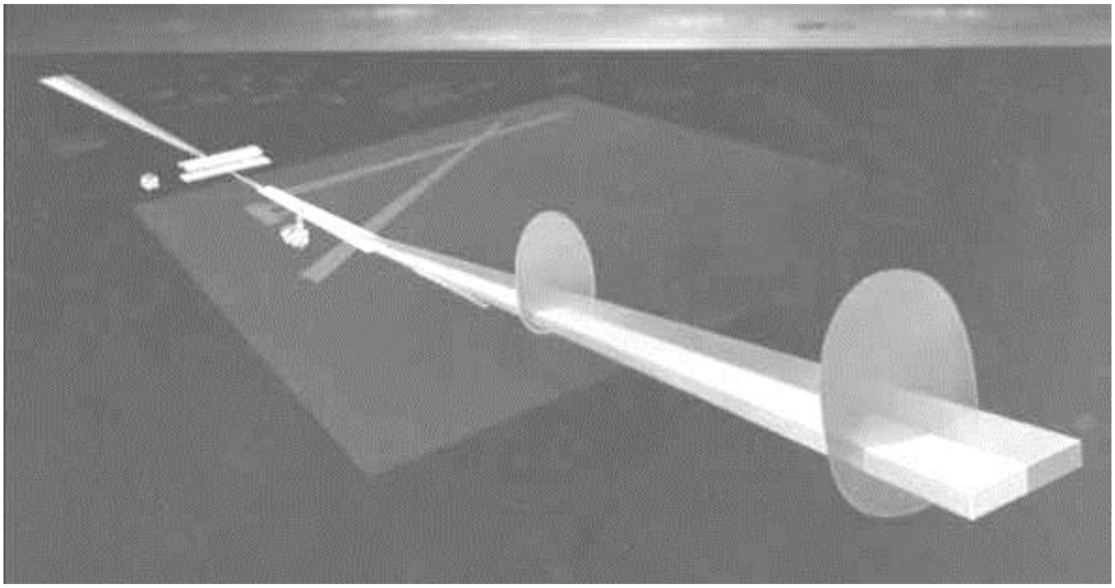
Whether or not these very early routes enjoyed any type of airborne inspection by Air Mail pilots has been lost to history. However, the passage of the Air Commerce Act of 1926 transferred the airway system to the Department of Commerce, which created an Aeronautics Branch with an Airways Division. With the installation of radio navigation aids, the Airways Division established airborne flight inspection as a safety requirement and by 1932 six pilots were employed by the branch as airway patrol pilots. These six pilots and the operations they conducted were the real predecessors of the flight inspection mission as it is known today.

The first practical radio navigation aid, introduced in 1928, was the low frequency Four Course Radio Range. Four directional lobes of signal were transmitted from the range station, two with a Morse code letter "A" (dot-dash) and two with an "N" (dash-dot). The lobes alternated so a course was produced where a balance of the "A" and "N" signals produced a steady tone. Pilots listened on their radio receivers to the transmitted signals and if a pilot heard a preponderance of "A" or "N," he knew he was off course and could make a course adjustment. The courses from two separate ranges could then be aligned with each other to create an airway segment. Station identification, also transmitted in Morse code, interrupted the navigation signal twice each minute. This new aid, rudimentary as it was, nonetheless created the first all-weather airways. The four-course ranges required airborne evaluation by the patrol pilots. They checked the radiated signals to make sure the transmitted courses provided proper airway alignment over the desired ground track. Minor adjustments were made by unbalancing the power output from the four antennas to shift the courses.

Each of the airway patrol pilots inspected 3,000-3,500 miles of Federal airways. The pilots were assigned to a Lighthouse district and patrol offices were established within that area. The Airways Patrol Headquarters were scattered at offices spread across the country. A variety of aircraft were initially assigned to the patrol pilots. The early patrol fleet consisted of five Bellanca Pacemakers, a Curtiss-Wright Sedan-15, several Stearman C-3Bs, and three Stinson SM-8As. Three earlier Douglas M-4s were phased out by the end of 1930. Most of the aircraft were utilized for both airway survey work and airway flight inspection. Later, Stinson SR-8Bs with an electrical system for radios replaced some of the early fleet.


In 1938, the Bureau of Air Commerce was reorganized as the Civil Aeronautics Authority, with newly established administrative Regions given charge of flight inspection within their own area. In 1940, the Civil Aeronautics Authority gave way to the Civil Aeronautics Administration (CAA), establishing the organizational framework that carried forth to the modern FAA. With U.S. involvement in World War II looming, flight inspection remained a relatively small organization within the framework of each of the regional offices. Beginning in 1940, fifteen new twin-engine Cessna T-50 Bobcats were purchased for use in the flight inspection fleet.

Work had progressed steadily since 1928 on the development of an instrument landing system. In that year, the U.S. Bureau of Standards began work for the Aeronautics Branch, incorporating a low frequency loop-type range localizer and position marker beacon. Army Lt. James Doolittle conducted a series of demonstration flights resulting in the first successful blind landing on September 23, 1929. As the conversion to the VHF frequency range was desired, research continued at the CAA Indianapolis Experimental Station, Indiana, where the first modern VHF ILS installation was demonstrated to the military and the airline industry in early 1940.



This system incorporated all the elements of the modern ILS, including aircraft instrumentation, which remains in use today. The localizer signal was standardized to use a VHF frequency in the range of 108 to 112 megahertz (MHz), while the glide path transmitter utilized a range of 330 to 335 MHz. Two marker beacons, termed the outer and inner marker, each transmitted on 75 MHz and illuminated a purple and amber light, respectively, in the cockpit. Also installed was a prototype runway approach lighting system for demonstration.

The development of the radio direction finder and, later, automatic direction finder (ADF) receivers enabled the use of low and mid-frequency non-directional beacons (NDB) to also establish airways. However, work progressed on converting the low frequency airway navigation transmitters to the VHF band, desirable due to the reduction in interference in the higher frequency range.

The Visual-Aural Range (VAR) was the first navigation range developed to utilize the higher frequency bands, but even though the VAR system introduced both the VHF frequency band and direct course read-outs to the airway navigational system, it was still limited by the number of navigable courses. The VAR system was installed on the New York-Chicago airway for demonstration purposes in 1941. However, the shortage of VHF equipment caused by the war effort impeded the aircraft installations and minimized the effect of VHF navigation through the war years.

The delay bode well for the development of the first truly versatile en route navigation system. The VOR was under steady development since 1937 and first deemed practical in late 1943. The creation of a rotating radiation pattern transmitted simultaneously with a stable reference signal created an unlimited number of possible courses and made true multi-course VHF navigation a reality. A frequency range of 112 to 118 MHz was set aside for the new navaid. The old four-course radio range was instantly made obsolete with the perfection of the VOR. Widespread installation of the VOR system in the U.S. began after the war and continued into the 1950s. When the first VOR airway was established in 1951, over 271 VOR units had been installed and commissioned. By June 1, 1952 over 45,000 miles of airways utilizing the VOR were in operation.

The advent of the ILS and VOR dramatically increased the importance of flight inspection as each installation required extensive commissioning checks and mandated regular rechecks of the transmitters. Instrument procedures developed using the ILS and, particularly, the versatile VOR were such that dependable instrument approaches would be possible at many smaller airports not previously used for instrument flying. These procedures had to be developed by the CAA regions and flight checked by the regional flight inspection sections, which only added to the potential workload. To handle the increased work, the CAA obtained nearly thirty war surplus Douglas C-47s and seventy-five Twin Beech C-45s. At least one C-47 and several Twin Beeches were assigned to each of the regional aircraft fleets for flight checks.

The installation of the VOR ranges went far to establish a reliable navigational tool. Distance Measuring Equipment, or DME, was then developed to enhance navigation by providing range information with the VOR signal and by 1950 the CAA was pairing DMEs with VOR transmitters to create VOR/DMEs. The U.S. military worked to develop its own navaid, creating the Tactical Air Navigation system, or TACAN, which provided both azimuth and range information to military aircraft. In 1957, a presidential commission mandated the dual installation of VOR and TACANs as VORTACs to create a national system of airways. The TACAN transmitters provided the DME signal for civil aircraft. In 1959, the International Civil Aviation Organization (ICAO) selected the VOR as the navigational-aid standard for the international community.

Through the early 1950s, the CAA developed a series of ambitious plans for the widespread installation of standardized navigational aids consisting of VOR/DMEs for the airways, plus long-range and terminal radar equipment and ILSs for airport approaches. However, federal budget restrictions resulted in little action taken with the CAA airspace plans. The continued growth of civil aviation and the advent of the jet airliner soon pushed airspace problems into the headlines. Several mid-air collisions, including one over the Grand Canyon in June 1956, pressed the Congress and federal government into making a dramatic new commitment to expanding the air navigation system. By the end of 1956 an overhaul of the system was begun, with a price tag in excess of $450 million.

For CAA flight inspection, the planned installation of hundreds of new VORs and ILSs demanded a likewise dramatic increase in flight inspection capability. Toward that end, the U.S. Navy transferred forty surplus R4Ds (Navy DC-3s) to the CAA for modification into the new "Type II" DC-3 flight inspection aircraft. The Type II DC-3 became the standard flight inspection aircraft system wide for nearly twenty years, with the CAA eventually operating nearly sixty DC-3s. The prime mission of the DC-3 fleet was envisioned to be ILS and terminal approach inspection, plus the detailed commissioning inspections of all new facilities. Each DC-3 operated with two pilots and at least one airborne electronics technician, a crew concept that has carried forth to modern flight inspection.

Also, to explore how VORs and other navaids performed at the high altitudes new jet aircraft were now routinely flying, the U.S. Air Force agreed to loan two Martin B-57 Canberra bombers to the CAA for high-altitude checks. The Air Force also pulled two Boeing KC-135s from the production line for fitting as high-altitude flight inspection aircraft for loan to the CAA.

The Semi-Automatic Flight Inspection (SAFI) program was developed in the late 1950s to perform long-range airway-type inspection. Five U.S. Air Force Convair C-131s were obtained and modified with DME positioning sensors and computerized recorders. The Convairs were fitted with Allison turboprop engines before they joined the flight inspection fleet. The SAFI program flew predetermined grids across the country looking at each of the en route VORTACs as part of the entire airspace system, a mission that continued until the early 1990s when VORTAC reliability was established and determined predictable.

Before most of this new equipment had been delivered, the CAA was transformed into the new Federal Aviation Agency (FAA). The desire to enhance the authority and federal control of the entire airspace system engendered the Congress to pass the Federal Aviation Act of 1958. This legislation created a new independent agency, separated from the Department of Commerce, and assigned it the final jurisdiction over civil and military aviation as they participated in the national airspace system.

The new FAA faced many problems with the expanding airspace system, but quickly established itself as a technically-proficient, competent authority on aviation matters. In 1959, the U.S. Army and Navy transferred their flight inspection programs to the FAA. The U.S. Air Force, under the prodding of a 1962 Presidential executive order, developed a new sense of cooperation with the FAA and, with "Operation Friendship," transferred much of its own flight inspection capability to the FAA. This transfer included its fleet of Douglas AC-54s, Douglas AC-47s, and Convair AT-29s for the FAA to perform routine Air Force flight inspection both domestically and internationally. The combat flight inspection mission was retained by the Air Force using Lockheed C-140 Jetstars in several flight inspection squadrons.

On the international front, the FAA worked in cooperation with the State Department and other agencies to help develop foreign air navigation systems that included flight inspection. In 1965, for example, nine DC-3s and DC-4s, obtained both from FAA and military sources, were provided to the governments of Columbia, Kenya, Mexico, and Vietnam for use in flight inspection or transportation. Other countries that received such assistance over the years included Canada, Spain, Brazil, Greece, Somalia, Argentina, and Chile. The FAA was also instrumental in developing a portable flight inspection package that many nations found more practical to use than establishing a dedicated flight inspection aircraft fleet.

The early 1960s were primarily devoted to standardization of the flight inspection mission across the regions and solidifying the gains made in the late 1950s. Installation of new navaids continued at a rapid pace. By the mid-1960s, FAA flight inspection remained organized at the regional office level but performed from nearly twenty Flight Inspection District Offices (FIDOs) spread across the country. The SAFI program was based at three Flight Inspection Field Offices (FIFOs), with the entire flight inspection program administered from Oklahoma City, Oklahoma, by the Bureau of Flight Standards within the FAA. Other aircraft employed in the FAA fleet included five Lockheed L-749 Constellations for Pacific and Far East flight inspection and several Lockheed TV-2s (T-33) for high-altitude work.

In April 1967, a reorganization occurred that transferred the independent Federal Aviation Agency to the new Department of Transportation to become the Federal Aviation Administration. Beginning in the late 1960s, an effort was made to consolidate the flight inspection fleet organization with a smaller, more efficient fleet. The DC-3s, though still reliable, were deemed too slow for the modern airspace system. Also, new technology using inertial navigation with DME updating and computer analysis was available that made the DC-3 installations obsolete. The FAA purchased a fleet of fifteen Sabreliner 80s to replace the DC-3s, with an additional fleet of five Sabreliner 40s for international work and five Aero Commander AC-1121 Jet Commanders to supplement the Sabreliner fleet. The Sabreliner 80s were equipped with the new Automated Flight Inspection System (AFIS) that utilized modern positioning technology with automated flight inspection analysis.

In 1972, the entire flight inspection program was reorganized into the Flight Inspection National Field Office (FINFO) and removed from most of the regional organizations. With the delivery of the new jet fleet, a dozen of the FIDOs were closed and consolidated to nine FIFOs, seven located domestically with two overseas offices at Tokyo and Frankfurt. In 1975, the FINFO was reorganized as the Flight Standards National Field Office (FSNFO). In 1982, the flight inspection program was removed from Flight Standards and incorporated into the new Aviation Standards National Field Office (AVN). AVN later incorporated other elements of Flight Standards including the Airmen and Aircraft Registry.

During the mid-1980s, in an effort to address fuel conservation and the structural condition of the Sabreliner 80 fleet, a decision was made to purchase a new flight inspection aircraft to replace the Sabre 80. Beechcraft offered a modified version of its Beechcraft BE-300 Super King Air turboprop-powered corporate transport. In 1986 the FAA ordered 19 of the Super King with an upgraded AFIS system, with deliveries commencing in 1988.

In 1991, the FAA assumed the entire U.S. Air Force flight inspection mission and accepted the transfer of the six Hawker C-29s (BAe-800) Air Force flight inspection aircraft into its fleet. The Hawkers were utilized for international flight inspection, supplanting the last of the FAA Sabreliners. Also, in 1991, the Aviation Standards National Field Office became the Office of Aviation System Standards (AVN). For a short period the field offices were redesignated as Flight Inspection Area Offices (FIAOs), by then located at Sacramento, California; Battle Creek, Michigan; Atlanta, Georgia; Atlantic City, New Jersey; Anchorage, Alaska; and Oklahoma City, Oklahoma. An International Flight Inspection Office (IFIO) was established at Oklahoma City to perform the world-ranging FAA flight inspection mission. Later, the field offices regained the FIFO designation and the Oklahoma City office became the Office of Special Operations (OSO). In the mid-1990s, instrument flight procedure development was consolidated in the new National Flight Procedures Office (NFPO) in Oklahoma City. AVN was also reorganized, losing the Airmen and Aircraft Registry and other regulatory functions, concentrating the mission to procedure development, flight inspection, and aircraft maintenance of the flight inspection fleet. In 2000, the aeronautical charting functions established in 1926 within the Department of Commerce were transferred to the FAA and the National Aeronautical Charting Office (NACO) was established in AVN.

With the 1990s came also the development of Global Positioning System (GPS) technology, a satellite-based positioning navigation source. The capability of Area Navigation (RNAV) was greatly enhanced by GPS and point-to-point navigation could now be routinely conducted. Thousands of new GPS approaches were developed to supplement and eventually replace those that require ground-based navaids, some incorporating vertical navigation as LNAV/VNAV standard instrument approach procedures (SIAPs). With the advent of Wide Area Augmentation System (WAAS), precision minimums comparable to those offered by Category I ILS equipment are now being published.

A new initiative for Required Navigation Performance (RNP) instrument procedures is underway, whereby a requirement of navigational accuracy is established for a procedure. The ability of an individual aircraft's Flight Management System (FMS) or RNAV system, using available internal, ground-based, or satellite based inputs, determines whether or not a particular RNP procedure can be flown. Also on the horizon is the Automatic Dependent Surveillance-Broadcast (ADS-B) system to replace FAA long range radars with new navigation and air traffic possibilities.

In the mid-1990s, the FAA flight inspection fleet was supplemented by the purchase of a six new Lear 60s and three Challenger CL-601s. After 2005, the Hawker jets were slowly phased out and replaced by new Challenger CL-604s to provide support for both USAF flight inspection mission requirements and FAA international commitments. Also, beginning in 2006, an effort began to upgrade the avionics and flight inspection equipment of the eighteen FAA Beech 300s with state-of-the-art technology to match the RNP, RNAV, and WAAS flight inspection requirements of the next decade.

Today, FAA flight inspection routinely inspects thousands of navaids and instrument procedures across the acronymic breadth of aerial navigation including ILS, MLS, VOR, DME, TACAN, GPS , RNP, RNAV, NDB, various radars, airport lighting, and conducts airborne obstacle evaluations. Each and every public-use instrument flight procedure, whether it is an airway, arrival, approach, or departure, is flight checked by an AVN flight inspection crew for navaid support, flyability, obstacles, and overall integrity. Continued advancements in avionics with Flight Management Systems (FMS) combined with GPS positioning and other, new high-tech possibilities for aerospace navigational and landing aids establishes an increasing role for flight inspection in the future. Despite the relentless march of technology, there remains the same need for an airborne evaluation of the aviation navigation systems and flight procedures as was established by the original air mail pilots more than eighty years ago.

Flight Inspection History
Written by Scott Thompson - Sacramento Flight Inspection Office (May 2008)