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CAPTAIN OF THE SHIP

L-049

PREPAR3D®

LOCKHEED CONSTELLATION

L-049 CONSTELLATION

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TWA
TRANS WORLD AIRLINES

LOCKHEED L-049 "CONSTELLATION"

By Mitchell Glicksman © 2016

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So, what is the most beautiful piston engine airliner? Pose this question amongst two or more aviation enthusiasts and you may be sure that a lively, possibly heated discussion will ensue. However, I would be quite surprised if most, if not all, would ultimately agree that the Lockheed "Constellation" was the most beautiful, graceful if you prefer, or at least amongst the top two or three.[1] The "Connie," as it was universally and affectionately called (much to the dismay of Eddie Rickenbacker of WWI fame who, as the owner of Eastern Airlines, thought the name to be too effeminate) was a spectacular and singular aeronautical design from the first rude sketch of "Excalibur" to the last L-1649 "Starliner."

Gathering many firsts and breaking many records in its almost five decades-long useful lifetime, Constellation consistently stands out from her sister airliners both visually and functionally. Sadly, the many luminous stars embodying this "Constellation" were ultimately eclipsed when at their brightest by the urgent, inexorable force of progress which saw the end of the age of the long-distance piston-engine airliners and the birth of the big, jet-powered transports. This new era of air-transportation in the U.S. began on 26 October 1958 when Pan American Airlines (Pan Am) flew a Boeing 707 with 111 passengers from New York to London. Soon, the jet-powered Douglas DC-8, Convair 880 and Sud Aviation "Caravelle" joined the 707 and long-range piston airliners were through.

Even so, there are many, this writer amongst them, who posit that even whilst swifter, no kerosene burning aluminium tube has ever come close to matching Connie's superb

1 Some astute aviation historians might claim the Republic XF-12 "Rainbow" to be most beautiful, and beautiful it certainly was; however, only two of them were built. One crashed and the survivor served solely in the U.S. Air Force for a very short time. Although plans were made for "Rainbow" to go into civilian service, it was never an airliner.

WRITER'S NOTE

The story of commercial aviation in the U.S. leading to Lockheed's inimitable L-049 Constellation takes us through the most dynamic, creative and exciting years in aviation, 1927-1947. The changes over these years in aeronautical concepts and design, public awareness and acceptance of aviation, vast developments in the piston engine as well as in metallurgy, aircraft structure methods and materials, electronic and hydraulic systems, radios for communication and navigation, etc. is greater than in any other period of a similar length. There's a great story to tell and I hope that you will enjoy reading about it.

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A confident-looking Charles Lindbergh standing in front of Ryan NYP, "The Spirit of St. Louis", a redesigned 1926 Ryan M-2 mail-plane powered by a 223 hp (166 kW) Wright Whirlwind J-5C radial engine. In order to make room for the extra fuel necessary for the cross-atlantic flight from New York to Paris and to maintain a stable centre of gravity, fuel tanks were built into what was formerly the pilot's and passengers' areas and the new pilot's compartment was located aft of them at the trailing edge of the wing. Special oil canisters were attached to the engine to keep it well-oiled during the flight.

grace and poise. Her story is full of ironies and surprises, of Geniuses, Presidents and Pioneers. You see, there once was this fabulously wealthy, incandescently brilliant, eccentric movie mogul, aviator and airline owner who had an idea for an airplane...

MODERN COMMERCIAL AIR-TRANSPORT ARISES IN THE U.S.

When discussing development of commercial aviation, there is a distinct break point separating the relatively primitive, early days of single-engine, two or three passenger transport and the rising of the modern airliner. As it happens, this break point is not only one of aviation's but is also one of the world's most significant events — the solo cross-atlantic flight of Charles A. Lindbergh[2], 20-21 May 1927 which won him the Orteig Prize of $25,000.00.

Lindbergh's purpose-built Ryan NYP carried 450 US gallons of gasoline (1,700 L; 370 imp. gal.) which weighed 2,710 pounds (1,230 kg), giving it an expected range of 4,000 miles. Fuel was stored in five fuel tanks: three wing tanks (153 US gallons total), the most forward fuselage tank (88 US gallons), and behind it the main fuselage tank (209 US gallons). The oil tank was placed behind the main fuselage tank and served as a most questionable "firewall" for the cockpit. The fuel tanks in the forward fuselage completely blocked any kind of forward view for the pilot which was only very slightly compensated for by a small, retractable periscope on the port side of the cockpit. Altogether this aeroplane was surely a handful to fly even when moderately loaded and must have been quite a bear when full.

Roughly dating photographs of the Spirit of Saint Louis as

2 I think it would be remiss not to make mention of some facts about Charles Lindbergh that are quite unpleasant but true:
While Lindbergh had many Jewish friends, some of them influential and well-known, he and his wife, Anne Morrow Lindbergh were held by many people to be anti-Semites from the evidence of Lindbergh's close association with and open admiration for Nazis as early as 1935 and as late as September 1941; He was an admitted fervent and unrepentant supporter of Adolph Hitler and the Nazis; He and Anne were the guests of Field Marshal Goering (Hitler's "paladin") and his wife at his home on numerous occasions; He accepted "The Service Cross of the German Eagle," a Nazi medal in October 1938; He advised the Luftwaffe and flight-tested numerous Luftwaffe aircraft; As a leader of "America First," a pro-Nazi organization in the U.S., Lindbergh strenuously opposed U.S. entry into WWII against the Nazi's. "America First" held that the Nazi's were essentially preserving Europe for "the white race" and cleansing it of its surplus flotsam populations (Jews, Gypsies, colored minorities, homosexuals, etc.), that the U.S. should favour the Nazi's efforts in this regard and at least allow them to finish the job without interference; He gave dozens of speeches as a leader of "America First," urging U.S. non-intervention in the war against the Nazi's in Europe and wrote articles in popular publications stating these views on dozens of occasions including a speech at Madison Square Garden on 23 May 1941. Of the Jewish people he wrote, among many other similar things; "Their greatest danger to this country (U.S.) lies in their large ownership and influence in our motion pictures, our press, our radio and our government." and "There are too many (Jews) in places like New York already. A few Jews add strength and character to a country, but too many create chaos."; He was a friend of Joseph P. Kennedy and a close consultant to Henry Ford, both notorious anti-Semites; Considered by President Franklin Roosevelt to be a Nazi, Lindbergh was refused permission to serve in the U.S. armed forces during the war; After WWII when revelations about the Holocaust came to light, Lindbergh still refused to change his favorable views about Hitler and the Nazis or to apologize for his former pro-Nazi activities. Sorry if this tarnishes anyone's lofty opinion of Lindbergh, but despite his truly heroic flight, this is also who he was.

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before or after the famous flight is facilitated by the spinner. If it still has the decorative swirl-finished one, it is before the flight as that spinner cracked during an engine run-up a few days before the take off. That damaged spinner was replaced by a smooth spinner that Glenn Curtiss had his on-site factory make for the "Spirit" which he generously gave to Lindbergh for the flight. Curtiss' replacement spinner is still attached to "Spirit" as can be seen in photographs of it hanging in the atrium of the National Air and Space Museum in Washington, DC. (See below)

Due to much that was untold in Lindbergh's own two-book account of his life and the famous flight (the hurriedly penned "We" in 1927 and the far better, 1954 Pulitzer prize winner, "Spirit of St. Louis" in 1953) and in an entertaining but incomplete, fictionalized and often misleading 1957 film starring Jimmy Stewart based on the later book, some of what many people have come to believe about Lindbergh's preparation for his flight is not exactly as it happened. Carefully researched sources including the meticulously written Pulitzer Prize winning biography, "Lindbergh" by A. Scott Berg, put a few things right:

1. Lindbergh began his flight to New York on 10 May 1927 from U.S. Army Air Corps airbase, Rockwell Field, North Island, San Diego, California and broke the non-stop long-distance record to Lambert Field, St. Louis, Missouri, flying 1,564 miles in fourteen hours and twenty-five minutes.

2. He left Lambert Field the next morning (11 May) and landed, not at Roosevelt Field, but at Curtiss field, Mineola, NY , 7 hours and 22 minutes later, breaking the transcontinental flight record by making the crossing in less than twenty-two flight hours.

3. Curtiss Field was privately owned by Glenn Curtiss who had a factory on its southern boundary and who owned a number of other airfields on Long Island, N.Y., including one where the "Green Acres Shopping Mall," Valley Stream, NY is currently located. Curtiss Field, located in what was then Mineola, NY (now East Garden City) was located adjacent and to the west of the U.S. Army Air Service airbase originally called "Hazelhurst Aviation Field No. 1 until 1920 when it was sold to civilian owners and re-named "Roosevelt Field."

   If you want to locate the Curtiss and Roosevelt Fields of 1927 on a modern map: Both Curtiss and Roosevelt Fields' were in what is today East Garden City, NY, south of today's Mineola. Their northern boundaries were at the east-west running Old Country Road. Roosevelt Field's eastern boundary was Merrick Avenue, where the telephone lines were (are) strung that Lindbergh cleared by only twenty feet. Curtiss Field's western boundary was Clinton Road and its eastern boundary was 3,000' due east from there. Curtiss Field's southern boundary was 1,300' due south from Old Country Road to a (then) golf course extending south to the then "Long Island Motor Parkway," today's "Stewart Avenue."

   In 1929 the entire property containing both airfields was sold, Curtiss Field becoming "Roosevelt Field Unit 2" , and the larger airfield to the east becoming 'Roosevelt Field Unit 1." In 1936 the eastern and larger part of Roosevelt Field (Unit 1) was sold so that Roosevelt Raceway (now sadly gone since 1988) could be constructed on that property. Today's shopping mall at Roosevelt Field is located on the most western and northern part of what was Curtiss Field and extends southward to Stewart Avenue.

4. Lindbergh stored and maintained the "Spirit" in a hangar at Curtiss Field, donated to him by Curtiss. He kept the "Spirit" there for ten days and flew at least six short test flights from Curtiss Field's 3,000' east-west sod runway from which he initially intended to take off on his flight to Paris.

5. Admiral Richard E. Byrd was also in the running to be the first across the Atlantic from New York to Paris and thus winning the Orteig Prize, but his Fokker C-2 Tri-motor crashed on a heavy takeoff test flight at Hasborough, New Jersey on 16 April, 1927. As Byrd's Chief pilot, Floyd Bennett, was injured in the crash and would require weeks of hospitalization, the flight was postponed until a replacement could be found. While Byrd waited, he very graciously offered the use of his 5,000' packed clay runway at Roosevelt Field to Lindbergh for his takeoff, which Lindbergh readily accepted.

6. While hangered at Curtiss Field, Ed Mulligan, one of Lindbergh's mechanics noticed a crack in "Spirit's" beautifully swirl-finished spinner. Glenn Curtiss had his factory, located on the field make a new one, but did not swirl-finish it. It was fitted to "Spirit's nose" a few days before the Paris flight and it remains there to this day.

7. On 13 May Lindbergh's mother, Evangeline, surprised him with a wire that she would be coming to Garden City for a visit on Saturday, 14 May. Friends report that his publication suitable sentiment regarding his mother's visit was "Good Lord!" She had taken the train to Garden City, N.Y. near Curtiss Field, and stayed for part of one day. Charles's mother watched him do two reassuring test flights that day, after which her son took her for a meal in Hempstead and then happily and promptly drove her back to the Garden City train station for her return trip. She had refused to allow photographers take a picture of her kissing him goodbye although faked composite photos of them in such a pose do exist. (Yes, this was commonly done even before "Photoshop")

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8. At dawn on 20 May 1927, the partially fuelled "Spirit' was lashed to a truck and most carefully towed down a steep embankment separating Curtiss and Roosevelt Fields to Roosevelt Field and its 5,000' hard-packed clay runway. Lindbergh took off from this East/Southeast runway, using almost all of it and barely clearing the telephone lines strung along Merrick Road on the easternmost boundary of Roosevelt Field. Lindbergh did not snag a telephone wire as dramatically but fictionally depicted in the film, "Spirit of St. Louis." Had Lindbergh tried to take off from the 3,000' sod runway at Curtiss Field, he surely would have crashed at the embankment at its end and died in the fiery explosion of the 2,750 pounds of fuel on board.

9. Hundreds of people witnessed Lindbergh's takeoff not the few seen in the film. No one gave him a makeup mirror before the flight, but a school teacher did hand him a St. Christopher's medal on a chain which he put in his pocket without looking at it. It wasn't put in the bag with the sandwiches by his friend as in the film. Not an important matter, perhaps, but why not portray these things as they really happened? Beware of Hollywood's "history lessons."

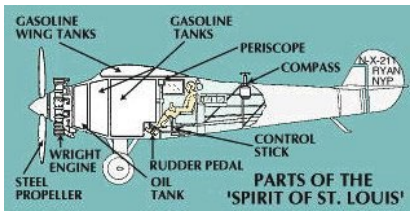
10. A two-seat Curtiss Oriole with a photographer on board took off behind Lindbergh, followed along side of 'Spirit" as far as the Long Island Sound and then turned back.

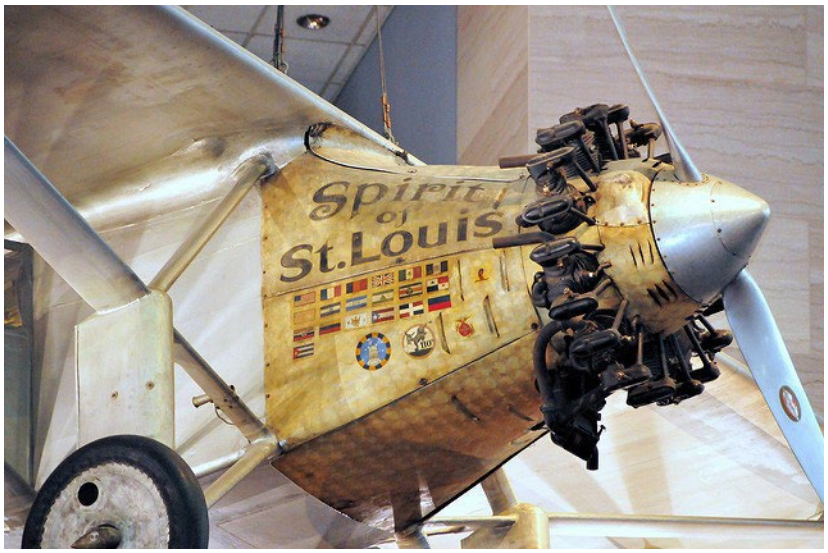
11. All exterior shots of "Roosevelt Field' in the film were taken at Zahn's Airport in North Amityville, NY, gone since 1980. It was one of the last of the 1920-30's type of airport and needed almost no alterations to pass for the real thing.

Lindbergh's solo flight to Paris is far more than an important aviation record. It represents in reality the age-old, beloved fable of the unconquerable spirit and courage of a single human being attempting an impossible task. More, it was a worldwide cultural quantum leap into the modern mindset that all parts of the planet are intrinsically connected and easily accessible. However, Lindbergh was not the first to fly across the Atlantic.

U.S. Navy-Curtiss seaplanes NC-1, NC-3, NC-4 began a crossing of the Atlantic between 8 and 31 May 1919. The route planned was from the Naval Air Station at Rockaway Beach, New York to Newfoundland, then on to the Azores and to Portugal, ending the flight in Plymouth, England. The flight took 24 days, with six stops. Fifty-three ships spread out across the Atlantic transmitted radio signals to give the aircraft points by which they could navigate. Only NC-4 made it all the way across, the other two aircraft being damaged or incapacitated at various points along the route.

The first non-stop flight across the Atlantic took place only fifteen days later on 14-15 July 1919. Ex-Royal Flying Corps (RFC) aviators William Alcock and Arthur Whitten Brown flying a much modified two-engine British Vickers "Vimy" bomber took off from Lester's Field, St. John's, Newfoundland, Canada and after a flight of 16 hours, 12





This how the "Spirit" looks today hanging in the National Air and Space Museum on the Great Mall in Washington D.C. It is in its original condition as it was when it returned to the U.S. after multiple international tours, thus the many nations' flags on the cowl. Note the plain aluminium spinner that Glen Curtiss made for Lindbergh when it was discovered that the original swirl-finish spinner had cracked a few days before the Paris flight. The original aluminium swirl-finish nose panels have naturally oxidized to a yellow/gold color over time and the Museum has wisely decided not to try to clean them as they are quite thin and likely very brittle and fragile by now. Also such would be dangerous regarding the preservation of the original painted markings, etc.

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minutes, "landed" in a bog near Clifden, Ireland. This won them the British newspaper, Daily Mail's prize of 10,000 pounds sterling (about $1.3 million in 2016) to the first aviator(s) to cross the Atlantic. They were also knighted by King George V.

In the U.S. in the 1920's, a person could travel long distances faster by rail than by aeroplane but that would soon change in the coming decade. Even though it was not the first flight across the Atlantic, (See above) the Lindbergh flight single-handedly shattered the previously, commonly held conception that aviation was limited to short, land-based operations and that the planet's continents were only reachable by ship. Suddenly, from a rather parochial, curious, but not really practical means of transportation for ordinary people (i.e., those who are not carnival daredevils), the entire world, with no limits, was now ripe and ready for everyone to explore and visit by air.

Lindbergh's flight was also about more than the practical matter of a new means of travel. The U.S. and people all over the World became enamoured, even fascinated with the romantic lure of the skies. The aeroplane, an invention then only twenty-four years old, was now seen to be an unlimited and serious scientific advance. This sudden tectonic shift cannot, I think, be quite imagined today when we are so accustomed to "miraculous" technological breakthroughs announced almost every week, any one of which would have been entirely unimaginable and would have seemed like magic in the 1920's. That single flight not only changed the way people thought about aviation but about the world and its geography, other countries, other cultures, other people, politics, science, technology, business ... and war. Wall Street investors saw a new popular and potentially lucrative industry emerge and jumped into it with both feet. Suddenly, the world became much smaller and suddenly European and Asian social and political matters were not quite such remote and distant things.

The combination of Lindbergh-inspired aviation zeal and lots of money were the white hot flames that forged modern commercial aviation in the U.S. Accordingly, modern commercial aviation as we know it can be thought of as "BL" (Before Lindbergh) and "AL" (After Lindbergh).

However, just as aviation was slow to develop in the U.S. before WWI[3], commercial aviation remained so in the U.S.

Boeing Model 40B-2, its pilot and its four valiant, progressive passengers. Photo circa 1929.

after the war. Whilst commercial air travel was burgeoning in Europe in the 1920's and '30's, particularly with the formation of the first airline, KLM, in Holland in 1919 and Deutsche Luft Hansa (now known as Lufthansa) in Germany in 1926, the progress of commercial air travel was considerably slower in the U.S. during this period as well.

BOEING'S FIRST AIRLINER

The first US airliner of sorts is generally considered to be Boeing's Model 40. It was introduced in mid-1927 as a civilian air-mail carrier in accordance with the Air Mail Act (Kelly Act) of 1925 which gradually privatized the U.S. Post Office's air mail service. Soon Model 40A was redesigned with a more powerful engine, a strengthened fuselage and provision for two passengers ride along with the mail in the forward enclosed part of the fuselage. This arrangement proved to be popular so in May 1928 Boeing introduced Model 40C which had and provision for four passengers in the enclosed cabin. Soon afterwards Model 40B-4 which had a 525 hp. (391 kW) Pratt & Whitney Hornet radial engine was introduced. This model remained in production and commercial use until February 1932.

THE FIRST U.S. LONG-DISTANCE AIRLINER

The next progression in airliner design was both a great advance for commercial air travel but was also a throwback to the WWI era. In 1925 Anthony Fokker, the same Fokker who had led his company to produce numerous fighters for

3 The four prolonged Federal patent lawsuits by the Wright Brothers beginning in 1909 against Glenn Curtiss and his partner, Augustus Herring, which were not finally decided upon final appeal until 13 January 1914 (Wright v. Herring-Curtiss. [Wright IV], 21 1 F.654; 1914 U.S. App LEXIS 1776. {C.C.A. 2d 1914}) is commonly believed to be and is often cited as the reason why advances in aviation were made difficult to impossible in the United States during that five-year period. However, a good argument with copious supporting evidence can and has been made by U.S. Patent Law experts Ron D. Katznelson and John Howells that the Wright v. Herring-Curtiss patent war as the reason for the suppression of U.S. aviation development is a myth that was deliberately promulgated by officials of the U.S. government at the time to convince Congress to pass laws creating Federal Eminent Domain condemnation over many aircraft patents, including and specifically the original and valuable Wright Brothers' patents. Further, that these officials used the threat of Federal Eminent Domain condemnation (which was never actually ordered) to convince major aviation patent holders to accept depressed royalties from their patents and to induce them to enter a cross-licensing patent pool whereby each patent holder could, upon payment of a depressed royalty, obtain a licence for use of the patent-protected products of each other. It is argued that this mostly favoured the U.S. government which was the main and largest U.S. purchaser of aircraft before WWI and which could then purchase aircraft and aviation technology for very low prices. This plan was additionally and substantially fuelled by the firm belief of many in the U.S. government that no person(s) or company(s) should "Own the Sky" as was the Wright Brother's apparent goal. In preventing that from taking place, the government's plan was highly successful. Meanwhile, evidence exists to show that aviation patents and designs actually flourished in the U.S. before WWI., although certainly not to as large an extent as those in Europe.

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1928 Fokker F. 10A, was an improved and more powerful F.10. It had three 425 hp Pratt and Whitney Wasp C radial engines and carried up to twelve passengers, but only eight well-to- do looking passengers appear to be about to board when this photograph was taken. Note the thick, cantilever, plywood-covered wing, the drag-producing, exposed engines and the W.W.I Fokker fighter-style fin and rudder.

the Central Powers in WWI (including the excellent Fokker D.VII, considered by many to be the finest fighter aeroplane of the war) became aware that a competition called "The National Air Tour for the Edsel B. Ford Reliability Trophy," more commonly known as "The First Ford Reliability Tour" was going to be held at Ford Airfield in Dearborn, Michigan from 28 September to 4 October 1925. It was to be a long distance aerial race, the course covering over 1,900 miles with stops in 10 cities.

In 1924 Fokker had produced a successful single-engine, seven-passenger airliner, F.VII, for the Dutch airline KLM. It was designed by Walter Rethel who would go on in the 1930's to design aircraft for *Bayerische Flugzeugwerke A G*, the aircraft company owned by aeronautical engineer Willy Messerschmitt. It was Rethel who later chiefly designed the Messerschmitt BF (later ME)-109 fighter.

Fokker wanted his aeroplane to win the 1925 Ford Tour very badly, not so much for the prize money, but to favorably establish his company and his aircraft in the U.S. He quickly put to work his trusty old head designer, Reinhold Platz, who had designed many of Fokker's WWI fighters, including, some say (and others dispute), the exceptional D.VII, modifying Rethel's existing single-engine Fokker F.VII into the three-engine Fokker F.VIIA/3M. When it was completed it was purchased by Henry Ford and shipped to the U.S. in time to enter the competition.

Similar to the single-engine F.VII before it, Fokker F.VIIA/3M Tri-Motor was powered by three 200 hp. Wright Whirlwind radial engines, had a fabric-covered, steel tube fuselage and a cantilever (no supporting struts), plywood-skinned wooden framed wing, the same structural formula that had been used by Fokker during WWI, and which was continued thereafter. Antiquated as F.VIIA/3M was, it won the Ford Tour.

Fokker continued to improve the F.VIIA/3M and in 1926 the twelve-passenger F.10 Tri-Motor went into regular airline service in the U.S., sixty-five being built. For the first time truly long-distance commercial air travel routes were established in the U.S. Fokkers' timing in developing this aeroplane could not have been better and in the following year, immediately after Lindbergh's flight, the airline business as well as Fokker's began to boom.

Whilst F.10's thick wing permitted it to carry sufficient fuel to travel 795 statute miles, it also created a good deal of parasite drag. This thick wing and all of the other myriad drag-producing items that hung out in the oncoming wind gave F.10 a top cruise airspeed of only 120 mph. However, the thick wing also gave F.10 excellent slow speed characteristics, permitting it to operate in and out of the hundreds of small, grass airfields that serviced medium and small towns across the U.S. In 1928, U.S. civil airports with paved runways of even moderate length still remained quite rare.

The Fokker F.10 and the more powerful F.10A established Fokker in the U.S. alongside a larger fleet of Ford 4-A and 5-AT Tri-Motors. All went well until 31 March 1931 when Trans World Airlines (TWA) Fokker F.10, Flight 599 from Kansas City, Missouri to Los Angeles, California crashed a few miles southwest of Bazaar, Kansas. All eight on board were killed, including Knute Rockne, the revered and beloved coach of the University of Notre Dame football team.

Whilst Fokker and its investors tried to blame the accident on a passing thunderstorm, meteorological readings for that day, time and place indicate that no such weather anomaly existed. After inspection of the crashed aeroplane the cause of the crash became widely accepted to be catastrophic structural wing failure.

As said, the wing of F.10 is made of laminated plywood covering a wooden structure. It was found that moisture

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had seeped through the plywood and into the interior of one wing which gradually attacked the glue bonding the wing's structure. This caused the wing's spar to give way, causing severe wing flutter at first and then the wing's detachment.

The startling death of Knute Rockne created grave doubts about the safety of commercial air travel. National public outcry caused The Aeronautics Branch of the U.S. Department of Commerce, forerunner once removed of today's FAA, to take immediate action. All Fokker Tri-motor aircraft were grounded pending further action. It was determined that thereafter they would be required to undergo frequent and rigorous inspections and maintenance of all interior structures. Transcontinental & Western Air (TWA), which had heavily invested in the Fokker Tri-motor, nearly went out of business because of a combination of these additional maintenance expenses and a great slacking off of business due to the public's mistrust of the Fokker aeroplane. Other positive changes, including regulations that aircraft accidents were now to be officially reported and how each accident was to be investigated were made, as well as the addition of numerous, much needed safety regulations to commercial air travel.

Fokker and his aeroplanes' reputation were seriously discredited and both the U.S. public and the airlines looked to other aircraft manufacturers, particularly those who made all-metal aeroplanes. As it happened, there was another aeroplane ready to fly and perfectly suitable for the job.

FORD – AIRCRAFT MANUFACTURER

The Stout Metal Airplane Company was founded by William Bushnell Stout in 1922 and was located on Ford Airfield which Stout and Henry Ford had built. Thereafter, Stout designed and built the single-engine Stout 2-AT "Pullman" which was a reasonably well-flying and performing airplane. Henry Ford, who had always had a great interest in aviation was impressed with Stout and purchased Stout's company in 1924.

As it happened, the Fokker F.VIIA/3M that won the 1925 Ford Tour was given as a present by its owner, Henry Ford, to his son, Edsel who named it "Josephine Ford" after his daughter. Edsel then lent this aeroplane to explorer Richard Evelyn Byrd for his now controversial and possibly successful 9 May 1926 North Pole Expedition which was also sponsored by Edsel.

As an aside, after the 1931 Fokker Tri-Motor crash that killed Knute Rockne, TWA representatives and supporters of Fokker, trying to replenish confidence in the Fokker Tri-Motor, pointed out that it was in fact a Fokker Tri-Motor that had safely carried Byrd and his engineer, Floyd Bennett on the hazardous journey to the North Pole. One may suppose that some people were reassured.

In any event, Fokker "Josephine Ford" was temporarily based at Ford Airfield in late 1925 after Byrd's flight. Whilst there, Ford engineers took numerous photographs and measurements of the aeroplane. In a remarkably short time thereafter, a single three-engine Stout 3-AT was produced by the Stout Metal Airplane Company Division of Ford Motor Company based on Stout 2-AT "Pullman." It was an all-metal aeroplane which was quite prescient in a time

Top Left: Stout 2-AT. Photo circa 1925. A pretty good aeroplane. **Bottom Left:** Stout 3-AT. As awkward and un-aerodynamic as it looks, the Stout 3-AT was even more dangerous to fly according to Rudolph William "Shorty" Schroeder, its first and only test pilot.

"Ford Airport during an airshow circa 1930. The two Ford Trimotors at left are parked in front of Ford's Stout Metal Airplane division plant, where the aircraft were built. Part of this facility, at the northwest corner of the property, still exists today and houses Ford's advanced powerplant and fuel cell labs. In the background is the Henry Ford Museum, constructed a few years after the airport." Caption by Mac's Motor City Garage.

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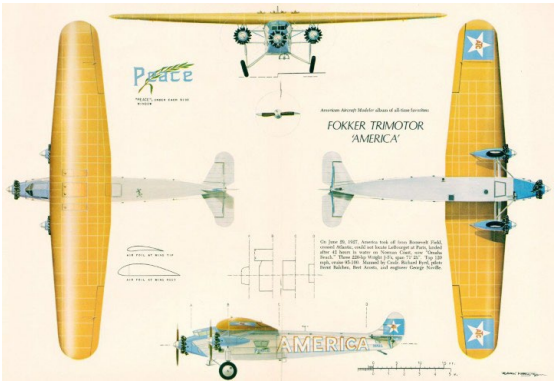
Top: Restored Pan American Airways' Ford AT-5. Its similarity to Fokker F.10 is surely more than a coincidence.
Bottom Left: This two-view of Ford AT-5 clearly shows the thick, drag producing wing.
Bottom Right: This 4-view of the Fokker F. 10 "America" shows the striking similarity between it and the Ford AT-4/5. The forward-slanting windshield was an attempt to reduce reflections from above but only succeeded in adding reflections from below.

This Ford 5-AT-39 Tri-Motor has had a long and very active life. She is depicted as she was flying for American Airways in 1933. After American Airways she spent some years with various operators in South America and was refurbished in 1962. In 1963 she was bought by American Airlines and repainted as she appeared in 1933 and used for publicity flying.



when this was not at all common aircraft structural practice. Whilst this terribly underpowered and poorly designed aeroplane was not produced beyond the prototype, before it flew Henry Ford publicly touted that it was "the airplane of the future." The Stout 3-AT had only one, almost disastrous flight during which it could barely maintain altitude after take off. Rudolph William "Shorty" Schroeder, Ford's test pilot, told Henry Ford that he would not ever fly that piece of "excrement" again. A most irate Henry Ford quickly removed William Stout from the aviation department's engineering staff and assigned him to publicity tours.

On 16 January 1926 Ford engineer Tom Towle was asked to remove all drawings of 3-AT from the Stout factory and to bring to the Ford Engineering Laboratory building across the field. At about 6 a.m. the next morning, a fire destroyed the Stout factory and all the Stout aircraft in it. The new Ford 4-AT was designed from the "saved" drawings of Stout 3-AT.

That month an entirely new aeroplane, the eight-passenger Ford 4-AT, a three-engine cantilever wing aeroplane was designed by Ford's chief aeronautical engineer, Tom Towle who hired MIT graduate Otto C. Koppen, John Lee, and James Smith McDonnell (later to found McDonnell Aircraft Corporation) as the redesign team of the awkward, dangerously performing, three-engine Stout 3-AT.

Thus, in early 1926 Ford 4-AT Tri-Motor began flying in the same skies as the Fokker F.10. It was remarkably, even suspiciously similar to the Fokker but it had one great advantage, like Stout aircraft which came before, 4-AT's airframe was all-metal. Whilst this feature would not become an important issue to the public until after the 1931 Knute Rockne/Fokker crash, Henry Ford reported to the press that the new all-metal Ford was "the safest airplane around." Ford Tri-Motors operated by Stout Airlines, later part of United Airlines were the first to carry a flight attendant, a young man.

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Whilst Ford 4-AT was as much of a throwback aerodynamically as was the Fokker F.10, the Ford had a corrugated duralumin skin[4] overall that was an improvement over fabric or fabric-covered plywood. The Ford had the same thick wing as the Fokker and for the same reasons, but the slightly improved 4-AT-E which had three 300 hp. Wright J-6-9 radial engines cruised at only 107 mph due to the extra drag of its corrugated skin. The larger and heavier Ford 5-AT could carry 10 passengers, but was even slower than the 4-AT, cruising at 90 mph.

In 1928 Transcontinental Air-transport, one of the early airlines which became TWA when it merged with Western Air Express in 1930, began flying what were called the first "coast-to-coast" flights with the Ford. The journey was actually two flights combined with two separate train rides, one from New York to Port Columbus, Ohio and another from Waynoka, Oklahoma to Clovis, New Mexico. Pan American Airways (Pan Am), which became Pan American World Airways in 1950, was founded in 1927 and flew Ford 5-ATs on its first southern international flights from Key West to Havana, Cuba. This was soon expanded to multiple-hop flights to Central and South America.

The days of the main line Tri-Motors lasted only until 1934 when advancing aviation technology relegated them to second-level transports — the evergreen and ongoing story of commercial aviation. They were simple aeroplanes, reliable, easy to fly and to maintain and, with a few notable exceptions, had a very good safety record. They were the first of the genuine airliners from which all else stem. Whilst Fokker and Ford Tri-Motors were a great leap forward for commercial air travel from single-engine biplanes, it was clear to most in the aviation community of the late 1920's that they were already an antiquated design concept.

The times were ripe for a breakthrough.

NOT A PLEASANT RIDE

Airline travel in the 1920's was distinctly uncomfortable. The cabins were drafty, cold and unpressurised. Boarding passengers were given chewing gum to help them to avoid painful ear aches at altitude and when descending. Exhaust and oil smells filled the cabin as well as the noxious smell of airsick passengers and of the disinfecting chemicals used to clean up after them. Most trips were long as the aeroplanes of this era were slow, could not climb higher than most mountain ranges and had to fly around them. They were also often delayed by and had to fly around bad weather, they could not fly after dusk or before dawn, and frequent refuelling stops had to be made. The ride was usually and uncomfortably bumpy, promoting airsickness, as the aeroplanes could not fly high enough to avoid the weather and ground thermals/turbulence. The aeroplanes were so noisy that normal conversation during the flight was impossible and many passengers took to sticking cotton in their ears during the flight to dull the roar of the engines.

Even so, the number of commercial air travellers rose year-by-year and especially after 20-21 May 1927 due to the huge, world-wide Lindbergh phenomena. The number of commercial airline passengers in the U.S. grew from fewer than 5,900 in 1926 to more than 173,000 in 1929.

BOEING STEPS UP AGAIN

Seeing the huge success of the Tri-Motors in air-transport, Boeing, never a company willing to be behind-times, quickly designed and built Boeing Model 80 in 1928. Whilst the Fokker and Ford aeroplanes had been a distinct reversion to earlier aircraft design practices, the hastily created Boeing was even more so. Yes, Model 80 had three engines and carried twelve passengers three-abreast in its

The Tri-Tail Boeing Model 80A-1. This was the latest advancement in airliner design in the late 1920's and early 1930's and would not be replaced until the revolutionary Boeing 247 in 1934. Photo circa 1930. It seems amazing that only thirteen years separate this aeroplane from the sleek and gracious all-metal Constellation.

4 The Ford Tri-Motor's corrugated duralumin skin was pioneered by Hugo Junkers, a German engineer and aircraft designer and became a trademark feature of Junkers aircraft until WWII. The company he founded in 1912, Junkers and Co. designed and developed the first all-metal aeroplane in 1915, the Junkers J.1 "Blechesel" which means Sheet metal Ass (Donkey). Whilst only one of this model was built to test the corrugated metal skin concept, the 1917 Junkers D.1 (factory numbers J7 and J9) monoplane fighter with the same type skin saw service in the German Naval Air Service where twelve of them were deployed.

In 1919 Junkers built the Junkers F.13 four-passenger, single-engine, cantilever monoplane, designed by Otto Reuter. Its skin was the same corrugated duralumin as Junkers had used before and it was the world's first all-metal airliner. 300 of them were built.

During the 1920's Junkers built a number of other successful all-metal airliners including the Junkers G.24 tri-motor incorporating corrugated duralumin skin culminating in the tri-motor JU. 52, affectionately nicknamed both and Iron Annie and Tante Ju, although the former is its mostly common name. Junkers' company went on to design and produce numerous successful combat aircraft for the Luftwaffe during WWII.

When the Ford Tri-motor was introduced, Junkers considered it to be all-too similar to the 1924 Junkers G.24. That the Ford had a high-wing and the G.24 a low wing did not in the least assuage Junkers' anger at Ford for "copying" his design. In fact, what Junkers was most infuriated about was the Ford's use of Junkers' patented corrugated duralumin skin. U.S. Patent law at the time did not extend internationally, so Junkers could do nothing about his claims in the U.S. courts; however, when Ford tried to export and sell their Tri-motor in Europe, Junkers successfully prosecuted a law-suit in Germany, enjoining Ford from so proceeding. In 1930 Ford counter-sued Junkers in Prague, Czechoslovakia (now The Czech Republic) hoping that anti-German sentiment in that country would help to defeat Junkers. After a lengthy and expensive legal battle, the Czech court unanimously found that Ford had indeed infringed upon Junkers' corrugated duralumin skin patent. Ford, losing for a second time, did not pursue the matter in Europe again.

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The rather snug-looking passenger cabin of the Boeing 80. Note the quaint lamps, fancy curtains and overhead baggage holders. The exit door and the door to the lav are aft of the seats. Photo: 7 July 1928

wide cabin (see photograph below); however, unlike the Fokker and Ford cantilever monoplanes, it was a biplane. This arrangement was selected to give the Model 80 a service ceiling sufficiently high so that unlike the Fokkers and Fords, it could fly over all but the highest Rocky Mountain ranges that lay along its route. This was before Federal Air Regulations prohibited flight with passengers above a cabin altitude of 8,000'.

One plus was that both the fuselage and wings of Boeing Model 80 were constructed of fabric covered steel and duralumin tube construction, far stronger and more durable than wood wing spars with plywood covering and a wood-framed fuselage. In at least one concession to passenger comfort if not to modernity, Boeing Model 80 was the first airliner that had a forced, fresh air ventilation system in the passenger cabin and a lavatory with running water. One may imagine what crude facilities the Fokkers and Fords may have offered, if any.

Boeing built only four Model 80s, mostly as conceptual test aircraft. Almost one year to the day after Boeing 80 went into service for Boeing Air-transport (which became United Air Lines in 1931) on 20 September 1928 the larger and more powerful Boeing Model 80A began commercial service. Longer than the 80, it carried eighteen passengers and was powered by three 525 hp. Pratt & Whitney R-1690 Hornet radials making it the largest and the most powerful commercial air-transportation aeroplane in the U.S. in the late 1920's. All of that 1,575 hp. pulled the huge and ungainly-looking Boeing 80A through the air at a cruise speed of only 125 mph.

On 15 May 1930 the Boeing Model 80A made history by becoming the first airliner which had female flight attendants on board. Boeing's flight attendants, the first "Air Stewardesses," were all unmarried Registered Nurses between the ages of 20 and 26 years. Because of the restricted space in the small passenger cabin, Air Stewardesses were required to be no taller than five feet, four inches, nor weigh more than 118 pounds. Passengers, however, had no such restrictions.

One more significant improvement was made to the Boeing Model 80A. It was discovered after many flights that the Model 80A's aft vertical area was insufficient for its power. Accordingly, on the now re-designated Boeing Model A-1, provision was made for the addition of two fins and rudders on the horizontal stabilizer, one on either side of the main fin and rudder. This made the Boeing Model 80A-1 the first airliner with a functional triple-tail, preceding the experimental triple-tailed Douglas DC-4E by eight years and Lockheed C-69/Constellation by thirteen years.

CURTISS CHIMES IN

Arguably looking almost as behind the times as the Boeing Model 80 which was introduced in 1928, Curtiss Aeroplane and Motor Company (Curtiss-Wright) seemed to be uncharacteristically temporarily bereft of what had been its famously forward and uniquely modern designs when it produced the T-32 "Condor" II in so late a date as 1933. This was initially to be a twelve-passenger "deluxe sleeper" (later versions accommodated fifteen day passengers), two-engine, two bay biplane (!) of both wood and metal construction with a modern-looking fabric and aluminium tube fuselage that suggests nothing other than a fat Douglas DC-1. Its undercarriage mostly retracted, its engine cowlings were the latest NACA design and its fuselage was fairly streamlined yet the biplane wings were strut and wire braced. This aeroplane was working against itself.

Powered by two 710 hp. Wright SGR-1820-F3 Cyclone radial engines Condors were able to cruise at a respectable 165 mph, and they were widely advertised to be "The World's First Complete Sleeper-Planes." Used primarily by Eastern Air-transport and American Airways, forerunners of Eastern Air Lines and American Airlines on extensive routes across the U.S., it was somewhat attractive to the USAAC who purchased two of them for use as executive transports, designating them YC-30, eight as a Bomber variant, designated as BT-32, and three as a cargo carrier, designated as CT-32. The U.S. Navy purchased two, desig-

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nating them R4C-1. Altogether, 45 were built, many of them eventually exported.

Whilst it was still on the drawing board the superb and fully-modern 1933 Douglas DC-1, which it partially resembled, made "Condor" immediately obsolete.

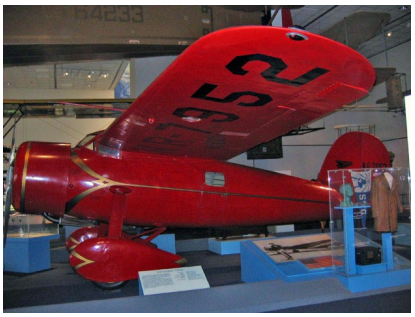
A NEW PLAYER HITS HOME RUN

Whilst Fokker and Ford Tri-Motors were plying the American skies in the middle to late 1920's, Allan Loughead, John (Jack) Knudsen Northrop and Kenneth Jay formed the Lockheed Aircraft Company in 1926 using a re-spelling of Allan's name for its title. Borrowing the plywood monocoque (stressed skin) technology of the Loughead S-1, a single-seat sport biplane that Allan and his brother, Malcolm, had developed and produced when they operated the Loughead Aircraft Manufacturing Company in 1920, they designed and produced the Lockheed Vega 1, the first version of what became one of the most significant aeroplanes of its era.

Designed in 1927 at Lockheed by Jack Northrop and Gerard Vultee, both of whom would later found their own aircraft manufacturing companies, the Vega 1 was a five-seat, single engine, high-wing cantilever monoplane with a monocoque fuselage and streamlined fixed undercarriage. It was at first powered by 225 Wright J-5A. B, and C Whirlwind radial engine. With a top airspeed of 135 mph, very fast for that time, the first Vega 1, "Golden Eagle" won every category in the Cleveland Air Races in 1928.

Later in 1928, the improved Vega 5B and C were produced specifically for airline operations. It had a rather tight provision for seven seats, was powered by a 450 hp. Pratt and Whitney R-1340 "Wasp" radial engine and had a new, NACA-designed, low-drag engine cowling. With a blistering maximum airspeed of 165 mph, Vega 5s, in particular "Yankee Doodle" NX4789, soon began breaking transcontinental speed records. The Lockheed Vega went on to become one of the most famous record breaking aeroplanes of all time. On 30 May 1932 Amelia Earhart flew a Vega 5B solo across the Atlantic, and in August 1932 flew solo across the continental U.S. breaking the woman's cross-continental speed record.

On 23 June 1931, Wiley Post and navigator Harold Gatty took off from New York and flew around the world in a record 8 days, 15 hours and 51 minutes in "Winnie Mae," a Vega 5. In 1933 Wiley Post completed the first solo around-the-world flight 7 days, 18 hours and 49 minutes also in a Vega 5.



Top: Wiley Post's famous Lockheed Vega 5, "Winnie Mae". Note the passenger's windows showing the Vega 5's commercial airliner roots.
Bottom: Amelia Earhart's Vega 5B as displayed at the National Air and Space Museum, Washington D.C.. Note her leather jacket along with her bust, that is, a bust of her head in the glass case.

U. S. Navy R4C-1, military version of Curtiss "Condor". NACA cowlings, mostly retractable undercarriage, fairly streamlined fuselage and all of this with those old-fashioned strut and wire braced biplane wings. What's wrong with this picture? Note the familiar-looking Douglas DC-type fuselage profile.

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NORTHROP'S CONTRIBUTION

Numerous other single-engine airliners were produced in the late 1920's and early 1930's. One such was Northrop 'Alpha," designed and introduced in 1930 by Jack Northrop's new company, using his experience at Lockheed co-designing the Vega. Northrop imbued Alpha with three major aeronautical advancements: First, he designed a stressed-skin wing containing independent fuel cells within making it the first "wet wing." This revolutionary design greatly increased Alpha's fuel capacity, increasing its range whilst keeping the weight of the fuel close to the aeroplane's centre of gravity. This feature was widely imitated thereafter, particularly in the Douglas DC-series airliners.

Northrop "Alpha" in USAAC test-aircraft colors. Note the fillet between the fuselage and wing, familiar today and since the 1930s; however, this was the first aeroplane upon which it was featured. Photo circa 1930.

Alpha's second aeronautical advancement was the use of drag reducing wing fillets between its low wing and the fuselage which had been developed at the Guggenheim Aeronautical Laboratory at the California Institute of Technology. The third advancement was the installation of rubber de-icer boots, the first ever on a commercial aeroplane. This feature, in addition to the most up-to-date radio navigation equipment and instruments gave Alpha the ability to safely and reliably fly at night and in all weather including into known icing conditions.

BOEING GOES ALL METAL

Other large single-engine airliners proliferated as they were inexpensive to run and to maintain. Among them was the 1933 Boeing Model 200 "Monomail," Boeing's first all-metal, low-wing, retractable undercarriage monoplane. With seats for eight passengers, the final version of the "Monomail," Model 221A, successfully flew a regular schedule for United Airways on the Cheyenne-Chicago route. This progressive aeroplane influenced commercial and military aircraft design for the rest of the decade.

LOCKHEED'S STARS SHINE ON BRIGHTLY

Lockheed, spurred onward by its success with the Vega and having the brilliant Gerard Vultee as its chief design engineer produced a number of single-engine airliners including the 1928 "Air Express," a parasol-wing derivative of the

Boeing Model 200 "Monomail". Advanced aerodynamics (for 1933) mixed with an open cockpit. This was typical of the 1930's reluctant transition to true modernity. Photo circa 1933.

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Lockheed "Orion", the last of the single-engine Lockheeds. There is something quite charming about this aeroplane; something both powerful and utilitarian whilst also an artistic aeronautic expression. Note the massive inward-retracting main undercarriage and fully enclosed cockpit (shown open here) Photo circa 1931.

Vega, the 1928 Model 8 "Sirius," of which a special float-plane version was built for Charles Lindbergh, the 1930 "Altair," essentially a retractable-undercarriage variant of "Sirius" and one of the first aeroplanes so designed, and the 1931 Model 9 "Orion," a large and powerful six-passenger, retractable undercarriage airliner whose top airspeed of 220 mph at sea level was faster than U.S. military aircraft of its time.

Orion was a hybrid of successful features taken from other Lockheed aircraft and the last one that would use elements of prior Lockheed designs. Orion is essentially an "Altair" but with the cockpit on the forward top of the fuselage as in "Vega" and an NACA cowling similar to that on Air Express, Lockheed's second aeroplane. Very similar fuselage and wing moulds were used on all of Lockheed's wooden designs.

These Lockheed single-engine aeroplanes were very fast in their day and had good range. Accordingly, in the first Bendix Trophy Race of 1931, of the nine aeroplanes competing, six were Lockheed designs: one Vega, three Altairs and two Orions. However, the race was won by Major James H. Doolittle (yes, that Doolittle) flying a purpose-built, single-seat racing biplane, the Laird LC-DW500 Super Solution aka "Sky Buzzard."

In October 1934 many U.S. aircraft manufacturers were stunned when the Bureau of Air Commerce banned the use of single-engined aircraft by commercial trunk (i.e. major multi-route airlines) airlines. Some manufacturers, such as Lockheed and Boeing had already philosophically and actually moved on to multi-engine aircraft by the time of this regulation.

DARK TIMES AND A NEW HOPE

The longest and deepest world-wide economic Depression began shortly after "Black Tuesday," 29 October 1929 when the combined effects of a decade of improvident and questionable economic practices and policies ticked off a sudden, steep down-turn in the New York Stock Market, creating an uncontrollable, cascading sell-off panic which, inter alia, caused stock prices to fall precipitously, essentially collapsing the U.S. economy and quickly thereafter collapsing the economies of virtually every country in the world. In the U.S., more than forty-billion dollars was lost in one year (approximately $562,000,000,000.00 in 2016).

That this catastrophe took place just as commercial air travel was beginning to become a popular and preferable way to travel was most inopportune. "The Depression," as it came to be called was, of course, just as a serious and almost fatal setback for the commercial aviation industry as it was for virtually every other industry. As businesses closed and shrunk, unemployment soared to eight-million in the U.S. (25%) by 1933. Even among the employed population, many of those who formerly might have been able to afford the price of an airline ticket now were compelled to tighten their economic belts and forego this luxury as well as many necessities. With the sudden fall-off of business, the new, burgeoning airlines were forced to cancel purchase contracts with aircraft manufacturers who, in turn, were forced to cancel purchase contracts for materials. All businesses were forced to lay off many of their employees who now, without steady income, could no longer afford to purchase many basic goods and food. This downward spiral played out similarly all over the world creating mass unemployment and extreme hardship for most of the industrial world's population.

After almost four years of the crippling Depression, in the Presidential election of 1932, Democrat Franklin D. Roosevelt easily defeated incumbent Republican President Herbert Hoover's bid for a second term. Along with winning the White House, the Democratic Party also won a majority in both houses of Congress. Hoover's policies limiting government regulation of the banking/investment industry during his administration (1929-33), among many other things were, fairly or not, widely blamed as causing the Depression. Roosevelt's victory was seen by most of the people in the U.S. and around the world as a fresh, new beginning, a cleansing rain that would soon wash away the current economic misery.

Despite the first Roosevelt Administration's many earnest attempts to end or at least to diminish the effects of the Depression by the creation of new administrations and authorities, most of which were declared unconstitutional by a very Conservative Supreme Court, the Depression in the U.S. did not essentially end until the commencement of WWII in Europe on 1 September 1939 when U.S. businesses began to sell supplies to Great Britain and other nations fighting the Nazis. In addition, in the late 1930's the U.S. military services began to spool up for what was seen to be a coming conflict involving the U.S. as well. Accordingly, U.S. businesses began to supply the armed services with what they required. This increase of industrial activity promoted a general long-awaited up-turn in the U.S. economy and quickly began to reduce the rolls of the unemployed.

Meanwhile, optimism created by President Roosevelt's inauguration on 4 March 1933, to some degree at least,

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eased the malaise that had settled into daily life and encouraged many businesses to take more chances and to try as well as they could to operate on a more normal, pre-depression footing. This optimism was also felt in the commercial aviation industry and, not perhaps entirely by coincidence, it was in 1933 that a revolution in commercial aviation occurred.

BOEING'S AND MARTIN'S ADVANCES EXPAND THE ENVELOPE

Seeking to manufacture multi-engine aircraft as well as supplying the United States Army Air Corps (USAAC.) with fighters, Boeing privately funded in a modification of its eight-passenger single-engine Monomail Model 221-A airliner into a two-engine bomber.

The resulting design, the Model 215 made its first flight on 29 April 1931 and whilst not the USAAC's first monoplane bomber, it was its first all-metal cantilever, low wing monoplane bomber.

Sleek, clean and powered by two 600 hp. Pratt & Whitney R-1860-11 Hornet B radial engines with new drag-reducing NACA cowlings and a semi-retractable undercarriage, including the tail wheel, the Boeing Model 215, designated YB-9 was the fastest U.S. bomber when it was introduced on 5 November 1931 with a top speed of 188 mph, just about matching the top speed of the USAAC's fastest single-engine fighter, Boeing P-12E at 189 mph.

The YB-9 design greatly advanced multi-engine aircraft by placing the engines directly in front of the wing on the leading edge rather than slinging them below the wing on drag-producing struts. It also had a cockpit-controllable rudder trim tab, the first on any U.S. aircraft. The improved 1932 Model 246 Y1B-9A went further still with a pair of slightly more efficient 600 hp. Pratt & Whitney Y1G1SR-1860B Hornet radials turning three-bladed propellers, metal covered control surfaces, and later a more efficient vertical tail surface. Whilst a giant step in the right direction, in some things the Y1B-9A design still held to older and by then outmoded concepts. Even with all of its innovations, Y1B-9A still had open-cockpit crew positions and no internal bomb bay. All ordinance had to be carried externally under the wings, largely negating the innovative drag-reducing elements of the aeroplane.

Touted as the "Fastest Bomber in the World," Y1B-9A was never ordered by the USAAC. Whilst this impressive Boeing bomber was being evaluated, the Glenn L. Martin Company in Baltimore, Maryland entered a competing and superior bomber design, the revolutionary, Collier Trophy-winning XB-907, with all-enclosed crew positions and many further innovations. It was accepted by the USAAC and designated B-10 and B-12. The 213 mph B-10/12 instantly made all existing U.S. bombers, including Y1B-9, obsolete, and set the standard for bomber design for decades. It had fully-enclosed engine cowlings, an internal bomb bay and an enclosed front gun turret, the first for any U.S. aircraft.

Although a failure as a potential and hoped-for military aeroplane, Y1B-9A led Boeing into the new world of large, multi-engine aircraft design and production of which it has been a leader ever since.

THE AIRLINER REVOLUTION(S) BEGIN

Some few aircraft designs stand out as being so innovative and forward-thinking that we call them "revolutionary" in that they make virtually all aircraft that came before them immediately obsolete and quaint. Boeing 247 is universally honoured as one of these.

An all-metal, anodized aluminium, low wing, two-engine, retractable-undercarriage, cantilever monoplane utilizing semi-monocoque construction, 247's design was imbued with all of the available aeronautical knowledge and innovation of its time.

247 first flew on 8 February 1933 and from that date, commercial air travel never looked backwards again. Among the innovations that 247 brought into common usage were: cockpit controllable trim tabs on all control surfaces, variable-pitch propellers, auto pilot, gyroscopic instruments for low-visibility (later IFR — Instrument Flight Rules) flying, and pneumatic de-icing boots for the wings and tail surfaces.

Its basic design was all-metal con-

Top: Boeing YB-9. Even though seen here in the Olive Drab and Orange-Yellow colors of the USAAC, it was not accepted by the USAAC. However, it did greatly influence the design of the first modern airliner, Boeing's 247.
Bottom: Martin B-10 in the new USAAC colors, seen here in formation with Boeing P-26A fighters in a line to the rear. No information available about this picture.

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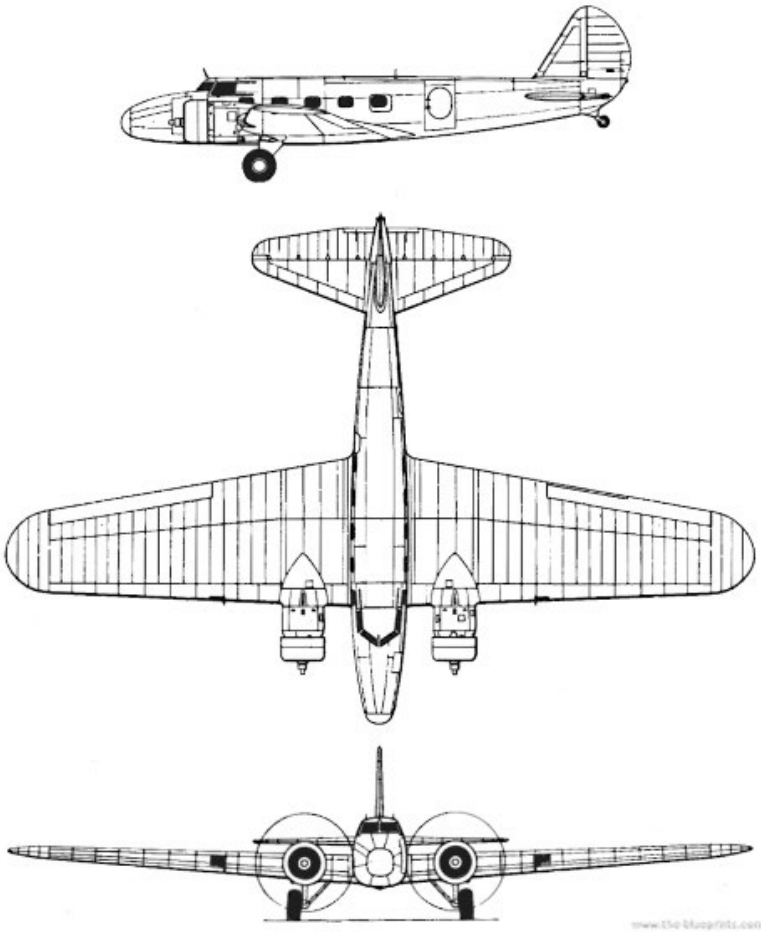

Three-view of the handsome and sleek Boeing 247. Note the thick wing which was a carry- over from past airliner designs and made necessary by the more primitive metallurgy of the 1930s. A thinner wing would have certainly added many mph to this aeroplane.

Top: This portrait of the 1933 Boeing 247D well-portrays the newly-adopted Boeing design formula. Picture two more engines, add a few bits and pieces and there is B-17D.
Bottom: Boeing 247D interior. Photo circa 1935

struction, low cantilever wing with engines in nacelles mounted on the leading edge of each wing became the model upon which all future piston engine, land-based airliners would follow.

247 carried ten passengers in greater luxury and comfort than any previous U.S. airliner. It featured thermostatically controlled cabin heating and cooling, soundproofed cabin, a galley for preparing (limited) in-flight food and beverage service, a lavatory, individual passenger air vents and reading lights. However, wing's main spar was mounted through the front of the cabin and some passengers had to climb over it to get to their seats.

In its initial incarnation, 247, whilst certainly impressive on many counts, did not exhibit spectacular performance due to its fixed-pitch propellers. Boeing took immediate steps to remedy this and very quickly after the first few 247s were built the improved 247D was introduced. Powered by two 550 hp. Pratt & Whitney S1H1-G Wasp radial engines turning Hamilton Standard adjustable-pitch propellers it had a top airspeed of 200 mph and a cruising airspeed of 188 mph at 8,000 feet, a rate of climb at sea level of 1,148 feet per minute and a service ceiling of 25,400 feet. However good all of these specs may have been, 247D's range was only 745 miles, insufficient for most western U.S. airlines where the distance between destinations could be as much as 900 to 1,000 miles.

Within five months after 247's first flight in February 1933 United Airlines (part of United Aircraft and Transport Corporation which also owned Boeing) had thirty of the sixty 247Ds it had ordered with more coming each week. TWA was also interested in buying 247Ds for its routes but was shut out by United's large order.

Frustrated, TWA looked around for an aircraft manufacturer to provide the aeroplane that they had in mind since 1932. TWA's original specifications for this new aeroplane were quite modest; it had to be all-metal, have three radial engines, cruise at 150 mph, carry twelve passengers and have a range of at least 1,080 miles. It also had to be able to service all of the airports on TWA's routes including the airport at Albuquerque, New Mexico, the elevation of which is 4,954'. In the summer the high temperatures there naturally give it an even higher density altitude. Additionally, TWA insisted that the new aeroplane would have to be able to takeoff and land with only one engine operating.

The 247D was faster than TWA's requirements and had only two engines which meant less expensive operating costs. It could handle airports a s high as Albuquerque and climb at maximum gross weight with only one engine running, however it did not have the required range, and only accommodated ten passengers.

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THE SECOND REVOLUTION

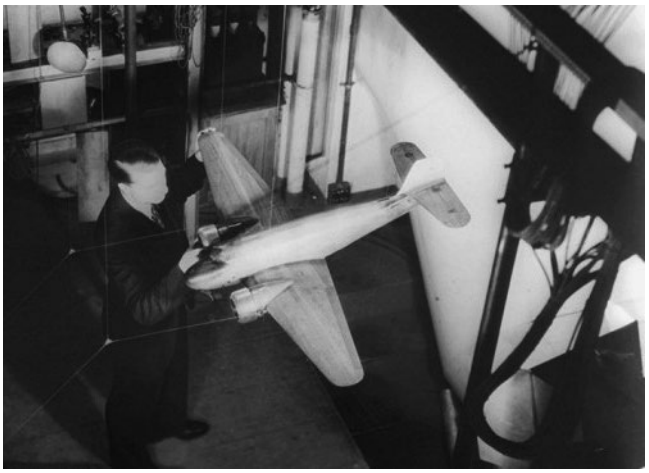
On 5 August 1932 Jack Frye, President of TWA sent a letter to Donald Douglas outlining TWA's specifications for a new airliner. Unknown to Douglas, Frye had already approached Boeing, but was not successful there. Boeing was more than satisfied with its plans for its forthcoming, revolutionary 247 which were coming along nicely.

Donald Douglas had great ambitions for Douglas Aircraft Company and he was intrigued with Frye's specifications, but cautious. Since the early 1920's Douglas Aircraft Company had been a successful supplier of a number of aeroplanes to all of the U.S. military services, including the elegant, gull wing B-7 bomber, the USAAC's first monoplane.

If Douglas built what Frye wanted it would be Douglas's first civilian aeroplane. Entirely confident that he and his design team[5] could design an aeroplane to more than satisfy TWA's specifications Douglas was, on one hand, hesitant to commit to designing and building this new aeroplane as he doubted that a sufficient number of them would be ordered. On the other hand, not at all pleased with leaving the field wide open to Boeing's 247, Douglas and his engineers went to work and designed the DC (Douglas Commercial) -1, the forerunner of the famous DC series of airliners. Introduced in July 1933 and powered by two 690 hp. Wright Cyclone SGR-1820F3 9-cylinder radial engines driving variable-pitch propellers, DC-1 outperformed the 247 both in speed and range, and with a twelve-passenger capacity, it had two seats more than the 247. DC-1 offered all of the amenities of the 247; however, its cabin was wider and more capacious than the Boeing and there was no wing spar in the cabin that passengers had to climb over.

Only one DC-1 was built as a test and demo model. Its maiden flight was on 1 July 1933 and it was extensively flown for the next six months. Seeing that the basic design was sound and practical, Douglas built a larger and improved version of DC-1, called DC-2. It was powered by two 730 hp. Wright GR-1820-F53 Cyclone 9-cylinder radial engines, and with capacity for fourteen passengers. TWA accepted DC-2 as its flagship on 15 September 1933. On 19 February 1934 a DC-2 made a record-breaking flight across the U.S., with fuel stops, in thirteen hours and five minutes of flight time.

DC-2 was what we today might call, "a smash hit." 198 DC-2s were produced from 1934-39. Nine U.S. airlines operated them, ninety were ordered by the various U.S. armed services before and during WWII, and many were purchased by seventeen foreign nations.



Clarence "Kelley" Johnson with the 55" scale wind tunnel model of the first, single tail design for Lockheed's Model 10 Electra.

Boeing's once revolutionary 247D could not compete with the new Douglas aircraft and so the short-lived reign of Boeing's 247 was over. *Rex mortuus est, Vivat rex!*

ANOTHER BRIGHT STAR FROM LOCKHEED

Even before the government's ban on single-engine airliners in October 1934, Lockheed was preparing to introduce its first all-metal, two-engine aeroplane, the Lockheed Model 10 "Electra" designed by Lloyd Stearman and Hall Hibbard. Yet another Lockheed aeroplane named for a star[6], it was introduced in 1935 was powered by two 450 hp. Pratt and Whitney R-985 Wasp Junior SB radial engines. So sleek and efficient was the Electra's design that it carried ten passengers faster than the Boeing 247D, and as fast as the Douglas DC-2, but with engines totalling only 900 hp. whilst 247D's engines totalled 1,100 hp. and DC-2's engines totalled 1,460 hp.

For airlines not requiring the four additional passenger seats of DC-2 it was the perfect choice. Lower in price and lower in overall per-hour operating costs, Electra 10 and its subsequent improved models A-E as well as the later Model 12 Electra Junior and Model 14 Super Electra were operated by thirteen U.S. and fourteen foreign airlines. Additionally, military versions were ordered by eight nations, plus the USAAC, the U.S. Navy, and the U.S. Coast Guard.

Electra was the first aeroplane of its kind to incorporate the latest known aeronautical methods of airframe streamlining and what would later be termed the "mass reduction" approach to aircraft design, e.g., eliminating as much as possible all that might add drag and/or weight. Lockheed had led the way in this method of aircraft design with its very efficient and sleek single-engine airliners and by

5 In 1933 Douglas Aviation's brilliant design team consisted of Donald Douglas, James H. "Dutch" Kindelberger, John Leland (Lee) Atwood, Arthur E. Raymond, Ed Burton, Jack Northrop, George Strompl and Fred Herman. Within this "dream team"

"Dutch " Kindelberger become North American Aviation's President and General Manager and he and Chief Engineer Lee Atwood went on to design and produce AT-6 "Texan," B-25 "Mitchell" and P-51 "Mustang," F-86 "Sabre" and other brilliant, ground-breaking aeroplanes; Arthur E. Raymond designed the DC-3, remained at Douglas until 1960, and was instrumental in the designs of every Douglas airliner from DC-2 through DC-8. He was a founding member of The Rand Corporation. Raymond was a Supervisor on NASA's Project Gemini and Project Apollo; Jack Northrop founded Northrop Aviation in 1939; George Strompl a talented Project Manager at Douglas, and Fred Herman, an up and coming engineer at Douglas were members of the design teams for DC-2 through DC-7.

6 Electra is officially catalogued as 17 Tauri, a blue-white giant star in the constellation of Taurus and is one of the nine brightest stars in the Pleiades open cluster. Electra and the other six most visible stars in this group are named for the Seven Sisters of Greek mythology.

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incorporating this philosophy into Electra's design, created the most aerodynamically efficient aeroplane of its day.

In 1933, when Electra was still on Lloyd Stearman (Lockheed's President and future designer of the Stearman PT-13 trainer and others), Hall Hibbard and Richard von Hake's drawing board, the great Clarence "Kelly" Johnson, then a green, twenty-three-year-old recent graduate of the University of Michigan and a newly hired Tooling Engineer at Lockheed, happened to give the design for Electra a look. He immediately and instinctively realized that it would have serious directional (yaw) stability problems with its then insufficiently large single vertical tail surface. When he rather brashly so advised Chief Design Engineer Hal Hibbard of this, Hibbard at first considered young Johnson to be working distinctly above his pay grade. However, to Hibbard's credit he did not dismiss the bold young man offhand, but backed Johnson's instinct and gave him the project of designing a solution, sending him back to the U. of M's new wind tunnel with a 55" scale wind tunnel model of the single-tail Electra. Tests conclusively proved Johnson's instinct to be correct and Electra's twin-tail was the result of Johnson's efforts and it became a trademark design of Lockheed thereafter. Johnson was immediately promoted to Design Engineer from which position he oversaw the design of P-38 "Lightning" and a bit later "Constellation."

Certainly the most famous flight of an Electra was that of Amelia Earhart's much modified Model 10E in her fatally tragic second attempt at a 'round-the-world flight with navigator Fred Noonan on 1 June 1937. Controversy, myth, legend and cinema abound as to what might have happened and as to the final resting place of Amelia, Fred and the Electra.

Lockheed Electra 10, the sleekest aeroplane of its time.

Amelia Earhart, a beloved aviation celebrity of the 1930s, stands before her modified Lockheed Electra 10 on 17 March 1937 in Oakland, California before flying it to Miami to begin her tragic second attempt at a 'round-the-world flight.

THE MOST SUCCESSFUL AIRLINER

Seeing how successful their DC-2 had been, in 1936 Douglas Aircraft Company with more than a little "push" from American Airlines, designed a larger and more powerful version of it, DC-3 and DST (the Douglas Sleeper Transport version). DC-3 was the culmination of this series of aeroplanes and it has proved to be a unique, timeless and most excellent aircraft, many of which are still in daily service today (2016). Having a cruise airspeed of 207 mph, it was as fast but no faster than the best of its contemporary competitors; however, it carried twenty-one sitting or fourteen to fifteen sleeper berths for a distance 1,500 miles with better passenger comfort than anything else in its day. It simply outclassed its competitors for a very long time and popularized commercial air travel as a viable and desirable alternative to rail. DC-3 raised the airline industry's bar once again leading directly to the four-engine airliners to come.

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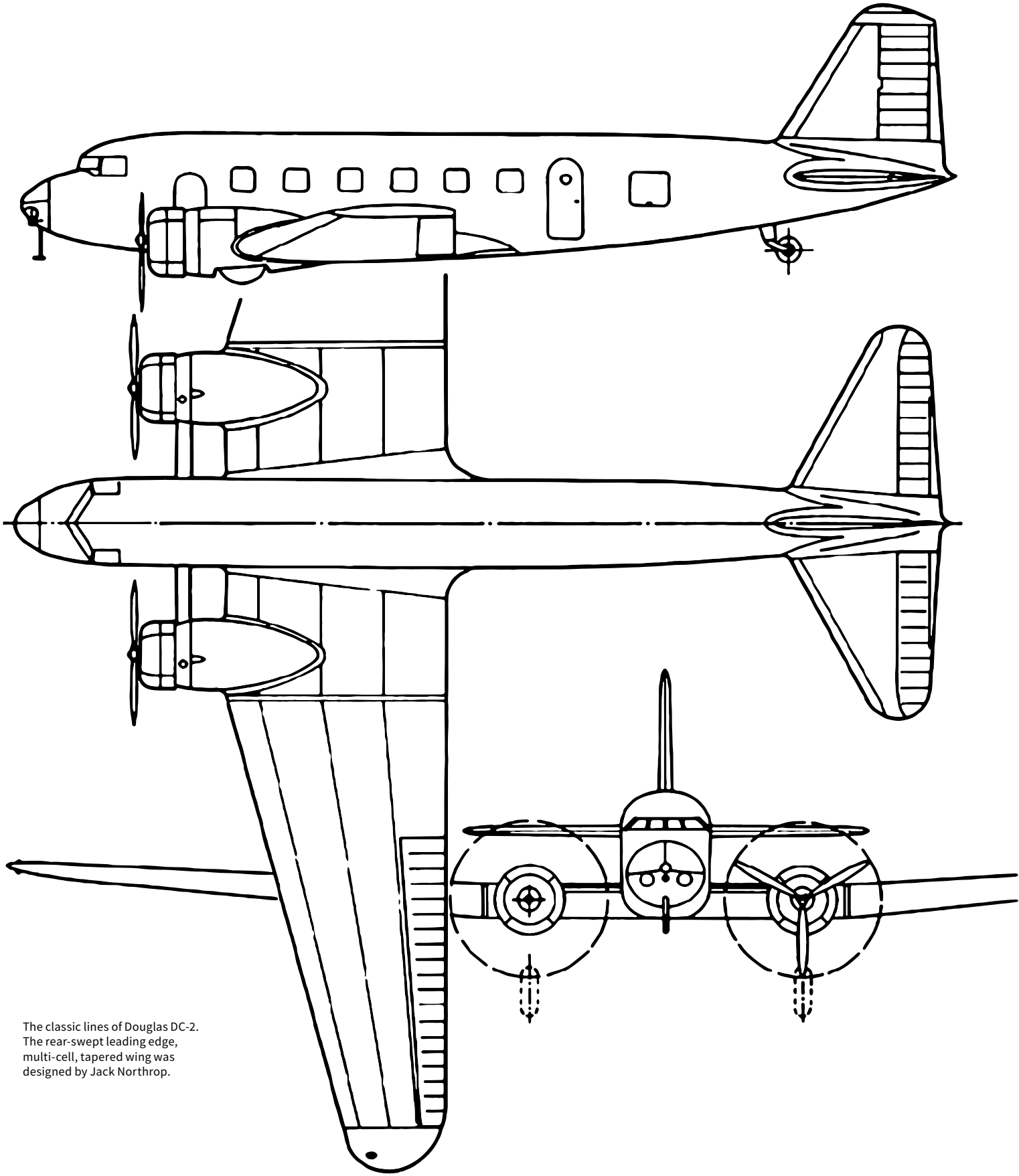

The classic lines of Douglas DC-2. The rear-swept leading edge, multi-cell, tapered wing was designed by Jack Northrop.

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Even though DC-3 weighed approximately 25,000 lb. when fully loaded with passengers, baggage and fuel, it could still operate in and out of the small grass airports that serviced smaller towns and even those located at high elevations. Its 1,500 mile range made long distance flights simpler and less expensive with less time-consuming fuel stops. In addition, it was rugged and relatively easy to maintain.

Powered by two 1,200 hp. Pratt & Whitney R-1830-S1C3G Twin Wasp 14-cyl. air-cooled two-row, radial piston engines driving two 3-bladed Hamilton Standard 23E50 series, constant-speed propellers, DC-3 had a service ceiling of 23,200', fully loaded, and could climb over most of the mountain ranges and bad weather that its competitors had to fly around. DC-3 pioneered true cross-continental commercial air travel and, with carefully-planned fuel stops, flew world-wide. By the 1930's, trans-continental and long distance passengers in the U.S. had become accustomed to taking Pullman-equipped trains in which they could travel both day and night, sleeping comfortably whilst the train chugged along, thus shortening the time of transit by many hours or even days. Transferring this system to long distance airliners made a lot of sense and was a big selling point for travelling by air. The DST's 14-16 sleeping berths and DC-3's 21-seat day cabin made it the first commercial airliner to enable its operators to make a profit solely flying passengers and not relying on additional mail and/or cargo.

Like many extraordinary things, DC-3 almost never was born. Donald Douglas had reluctantly built DC-1 and 2 and only after TWA's Jack Frye had wheedled him into it. Well, DC-2 proved to be highly successful which allowed the skeptical Mr. D to breathe a little easier.

Now, just about two years after that ordeal, the story goes that in early 1936 American Airlines CEO C. R. Smith began to call Douglas on a regular basis with an urgent request. Douglas couldn't refuse Smith's calls, American Airlines had purchased a goodly number of DC-2s and could not therefore be ignored. It might have gone something like this:

Donald Douglas's secretary's phone: *Brrrring, Brrrring*

DD's secretary: Douglas Aviation, office of the President, how may we help you?

Voice on the phone (somewhat grumpy): This is Cyrus Rowlett Smith, President of American Airlines, let me speak to Donny.

DD's secretary: (button push) — Mr. Douglas, I have a Cyrus Rowlett Sm....

DD (somewhat resigned): Alright Thelma, just put him through." (click) "Well C.R., how the hell are you?

CR (more than somewhat grumpy): Well, Donny, I'm feeling just as fine as when I called you this morning and the morning and afternoon before that. I'm feeling just f***ing fine, thank you. So, what are you gonna do about what I asked you?

DD (with some unction): I'm glad you're fine C. R. Listen, I've been thinking about your request for a larger DC-2, and yes, I know that the 2's cabin is only 66" wide and too narrow for side-by-side sleeping berths and... say, why do you need side-by-side berths anyway?

CR (with forced patience): Donny, if you weren't who you are I'd think you weren't running on all cylinders. Have you ever heard of the "mile-high club?

Typical airliner "Pullman" sleeper accommodations.

Douglas prototype DC-3/DST. Photo circa 1936.

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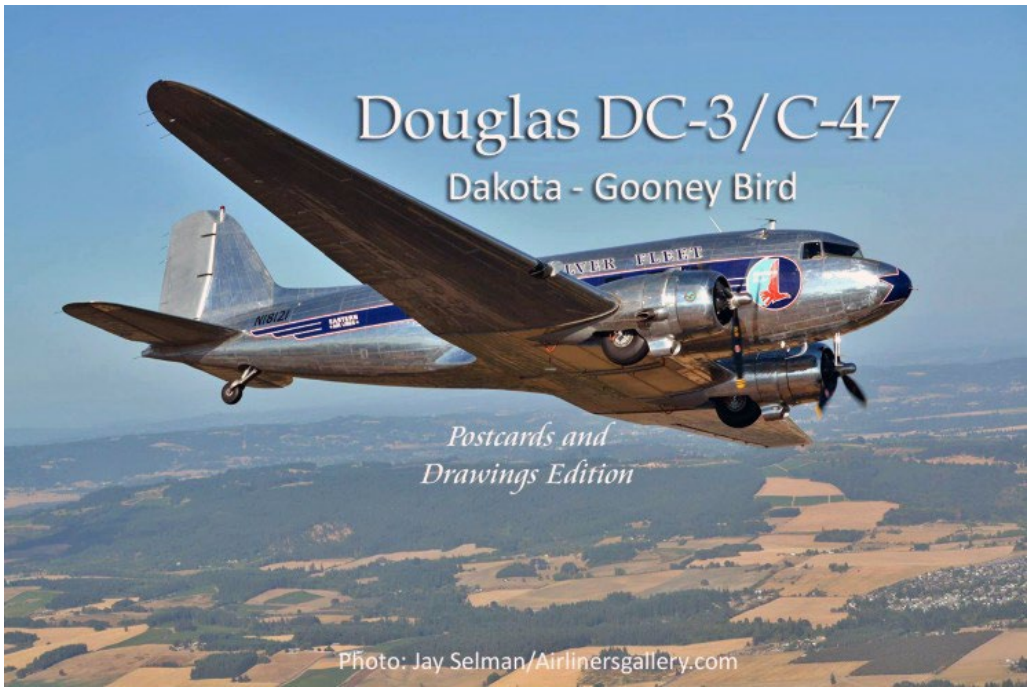

The ubiquitous, legendary and timeless Douglas DC-3 seen here in Eastern Airlines colors. One of the most successful aeroplanes of all time, it dominated air-transport world- wide from the time it was introduced in 1936, through WWII as C-47/Dakota, and well after. DC-3 was also known as "Gooney Bird", "Skytrain" and "Raisin Bomber" for its gallant service during the Berlin Airlift: 26 June 1948-11 May 1949, when it was often used to drop candy to bombed-out, hungry German children. Still in use in many forms and in many nations to this day, DC-3 is perhaps the most durable and versatile aeroplane ever built. The first of the truly modern airliners, DC-3's design and passenger accommodations in 1936 set the pace for all future commercial air travel.

A suitably awed (and well-tanned) Donald Douglas shaking hands with President Franklin Delano Roosevelt whilst receiving the Collier Trophy (on the President's desk in foreground) in 1935.

"Fifty Years a Lady", a painting by Craig Kodera.
"In my painting," said Craig Kodera, "I strove to evoke a sense of warmth, nostalgia and romance. Never have so many stories been written about a single airplane; never has an airplane been so much a part of our consciousness. It seems that everyone, at one time, has flown in a DC-3. This painting is for all of them. As unique as the airplane is, so too is the painting. My goal was to capture not just the airframe but indeed the spirit of aviation which is the Douglas DC-3." Amen, Craig.

DD: The what? Oh, oh yeah. Yeah, I get it.

CR: Yeah, and without side-by-side berths no one is gonna get it, capiche?

DD: So what you're telling me is I've got to design an entirely new plane, wider than the DC-2 so that we can put twin sleeping berths in it, right?

CR: That's it Donny boy. Seriously, you've got a great airplane in the two. Just think what we here at American and the folks over at TWA, Eastern and United could do with say, a 15 sleeper, 20 day seat, 1,200 mile airplane. By god, I bet you'd sell hundreds of them. Hell, I'll commit right now to buy twenty, sight unseen, with more orders to come. Really Don, the world is waiting.

Later in '36 the world got what it was waiting for — DC-3 and DST. Production of the civilian DC-3 ended in 1942, the first full year of WWII for the U.S., and by that time 607 had been built and sold before they came off the assembly line. This had to reassure Douglas as to the efficacy of the whole DC-3 project as it was the most numerous, by far, of any airliner built until then. In any event, history has proven that Donald Douglas had nothing to reproach himself about DC-3. The military version, C-47/R4D/Dakota added a further 16,000 sales and it was purchased or built under license by more than 40 domestic and international operators. DC-3s have flown deep into formerly unknown regions of the Amazon, operated from the trackless ice-world of the Antarctic to the remotest regions of Africa, and in every continent and country in the world.

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A full history of this aeroplane would surely include its stellar record of service in every combat theatre of WWII, as C-47/R4D/Dakota, however, that would require an entire book in itself and is beyond the scope of this discussion. DC-3 advanced aviation in immeasurable ways. As a civilian airliner it set the tone and pace for the Lockheed Constellation to come.

THE LAST OF THE TWO-ENGINE MAINLINERS[7]

In the years immediately after DC-3 commenced its absolute dominance in the commercial air-transport industry, very few new designs of its size and type emerged. After all, what was the point of competing with a sure winner? Except for Douglas' abortive DC-4E project, the only two new commercial aircraft to be successfully introduced in the U.S. after 1936 and before WWII (7 December 1941) were the Lockheed Model 14 "Super Electra" and Model 18 "Lodestar."

Introduced in October 1937, Model 14 Super Electra was, as its name implies, a super-sized Electra 10 designed by a team led by Don Palmer, with seats for 12-14 passengers, powered by two 900 hp. Wright SGR-1820-F62 Cyclone 9-cylinder, air-cooled radial piston engines. Super Electra featured a new type of flap, the Fowler flap[8] giving it excellent slow speed characteristics, and a high speed wing design which extends its performance envelope enormously and beyond anything else currently in commercial service. With a top airspeed of 250 mph, a cruise of 215 mph at 8,000' and a ferry range (with additional fuel tanks) of 2,125 miles, Super Electra was the fastest U.S. commercial airliner in the late 1930's. It was not in any way competition for DC-3, but it gave Boeing 247D and DC-2 a very good run for the money. 354 Model 14s were built which in the economically challenging late 1930s was a very good number of aeroplanes, indeed.

Electras of various kinds were the apparent first choice of long-distance record seekers. A man in a Super Electra who would soon become instrumental in the development of the Lockheed Constellation took off from Floyd Bennett Field in Brooklyn, New York on 10 July 1938 with a crew of four and circled the globe around the narrow northern latitudes. They stopped only long enough to top off the fuel and oil at Paris, Moscow, Omsk, Yakutsk, Fairbanks, and Minneapolis, landing back in New York on 14 July. The total distance flown was 14,672 miles and the total time was 3 days, 19 hours and 17 minutes. The man was Howard Hughes.

However well the Model 14 did as a commercial airliner for Lockheed, it was nothing in comparison to what it did for Lockheed as a military transport and light patrol bomber. The idea that the Model 14 would make a good light bomber is attributed to Clarence "Kelly" Johnson as is the re-design of Super Electra. Accordingly, in late 1937 Lockheed published a cutaway drawing of Super Electra, showing it internally set up as such. By chance, the drawing came to the attention of the British Purchasing Commission (BPC) who was also just by chance looking for a suitable maritime patrol aircraft design to supplement the RAF's Avro Anson.

Lockheed Model 14 "Super Electra". Photo circa 1939.

Great Britain's Prime Minister, Neville Chamberlain returning to England on 30 September 1938 after the second Munich Conference on 28-30 September. He is holding up the agreement that he made with Adolph Hitler giving Germany permission to absorb a large portion of certain provinces of northern Czechoslovakia in Bohemia, Moravia and Silesia, called the "Sudetenland" or "Southern Land", where many culturally and traditionally German Czechoslovakians resided. This became notoriously known as "The Great "Appeasement" and led to the fall of Czechoslovakia on 15 March 1939. The aeroplane in which Chamberlain flew back to England, its characteristic twin-tails seen here behind him, is a British Airways (the pre-war airline) Lockheed Model 14 Super Electra.

7 By "Mainliner" I mean those aircraft which flew the airlines' chief, long distance routes. Of course, two and three-engine aircraft have been and are U.S. airlines' short(er) haul aircraft since the advent of the four-engine airliners and are an equally important factor in commercial aviation.

8 Seen here, the Fowler flap was the invention of aeronautical engineer Harlan D. Fowler in 1924 who later won the 1949 Franklin Institute "Wetherill Award" for this invention. It was tested by the legendary Fred Weick at NACA in 1932 and found to be a revolutionary aeronautical advance. Fowler flaps were first installed on the Martin 146 bomber prototype in 1935. The 1937 Lockheed Electra Model 14 was the first production aircraft in which a Fowler flap was installed.

The Fowler design may be either a split flap (as seen here), that is, where the top of the trailing edge remains stationary as the flap is lowered below it, or more commonly a full trailing edge flap where part of the entire trailing edge is lowered. The unique feature of the Fowler is that it moves rearward as well as changing angle. This increases the actual area of the wing by lengthening the local chord, thus reducing the overall wing-load of the aircraft and increasing the local Reynolds Number. This increases wing's coefficient of lift (Cl), increases the wing's local Alpha and begins to increase drag proportionally after lowering approximately 25º which has the effect of, among other things, permitting a steeper approach without increasing airspeed (similar to a speed brake) whilst also reducing the airspeed at which the aircraft will stall.

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Lockheed Model 18 "Lodestar" operated by Alaska Star Airlines, later to become Alaska Airlines in 1944. Photo circa 1942.

An RAAF Lockheed "Hudson Mk I" looking quite bellicose. The blue and white roundels and fin flashes are the usual tri-color Type A, red centre, white and blue circle RAF/RAAF roundel and fin flash but with the red centre circle of the roundel and the forward red stripe of the Type A fin flash omitted. This insignia modification was done on all Allied aircraft throughout the Pacific Theatre beginning May 1942 for fear of the red circle being mistaken in combat for the red Japanese Hinomaru. The current, more familiar RAAF roundel with red kangaroo facing left or forward in the centre was adopted on 2 July 1956. Prior to that, the RAAF displayed the usual RAF roundels.

Lockheed learned that the BPC were coming to discuss Super Electra as a possible military aeroplane and feverishly modified one from the assembly lines according to Johnson's drawings in only five days and nights.

On 10 December 1938, Lockheed flew a demonstration of the militarized version of the Super Electra for BPC. After making the few changes that were requested by BPC in only 24 hours, Lockheed won a contract for up to 250 of what was to be called "Hudson Mk I." Powered by two 1,100 hp. Wright Cyclone GR-1820-102A radial engines it had a very respectable maximum airspeed of 246 mph at 6,500 feet. Lockheed, which had never before produced any kind of military aircraft now found itself supplying the RAF with a light patrol bomber, eventually complete with a Boulton-Paul Type C electro/hydraulic dorsal machine gun turret. Hudson's performance is comparable to the Nazi's Heinkel 111H-2 bomber.[9]

Lockheed's Model 18 "Lodestar" was a last gasp attempt to compete with DC-3. As a commercial airliner, Super Electra had been less than successful at this. It was faster than DC-3 but carried seven less passengers and was more expensive to operate. By further stretching Super Electra's fuselage another 5'6," eighteen passengers could now be accommodated, which Lockheed considered to be close enough to DC-3's twenty one. Powered by two 1,200 hp. Wright R-1829-87 nine-cylinder air-cooled radial engines, "Lodestar" had a ferocious top airspeed of 266 mph. Introduced in March 1940, sales of Lodestar were slow in the U.S. as hundreds of DC-3s had already been purchased and were operating with all of the domestic airlines.

Foreign sales of Lodestar were far better, nine having been purchased by the British Overseas Airways Corporation (BOAC), now British Airways, twenty-nine by the Netherlands East Indies, thirteen by New Zealand National Airways Corporation, twenty-one by South African Airways, and twelve by Trans-Canada Air Lines.

Lodestar's excellent performance specs and Lockheed's highly successful Hudson caused the USAAC to take interest in the aeroplane. In the build-up to WWII starting in 1940, a number of commercial Model 18 "Lodestars" were impressed into military service and designated C-60 by the USAAC and R5O by the USN. In February 1940 the RAF, already quite pleased with Lockheed's Hudson patrol bomber, ordered 188 of the larger and faster Lodestars which they named "Ventura." After 7 December 1941, a further order for 487 improved Venturas, Ventura Mk II was partially diverted to the USAAF which ordered 200 more and designated them

Lockheed PV-1 "Ventura" in U. S. Navy mid-WWII Pacific Theatre, tri-color camouflage.

9 2,941 Lockheed Hudsons in eighteen variants saw service throughout WWII with the RAF, RCAF, RAAF, RNZAF, USAAC-F, USN, Brazilian AF, Chinese Nationalist AF, Royal Netherlands AF, Portuguese AF, South African AF, Irish Air Corps, and the Israeli AF. The immediate and totally unexpected commercial success of the Hudson gave fresh courage to Lockheed who, to everyone in the aviation industry's surprise, entered an aeroplane pursuant to the USAAC's 1937 specifications for a twin-engine, high-altitude "interceptor" having "the tactical mission of interception and attack of hostile aircraft at high altitude." Lockheed's design team led by Hall Hibbard and Clarence "Kelly" Johnson came up with an unusual arrangement of twin beams and a twin tail (by then a Lockheed trademark) with a central "pod" for the pilot, guns and ammo. This resulted in Model 22, later designated by the USAAC-F as P-38 "Lightning."

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B-34 "Lexington."

In early 1942 the USAAF was, by tradition, responsible for land-based coastal anti-submarine patrols. Naturally always deeply resentful of this, the USN created plans for a land-based Naval air mission using fast, heavy patrol aircraft to find and sink Nazi submarines which were known to be operating in waters proximate to the U.S. The matter was resolved to both service's satisfaction when the USAAF needed the Navy plant in Renton, Washington State for the manufacture of Boeing B-29 Superfortresses. The Navy gave the plant to the USAAF in return for the right to operate land-based anti-submarine patrols and the transfer of all current B-34s to Naval service. Further, a navalised version of the B-34, named PV-1 Ventura would henceforth be built for the USN by Vega, a subsidiary of Lockheed. PV-1s served from the Aleutians to the Solomon and Gilbert Islands.

In 1943 Lockheed designed and built PV-2 "Harpoon," an even larger version of PV-1. After discovering serious problems with the new wing, it finally went into combat at the end of 1944 as PV-2D. With eight forward-firing .50 calibre machine guns it was used primarily as a formidable ground attack aeroplane. The RAF, RAAF, RNZAF, RCAF, South African Air Force, Soviet Air Force, also flew Venturas, and later a few Harpoons until the end of the war.

After WWII ex-military PV-1 Venturas were converted to civilian use as luxury executive transports by Howard Aero in San Antonio, Texas. With the fuselage stretched a further four feet, huge picture windows, decadently luxurious interiors, generous baggage compartments where the weapons and bomb bays had been, provision for more fuel, the Super Ventura was a prestigious, comfortable, desirable and most capable private corporate airliner. In the 1960s 18 Super Venturas, now called Howard 350s, were produced with heavier-duty PV-2 undercarriages. Nineteen or more Howard 500s were built with pressurised cabins. These ultra-transports were powered with two 2,500 hp. Pratt & Whitney R-2800-CB17 twin-row "Wasp" radial engines, had a top airspeed of 410 mph and cruised at between 350 and 378 mph at 25,000 to 35,000'.

WANTED: TWO MORE ENGINES PLEASE

All was going swimmingly well for the booming airline travel business in those innocent years between Lucky Lindbergh's great 1927 flight and the terrible and public faith-chilling, fatal crash on 31 March 1931 of a TWA Fokker tri-motor in which all on board were killed including the beloved Notre Dame University football coach, Knute Rockne. With that single stroke the reputation and public confidence in commercial aviation in general, and Fokker aircraft in particular was greatly shook.

However, in that halcyon year of 1929, before another kind of crash, aeronautical progress was healthy, its vistas seemingly unlimited. Whilst every manufacturer of large aircraft in the U.S. was busy trying to perfect a really useful two-engine airliner to replace the antiquated Ford and Fokker Tri-Motors, Anthony Fokker was hard at work with his formidable design team to develop a four-engine airliner.

NO, YOU BE A LONE EAGLE

A POEM BY OGDEN NASH

Ogden Nash

This and other equally clever, subtlety hilarious poems may be found in "Loving Letters from Ogden Nash: A Family Album" edited by Linell Nash Smith, Nash's daughter.

This inimitably humorous poem by the inimitable Ogden Nash came about after he witnessed the non-fatal crash of one of the world's first four-engine airliners, Fokker F-32 on 27 November 1929, mentioned on the next page.

I find it very hard to be fair-minded

About people who go around being air-minded. I just can't see any fun

In soaring up up up into the sun

When the chances are still a fresh cool orchid to a paper geranium That you'll unsoar down down down onto your (to you) invaluable cranium.

I know the constant refrain

About how safer up in God's trafficless heaven than in an automobile or a train

But ...

My God, have you ever taken a good look at a strut?

Then that one about how you're in Boston before you can say antidis- establishmentarianism

So that preferring to take five hours by rail is a pernicious example of antiquarianism.

At least when I get on the Boston train I have a good chance of landing in the South Station

And not in that part of the daily press which is reserved for victims of aviation.

Then, despite the assurance that aeroplanes are terribly comfortable I notice that when you are railroading or automobiling

You don't have to take a paper bag along just in case of a funny feeling. It seems to me that no kind of depravity

Brings such speedy retribution as ignoring the law of gravity. Therefore nobody could possibly indict me for perjury

When I swear that I wish the Wright brothers had gone in for silver fox farming or tree surgery.

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The Fokker F.32 was certainly a precocious aeroplane in 1929 with a seating capacity of 32 or sleeping capacity for 16. This was far greater capacity than even DC-3 which first flew seven years later. The F.32 was so far advanced of what was then flying the commercial airways that it might have been considered to be an object in a futuristic science-fiction story. However, neither H. G. Wells nor Jules Verne had anything to do with this monster aeroplane.

F.32 had a 99' wingspan, a 69' 10" fuselage length, a height of 16' 6" and was powered (or should I say "under-powered") by four 450 hp. Pratt & Whitney R-1340-7 Wasp, 9-cylinder, air-cooled radial engines mounted back to back, two under each wing. It was the second largest aeroplane in the world in 1929, the largest being the enormous Dornier DO X.[10]

Whilst Western Air Express, Universal Airlines (later Braniff Airlines) and Royal Dutch Airlines (KLM) all expressed interest in the aeroplane, uncertain economic conditions caused only Western Air Express to actually purchase only two of the total of seven F.32s built.

A good deal of confidence in F.32 was shattered when one crashed during a demonstration flight at Roosevelt Field, Long Island, New York on 27 November 1929 wherein a take-off on three engines was attempted. Many in the aviation industry were already of the opinion that this new Fokker was underpowered and that furthermore, the aircraft's back-to-back engine configuration, with an engine on each end of the under-wing nacelles caused each front-engines' two-blade propeller to create rearward turbulence which greatly interfered with the rear-engines' three-blade propellers' efficiency. Additionally, the rear engines suffered from severe cooling problems.

One of F.32's port engines was intentionally stopped for the three-engine takeoff demonstration, but the other port engine quit immediately after take-off and the Fokker crashed onto a nearby house. No one was killed, but the pilot and a crew member were injured.

This episode ended four-engine airliners in the U.S. for almost a decade, but by the end of the 1930's the enormous success of DC-3 gave the entire airline industry an injection of new optimism for further expansion, including larger aeroplanes.

10 The Dornier DO X airboat was powered by twelve 455 hp. Curtiss Conqueror water-cooled V12 engines carried up to 100 passengers in regular multi-stop transatlantic flights. Only three were built, but by 1932 and the onset of the Great Depression it was no longer regarded as a viable commercial aeroplane. One of this legitimate pride and wonder of Deutschland was thereafter displayed at Deutsche Luftfahrt-Sammlung at Lehrter Bahnhof, a museum in Berlin, and was most unfortunately destroyed during an RAF bombing mission.

No, this is not a photo of a vastly over-booked Fokker F.32. Looking, however, like something out of H. G. Wells' "Things to Come", this is one of the two Western Air Express Fokker F.32s in service in and around 1929-31. Fokker's trademark thick, cantilever wing is evident as well as the notorious back-to-back engine arrangement. A behemoth of an aeroplane, it represented the latest optimistic aeronautical advance of its time. Here we see the passengers standing on top of it and the three-man crew and the stewardess, who know better, standing below on terra firma. Such photos as this one were often used as publicity to prove the strength of an aeroplane's wing.

This 1939 ad hardly needs any sub-print. The picture alone is sufficient.

Far Left: Still photo from H. G. Wells' "Things to Come", a 1936 London Film Productions/ United Artists film produced by the great Alexander Korda and directed by the great William Cameron Menzies.

Left: In the 1930's, advertisements showing the availability of Pullman-style sleeping, as well as china plate/silver service dining accommodations in airliners was considered a very effective way to increase public acceptance and preference for air travel over rail. Undeniably much faster, if one could travel as comfortably pampered by air as by rail…

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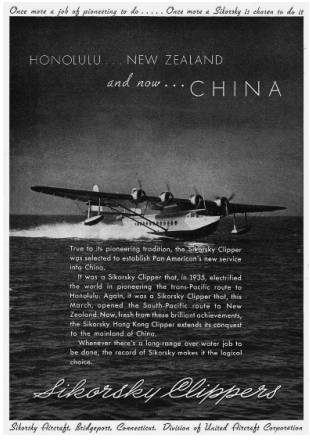
Dornier DO X Flugschiff ("flying ship") about to make its first flight. Suffering from the same inefficient back-to-back engine arrangement as the Fokker F.32, even with twelve engines it was woefully underpowered with a truly anemic rate of climb (less than 250 fpm), absolute ceiling (1,650') and top speed (105 mph). Set up in every way more like a ship than an aeroplane, three were built and successfully proved that commercial transatlantic flights were feasible.

In the late 1930's, even when the advertised product was, as here, not at all aviation related, the use of aviation images particularly where a female aviator, not-so-subtly referencing Amelia Earhart were pictured, was seen to be a helpful sales device.

In the late 1930's DC-3 was the latest thing in measuring the extent of human technical progress.



Sikorsky S-42 was generically known in its time as "The China Clipper" as were all of the other trans-pacific flying boats, likely because of dramatic advertisements like this one in all of the popular magazines and newspapers as well as the popular 1936 Warner Brothers film "China Clipper", starring Pat O'Brien and Humphrey Bogart. "The China Clipper" in the film was not, however, Sikorsky's S-42; it was Martin's M-130.

The emphasis of women aviators in advertising was a way to boost aviation in general by tacitly saying to men: "If a 'mere' woman can do it, well then, how about you?" Such casual, antediluvian, sexist attitudes were "de rigueur" and were unapologetically publicly expressed in days past, and are hopefully long gone.

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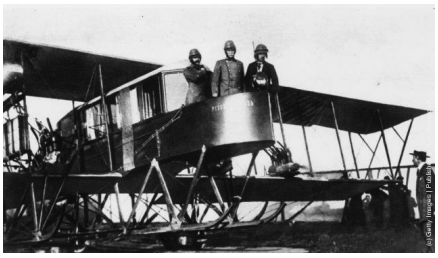

Sikorsky Ilya Muromets shown during WWI with its crew of manual engine starters.

Above, Top: Sikorsky's Russky Vityaz (Le Grand) the world's first four- engine aeroplane and first airliner. Yes, that is an open walkway in front of the cockpit for passengers to step out onto for a really good, if a bit windy, view whilst in flight. Russky Vityaz had two comfortable cabins for up to seven passengers, a saloon and a washroom – in 1913!
Above, Bottom: Sikorsky's 1913, 97' 8" wingspan Ilya Muromets, the world's first four-engine bomber. Maybe it's a Russian thing, like sitting backwards on the sill of an open window on an upper floor and bending backwards towards the outdoors whilst drinking an entire bottle of rum. (see/read: "War and Peace" by Leo Tolstoy - Chapter IX), but here again there are people standing on the fuselage whilst in flight without any apparent railing or support. These three in the foreground seem to be easily keeping up with the less-than-swift Ilya Muromets.

U.S. MANUFACTURERS TAKE THE FOUR-ENGINE PLUNGE

Igor Ivanovich Sikorsky (Russian: ИИ горь ИваИ нович СикоИ рский) was born in Kiev, Russia on 25 May 1889. Sikorsky was a bold and very forward-thinking aviation pioneer, designing and flying the Russky Vityaz (Le Grand) in 1913, with an upper wingspan of 91' 10," It was the world's first four-engine aeroplane and the world's first airliner. Only one was built; however, it flew successfully and set Sikorsky on his way to design an even bigger, "grander" aeroplane. In the same year, most spectacularly, Sikorsky designed the first four-engine bomber, Ilya Muromets, which was the largest aeroplane in the world in its day.

After WWI (The Great War), and more significantly the Russian Revolution, Igor Sikorsky, a devoted capitalist/industrialist at heart, emigrated to the United States in 1919. He founded the Sikorsky Aircraft Corporation in 1923 or 1925 (sources differ) and set up shop at Stratford, Connecticut (present day Sikorsky Memorial Airport) in 1929. In July of that year Sikorsky Aircraft Corporation became a part of United Aircraft and Transport Corporation (now United Technologies Corporation) and soon thereafter became a part of Vought Aircraft which, along with Chance-Vought which designed and built the famous F4U "Corsair," one of the most effective WWII naval fighters. In the 1930's Sikorsky designed and built two successful four-engine flying boats, S-42 and VS-44 "Excalibur" (the name of King Arthur's legendary, magic-infused sword), and designed, but never built a six-engine flying boat planned for Pan Am.

Igor Sikorsky, who despite popular opinion did not invent the helicopter, was the first to develop it as a practical aircraft. He designed and built Sikorsky R-4 the concept upon which most later helicopters have been based. Sikorsky Aircraft Corporation is best known today as a leading manufacturer of helicopters.

BOATS THAT FLY, OR AEROPLANES THAT FLOAT?

The reason that the flying boat was the most practical type of aircraft for travel to the Asian East was that in the 1930s there were very few airports in that part of the world, particularly few near the large coastal cities to which tourists wished to go, and none at all which were of sufficient size to handle large and heavy aircraft. On the other hand, it was no problem for a large Flying Boat to land and takeoff in the limitless span of open water near these cities; and additionally, docks were a lot less expensive to build than airports with long, paved runways. Flying Boat passengers were also surely much calmed in their minds when flying over such vast expanses of the Pacific Ocean in an aeroplane that could, if needs be, float.

The Sikorsky Aircraft Corporation (today a Lockheed Martin Company) literally took the four-engine "plunge" with its S-42, a long-range commercial flying boat[11] which

11 S-42 was more appropriately a "Flying Ship," although it and none of its type have ever been called anything other than "Flying Boats." According to hoary seafaring lore, a ship can carry a boat, but a boat cannot carry a ship. S-42s and other "Flying Boats" (sic) carried life rafts, i.e. boats, so QED, they are ships. True, an S-42 might be carried aboard an aircraft carrier (at least a modern one), but that would be the exception that proves the rule. Also, more practically, a ship's captain always gets rather annoyed if you refer to his vessel as a boat, but a boat's captain never gets annoyed if you refer to his vessel as a ship.

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Sikorsky Aircraft created to meet Pan Am's 1931 specifications. The aeroplane had to include wing flaps, variable-pitch propellers, and a full-length hull with the tail attached. It took three years to get it right and the first S-42 had its maiden flight 29 March 1934. During its testing the S-42 prototype quickly established ten world records for carrying the most payload to the highest altitude. A total of ten were built, the most famous two of them being "Flying Clipper" and "Pan Am Clipper."

Powered by four 660 hp. Pratt & Whitney R-1690 Hornet supercharged radial engines, with accommodations for 37 seated passengers or 14 sleeping berths, a maximum airspeed of 188 mph, a range of 1,930 miles, S-42 was the most advanced airliner of its day and proved to be very commercially successful. "Flying Boats" were aptly so-named because they were aeroplanes whose fuselages were essentially large boat (ship) hulls. S-42s operated in the Caribbean, from the continental U.S. to Central and South America, and across the Pacific and Atlantic oceans until WWII made such operations impractical.

VS-44 "Excalibur" was designed in 1940 by Sikorsky Aircraft whilst it was a part of Chance-Vought, and was primarily intended for transatlantic passenger crossings. Powered by four 1,200 hp. Pratt & Whitney R-1830-S1C3-G radial engines it had the same horsepower as a B-17.

VS-44 carried more than 40 passengers in luxury. Four were built, three of them for American Export Airlines (AEA), a part of the American Export Lines steamship line. AEA collectively called their VS-44s "Flying Aces," intentionally similar to the steamship line's ships called the "Four Aces." Individually the AEA VS-44s were named Exeter, Excalibur and Excambian, which were also the names of three of American Export Lines' four ships. VS-44 was the last of the great Sikorsky flying boats and was fitted out with all of the elite, first-class accoutrements of a luxury ocean liner. On board of the fully heated and ventilated cabin were full-length double sleeping berths, separate private dressing rooms, a full gourmet galley, a bar/lounge, a smoking lounge, a dining room and a snack bar.

Excalibur's provisions for passenger comfort were not only splendidly Babylonial, the aeroplane was a great aeronautical performer as well with a cruise airspeed of 160 mph and a whopping range of over 4,000 miles when fitted with additional fuel tanks. Its chief competitor was Boeing's 74 day passenger 314 Clipper, a larger and more powerful aeroplane than Excalibur but not, apparently, so much more superior a design. Even with 1,600 more total horsepower, 314 Clipper was 5 mph slower fully loaded and with a range 315 miles shorter. Even so, in 1939 Pan Am was more impressed with the larger and uber-luxurious 314 whose passenger capacity which was almost twice that of the Sikorsky. Passing on the Sikorsky, Pan Am purchased six Boeing 314s, and later six 314As to augment its three aerodynamically advanced Martin 130s. This was a serious economic blow to Sikorsky Aircraft Corporation almost went bankrupt when it was unable to recoup Excalibur's development costs. As a result, the spectacular Excalibur was the last fixed-wing aeroplane that Sikorsky ever produced.

During WWII the U.S. Navy impressed AEA's three VS-44s and put them into service as transatlantic military transport aircraft between New York City and Foynes, Ireland, designating them JR2S-1. The Excalibur crashed in 1942 and the Exeter was sold to a Uruguayan airline and crashed on 15 August 1947.

However, the fate of the Excambian is a wild and twisted tale that a maser fiction writer could not improve upon. In 1949 the Excambian was sold to Brazilian Tampico Airlines but it was left stranded in Ancon Harbour, Peru. This very well might have been the end for the Excambian, but it was not. She was purchased by two Americans in 1958 and ferried to Long Beach, California where she was refurbished, renamed "Mother Goose," and used to ferry tourists to and from the island of Santa Catalina, "26 miles across the sea" until 1967. In that year, Actress Maureen O'Sullivan's husband, aviator par excellance Charlie Blair, the owner of Antilles Air Boats at Charlotte Amalié (Amal-yay), St. Thomas, bought the Excambian and used her to take passengers to and from the various Virgin Islands.

Sikorsky VS-44A Excambian as JR2S-1 in better days, seen here in U. S. Navy Blue-Grey/Light Gull Grey camouflage with American Export markings rather than Naval military markings.

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On 3 January 1969, whilst landing in Charlotte Amalié Harbour, the Excambian hit some hidden rocks and was damaged beyond repair. I am sad to say that in 1972 the Excambian was beached at St. Thomas and shamefully converted into a hot dog stand for too long a while (any while was too long). In 1976, Blair gave the aeroplane to the National Naval Aviation Museum at NAS Pensacola, Florida. The Naval museum permanently loaned Excambian to the New England Air Museum at Bradley International Airport in Windsor Locks, Connecticut who had her trucked 67 miles west to Sikorsky Memorial Airport in Stratford, Connecticut for restoration. Once there, she was hangared no more than 300 hundred yards from where she had been born. It took ten years to restore the Excambian to its former glory and in 1997 she was returned to the New England Air Museum, reassembled, painted and put on permanent exhibition, a fitting end to the noble "Excambian," ironically the last remaining American-built commercial transoceanic, four-engine flying boat.

MARTIN

In 1934 Pan Am published a set of specifications for a flying boat that they wanted to purchase. The Glenn L. Martin Company, anxious to join the ranks of the manufacturers of large flying boats, designed and submitted M-130, which featured a clean, lower drag airframe and four 830 hp, later 1,200 hp. Pratt & Whitney R-1830-S2A5G Twin Wasp 14-cylinder radial engines, driving Hamilton-Standard "Hydromatic" constant-speed propellers.

Accommodating 36 day seats and 19 sleeper berths, with a cruise airspeed of 130 mph and a range of 3,200 miles, M-130 satisfied Pan Am's specs. Three were built, China Clipper (the real one), the Philippine Clipper and the Hawaii Clipper. A single, larger, twin-tail M-156, called Russian Clipper was built for the Soviet Union.

Most likely because of magazine and newspaper advertisements announcing flights to China such as Sikorsky's for its S-42 (below), as well as the release of the popular 1936 Warner Brother's film, "China Clipper," the public began to generically refer to all transpacific flying boats, Martin M-130, Sikorsky S-42, and Boeing 314, as "China Clippers," although it was only Martin's M-130 which was featured in the film.

Operating across the Pacific Ocean from 1938 through 1945, both in civilian and U.S. Navy guise, all three Martin Clippers were lost in fatal crashes, Pan Am's "Hawaii Clipper" in July 1938, the U.S. Navy's "Philippine Clipper" in January 1943, and "China Clipper" in January 1945.

The streamlined and efficient early model Martin M-130 made the most of its total 3,800 hp whilst its competitors required 4,800 hp and more to perform the same task. Photo circa 1940

This is the actual M-130 "China Clipper" in late-war U. S. Navy camo., overall Sea Blue. Photo taken in its last days as a U. S. Navy transport, circa 1944.

1936 Warner Brothers flyer for "China Clipper". Note the rough and highly inaccurate drawing of what is supposed to be a Martin M-130 which is featured in the film. Also note Humphrey Bogart's name placed low in the credits.

DOUGLAS

As early as 1936 and even before the DC-3 had flown, Douglas Aviation had been toying with the idea for a four-engine airliner. What they came up with was called DC-4 (the next number design from the company and also for its four engines). It was later and more commonly called DC-4E, the "E" for experimental. It had capacity for 42 (later 52) seated passengers or 16 sleeper berths as well as a number of "firsts" for a large airliner: a nose-wheel, power-boosted flight controls, a pressurized cabin, air conditioning, internal auxiliary power units, a low triple-tail, an A/C electrical system. It was powered by four 1,450 hp. Pratt & Whitney R-2180-A Twin Hornet 14-cylinder radials mounted on the wing with distinct toe-out, particularly the outer two engines.

One was built. United Airways did the test evaluation flights during 1939 and found that this early DC-4E would be expensive to operate and maintain and in its 52-seat incarnation, did not perform nearly up to what Douglas had hoped.

A redesign reduced the aeroplane's

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size and simplified much of the complex systems, eliminating the pressurized cabin. This new aeroplane was also called DC-4, the larger original aeroplane now re-named DC-4E in an attempt to avoid confusion which attempt has, for the most part, miserably failed. In late 1939 the lone DC-4E was sold to Imperial Japanese Airways who was then buying as many different U.S. aeroplanes as it could for the purpose of reverse engineering and technology transfer for the Japanese military aviation establishment. A fraudulent Japanese press release said that the DC-4E had crashed into Tokyo Bay, but it was actually hidden away and was being carefully studied by the Japanese aircraft manufacturer, Nakajima. What the Japanese learned from the big Douglas was used to design the Nakajima G5N bomber which was no more a successful design than the DC-4E itself had been.

Douglas Aviation left the four-engine concept alone for a few years and wisely heavily concentrated on developing what became DC-3. Douglas Aviation never again designed a triple or even a double-tail airliner.

BOEING

Boeing, which had eschewed building any more small aeroplanes earlier in the 1930s, had a four-engine airliner design of its own on the boards. Having already garnered much valuable experience in 1935 with their Model 299, which became the venerable B-17, in 1937 Boeing took the already well-proven wings, tail, rudder, undercarriage, engines and their nacelles from B-17C and put them on a newly-designed fuselage of a circular cross-section in order to facilitate cabin pressurization, a feature which would be a first for a large U.S. airliner. The new Boeing would be powered by four 1,100 hp. Wright GR-1820-G102A radial engines and called 307 "Stratoliner."

Still unflown, Pan Am placed a pre-order for eight of the pressurized, 33-35 seat, 241 mph top airspeed, 215 mph cruise Stratoliners. Transcontinental & Western Air (TWA, later to be called Trans World Airlines) pre-ordered five. This was sufficient for Boeing to begin production of the 307.

TWA Boeing 307 in flight. Rare color photo. circa 1940.

Boeing 307 as C- 75 in USAAF colors: Olive Drab 41/Neutral Grey. A screenshot from FS9 of Jens B. Kristensen's Boeing 307 with some mods by Glenn "Ozbeowulf" Duncan into a C-75 with appropriate panel.

A forward-thinking design by any standards, it was not as well thought-out as it should have been. While virtually every other manufacturer of large aircraft was turning to tricycle undercarriage as the new "standard," 307 Stratocruiser had an anachronistic tail wheel.

This was not 307's the only design flaw. The first production 307 had a successful maiden flight 31 December 1938; however, it crashed during a two-engine operation demonstration flight on 18 March 1939, killing all ten on board. The pilot found that he had to use full rudder-deflection to counter the yaw when only two engines were running on one side. This caused aerodynamic rudder-lock, preventing the rudder from being returned to centre when all of the engines were once again running. Accordingly, this inadvertently crippled 307 went into an unrecoverable spin.

A long dorsal fin was added to the existing one (and was also added to all existing B-17s as well) and this was shown to prevent 307's fatal rudder lock problem. Boeing 307 Stratoliner was introduced 8 July 1940 as the Battle of Britain was raging in the southern English skies.

The first actual customer for Boeing 307 Stratoliner was none other than Howard Hughes. In late August 1939 he had it fitted it out with enormous fuel tanks in preparation for an attempt to break his former 'round-the-world record set in a Lockheed Super Electra in July 1938.

Hughes was all ready to set out on the first leg of his flight on 1 September 1939 when breaking news flashed all around the world: Nazi Germany had invaded Poland. Europe was in shock and chaos and everyone understood that the war that virtually all the nations had dreaded but had not done enough to prevent, had commenced. Hughes had the extra fuel tanks removed from the aeroplane, fitted it with much more powerful 1,600 hp. Wright R-2600 engines, and created an ultra-luxurious "flying penthouse." As it turned out, Hughes hardly ever used it and in 1949 sold it to oil tycoon Glenn McCarthy.

Ten 307s were built and nine were delivered in March and April 1940. TWA received five 307s (Comanche, Navajo, Zuni, Cherokee and Apache) flying routes with three stops between Los Angeles and New York, Pan Am received three 307s (Clipper Rainbow, Clipper Flying Cloud and Clipper Comet) flying regular scheduled flights from Miami to Central and South America and, as mentioned, one 307 went to Howard Hughes.

Came 7 December 1941, and the next day the U.S. was in the war. Aeroplanes of all kinds were immediately required by the USAAF and any useful-looking civilian aeroplane was fair game. Pan Am was permitted to continue its 307 flights to Central and South America with its own crews under the strict control of the U.S. State Department. TWA's five 307s were purchased by the USAAF for transport aircraft and designated C-75; however, their revolutionary pressurization systems were removed to reduce weight.

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Painting by Ron Cole of Pan Am's 314, "Pacific Clipper."

The immense Boeing 314, the largest of the U. S. flying boats. Photo circa 1941.

found Excalibur to too small for its purposes.

By 1936 Boeing was well-experienced with ultra-large (for that time) aircraft having developed and flown its prototype B-17 in 1935. Determined to win Pan Am's contract Boeing designed and submitted a 152' wingspan 106' long Flying Boat that could accommodate 74 daytime passengers and 36 sleeping berths. This was the Boeing 314, the largest of the U.S. flying boats with passenger accommodations almost twice that of its nearest competitor, Sikorsky's 40-passenger "Excalibur."

Powered by four 1,600 hp. Wright Twin-Cyclone radial engines, Boeing 314's total of 6.400 horsepower made it the most powerful commercial aeroplane in the world at is introduction in 1939. Boeing's engineers incorporated short, airfoil shaped, lift-producing Dornier-style sponson water-stabilizers beneath the wing instead of heavy outboard wing floats which would have had to be retracted by heavy motors to reduce their drag in flight. These sponsons were also used as the passengers' entry/departure ramp. 314 was the first successful U.S. airliner with a triple-tail which it required to balance yaw stability, offsetting the enormous side surface of the forward fuselage.

In 1944 the USAAF returned these now very weary five 307s to TWA. Essentially worn out, TWA sent them back to Boeing for a complete re-build. The wings and horizontal stabilizer of the latest B-17G, new, more powerful engines and a new B-29-type electronics system were installed and passenger accommodations were increased to 38. Whether the cabin pressurizing system was re-installed is not known to this writer, although it is likely that it was. TWA began to fly their new 307s and continued to do so even after it had purchased an entire fleet of new Lockheed Constellations. TWA's old 307s soldiered on for five more years and were retired in April 1951.

Pan Am was a major player in the Flying Boat industry of the late 1930s and early 1940s. Its enormous economic power meant that U.S. aircraft manufacturers gave it more than serious attention. In 1936 Pan Am published notice that it was seeking to purchase six flying boats that could meet it strict specifications which included having sufficient range to cross the Pacific and Atlantic oceans with few stops or preferably, non-stop. As mentioned above, among the aeroplanes considered was Sikorsky's VS-44 Excalibur, but Pan Am was trying to both raise the bar of ultra-luxury air travel and carry more passengers on each flight. Accordingly, it

314's performance in the air, cruising at a maximum of 188 mph, but only 155 mph when fully loaded, was almost as fast as Sikorsky's VS-44 and faster than Martin's 130, which was not surprising given 314's thousands more horsepower. In addition to this, 314 outshined all other competition in its passenger accommodations. Rivaling and in some ways even besting many ocean-going liners, 314's one-class accommodations featured luxury staterooms, huge lounges and dining rooms available at all hours, the galleys were run by chefs and staff from some of Europe's finest four-star hotels and restaurants, there were separate dressing rooms and lavatories for men and women, six-course meals were served by a huge staff of experienced waiters, Damask linen table cloths, bone china plates, Waterford crystal goblets and sterling silver service adorned each table with service available at virtually any hour. The standard of luxury on Pan American's Boeing 314s has never been matched by any heavier-than-air-transport.[12]

12 Possibly only the L Z 129 Hindenburg hydrogen-filled dirigible had equally luxurious passenger accommodations to Boeing's 314. However, the Hindenburg's cabins were reputed to be somewhat cramped while 314's were not.

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The U.S. War Department purchased Pan Am's 314s during the war and used them for special long-range transport duty designating them C-98. One such famous flight was the one in which President Franklin D. Roosevelt and his entourage traveled in a C-98 which had been Boeing 314 "Dixie Clipper" to the Casablanca Conference to meet with Britain's Prime Minister, Winston Churchill and The Free French Government leader, Gen. Charles De Gaulle on 12-24 January, 1943 at the Anfa Hotel in Casablanca, French Morocco in North Africa.

Three of the U.S. War Department's 314s were sold to the British Overseas Airways Corporation for special transatlantic flights. PM Winston Churchill was initially opposed to this purchase, but after he flew in two of them during the war, he was effusive in his praise for the 314 and, it may be well-assumed, particularly for its more-than-comfortable accommodations.

Some of the U.S. government's 314s were returned to Pan Am near the end of the war, but by then the huge flying boats were no longer required for long-distance over-water travel. During the war the Allies had built many large, new airports for bomber operations in the Far East and elsewhere with long runways, and by then a new breed of fast, long-range, inter-continental airliners had been born. One of these was Lockheed's Constellation.

DOUGLAS DC-4, CONSTELLATION'S EARLIEST COMPETITOR (AND ALSO NOT)

The failure in the late 1930's of Douglas' DC-4E to reach production (See above) did not mean that the four-engine concept was not still being pursued at the Douglas Aircraft Company. By the late 1930's and early 1940's Douglas, as well as every other manufacturer of large passenger aircraft well-understood that the four-engine airliner was the foreseeable future of all long-distance, transoceanic and worldwide commercial air-transport. Given the major air carriers' strong negative responses to DC-4E, Douglas realized that perhaps it had indeed been a bit too ambitious with regard to its size and complexity. Accordingly, a new, smaller, simpler and more operationally economical aeroplane was designed, one that hopefully would not scare off potential purchasers. This was the forty + passenger DC-4.

Eastern Airlines and United Airlines, the most prolific purchasers of Douglas's DC-3, were particularly interested in a new, four-engine airliner from Douglas and were ready to make large orders for same. Naturally encouraged by this, Douglas lost no time in getting the DC-4 design off the drawing boards and into a flying prototype.

Some of DC-4E features were retained, such as the tricycle undercarriage, a cylindrical cabin similar to Boeing's 307. This, as it turned out was quite the best choice as a cylinder is most fluently amenable to lengthening and pressurizing which later made DC-6/7 an easy upward transition. Like DC-4E's cabin, DC-4's cabin was originally going to be pressurized; however, in the interest of economy and simplicity this feature was not made standard but was only available by special order, which was never ordered.

That which was most saliently abandoned from DC-4E was its size and its expensive-to-build, aerodynamically inefficient triple-tail. A single, more efficient vertical tail topping at 27' 6," only two feet taller than DC-4E's triple-tail, was designed for DC-4.

We all know of Robert Burn's often quoted bromide, "The best laid schemes o' mice an' men Gang aft a-gley" (go often awry) was never more apt than in the situation facing both Douglas and Lockheed in 1941. Just as DC-4 was ready for production and the expected virtual certainty of plentiful sales to every major U.S. airline was about to become a reality, the United States found itself embroiled in a new world war.

Douglas's DC-4 and Lockheed's L-049 "Constellation" were developed literally at the same time; however, DC-4 flew first on 14 February 1942, two months and seven days after Pearl Harbor, beating Constellation's first flight on 9 January 1943 by five days less than eleven months. Orders from the government were that DC-4s were to be built as fast as possible and every one was to go to the USAAF as C-54 "Skymaster" or to the USN as "R5D." Between 1942 and 1947 1,170 C-54s were built for use by the U.S. and foreign military services.

Restored USAAF C-64 "Skymaster" in early-war markings and colors: Olive Drab ANA 613 above and pre-ANA Neutral Grey QMA #43 below, at Chico, California in 1982.

President Franklin D. Roosevelt, PM Winston Churchill and General Douglas MacArthur were frequent flyers on C-54s during WWII. The RAF, French Air Force and more than thirty other nations used C-54s for long-distance air-transport. The United States Air Force (USAF) was created by the signing of the National Security Act of 1947 by President Harry S. Truman whilst he was appropriately on board his personal C-54, "Sacred Cow." During "The Berlin Airlift" (26 June 1948-12 May 1949), more than 300 USAF C-54's flew thousands of

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sorties carrying food, medicine, heating fuel, etc. to the isolated people of West Berlin.

During WWII Douglas Aircraft Company began to develop a DC-4 for commercial use after the war; however, after the war ended in 1945 many hundreds of military C-54s were surplused and bought cheaply by U.S. air carriers. This cut deeply into the sales of any newly built DC-4s; however, Douglas' unsettled and unsettling bottom line was somewhat assuaged by the hundreds of C-54s and R5Ds which the airlines who had bought them sent back to Douglas for extensive re-fitting and re-equipping to civilian DC-4 standards.

Airlines which bought re-civilianized DC-4s include: Western Airlines, Pan American Airways, Northwest Airlines and National Airlines and in the U.S., as well as Iberia Airlines (Spain), Scandinavian Airlines System (SAS) , Sabena World Airlines (Belgium), Royal Dutch Airlines (KLM), Swissair, Air France, Avianca (Colombia), Cubana de Aviación, South African Airways, Aerolíneas Argentinas and Aeropostal (Venezuela). Soon newly built Douglas DC-4s were used fly regularly scheduled transatlantic flights from cities in South America and Cuba to cities in Europe. The first airlines to do this include: Aeropostal, Aerolíneas Argentinas and Iberia Airlines in 1946, and Cubana de Aviación in 1948.

In some ways DC-4 was a direct competitor of Constellation, but in some ways it was not. L-049 Constellation has seating capacity for 60, twenty more passengers than DC-4 in its normal civilian configuration and L-049 Constellation's payload is 7,188 lb. greater. Constellation's cruise airspeed is 313 mph compared to DC-4's cruise airspeed of 227 mph, a full 86 mph difference. DC-4's service ceiling is 22,300' and Constellation's service ceiling is 25,300. This may not seem to be much of a difference until it is realized that DC-4 cannot legally fly above 8,000' with passengers as it is an unpressurized aeroplane, whilst the pressurized L-049 Constellation can fly with passengers at 20,000 whilst maintaining the legal maximum cabin altitude with passengers of 8.000'. Later and improved pressurization systems permitted Connie to fly much higher whilst maintaining the legal cabin altitude.

In the immediate post-war era, Lockheed's L-049 (introduced 5 Feb. 1946) and Boeing's 377 Stratocruiser (introduced 1 April 1949) ruled the long-distance, high-altitude commercial skies. DC-4 was used mostly for charter and short distance routes. In all, only 78 commercial DC-4s were built as compared to 1,162 military C-54 "Skymasters," many of which were converted to civilian specifications after the war.

It was not until DC-6 (April 1949), a lengthened, pressurized and more powerful version of DC-4, eventually powered by four, super-reliable Pratt and Whitney R-2800s, and more particularly the later DC-7 (November 1953) with four Wright R-3350's that Douglas finally found the correct formula with which to truly compete with Connie which had already been flying commercially for twelve years. To match the devilishly swift Constellation, Douglas DC-7 pilots were required to use very high power settings on those Wright R-3350s which resulted in many engine failures due to overheating the rear bank of cylinders. It was said that "A DC-6 is a four engine airplane with three-bladed props, while a DC-7 is a three-engine airplane with four-bladed props."

TWA DC-4. Photo circa 1956. Note the utilitarian lines and proportions of DC-4 which were carried over to DC-6/7. Compare them to Constellation's graceful curves (below).

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The progressive but strange-looking, slow, heavy and deeply flawed Bell XFM-1 "Airacuda" was labeled a "heavy fighter" before wartime experience turned that phrase into an ironic oxymoron.

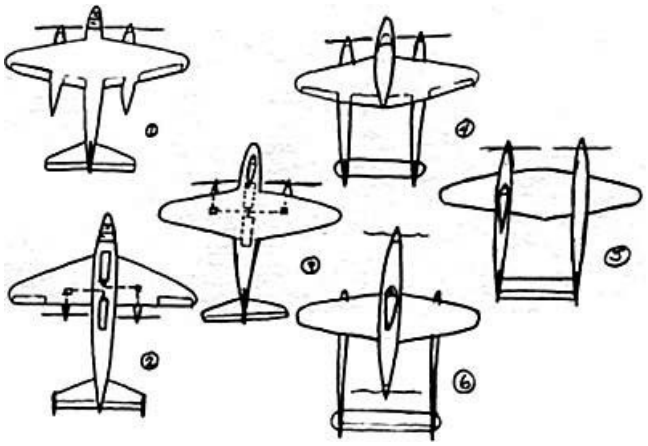
LOCKHEED RISING AND THE BIRTH OF CONSTELLATION

As we have seen, there was a great leap forward in commercial aviation in the middle to late 1930's. The day of the long-distance four-engine airliner had come in the form of both land and sea based aeroplanes. With the exception of the huge flying boats which were not in any event built in large numbers, the major U.S. airlines, pleased with the easy maintenance and low-cost operations of two-engine aircraft, were reluctant to support the new, larger, four-engine designs. Rejecting outright Douglas's DC-4E and barely accepting Boeing's 307, the writing, however, was clearly on the wall — as the decade waned, a new age of air travel had begun which would surely have flourished then, but for WWII.

In 1937 Lockheed was in a period of unaccustomed hectic and most profitable business with the commercially and critically hugely successful Electra and Super Electra/ Hudson Patrol Bomber. In that same year, the USAAC presciently published Circular Proposal X-608, a list of performance goals for a twin-engine, high-altitude "interceptor" which was to have "the tactical mission of interception and attack of hostile aircraft at high altitude."

Lockheed had submitted a design to the USAAC for a two-engine fighter in 1936 but had lost to the progressive but awkward Bell XFM-1 Airacuda. Disappointed by that experience, when Hall Hibbard and Clarence "Kelly" Johnson, Lockheed's top engineers, read that the Army's specs called for a maximum airspeed of at least 360 mph at 20,000', and a climb to 20,000 ft. within no more than six minutes, they wondered if even their fertile and creative brains could create such an aeroplane. Much encouraged by the overwhelming success of the militarization of their Model 14 Super Electra into Hudson Bomber, they started to draw some designs.

Doing some initial calculations, the math told them that a conventional two-engine design (with which they were much experienced) would be too heavy and would produce too much drag to meet the Army's specs regarding the performance that the Army required. Many interesting shapes and arrangements were drawn until they hit upon one that they thought would work.



This is a copy of some of what Clarence "Kelly" Johnson's scribbled whilst trying to find a suitable form for the proposed Lockheed Model 22 which became P-38. Note that two designs (2 and 3) included engines mounted in the fuselage turning outboard propellers on the wings.

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Going with an unusual layout for a fighter of twin-beams for the main undercarriage wheels, engines, radiators, turbochargers[13] and vertical tails, a central pod for the pilot and guns and a tricycle undercarriage, Lockheed Model 22, which the USAAC designated P-38 "Lightning," was born.

Investing over $600,000 of its own money in the XP-38[14] prototype Lockheed built Model 22 and it exceeded all of the USAAC's specifications. Part of P-38's success was its efficient airfoils and wing planform which permitted it to perform so well at high altitudes. This excellent wing was not forgotten at Lockheed with regard to future designs as we shall see.

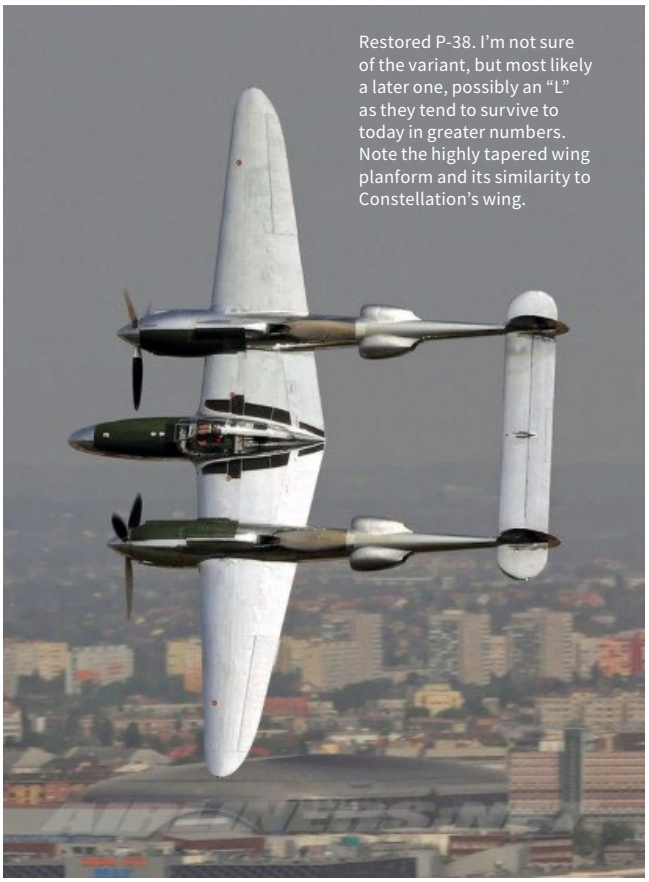
All of the components of an aeroplane's structure are designed with the understanding that compromises must be made. What benefits the aeroplane in one place, is taken away from it in another, and so on. Sometimes, however, a particular design feature fortuitously resolves more problems than it creates. After hitting upon the twin-beam design for P-38, it was soon discovered that a number of solutions to the usual design problems were solved.

When Hibbard and Johnson were contemplating the wing design for P-38, they realized that as long as the twin beams contained the large main undercarriage wheels, turbochargers, retract motors and mechanisms that those things, which are usually contained in the wing, they would have leave to design a thinner, cleaner, and simpler wing. Only on-board fuel tank capacity remained as an issue.

The broad-chord inner sections of the wing from the fuselage to the twin beams were designed to be thick enough so as to contain large fuel cells, have a deep enough spar to carry the beams and be aerodynamically efficient. Accordingly, the planform and airfoils selected for P-38 made it one of the cleanest and fastest aeroplanes of its era. When it later came time to design a wing for Constellation, Hibbard and Johnson looked to P-38's basic wing planform and airfoils: high aspect-ratio, sharply double-tapered, NACA 23016 airfoil at the wing root and the NACA 4412 airfoil at the wing tip.

In 1938, during the same time that P-38 was being designed and tested, Lockheed was contemplating a four-engine design which would be larger than the Electra Model 14 to compete with the industry-dominating DC-3 and Boeing's new, four-engine, pressurized 307. Lockheed Model 44, soon to be called "Excalibur" (apparently a popular aircraft name) was intended to be an improved "Lodestar" potentially capable of carrying 38 seated passengers (six more than DC-3 and the same as 307) and cruising at 268 mph at 12,000' (61 mph faster than DC-3 and 53 mph faster than 307). "Excalibur's" range was initially expected to be better than DC-3's but not quite as good as 307's, however ways of expanding its range were well within the range of possibilities.

Lockheed's talks with executives from Pan Am about "Excalibur" made it clear that they would not be willing to purchase a new four-engine land-based airliner that did not have capacity for at least 30 passengers and have a cruising speed of at least 270 mph. This was soon increased to 36 passengers and 300 mph, 112 mph faster than the latest Boeing 314A Clipper, though carrying 38 less passengers, and 115 mph faster than Boeing 307 with approximately the same amount of passengers. Pan Am's specs reflected the common belief in the late 30's that land-based transcontinental airlines could not fill more than thirty to thirty-five seats on a regular basis, if that many, as well as the understanding that passengers naturally wanted to get to their destinations as quickly as possible.



Restored P-38. I'm not sure of the variant, but most likely a later one, possibly an "L" as they tend to survive to today in greater numbers. Note the highly tapered wing planform and its similarity to Constellation's wing.

13 The difference between a turbocharger and a supercharger is that a turbocharger's compressor wheel is spun by hot exhaust gases which are compressed and sent back to the manifold and a supercharger's compressor wheel is spun by a mechanical connection to the engine which compresses incoming air and sends it to the manifold. Both send compressed gasses or air and pass them back to the engine manifold to allow higher manifold pressure when at high altitudes where the available outside air is rarefied

14 The XP-38 was Lockheed's sole example of the new aeroplane and it was developed in deep secrecy for a while, but the Army decided to test its speed and range. A transcontinental flight with two refuelling stops, from March Field, California to Mitchell Field, Long Island, New York was arranged to commence on February 11, 1939. All went well, the average airspeed of the XP-38 being clocked at 340 mph. However, on the approach to land at Mitchell Field, one engine suddenly quit, the aeroplane sank and hit the tree tops before reaching the runway and crashed, totally destroying Lockheed's sole prototype. Test pilot Lt. Benjamin S. Kelsey was seriously injured but survived. Despite the tragic crash the Army was duly impressed with the XP-38 and ordered 13 YP-38s. It went on to become one of the Allies' finest and most versatile combat aircraft. By the end of WWII 10,037 P-38s had been built. The top two U.S. WWII aces, USAAF Major Thomas B. McGuire (38 kills) and USAAF Major Richard Bong (40 kills) flew P-38s.

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P-38's tricycle undercarriage[15] was a first for Lockheed. It worked out so well that it was planned that "Excalibur" would have a nosewheel as well. Full-scale mock-ups and test models were built in contemplation of the commencement of production of "Excalibur" for Pan Am. However, in 1939, before production could get under weigh, a man who had just bought controlling stock of a certain major airline and had taken charge of it, as was mentioned before, had an idea for an airplane.

The major airline was TWA (standing then for Transcontinental & Western Air) and the man, Howard Hughes.

Here is just as a short reminder of what Mr. Hughes' aviation related records and influence were as of the late 1930s:

- 1927-30 — Hughes produced the film "Hell's Angels" starring the incendiary 18-year-old Jean Harlow. One of the earliest partially-talking films, it also included a scene in Technicolor. The late and great Paul Mantz, was the principle stunt pilot. Hughes himself flew in the film and was seriously injured in a stunt that Mantz had warned him was too difficult to pull off safely. It was. Hughes spared no expense on the production, temporarily assembling the world's largest collection of authentic WWI-era fighter aircraft that time. "Hells Angels" is considered to be one of the great aviation films.

- 1932 — As "Charles Howard," Hughes worked anonymously as a Co-pilot for American Airlines. He wanted to learn about the airline business from the ground up.

- 1933 — Specially modifying a Boeing Model 100A (civilian version of the USAAC's P-12E fighter), Hughes set a speed record of 212 mph at Los Angeles Airport.

- 1934 — Created "Hughes Aircraft Company," essentially a think-tank of the greatest aviation minds in the U.S. They come up with the highly innovative Hughes H-I racer which, on 13 September 1935 and flown by Hughes himself, set a new aircraft speed record at 352.39 mph before crash landing in a farmer's field. Hughes became, for a while, the fastest man in the world.

- 1936 — Hughes set the speed record in a Northrop "Gamma" for non-stop flight from New York City, New York to Los Angeles, California in eight hours and twenty minutes.

- On 19 January 1937, in his H-1 modified with longer wings called H-1B, Hughes broke his own previous record for a transcontinental non-stop flight from Los Angeles, California to Newark, New Jersey in seven hours, 28 minutes, 25 seconds.

- On 14 July Hughes completed a record setting 'round-the-world flight in a modified Lockheed Model 14 Super Electra in three days, nineteen hours and seventeen minutes, beating Wiley Post's 1933 record.

- Hughes received numerous awards as an aviator, some of the more notable being: the Harmon Trophy in 1936 and 1938, the Collier Trophy and the Bibesco Cup of the Fédération Aéronautique Internationale (FAI) in 1938, a special Congressional Gold Medal in 1939 and the Octave Chanute Award in 1940.

Looking like a movie star himself, this is Howard Hughes on 13 September 1935, two months before his 30th birthday, and the day that he broke the world's speed record by flying 352.39 mph in this remarkable and influential aeroplane, the Hughes H-1, on its first flight. Republic P-47, Focke-Wulf 190 and Mitsubishi "Zero-Sen" have all been said to have been highly influenced by the H-1 and all of their designers have denied it. However, many find that there is more than a coincidental look about all of these aeroplanes.

15 The period starting in 1939 and during the next few years saw the coming of the tricycle (nosewheel) undercarriage both in civilian and military aircraft. There was no turning back once the benefits of having good visibility and handling whilst on the ground as well as far less accident-prone takeoffs and landings that a nosewheel afforded were understood and experienced. The 1936 Douglas DC-3 and the 1940 Boeing 307 were the last major U.S. airliners with tail wheels. The 1939 B-17 and the 1941 Lockheed B-34 "Ventura"/"Harpoon" series were the last USAAC-F bombers with tail wheels. The 1941 Consolidated B-24 "Liberator," North American B-25 "Mitchell" (a good name), Martin B-26 "Marauder," Douglas A-20 "Havoc" and A-26 "Invader," as well as the 1944 Boeing B-29 "Superfortress" all had nosewheels. As for the fighters, the 1940 Lockheed P-38 "Lightning," the 1941 Bell P-39 "Airacobra," the 1943 Bell P-63 "Kingcobra" and Northrop P-61 "Black Widow" all had nosewheels. Once the jet age dawned, tail wheels quickly became a thing of military aviation's, and soon also civilian aviation's past.

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As the new majority stockholder of TWA and enjoying a good relationship with Lockheed having had a good deal of success in their Super Electra (See above), Hughes became interested in Lockheed's latest airliner design, the Model 44 "Excalibur" which was announced in April, 1939. Hughes had a great deal of respect for Lockheed's engineers as well as the company's foresight and overall brilliance, but he was not at all impressed with the "Excalibur's" specs.

On 21 June 1939 Hughes invited Lockheed's President Robert E. Gross, along with engineers Hibbard, and Johnson and TWA's President and experienced aviator Jack Frye to visit with him at his opulent private Hollywood Hotel bungalow. Looking for a new, larger and faster airliner for TWA, Hughes and Frye began discussions with Hibbard and Johnson about the range, speed altitude and capacity that they wanted the new aeroplane to have. It was to be capable of flying non-stop, coast-to-coast at 100 mph faster than any airliner currently flying, above the weather, which required a pressurized cabin, and turbo/supercharged engines (Wright R-2600 was the most powerful engine at the time until the R-3350 was announced), sleeper berths for 20 passengers (which Hibbard and Johnson considered to be too few), altogether a very tall order in 1939. Hibbard and Johnson went to work.

Around three-weeks after their first meeting, in mid-August 1939, after having been informed by Lockheed that the old "Excalibur" design had indeed been wholly reconfigured and that, "if he was interested," he could see sketches, blueprints and specifications of it, Hughes invited Gross, Hibbard and Johnson to bring them to his leased "pleasure dome" of a mansion at 211 Muirfield Road , Los Angeles, California in the city's Hancock Park area. The men of Lockheed arrived with the papers and in a few minutes initial design blueprints and drawings were immediately laid out on the floor. Hughes literally crawled all over them, much impressed and excited about what he saw. When he asked the name of this new aeroplane, he was told, "Constellation." Hughes inquired what the price of each Constellation was estimated to be, Robert Gross unhesitatingly told him. Hughes did not blink.

Sultry Jane Russell, who proved that diamonds were not necessarily a girl's only best friends, is seen here not necessarily wearing the cantilever brassiere that Producer Howard Hughes invented for her star-making performance in the 1943 film "The Outlaw". Russell has said that she never actually wore "the ridiculous thing" in the film, but told Hughes that she did. In any event, both Hughes and movie audiences were dually satisfied.

Contrary to myth, whilst Howard Hughes did design a cantilever brassiere for actor Jane Russell, whom he deemed to be apparently in need of such a device, he did not design nor did he actively participate in the actual day-to-day design of Constellation. However, there is no question or doubt that Howard Hughes influenced Connie's design and development significantly.

However, what Hughes certainly did actively participate in was the funding for this new Lockheed re-design of "Excalibur." Configured to meet Hughes and Frye's specifications, L-049 Constellation was priced at no less than $450,000.00 per aeroplane ($7,745,859.71 in 2016 given cumulative inflation since 1939 of 1,621.3%). This made Constellation the most expensive land-based airliner to that time. The problem was that TWA did not have anything like sufficient capital on hand to fund this project, so Hughes funded it with capital from The Hughes Tool Company, which he had inherited from his father.

A contract between The Hughes Tool Company, TWA and The Lockheed Corporation was drawn up. TWA was to be the exclusive purchaser of forty "Excaliburs," as it was still called, as cover for what was already named "Constellation." Once "Excalibur's" price and time of delivery, etc. was negotiated Hughes had two more clauses to add to the contract. The new aeroplane's development and existence was to be kept in strict confidence until TWA had received the thirty-fifth Constellation, and no other airline which purchased the aeroplane thereafter could use it for east to west to west to east transcontinental flights for a period of two years after TWA received its fortieth Connie. In this way Hughes and Frye hoped that they would steal the march on their chief competitor (and good friend) Juan Trippe of Pan Am. The contract, executed 10 July 1940, was the largest single order for aircraft by any U.S. airline to that date.

As well may be imagined, when the other airlines heard about the unusual terms of this contract they were not happy but were grudgingly contented to get their Constellations when they could. However, this was not the case with American Airlines (AA) which was so irate and incensed by what it considered was an entirely unfair arrangement intended to foster TWA and do AA harm that they told Lockheed (and the world) that they would never again purchase another Lockheed aeroplane.

Accordingly, true to its word, AA did not purchase or operate Connies...well, not exactly. After AA purchased American Export Airlines (AEA), commonly known as Am Ex, on 5 July 1945, which AA renamed American Overseas Airlines (AOA), AOA purchased seven L-049 Constellations which it flew on transatlantic routes from 23 June 1946 until August 1949, when AOA's Connies were replaced by Boeing 377 "Stratocruisers." By the time Lockheed's next airliner, the revolutionary 1959 turboprop L-188 Electra was put on

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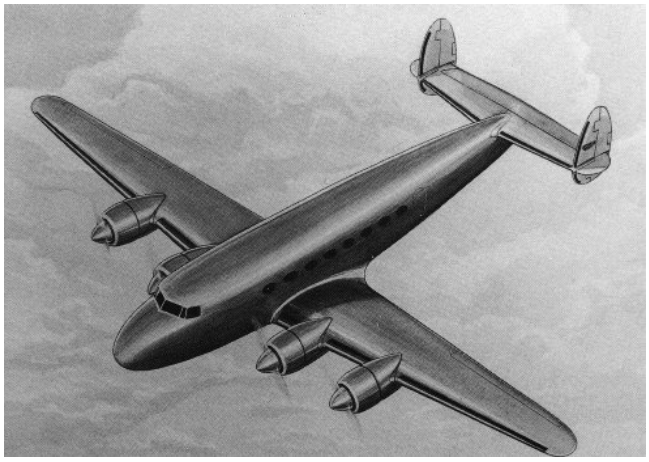
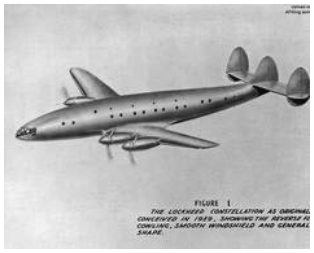
Lockheed's next conceptual factory drawing of the proposed Model L-044 "Excalibur" which was shown to Howard Hughes in the spring of 1939. Note the triple-tail of the later design, the conventional windshield design, "reverse-flow"-style cowlings with large spinners and the larger radial engines (Wright R-2600s) which were then contemplated to power the new aeroplane. Also note that Lockheed expected that "Excalibur" would be purchased and operated primarily by Pan American Airways (PAA), which must have rankled Hughes. This is the true first ancestor of Constellation.



Lockheed factory conceptual drawing of early "Excalibur" design with Lockheed's (Clarence "Kelley" Johnson's) signature twin-tail configuration. A third, central vertical fin and rudder was added later. Note the "reverse-flow"-style cowlings with large spinners.



Early 1939 Constellation design study. Four very popular, smaller and light-weight 1,200 hp Pratt and Whitney Twin-Wasp R-1830 engines were contemplated for a while, as drawn here. Note the conical windshield design that was Type I of six distinct (and sometimes strange) design concept candidates for Connie's nose (See page 49).

the market, AA had apparently somewhat cooled down and purchased forty L-188's, becoming a primary user of the aeroplane. Moral: Never say "never."

Lockheed went to work on Connie's design and built a non-operational mock-up of the passenger cabin. Upon inspection of it, Hughes and Frye were not at all pleased. It was neat and utilitarian, but not at all what they expected. What they had envisioned and thought that they had clearly conveyed to Lockheed's executives was that the passenger cabin was to be, well…opulent. To make it so they hired one of the most well-known and successful design engineers of that time, the French-born American Raymond Lowery, popularly known as "The Man Who Shaped America, The Father of Streamlining and The Father of Industrial Design."[16]

Lowery had previously designed the luxurious interior of Hughes' personal Boeing 307 and knew what Mr. H liked. In its turn, Lockheed was happy to have the services of such a celebrated engineer to do the touchy detail work of designing the passenger cabin to Hughes liking.

THE NAME

Between 1927 and 1941 Lockheed named its aircraft after stars: Vega, Sirius, Altair, Orion, and Electra. Ventura was not named for the city in Southwestern California, but for

16 Raymond Lowery did indeed do much to shape the look of America prior to WWII. He designed the Shell, Exxon, TWA and the former BP logos, Coca-Cola vending machines, the Lucky Strike cigarette package, the Greyhound Sceni-cruiser bus, Coldspot refrigerators, and many train liveries. Later Lowery designed the beautiful Studebaker Champion, Starliner and Starlight coupes and the unique and imaginative Studebaker Avanti automobile as well as the Air Force One livery.

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The magnificent L-049 Constellation in-flight front view. One source of Connie's speed and efficiency is apparent from this view of her clean aerodynamic lines.

its meaning in Spanish: luck or fortune. When the Model 049 "Excalibur" was rejected by TWA and completely re-designed, Lockheed kept the model number and felt that a new aeroplane deserved a new name — but what to call it? There was surely no shortage of stars to choose from, however this new, larger, four-engine, pressurized airliner project was the grandest, most expensive and most ambitious that Lockheed had ever embarked upon. It was as big a venture as all of the other Lockheed "stars" put together, and what is a group of stars put all together called ? A Constellation. Lockheed described Connie as "Model 049" during her initial stage of development. After that it was "L-049."

DESIGNING THE L-049 CONSTELLATION

Designing the new aeroplane that Howard Hughes had suggested and which became Model L-049 (later "Constellation"), Lockheed set forth to create the finest and most advanced airliner possible. The basic layout of low-wing, all metal, semi-monocoque (stressed skin) was not revolutionary in 1939, but as with many things, the angels (and the devils) are in the details. It is well to remember that unlike its competitors, Boeing, Sikorsky Martin, Northrop and Douglas, Lockheed had no prior experience designing and manufacturing four-engine aircraft. Lockheed's success had been with smaller aeroplanes such as the swift single-engine airliners, the twin-engine Electra series and the fabulous P-38.

Like virtually all creative aeronautical engineers since the Wright Brothers, Hibbard and Johnson were not at all above "borrowing" good ideas from other aeroplanes, even those not designed by them[17]. Just as their P-38's tricycle undercarriage had been planned for the unbuilt "Excalibur," such was designed into Model 49. The fully-cowled engines that Boeing had pioneered, the layout of Boeing's B-17, Northrop's flat, centre wing stub, Douglas's triple-tail on the aborted DC-4E, and other similar ideas had all been processed through Hibbard's and Johnson's minds before they put pencil to paper to create the design of Constellation.

THE WING

The high aspect-ratio[18] wing (9.17:1) that was designed for Constellation was a very closely scaled-up P-38 wing. Seeing how well this wing planform had helped to give early P-38s a blistering top airspeed of 413 mph at 20,000', Hibbard and Johnson wisely decided to use it for Model L-049.

Just a note regarding using the P-38 wing plan form: Readers of A2A's T-6 Manual may recall that when North

17 Douglas's DC-4 was in development simultaneously with Constellation but beat it into production by almost eleven months and so gets the prize for being the first tricycle undercarriage airliner. The necessities of WWII that had just begun for the U.S. at that time meant that neither of these aeroplanes would be used as civilian airliners before they were all grabbed by the military services until the end of the war. After that, both aeroplanes were extensively used in civilian and military service of one kind or another for decades.

18 The aspect-ratio (AR) of a wing is its span divided by its mean (average) chord (the distance from leading to trailing edges). For a constant-chord wing the formula for aspect-ratio is: AR = b/c, where "b" is the span and "c" is the chord. To determine AR of a tapered wing the formula is: AR= b^2/S, where b^2 is the wingspan squared and S is the wing's area. All else being equal, a higher AR wing is more efficient than a lower AR wing as drag-producing tip vortices are located farther away from the greater mass of the wing. A higher AR wing also usually has better high-altitude performance both with regard to airspeed and ceiling. Some of the negative characteristics of a high AR wing are that it is more prone to bending and torsional distortion, it will usually have a reduced roll rate compared to a lower AR wing due to its greater mass inertia as well as its greater aerodynamic damping. However, aileron response is likely to be increased due to the ailerons being located at a longer moment arm on the roll axis. Due to a high AR wing's lower average Reynolds Number the useful range of angles of attack (Alpha) is reduced in proportion thereto, i.e. a higher aspect-ratio wing will stall at lower Alpha than one with a lower aspect-ratio. Fowler flaps which, as previously mentioned, extend rearward as they are lowered increase the local chord of the wing and thereby increase the local Reynolds Number as well, permitting the wing to reach a higher Alpha before stalling. The only negative aspect of the Fowler flap is that it requires a very complex system of hinging, rails and motor to operate.

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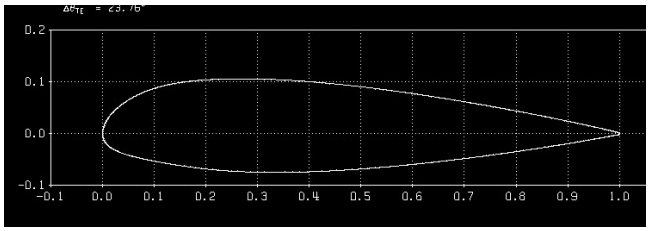

Connie's root airfoil -- NACA 23018. Note this airfoil's exaggerated thickness compared to its chord (leading to trailing edge). It is apparent that this airfoil was chosen, inter alia, for its ability to contain large quantities of fuel which well-served both P-38 (which had a very similar NACA 23016 airfoil) and Constellation.

Connie's and P-38's tip airfoil -- NACA 4412. A far sleeker and thinner airfoil as one might expect. As P-38's and Connie's wing tapered from root to tip a very efficient, gradually diverging span-wise conflation of these two airfoils created an excellent and very clean wing profile.

American Aviation engineers down-sized DC-3's wing for use on the much smaller T-6, they apparently overlooked Aerodynamic Scale Effect (ASE) which caused numerous unsolvable problems for early model T-6s. Here, *upsizing* the smaller P-38 wing for use on Constellation did not have a similar negative effect because increasing the size of a wing does not generally create ASE problems for complex aerodynamic reasons that are beyond the scope of this discussion. ASE is a one-way phenomenon — take a smaller wing and expand it, you're alright; take a larger wing and diminish it, watch out!

The airfoils they chose were NACA 23018 for the wing root (just a bit thicker and very similar to that of P-38) and NACA 4412, the same as P-38. A laminar flow airfoil was contemplated because of its reputation for low drag, but was rejected early in the design phase for a proven non-laminar flow wing shape that would be both a better lifter than a laminar section and also gentler at slow airspeeds. This was one of a few compromises not made towards increasing airspeed.

Connie's wing has no wash-out, which is wing twist slightly raising the trailing edge at the outer section to reduce tip-stall tendency. This is generally a practical and safe aerodynamic design practice; however, it does tend to add drag to the overall wing profile. In its design phase speed was king for Constellation and all (or nearly all as above) that reduced it was anathema. In this it is clear that Hibbard and Johnson, influenced by Howard Hughes' not-so-gentle urging, were leaning heavily towards high airspeed for Model 049 and were willing to compromise in that direction. As it turned out, Constellation, which came of Model 049 is both very fast and also most able to carry great loads.

Connie's cantilever wing's leading edge is swept back 7.5° and the dihedral is also 7.5°. The ailerons and trim tabs were initially covered with fabric.

Each wing has three separate panels. The larger inboard panel attached to the fuselage stub and was not intended to be removable under normal circumstances. Each inner wing panel contains two engine nacelles, fuel tanks for same, one main undercarriage assembly and flaps. The outer wing panel was intended for easy removal if required and each initially contained one fabric covered aileron which after the twenty-third Constellation was metal covered. The wing tips contain the navigation lights and were also easily removable. Pneumatic Goodrich rubber de-icing units could be fitted to the leading edge of each of the outer wing panel.

Lockheed L-049 on display at the Pima Air and Space Museum, Tucson, Arizona. This is very like the first view of Constellation that I had when my Mother and I took our very first flight in June, 1954. The seating then was not in rows but in individual sections with four seats, each pair of seats facing each other with a table between. I sat facing forward opposite my Mom and I remember accidentally spilling milk across the table onto her nice traveling dress. Whilst cruising at altitude I looked out of the window and exclaimed that we must be flying upside down! When my Mom asked me why I thought so, I told her that it was because the clouds were below us.

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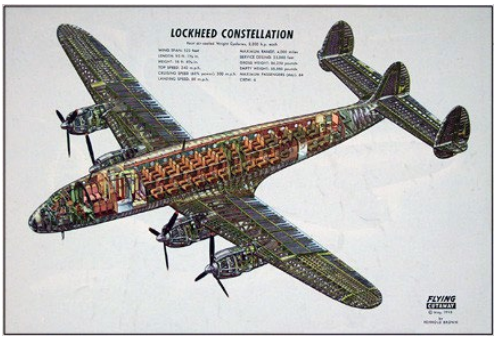
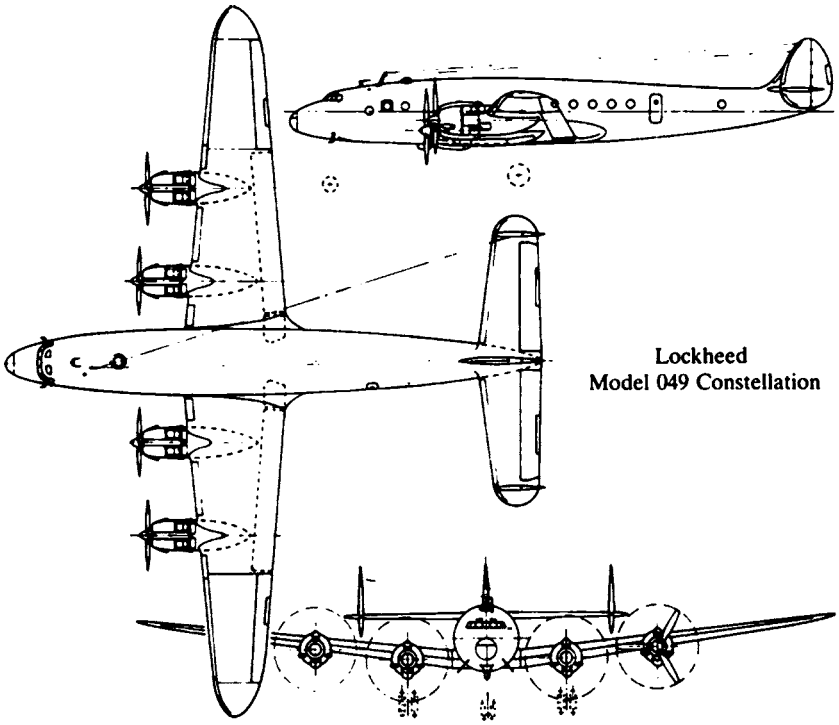
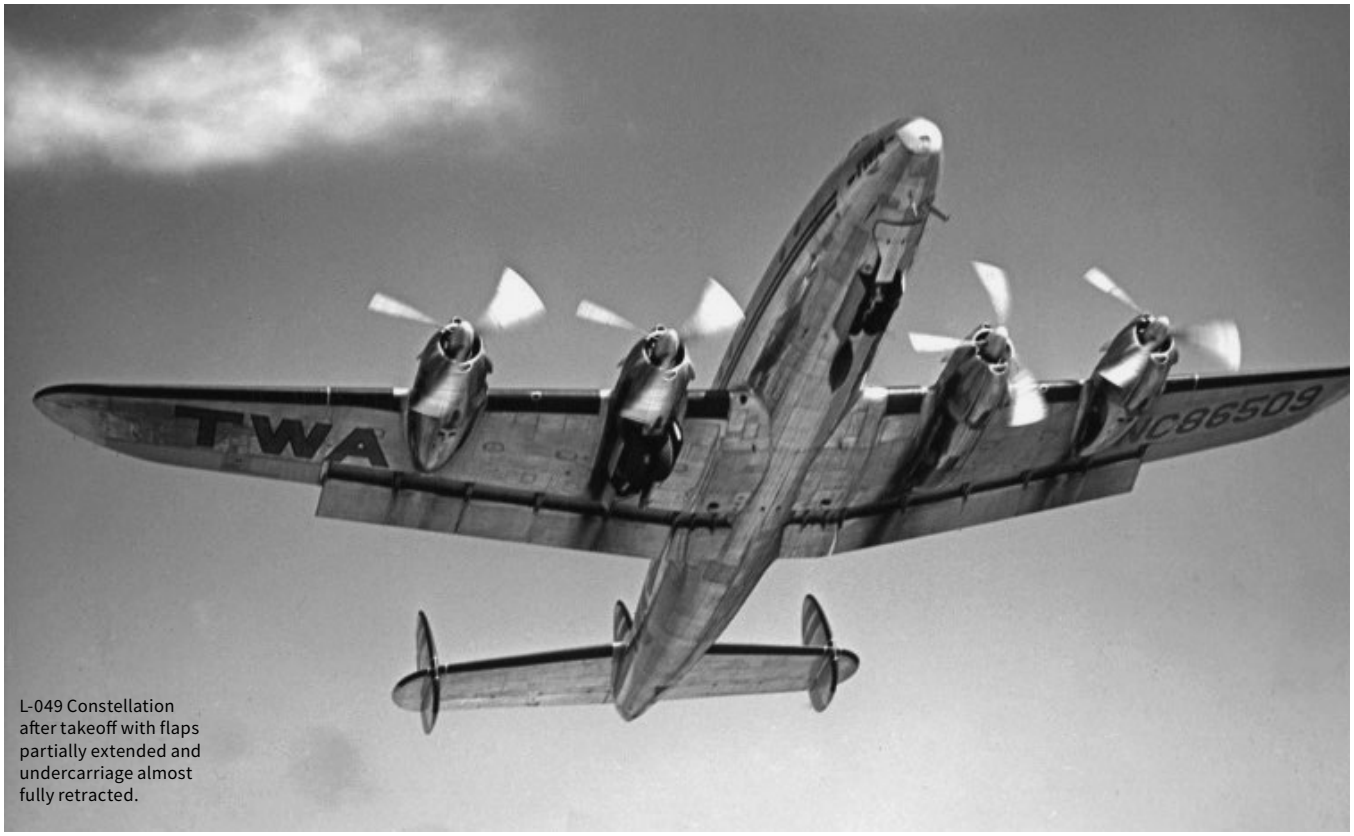
Early 1950’s TWA Constellation seating arrangement, as I remember it.





Three-view of Lockheed L-049 “Constellation”. Note the circular shape of the fuselage and overall clean aerodynamic lines.



L-049 Constellation after takeoff with flaps partially extended and undercarriage almost fully retracted.

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The wing was constructed with two full-span web-type aluminium spars and with ribs of stamped aluminium. L-049 has four fuel cells, two fuel cells located in each inner wing panel between the spars and ribs. Later Constellation variants had fuel cells in the outer wing panels as well, and some L-1049 Connies had tip tanks. L-049's total fuel capacity is 4,690 U.S. gallons, 780 U.S. gallons in the innermost cell and 1.555 U.S. gallons in the outermost cell. The reason that the innermost fuel cell has reduced capacity is that it is "H" shaped to accommodate each main undercarriage mechanism, as well as the retracted strut and wheel.

The Connie's Fowler flaps were in six sections, one short section under the fuselage and five sections linked together to form one flap unit on each inner wing panel. When lowered in its first half the Fowler flap extends mostly rearward and slightly downward to increase wing area and in its second half lowers downward incrementally to 42º.

THE FUSELAGE

The unique and sinuous shape of Constellation's fuselage is one of this aeroplane's most conspicuous points of identification. It has been called "fish-like" or "dolphin-like," which is another thing altogether as a dolphin is not a fish but is a marine mammal. Either way, Constellation's fuselage beautifully and subtly swoops downward at the nose an upward at the tail. Some have called it an airfoil, lift-producing shape; however, this is only partially, possibly just coincidentally correct.

Taking nothing anything away from the felicitous beauty of Connie's fuselage, its shape was determined by purely practical concerns. Some time well-after Connie began to amaze the world with its speed and beauty, Clarence "Kelly" Johnson and Howard Hughes both posited that her curvaceous fuselage possibly added four or five mph over a conventional pointed tube design, but this opinion was never tested for accuracy. That Connie's fuselage ended up looking great and perhaps is a bit slipperier through the air may just simply be fortuitous kismet.

Not intentionally trying to burst anyone's aesthetic bubble, but the nose swoops down to reduce the length of the already very long nosewheel strut. The tail swoops up to bring the horizontal stabilizer and elevators out of the direct propellers' slipstream wash. (See the three-view drawing above). The earlier, unsuccessful but revolutionary Douglas DC-4E (not to be confused with the very successful Douglas DC-4) also placed its horizontal stabilizer above the propeller's wash. Connie's swooped-up tail presented another problem as is often the case with design — solve one problem and get another. (See below)

The fuselage was built in eight sections which made later stretching fairly easy. Connie's fuselage cross-section is a circle (not by coincidence the same as the first pressurized airliner, Boeing 307) which gently tapers towards the nose

"ANY LANDING THAT YOU CAN WALK AWAY FROM..."

This non-fatal accident took place at (just beyond) Chicago's Municipal (Midway) Airport (MDW) on 18 December 1949. This TWA Lockheed L- 049-46 "Constellation" was returning to MDW after having turned around mid-flight because of poor weather ahead. MDW weather service reported the local ceiling to be 300 feet, visibility at 1-1/2 miles with moderate fog and smoke, and a west- southwest wind variable at 8 mph. The pilot attempted two ILS approaches (ILS was something new in 1949) to runway 13R, and on the second try landed 3,200 feet beyond the approach threshold. The Connie then rolled down the remaining 2,530 feet of runway 13R, plus an additional 875 feet beyond its end, going right through the airport's substantial steel-wire boundary fence, skidded across a car-filled carpark, struck a wooden structure billboard as well as a thick stone column and knocked down a lamppost before finally coming to rest in the middle of a busy local street across from the "Acme Drill Co." (One of whose customers was a certain W. E. Coyote) Remarkably, there were no resultant injuries except to the Connie Captain's pride, reputation and employment. The official CAB report of this accident ends by saying: "Contact with these structures extensively damaged the aircraft." You think?

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and tail from its widest point, where the main wing spar crosses the bottom fuselage quarter. The circular shape was selected for a number of reasons, perhaps the foremost being that it is easier to predict and control the stresses of pressurization in a uniform, circular container rather than in one that is ovoid, has sharp corners, and/or varies widely. Additionally, such a uniform structure usually presents far fewer compound curves to build and sheet[19], although Connie's beautifully swooping fuselage presents many compound curves and it was far more expensive to build than, say, a DC-6's linear fuselage.

Republic "Rainbow" in the markings of the U. S. Army Air Force shortly before it became the independent U. S. Air Force. Proposed as a reconnaissance/aerial photography aircraft, "Rainbow" (USAAF designated XF-12, USAF designated XR-12) it had a top airspeed of over 470 mph at 45,000', making it one of the fastest piston-engine aeroplanes in the USAAF's inventory. However, the prototype's first problematic flight was not until 10 July 1947 when even faster jet-powered aircraft such as RB-47 were already being used for this mission. Accordingly, none were ordered and only two were built. Quel dommage, it certainly is a beauty.

One area of fuselage design that has always plagued aeronautical engineers is the "windshield step," i.e., where the windshield, by necessity, suddenly pops up from the otherwise nicely streamlined nose. Designers had initially swept the windshield forward or straight up, as with Fokker and Ford Tri-Motors, in an attempt to keep excess snow and ice off the windshield and to maximize visibility at night when reflections often distorted the pilot's view. In the early 1930's, aerodynamic cleanliness was not so much of a serious factor regarding windshield design what with dozens of other drag producing items including un- or semi-cowled engines, entire undercarriages and whatnot all protruding from the airframe.

What was soon discovered was that the forward-sweeping windshield reflected lights from the cockpit interior and the ground, negating its usefulness in that regard. Windshields thereafter tended to be upright or very slightly swept back, which did little to create a more aerodynamic "step." In the middle-to-late 1930's, Lockheed's Electra series had the most swept-back windshields of any aircraft in its day and its sleek "windshield step" certainly added to its superlative performance, a factor that was did not go unnoticed by Lockheed itself as well as other manufacturers and designers.

A "no step" approach was used for Boeing's B-29, wherein it was expected that its smooth, rounded nose would minimize drag. The same was contemplated for Constellation, but in a design more similar to Republic's XF2 "Rainbow," considered by many to be one of the most beautiful aeroplanes of all time. This design concept postulated that Constellation's the nose would be an uninterrupted continuous 360º cone. A mock-up of this arrangement was made, but it resulted in unacceptably poor pilot visibility. The result was as usual, a compromise, but one that leaned towards clean aerodynamics whilst maintaining good visibility.

Lockheed's engineers' recent experience with the design of P-38, one of the cleanest aerodynamic designs of its day, led them to take pains to carefully form as clean a windshield step as possible whilst maintaining good visibility for the pilot. This was done in the usual Lockheed fashion, by thinking literally "outside the box." Six distinct versions of the nose of Constellation were drawn and considered (see drawing below). The large, square pane, upright windshield found on DC-3 and many large transport aircraft that had come before offered no help in cleaning up the nose profile and creating a better "step," so Hibbard and Johnson created something new, a wrap-around windshield made of nine smaller panes.[20]

Never lacking for innovative thought, Lockheed engineers contemplated a novel (even for today) de-frosting method for the windshield — infra-red rays. While this inventive concept did not make it beyond an interesting discussion

19 Another early pressurised aeroplane, Boeing C-97 and its civilian version, the extraordinary 377 Stratocruiser (which A2A has modeled) from which it was derived shared the distinctive "double-bubble" fuselage cross-section, resembling a figure-eight, allowing for pressurization of a large cabin with two passenger decks. The 377's structure was enormously complicated and expensive to build which along with its complex engines' poor maintenance record surely contributed to Stratocruiser's small production total of 55.

20 Boeing's 307, which was developed simultaneously with Constellation has a windshield made of ten small wrap-around panes. This is more likely a case of "brilliant minds think alike" than any kind of imitation in either direction. In any event, Boeing 307, which was the first pressurized airliner, was a tail-dragger like Boeing's 1935 B-17. In this it was more than a little anachronistic and not at all in keeping with the late 1930's and 1940's new wave of tricycle undercarriage aeroplanes.

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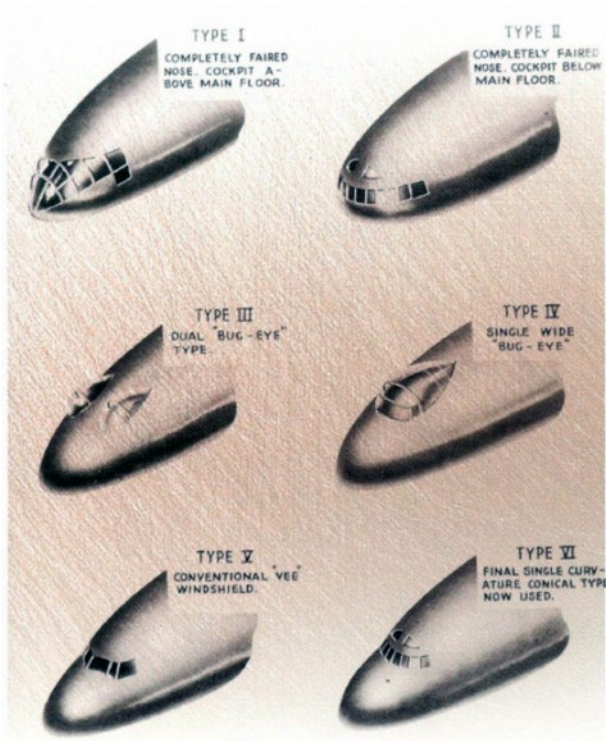
and information about it is sketchy at best, it was not at all really such a strange idea. In another, similar application, since 1995 infrared airframe de-icing using huge, drive-through hangars have been built and tested at Buffalo and Rochester Airports in New York State, and are currently commissioned and in use at Newark International Airport in New Jersey, Rhinelander-Oneida County Airport, Wisconsin, and Kennedy International Airport, New York.

L-049 Constellation's passenger windows were also rather small and were circular to even the stresses of pressurization around their frames. Aircraft designer and manufacturer, De Havilland, might have paid closer attention to and learned something from Constellation's window design when they built the jet-powered, pressurized DH 106 "Comet" which first flew on 27 July 1949, its first commercial flight on 9 January 1951.

"Comet" was not the first jet-powered airliner; that honour goes to Vickers VC.1 Viking G-AJPH, which first flew on 6 April 1948; however "Comet" was the first jet airliner to go into regular service. Unfortunately, it was not as well thought-out as one might have expected of such a venerable firm as De Havilland. The fully pressurized "Comet" had passenger windows which were large and square. After a number of catastrophic in-flight "Comet" airframe failures, it was found after extensive testing that a major contributing factor was that under full cabin pressurization, stress around the square windows' corners, which stress was found to be much higher than expected, caused a major failure of the window panels. This, plus catastrophic airframe metal fatigue, was found to have lead to "Comet's" explosive decompression at altitude. The tragedy of it is that Lockheed had already figured this all out by 1939.[21]



Lockheed Constellation's six contemplated nose designs. Few, if any other aircraft manufacturers have been so willing to take the time to seriously explore so many possible optional designs of every component that goes into such a complex aeroplane as Constellation, even some that were, well… quite odd. Type I was similar to Republic's beauteous "Rainbow" and Type VI is what was finally decided upon. (Just for fun I would have liked to see Type III win. Imagine Connie with that sea-monster's nose!)

Constellation's circular fuselage had an additional perquisite, it granted generous passenger accommodations, something completely unknown to the mass of today's airline travelers. It was a full 11' 7 ½" wide, almost 2' wider than Douglas's DC-4 (but 4 ½" narrower than Boeing 307). The cabin pressurization system was driven by number one and four engines which provided 4 psi. At 9,000' the cabin was still at sea-level, at 15,500' the cabin was at 5,000' and at 20,000' the cabin was at 8,000'.

L-049's cabin heating and cooling were available and quite effective. A cabin temperature of 75° F could be maintained when the outside air temperature was 110°F. Similarly, a cabin temperature of 73° could be maintained when the outside air temperature was -15°F.

The USAAF fitted its second C-69 and all others thereafter with a fiberglass astrodome to the top of the cockpit over the Navigator's compartment. The Navigator could enter it for sun/ star sightings and such by standing on a stool which tucked away when not in use. The USAAF also installed "eyebrow" windows in C-69, above and behind the windshield, ostensibly for extra pilots' visibility when in formation. However, Lockheed did not continue them on the L-049s manufactured after the war.

THE ENGINES

Model 49 Constellation was, from the first, intended to be powered by whatever was the most powerful radial engine available. At the time of Excalibur/Constellation's earliest development phase in 1938, Wright R-2600 (See below) was the choice, however when the more powerful Wright R-3350 eighteen-cylinder, supercharged, Duplex Cyclone radial engine was announced, it became Connie's engine for all time.

Wright R-3350 was based upon Wright's R-2600, the first practical Wright twin row radial engine which was introduced in 1937 and was produced until the end of WWII. Initially a 1,500 hp. engine, R-2600 was continually refined and by war's end was producing 1,900 hp, nearly equalling its closest competitor, Pratt and Whitney's superb R-2800.

21 Actually, Lockheed had figured out practical cabin pressurization in its XC-35. This was a modified, pressurized Electra Model 10, and one was built at the specific request of the USAAC which first flew on 9 May 1937. It was so successful and reliable, not to mention comfortable at high altitudes that Louis Johnson, Assistant Secretary of War in President Roosevelt's Administration and Secretary of Defence in President Truman's Administration, used it as his personal official executive transport for many years without incident. The knowledge about pressurization that was gleaned from this experiment served the development of Boeing 307, the first pressurized airliner and B-29, the first mass-produced, pressurized bomber. The very first pressurized aeroplane was the 1921 Engineering Division USD-9A, a modified De Havilland DH-9.

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Wright's reliable R-2600s powered Boeing 314 Clipper, North American B-25, Martin Baltimore, Douglas A-20 Havoc, Martin Mariner, Grumman TBF Avenger and Curtiss SB2C Helldiver, among many other aircraft.

Taking R-2600 up a notch or two, Wright R-3350 was intended to be the ultimate double-row radial engine. It is essentially two rows of the old standby nine-cylinder, 1,000 – 1,200 hp. Wright R-1820 "Cyclone" 9 that powered Grumman F-3-F (1-3), all variants of Boeing B-17 and 307, Douglas SBD "Dauntless," many variants of Douglas DC-3, General Motors FM-2 Wildcat, Lockheed Model 14 "Super Electra," Lodestar and Hudson, as well as many of others.

Prototypes of R-3350 had been tested at Wright since 1936, but the less exotic R-2600 programme took precedence, delaying progress in the R-3350 for a few years. Additionally in 1939 Wright, having been duly impressed for years with Rolls-Royce's remarkable twelve-cylinder, liquid-cooled "Merlin," was still trying to develop the latest in a series of giant, liquid-cooled engines. Their latest venture was a super-complex, touchy, monster of an engine with, count 'em, forty-two cylinders (seven banks of six cylinders each in a radial configuration)! This engine powered Lockheed XP-58 Chain Lightning, Vultee XP-68 Tornado, and the Republic XP-69 (a P-47 variant). Countless precious engineering and manufacturing hours went into the development of this improbable, ponderous power plant, and all pretty much for nought as it turned out, the jet age having already begun by the time R-2160 was being tested. Meanwhile, the excellent and far more practical R-3350 project went a-glimmering until wiser heads at Wright finally said "enough" to R-2160.

Wright's announced test versions of R-3350 reported 2,200 hp. at 2,800 rpm at sea level which was impressive indeed in the late 1930's. The new engine immediately caught the eyes of the military and of Howard Hughes, both always anxiously searching for the latest advances in aviation. When Hughes was actively lobbying Lockheed for a new airliner for TWA in 1939, the engine that was first chosen to power Constellation was Wright R-2600; but, after many calculations Lockheed engineers found that four of these would not produce sufficient power to meet the performance specifications that Hughes and Frye demanded. It looked like the new airliner might not be able to deliver the performance that everyone hoped for when the new, more powerful Wright R-3350 was announced to save the day.

Always looking for a new idea that did not go down the well-trodden path, early in Connie's development Lockheed engineers came up with a novel way to sufficiently cool the new double-row Wright R-3350s. The problem with the usual front end air-cooling was that the back row of cylinders did not get their share of cooling air and ran hot.

A reverse-flow engine cooling system was created that would take in cool air from open ducts in the leading edge of the wing and then send it to the rear of the engines under natural pressure with the excess air exiting out of the front of the engines between the cowling ring and the spinner. Special streamlined spinners were made for this system which looked much like those used later on Lockheed's turboprop aircraft such as the 1957 L-188 "Electra."

In any event, this innovative but complex reverse-flow system was abandoned when it was found that there was no significant gain in cooling or reduction of drag over conven-

Scale models of Lockheed's P-38 "Lightning": and XP-58 "Chain Lightning" to show comparative sizes and designs. Both of these aeroplanes were considered to be obsolete and unnecessary after the end of WWII.

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tional front end cooling.

From the outset, R-3500s had Chandler-Evans top-mounted carburettors which caused no end of trouble in the form of in-flight engine fires. All during C-69's (the USAAF's designation for Constellation) initial testing period and well after that engine fires plagued C-69, grounding it for a great deal of time. At the same time R-3350 powered B-29s were also experiencing engine fires.

C-69s and B-29s suffered with these carburetted R-3350s all through the war. Of course, the solution to this problem that was on Wright's, Boeing's, Lockheed's and the USAAF's minds was fuel injection. However, while this basic technology was known from the time of the early automobile and German engineers had advanced practical fuel injection technology for aircraft engines as early as 1938; in the early 1940's engine manufacturers in the U.S. had not yet perfected a reliable fuel-injection system for a large, double-row aircraft engines to the close tolerances required.

Wright and the USAAF well-understood that under-trained and inexperienced aircrews were mishandling their R-3350s, inadvertently causing serious, fire-inducing backfires. For some inexplicable reason no one thought that such may be liable to occur in large, highly-supercharged engines with enormous, unsophisticated, mechanically-carburetted induction systems containing many cubic yards of hot, compressed, explosive gasoline/air vapor. After all, what could go wrong?

Realizing that re-training aircrews in the intricate niceties of operating these fire-prone engines would take too long and/or ultimately be in vain, other solutions were tried which were more or less (rather less than more) successful. One idea was to use the newly developed Bendix-Stromberg pressurized carburettors to serve as fuel disbursement units, metering fuel to two nine-cylinder injection pumps in each engine. Yes, it was as complicated as it sounds, but it worked after a fashion. At least the frequency of R-3350 engine fires was vastly diminished, but not virtually eliminated until further improvements were made after the war.

After a fatal in-flight engine fire on a TWA Connie on 11 July 1946, which was the most recent but only one of many such fires on C-69s and B-29s during the previous two years, all B-29s and Constellations were grounded until the reason for the fires could be sorted out. After the usual thorough investigation, the source of the fires was traced, among other things, to the fuel delivery system (surprise!). Wright finally replaced the 3350s' carburettors with a fuel injection system which ended the problem. After re-fitting every Wright R-3350 in every Connie, B-29 and the other aircraft using this engine, the grounding was lifted on 23 August 1946.

SUPERCHARGERS AND WHY

The air is heaviest and densest and exhibits the greatest natural atmospheric pressure at sea level because it is at the very bottom of the earth's atmospheric sea and is being pressed upon by the entire atmosphere above it. A piston engine produces its greatest amount of power at sea-level where it is breathing heavy, dense, high pressure air and its possible manifold pressure is at its optimum. However, as altitude increases and there is less and less atmosphere above, the weight, density and atmospheric pressure of the air decreases, i.e., becomes "rarefied. As the altitude at which a piston engine is operating increases above sea-level, the rarefied air which it is breathing becomes less and less sufficient to maintain sea level manifold pressure and power gradually diminishes.

In order for Constellation, or any pressurized piston engine aircraft to take full advantage of its high-altitude capabilities, its engines must be capable of producing all or at least a good percentage of its sea-level power when at higher altitudes. To do this the rarefied air that the engine breathes in must be returned to as close to sea-level weight, density and atmospheric pressure as possible at the manifold. This is where super/turbo chargers come in.

A supercharger (see footnote 14) compresses the incoming air and sends it to engine's manifold to be mixed with fuel so that the engine may continue to produce sea-level (or close to it) power at high altitudes. The supercharger in the Wright R-3350's that powered the first L-049 Connies was a simple, single stage, two speed unit, mechanically driven by a transmission from the main crankshaft. In 1941, Wright sought to improve upon the General Electric superchargers that had been previously almost universally used in big radial engines and the new unit proved to be satisfactory. That is, except for the exhaust-gas inlet pipes which had too sharp a bend in them for good efficiency and which were soon replaced with gentler curving conduits.

Later R-3350s had dual-stage superchargers, and in 1953 L-1049C "Super Constellation" received the first 3,250-3,400 hp. Wright R-3350-745C18BA-1R-3350, fuel injected Duplex-Cyclone, "Turbo-Compound"[22] engines, the last and most dramatic advance in piston engines.

For all of its teething problems, Wright R-3350 is a very sturdy power plant. The recommended TBO (Time Between Overhaul) of the Wright R-3350 is 3,500 hours, considerably more than its competitors (e.g., the TBO of Pratt and

22 The Turbo-Compound (TC) system (also called a"blow-down recovery system") adds 450-500 hp. by directly re-using exhaust gases which are fed into a power-recovery system geared to the engine crankshaft via a hydrodynamic, fluid transmission. It is not purposed for high-altitude power retention through increased manifold pressure as is a turbo/supercharger. The TC system increases horsepower at all altitudes and may be used along with a turbo/supercharger. The TC system is different from the standard turbo/supercharger in that it does not utilise an air compressor; and accordingly, does not feed compressed exhaust gasses or air to the manifold of the engine. According to the Curtiss-Wright Corporation, Wright Engine Division, the Turbo -Compound System's benefits are:

- It offered a direct increase in engine power and economy over the complete operating range without introducing additional basic engine development problems.
- Its simplicity eliminated the necessity of additional pilot or flight engineer attention at any time.
- The blow-down system could be designed for a weight to power ratio of .9 lbs/BHP recovered, whereas the exhaust pressure turbine system considered required 1.3 lbs/BHP recovered.
- Compounding by a blow-down turbine appeared ideal for future development, since a turbo-supercharger or even an additional pressure system power recovery unit could be added at some later date.

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One of L-1049C "Super Constellation's" four Wright R-3350 745C18 BA-1R-3350 Duplex-Cyclone engines.

"Rare Bear", a much modified Grumman F-8-F "Bearcat", seen here on 21 August 1989 setting all the world a-blur when it set the official speed record for a piston plane of 528.31 mph at Las Vegas, Nevada. It is powered by a modified variant of a Wright R-3350 745C18 BA-1R-3350 Duplex-Cyclone, "Turbo-Compound" engine which in a slightly simpler form also powered Lockheed L-1049C "Super Constellation."

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Whitney R-2800 is 2,500 hrs.). Run conservatively and looked after, particularly during the first twenty-five hours of operation for a new engine and after overhaul/re-build, the fuel-injected R-3350 has proved, at last, to be a very reliable engine. When the USAAF returned its C-69s to civilian use after WWII, they all had the latest, most refined (carburetted) version of these engines and they remained the only power plant used in the Constellation through every variant and model upgrade.

Even in recent times Wright R-3350-745C18 BA-1R-3350 Duplex-Cyclone, "Turbo-Compound" engine , albeit much modified, is the engine of choice for Reno Air Race aircraft such as the greatly competitive "September Fury," a highly modified Hawker Sea Fury, and the world's fastest piston aeroplane, "Rare Bear," a modified Grumman F-8-F "Bearcat" which on 21 August 1989 established the official speed record for a piston aeroplane of 528.31 mph at Las Vegas, Nevada.

THE PROPELLERS

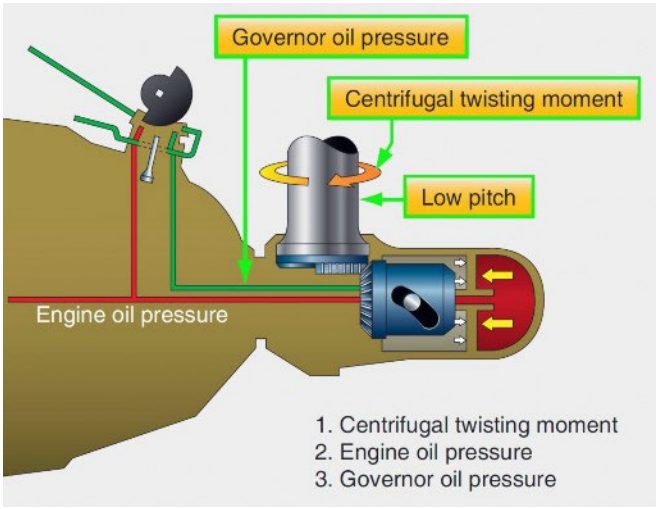
Each of L-049 Constellation's Wright engines turned Hamilton-Standard (H-S), three-blade "Hydromatic," adjustable/constant-speed, full-feathering, (later reversible) propeller with a diameter of 15' 2." These were chosen in order to make the most of the engines' power at a cruise setting at altitudes of over 30,000' to maximize the efficiency of the large diameter of the propellers, they were geared sharply downward, turning them far slower than the engines' rpm. This was necessary to avoid the tips of the long propellers from approaching the speed of sound and thereby creating a good deal of drag, losing a good deal of thrust and even producing negative (forward) thrust under certain conditions. A remarkable aeronautic breakthrough, the H-S "Hydromatic" propeller permitted a larger range of pitches and a closer tolerance of pitch control than anything else in its class. Having developed and introduced the world's first controllable-pitch propeller in 1930, Hamilton Standard continued to develop and refine its design throughout the 1930s and 1940's by placing a larger, multi-direction, hydraulically-actuated piston located in a large metal dome on the front of the propeller as well as larger oil pumps and longer cams providing a wider range of pitches, and a new feature, propeller feathering (where the propeller sits at edge to the oncoming air).

By 1937, this new propeller was available and in previously unheard-of diameters to get the most thrust out of the latest and most powerful engines. The H-S "Hydromatic" propeller was installed on the majority of U.S. military aircraft in WWII and a significant percentage of all Allied aircraft.

In the late 1930's, turbo/supercharged aircraft engines were becoming more powerful and this, coupled with improved aircraft design, began to permit aircraft to operate at above 30,000' where the air temperature is -34.44°C (-30°F). On many occasions, particularly where there were clouds and/or high humidity at altitude, the engines would seem to suddenly run rough and vibrate. It was not, however, the engines that were causing this, it was the propellers.

This rough-running and degraded performance was caused by ice which was usually, but not exclusively, formed by droplets of super-cooled water which exist in highly humid air as well as in stratiform and cumulus clouds. These water droplets form into ice when they are struck by a passing aeroplane, abruptly crystallize and build up on the wings and propellers' leading edges, distorting and disrupting their airfoils. This ice does not form equally on all of the propeller blades and thereby unbalances the propellers causing vibration and degraded performance. Observing wing-icing was not a problem, but before propeller feathering came into existence icing could not, of course, be seen on a spinning propeller. Even when pilots suspected that the propellers had iced-up, they could not visually observe and confirm exactly where the ice was located on the blades and how it had formed.

The early method to remove suspected propeller blade ice was an alcohol and glycerin mixture sprayed on the blades through small nozzles at the base of each propeller blade to melt the ice. This was not effective because it was not yet known just where the ice had started and where it had built up and the chemical spray hit the blades randomly and flew off the tips. It was not until the propeller feathering system came into being for entirely other purposes, that through fortunate coincidence it became possible also to learn more about propeller blade icing. If a propeller was suspected of having ice buildup, red-dyed de-icing fluid would be sprayed on the blades as was usual, then the iced up propeller would be feathered and photographed when still. The result of studying these photos lead to a greater understanding of when, where, and how ice developed on propeller blades and eventually to an inflatable rubber leading edge boot on each propeller blade, similar to that which is used on wings and tail surfaces, which when inflated, cracks the ice which then flakes off before it can build up.



A simplified diagram of the Hamilton-Standard propeller pitch-control system.

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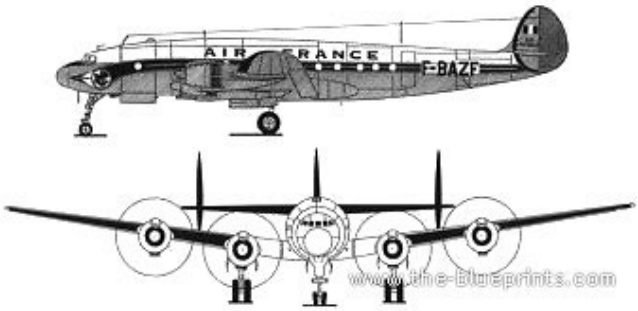
U. S. Marine Corps' North American PBJ-1J "Devil Dog". The USAAF designated this type B- 25J-2. Note the "capped" horizontal stabilizer.



Looking at a front-view of Constellation we see how carefully the entire matter of the position of the tail surfaces vis the propeller wash was planned:
The horizontal stabilizer is positioned above the propeller discs and each of the outer fins/rudders are positioned between the propeller discs. This was done in an attempt to minimize the influence of direct propeller wash-induced turbulence on the tail surfaces.

This photo clearly shows how Constellation's outer fins/ rudders are mounted inboard of the horizontal stabilizers' tip.

During the 1940's, another life saving feature was added to the Hydromatic propeller — reverse pitch. After WWII, as aircraft became larger and heavier, adequate wheel breaking after landing was a serious problem. Many accidents wherein a large aeroplane would land a bit long on the runway and roll through the opposite airport fence had occurred. (See above). The solution was not simply better brakes. Some more powerful way of shortening the roll-out of heavy aircraft was necessary to be found. H-S engineers studied the problem and ingeniously re-designed the Hydromatic propeller so that after landing the pilot could push the blades past feather and into beta (reverse) pitch that with a concurrent moderate increase in power produced a powerful reverse-thrust braking force. Of course, the propeller shafts' bearings had to be re-designed to take the negative load when the props were in beta mode, but this was not much of a problem.

It was soon proved that the landing roll could be shortened by as much as 40% with both wheel brakes and reverse thrust applied as compared to only wheel brakes.

TRIPLE-TAIL

That signature Constellation triple-tail which had been originally a part of "Excalibur's" design was inspired by Douglas's unsuccessful DC-4E (See above). Hibbard and Johnson knew that a large single tail would be more efficient, lighter and simpler to build, and would produce less drag than a triple-tail but they were not wedded to a single-tail design. It was Johnson, after all, who had so brilliantly conceived and designed the twin-tail for Electra 10. However, the top of the vertical tail surface(s) sit necessarily much higher on aircraft with a tricycle undercarriage than on aircraft with a tail wheel. If Constellation had a single vertical tail surface it would have had to be quite tall in order to handle the yaw of its powerful Wright R-3350s in the event of an engine failure and the hanger doors of the late '30s- early '40s would have been too low to accommodate it.[23] By dividing the rear side-load between three vertical tail surfaces, each could be much smaller and lower than a single tail, thus solving the hanger problem.

Each of Constellation's vertical fins are complete vertical stabilizer and rudder units and are unique. Their shape is a dual ellipse, somewhat pointed at the top and rounded below. Other twin-tail designs of that time and later such as North American's B-25 and Consolidated's B-24 have the two vertical tail surfaces "capping" off the horizontal stabilizer, that is, the vertical tail surfaces are located at the very ends of the horizontal stabilizer. Lockheed's design for Electra, Ventura and P-38, and Constellation (but not

23 Boeing's 1938 B-17, 1940 307 "Stratoliner" are single-tail aircraft with powerful engines necessitating a large vertical tail surface. However, 307s have tail wheels so their large vertical tail surfaces could still (just) fit through normal hangar doors. Boeing's 1949 377 "Stratocruiser" is powered by four 3,500 hp. Pratt & Whitney R-4360-B6 Wasp Major 28-cylinder radial engines, turning four-bladed propellers. Accordingly, it requires a very large tail surface. As it has a tricycle undercarriage its necessarily tall single vertical tail surface tops at 38' 3," far higher than the hangar doors of its time. Boeing's hanger-door solution for this aircraft was to have the entire fin and rudder swing down parallel to the horizontal stabilizer for hangaring and raised again for flight.

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Harpoon which had "capped" vertical tail surfaces, see photo above) has the two outer vertical surfaces extending below the horizontal stabilizer to which they were attached, with a sub-rudder also below and the short, round tips of the horizontal stabilizer extending beyond the outer vertical tail surfaces.

It is an axiom of fluid dynamics, which includes aerodynamics, that interference drag is generated when the flow across one solid component moving in a fluid (air, which is a gas and not a liquid, is treated as a fluid by engineers because of its peculiar properties) is forced to mix with the flow across an adjacent or proximal component wherever two surfaces meet. If the angle where they meet is relatively acute, i.e., approaching 90° or less, interference drag increases exponentially and in proportion to the acuteness of the angle. Accordingly, good aerodynamic practice dictates that aircraft's surfaces be designed, if possible, with as few places of intersection as possible, that where they occur they meet at as moderate an angle as possible, and that fairing be provided when possible to additionally moderate the angles at the places of intersection. With this in mind we can see that Lockheed's unique arrangement of tail surfaces as described above will necessarily generate additional interference drag.

In a single-tail arrangement, also called "cruciform," there are only four places of intersection where interference drag may occur. A "capped" twin tail, such as seen on North American's B-25 has the same number of places of intersection as a single-tail design (four). In Lockheed-designed twin-tail aircraft there are eight such places of intersection, and in Constellation, with its two outer and one central vertical tail surfaces, there are ten.

Additionally, by Lockheed carrying Constellation's, etc. horizontal stabilizer past the vertical tail surfaces and ending it with the usual tips, the vortex that is always produced at an aerodynamic surface's tip occurs. Because wing, stabilizer and to a lesser degree rudder tip vortices produce drag, eliminating tips when possible also eliminates their vortices and their drag. This is one important reason that so many designers who wish to use a twin-tail arrangement cap off a horizontal stabilizer with vertical fins.[24]

It is a mystery why Lockheed, always so careful and so often brilliantly informed in its designs, created a tail surface arrangement in so many of its aircraft that produced extra, unnecessary drag when it would have been a simpler (if less stylish) solution to cap off the horizontal stabilizer with the two outer vertical surfaces. In any event, P-38 and Constellation certainly did not suffer for want of speed despite their unnecessarily draggy tail surface arrangement; but how much more speed might have been possible if that drag had been eliminated?

Connie's outer vertical tail surfaces are interchangeable with each other but not with the center vertical tail surface. The elevators are also interchangeable, but must be flipped over in order to exchange them so that the inner and outer elevators' sides, trim tab positions and main hinge points properly line up. This creates the strange necessity of initially placing the left elevator's trim tab hinge at the top and the right elevator's trim tab hinge at the bottom so if the elevator is flipped they remain in their original places.

THE UNDERCARRIAGE

Lockheed had planned all along for Constellation to have a tricycle undercarriage even whilst still called "Excalibur." The only other airliner at that time which had such an undercarriage was Douglas' DC-4E, the tri-tailed experimental aeroplane that was rejected by the major airlines as too big, too complex and too expensive. Douglas' redesign of DC-4E which became DC-4 which was designed concurrently with Constellation, also has a tricycle undercarriage. Whilst both Constellation and DC-4 have two wheels on each main strut, only Constellation has two wheels on the nose strut.

Constellation's brakes are hydraulic as is the retraction system. The main struts retract forward into the inboard engine-nacelles and the nose strut retracts rearward into the bottom of the fuselage. When retracted all wheels and the wheel wells are fully enclosed, covered by streamline doors.

If a hydraulic-system failure or simply a nose undercarriage strut failure occurs in Connie, the forward-extending nose undercarriage strut cannot be as reliably extended and locked down by the usual gravity-fall operation, as may the rearward extending main undercarriage struts. This is because the force of the oncoming air may tend to hinder the forward extending nose undercarriage strut but will tend to aid the rearward extending main undercarriage struts. Accordingly, if all else fails, the nose undercarriage struts can be securely extended and locked by an auxiliary electric hydraulic pump and the main undercarriage strut can be extended and locked by a manual override extension system.

The nose undercarriage strut has two 33" tires, a first for this kind of aeroplane. They are toed outward for directional stability at high speed on the ground. This is a true redundant system in that if one tire should go flat, Connie is fully capable of carrying on with only the other.

Each main undercarriage consists of two 49" wheels with separate and independent brakes on each wheel. Similarly to the nose undercarriage, if a tire on any main strut should go flat, the aeroplane can operate safely on the other tire.

Connie sits high on its long undercarriage struts, higher in fact than most similar aircraft because Lockheed wanted to insure good ground clearance for Connie's 15' 2" propellers' tips (particularly the inboard propellers which sit considerably lower than the outboards) and thereby reduce pitting and other damage caused by loose ground debris, stones and the like.

24 You may notice that many long-distance jet airliners have small, non-moving, aerodynamic projections at their wing-tips. These projections are call "winglets" and are there to smooth out wing tip vortices. This reduces drag and permits jets so equipped to fly farther and faster at lower power settings, thus consuming less fuel for a given flight.

FOR SIMULATION USE ONLY

THE FLIGHT CONTROLS

To manipulate Constellation's enormous ailerons, elevators and multiple rudders, a hydraulic boost system was utilized with a manual override in the event of a hydraulic failure. Of course, the pilot's own force was to be multiplied, but by much? Lockheed's engineers, who were pioneering this type of boosted control system, began to inquire amongst pilots as to what might be optimum. Of course, opinions varied and they were, at best, merely guesses.

Guesswork goes against the engineer's grain. Facts, numbers, ratios, formulae and such are his or her métier. After much study and experiment Connie's control boost forces were finalized at 9.33 x 1 for the elevators, 26 x 1 for the ailerons, and 23 x 1 for the rudders. The pilot's/co-pilot's control wheel/column and rudder pedals were connected to the hydraulic actuators by long cables such as had always been used. The cables were, in turn, attached to the hydraulic actuator's motors located at each individual control surface and to the control surfaces themselves in the event that manual override became necessary. These hydraulic actuators moved the controls in a manner something like power-steering in an automobile. An artificial force-return system on the control cables provided the "feel" that the pilot and co-pilot required in order to properly fly the aeroplane. Whilst at first rather crude and mechanical feeling, in a short while this system was refined until the pilot's/co-pilot's sense of the aeroplane felt more natural.

In order to bank an aeroplane, that is, to produce a rolling motion along its longitudinal (nose to tail) axis, hinged ailerons located on the trailing edge of the outer sections of each wing move (are displaced) by operation of the control wheel in the cockpit. Both ailerons work together moving in opposite directions to bank the aeroplane. To bank left, the left (or "inside" because that is the direction towards the turn) aileron must displace upwards, reducing lift and lowering the left wing, and the right (or "outside" because that is the direction away from the turn) aileron must displace downwards, increasing lift and raising the right wing. The opposite is the case for a bank to the right. Aileron down = wing up, aileron up = wing down; or wing up = aileron down, wing down = aileron up.

When banking an aeroplane, unless otherwise corrected for, the ailerons' equal displacement at the outer sections of the wings will produce what is called "adverse yaw." Yaw is the turning of an aeroplane about its vertical axis (top to bottom). Adverse yaw is a force that pulls the nose of an aeroplane in the opposite direction of the bank. Bank left, nose goes right, and *vice versa*.

Adverse yaw occurs because when one aileron displaces downward, the angle of attack (Alpha) at that part of the wing is increased. In most instances increased Alpha increases lift. This increase in lift causes that wing to rise and to bank the aeroplane around its longitudinal axis. The problem is that when lift occurs, there is a simultaneous and proportional increase in a type of drag called "induced' drag" (drag that is brought about by the creation of lift). Induced drag pulls the aeroplane in the direction of the rising wing and opposite the direction of the bank.

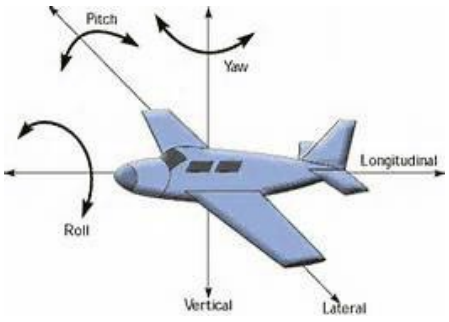
At the same time, the aileron on the opposite wing (inside wing) displaces upward, the angle of attack (Alpha) at that part of the wing is decreased and lift is therefore decreased causing the wing to lower, also banking the aeroplane around its longitudinal axis. This decrease in lift also decreases the induced drag at that part of the wing, making the lowering wing want to speed up and move forward and thus adding to the adverse yaw.

Since the downward displacement of an aileron causes most of the trouble, the fix for adverse yaw is called "aileron differential." This is created by rigging the ailerons so that each ailerons' upward displacement is more than its downward displacement.

Aileron differential does not completely eliminate adverse yaw in every case, however it does diminish it to a large extent. Connie's ailerons are differentially rigged to displace 25° up and 10° down, the elevator displacement is 40° up and 20° down, and rudders displace 30° to each side.

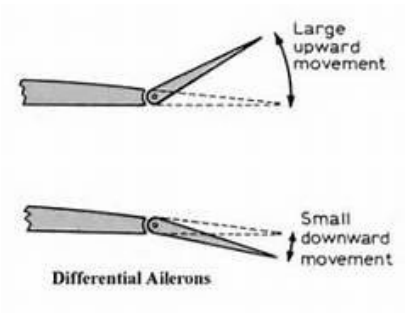
FLIGHT DECK

Constellation has always been thought of as a comfortable, even roomy aeroplane for its passengers and this is so (except perhaps for the stretched L-1649 in high-density mode with seating for ninety-nine). Unfortunately,



The three axes of an aeroplane.

How adverse yaw is produced.



Differential Ailerons

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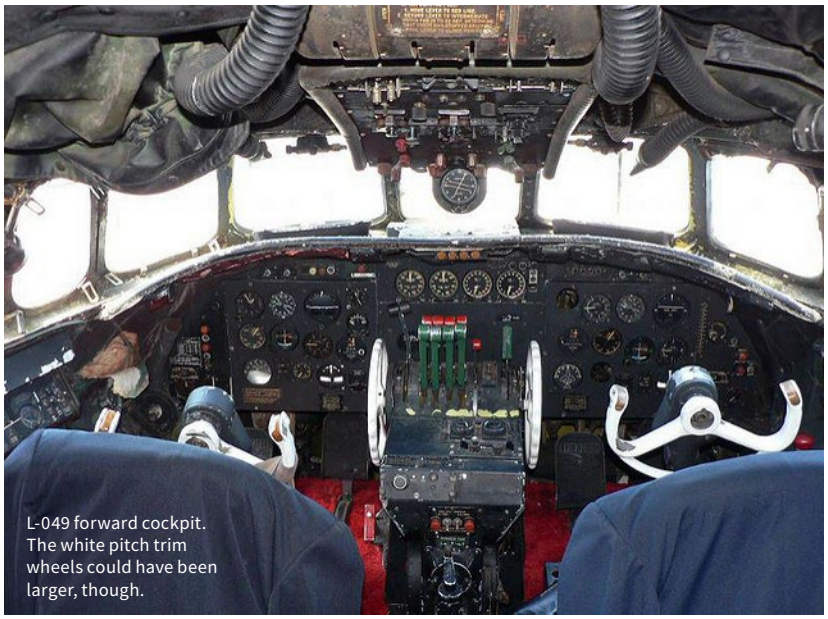

L-049 forward cockpit. The white pitch trim wheels could have been larger, though.

Got enough stuff? With the Co-Pilot's seat removed for clarity, the Flight Engineer's station on the right in the foreground and he Co-Pilot's switch panels on the right forward side of the cockpit are just a part of all that the crew of piston-engine airliners in the 1950's had to deal with. Jets are so much simpler. Note the plethora of engine controls under the main panel at the Flight Engineer's station.

the cockpit was apparently not similarly designed for the comfort of the flight crew. It would be generous to call it "tight." Cramped, cluttered and overcrowded would be more accurate.

In the days of Connie's intercontinental flights a four-person flight crew (Pilot, Co-pilot, Radio-Operator, Flight Engineer) was the norm with an occasional fifth crew member (Navigator) on board as well:

The Pilot (left seat) and Co-pilot (right seat) sits facing forward at dual controls and instruments, of course, but no one else in the cockpit does.

The Flight Engineer, who looks after everything electrical, mechanical and hydraulic plus the operation and control of the four engines and their systems (throttles, propeller pitch, mixture, carburetor air, superchargers, fuel management, oil supply, magnetos, starters, cabin pressurization, heat, air conditioning, lighting, etc.) sits behind the Co-pilot facing outward to starboard. His complex main panel and the attendant controls for all of that for which he is responsible fills the space in front, above and to the left of him.

The Radio-Operator sits behind the Pilot facing aft and handles all communications with the ground.

The optional Navigator (mostly a throwback position to WWII bombers as navigation became more and more electronically monitored and controlled by Pilots) sits in a separate section on the port side, separated from the main cockpit by a bulkhead, wherein the various necessary navigational equipment are located. He also sometimes has a clear, Plexiglas dome above for taking sun and star readings.

Every available space from the floor to the walls to the ceiling of the cockpit is filled with radios, switches, controls for various systems functions and the like, often without any seeming regard for ergonomic concerns or even basic logical layout. If there is a Navigator in the crew there is no room in the cockpit for a "dead-head" seat, that is, one usually occupied by a crew member of a different crew, an employee or guest of the airline (the "dead-head") who needs a ride but does not participate as a crew member on the flight. If the crew does not include a Navigator, a dead-head may sit at his station.

THE "SPEEDPAK"

The last twelve L-049s and every Connie after had the option to carry an aerodynamically-shaped appendage called a "Speedpak" which is attached under the fuselage for carrying extra baggage and such. Adding 349 cubic feet and up to 8,300 lb. of usable cargo the Speedpak only reduces Connie's airspeed by twelve mph. Lockheed had received a request by Eastern Airlines for this additional cargo capacity and it was tested on a USAAF C-69. Loading and unloading operations were facilitated by Speedpak's built-in elec-

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A Speedpak ready to be attached under this Western Airlines Connie L-749, the third major variant of Constellation. Photo circa 1958

tric hoists. To facilitate moving it on the ground, recessed wheels were located under its front and back. Used mostly on shorter routes, Speedpaks were usually only carried when the weight of the passengers and fuel-on-board were low enough to permit the extra cargo load.

CONSTELLATION BEFORE PEARL HARBOR

Even with war raging in Asia and just beginning to gin up in Europe, commercial life in the U.S. in 1940-41 went on as usual. Howard Hughes and Jack Fry placed their order with Lockheed for the first batch of nine L-049 Constellations in February 1940. At the same time, Lockheed was very busily manufacturing its Model 18 "Lodestar" for commercial purchasers; however, most of these were impressed into military service and designated C-60 by the USAAC and R50 by the USN. In February 1940 the RAF, well-pleased with Lockheed's Hudson patrol bomber, ordered 188 of the larger, more capable militarized Model 18 Lodestars which they named "Ventura."

In early 1940 Lockheed began to build L-349, a longer range variant of L-049. TWA increased its order to forty L-049s as Hughes had promised, and Pan Am ordered ten L-049s and thirty L-349s. Had not the rest of the world not already been plunged into war all of this civil aviation commerce would have been just peachy, but the war in Europe and Asia gave the U.S. government other ideas about aircraft production. The Commercial Aircraft Priority Committee (CAPC), a powerful, bipartisan, Congressionally created authority was formed in 1940 to oversee the production of aircraft in the U.S. and to apportion to the military services that which might be required.

By January 1941 the CAPC was busily informing U.S. aircraft manufacturers what and how many aircraft they were to build. Whilst this might seem to be rather dictatorial and perhaps even unconstitutional, U.S. aircraft manufacturers did not protest, no lawsuits were filed and no actions were commenced in the Federal Courts. U.S. aircraft manufacturers all realized that: One, half the world was already at war and the other half, including the U.S., was about be drawn into it: Two, that given the world situation, a strong U.S. military was necessary and that included lots more aircraft; Three, more practically, the War Department and the individual military services had the power to choose what they wanted and from whom they would obtain it; and Four, the government's money was as good or better than anyone else's.

No aircraft manufacturer wanted to be seen as unpatriotic, and even more importantly left out of this lucrative and expansive program. And so they meekly went along with what would surely have been seen in another, more peaceful time as Fascistic a programme as anything that ever existed in the Axis nations.

Commercial airliners such as Douglas's DC-3 and 4 and Lockheed's Constellation as well as various long-range flying boats and such were "drafted" into military service. Sometimes the experienced civilian airline crews of these special aeroplanes were also drafted to operate them for the military. All of this and what followed prevented the commercial debut of both DC-4 and Constellation until after the war. As of 4 May 1941 the plan was that the USAAC would take possession of all of the 40 L-049s that were to go to TWA, all ten of the L-049s and all thirty L-349s that were to go to Pan Am, initially designating the L-049's as C-69, and the L-359s as C-69A. A further 180 L-049s were to be built by Lockheed to be designated C-69B. Somewhat typically for the military, such a simple and sensible plan did not have a long shelf life and so Connie began her long, convoluted and checkered WWII military "career."

FOR SIMULATION USE ONLY

CONSTELLATION DURING WWII

THE FIRST PLAN

In December 1941, just after the U.S. was attacked at Pearl Harbor and was thus launched into WWII, the USAAF made provisions for Lockheed to obtain both design drawings and material from Douglas so that Pan Am's L-349s (C-69As) and the newly Lockheed-built C-69Bs (which were also L-349s) could be converted into military cargo and troop-carriers with capacity for up to 100 soldiers and their gear. The floor was to be reinforced and large cargo-type double doors installed where the passenger door had been and a second cargo door installed forward of the wing on the port side.

In order to carry this load plus full fuel, Connie's gross weight was to be increased from 67,000 lb. to 86.000 lb. This enormously increased both the wing loading (wing area/gross weight) and power loading (horsepower/gross weight) to the point that it was considered by many that Connie would be markedly unsafe to fly when fully loaded to the new gross weight.

Also, and most absurdly, metal gun aiming grommets were proposed to be built into all passenger windows (as in the windows of USAAF's DC-3 derivative, C-47) so that the troops on board could fire with their rifles at any attacking aircraft (Apparently, pressurization in C-69, which had been one of Connie's most attractive features, was now completely "out the window," so to speak). One may, with considerable humour, contemplate and picture dozens of infantrymen in such a C-69, entirely untrained in aerial gunnery with their M-1s poking out of the passengers' windows and all firing away with great enthusiasm but with little to no effect on whatever other aeroplane, friend or foe, might have ventured too close. Fortunately for all involved, this plan was never instituted. It might have been effective in combat after all as an attacking enemy pilot might have laughed himself to death at the sight.

As it turned out, confusion and disagreement amongst USAAF planners cancelled this plan and a new one was made.

THE SECOND PLAN

On 14 June 1942, the Constellation procurement program was changed again. At that time Lockheed had only begun to build the first twenty-two Connies of which the USAAF only accepted fifteen. All of this may seem strange in that the first flight of any Constellation had not yet taken place. This new plan provided that 313 C-69, C-69A, and C-69Bs were eventually to be purchased by the USAAF; however, during the intervening six months after 7 December many in the higher offices of the USAAF had changed their minds and re-thought this plan. It was now decided that for the time being it would be better for Lockheed to concentrate on building P-38s in its main Burbank plant and B-17s in its nearby Vega plant in addition to those B-17s being built by Boeing, and Douglas, rather than enter into such a large C-69 building programme.

THE THIRD PLAN

Still with the maiden flight of Constellation/C-69 still in the future, a new USAAF procurement programme for C-69s was instituted in September 1942. It was decided that only eleven C-69s would be purchased by the USAAF which included the nine L-049s that were to go to TWA would be converted to C-69s. Because of confusion regarding multiple overlapping contracts, these nine would not be purchased from Lockheed, but would be purchased from TWA. The other two would be purchased from Pan Am. All totalled, 251 C-69s, C-69As and C-69Bs were now planned to be purchased by the USAAC at an average price of approximately US$650,000.00 (US$9,541,082.82 in 2016 with a cumulative rate of inflation of 1367.9%); however, by the end of 1942 only eleven C-69s were actually purchased by the USAAF.

CONNIE'S FIRST FLIGHT

As noted before, all of these feverish financial negotiations and government plan changing took place before the first Connie ever took wing. Such wide-eyed, trusting optimism that there would be little or no major problems with the completely untested, unfledged aeroplane, particularly one so complex and innovative is rarely to be found in such circumstances. In any event, the first flight of Constellation was scheduled to take place on 31 August 1942 but that date was passed by more than four months until on 9 January 1943 Constellation/C-69 flew for the first time. It would be neat history indeed if it could be reported that everything went perfectly after that and that no problems of any import surfaced, etc. Unfortunately, the real history is, as usual, not so neat.

This is the first USAAF Lockheed XC-69 prototype, which had is first flight on 9 January 1943. It is easily identified as such because it is reliably reported that was painted in full USAAF camo (Olive Drab 41 on top, Neutral Grey underneath), had the white star in blue circle with no red centre circle insignia, no Army serial numbers on the tail, and most unusually, large Lockheed logos on the tail and nose. This C-69 was a USAAF aeroplane at this time and as such would not ordinarily be marked with civilian factory logos, especially not so prominently.

FOR SIMULATION USE ONLY

The first USAAF XC-69 prototype on the day of its first flight, 9 January 1943. It carried a civilian serial number - NX25600 and Lockheed logos. The beautiful, sinuous fuselage, unique to Connie, is clearly shown here.

For Connie's maiden voyage, Lockheed borrowed Edmund T "Eddie" Allen, a civilian engineer from Boeing who was fully a familiar with large four-engine aeroplanes such as B-17 and the new XB-29 project for which he was a test pilot. Allen also had experience with the new problematical Wright R-3350 which was the engine which also powered the XB-29.

Lockheed, having never before built a four-engine aeroplane or one as large and heavy as Constellation, had no such experienced test pilots of its own. However, Lockheed's chief test pilot Milo Burcham, who had tested the P-38 prototype, was the Co-pilot on Connie's first flight; getting in some four-engine right seat time, I suppose. Highly unusual if not rash, Clarence "Kelly" Johnson, Dick Stanton and R. L. Thoren, Constellation's principle engineers, flew as Connie's crew, Thoren as the flight engineer.

High-speed taxi tests were made on the Burbank Airport runway, after which a plume of flame shot out from one of the engines when the throttle were retarded to idle, surely making all present once again a bit nervous about the choice of engines[25]. Once all settled down, Eddie Allen opened the throttles and Connie took wing for the first time. Allen left the undercarriage down as he twice circled Connie around the Lockheed Plant to give all of those who had built her and who had assembled to watch on the hangar roofs and in the parking lot, a good look at what they had wrought.

Heading north from Burbank Allen retracted the undercarriage and climbed for altitude. A B-17 and a Lodestar were the camera aircraft. After an hour or so of flight testing which included hands-off trim, steep turns, slow flight, stalls and mock landing approaches, Allen opened up the throttles and performed multiple speed runs which proved in reality what Hughes, Fry, Hibbard and Johnson, suspected all along; that Connie was the fastest aeroplane in its class.

After flying to Muroc Dry Lake (now Edwards AFB) in record time Allen landed and commenced a series of five takeoffs and landings before returning to Burbank. The test flight was reported to have proceeded as expected and without incident.

FURTHER TESTING, TESTING, TESTING... AND GROUNDING

Satisfied with the initial test flights, the USAAF returned the XC-69 prototype and three others to TWA for further testing. TWA stripped them of the USAAF camo and painted them in TWA's familiar red livery but with USAAF serial numbers on the tail between the TWA's red stripes. Another few XC-69s went back to Pan Am for the same purpose. What they did about their paint is not known to this writer.

Once C-69/Constellation began to fly on a more regular basis, Lockheed became less and less satisfied with its Wright R-3350 engines. The early version of the engine had a carburettor with an air intake that had a 90º turn in it which intermittently restricted airflow, causing an over-rich mixture and power reductions without warning. Also, the rear row of cylinders tended to seriously run hot in flight, and the entire engine was prone to overheating when operating for even a short period on the ground, not unlike Rolls Royce/Packard "Merlin" engines.

When Boeing's XB-29 project reported that it was having

25 Before C-69's first flight, B-29s which used the same Wright R-3350 engine as C-69 had been reported to have had a number of engine fires, some of which destroyed the entire aeroplane.

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similar problems with this engine, Lockheed asked the USAAF if they could switch C-69's engine to the reliable and well-vetted Pratt and Whitney R-2800 which was only slightly less powerful than the Wright. Studies were authorized which proved the P&W engine to be a better bet, but nothing came of them. The USAAF was determined that C-69's (and B-29's) engines would be the Wright R-3350, and that was the end of the discussion.

During longer distance tests it was discovered to everyone's definite pleasure (but not a surprise to Lockheed, Hughes and Frye) that sweet C-69/L-049 Connie had a top speed of at least 365 mph (see spec chart below), faster than many first-line fighter aircraft at the time and particularly faster than the latest model P-40 Tomahawk (357 mph at 15,000') and Mitsubishi A6M5 "Zero-Sen" (345 mph top and long-range cruise airspeed of only 230 mph). This first Connie had a published cruise speed at 65% power of 313 mph (although many pilots claimed far faster cruise airspeeds) and a service ceiling of 24,000 ft. which it could take partial advantage of because of its pressurized cabin.

However well C-69's slick airframe performed, during this extended test period further engine problems arose and a bitter relationship arose between Lockheed and the Wright Engine Division of the Curtiss-Wright Corp. Lockheed claimed that Wright's underdevelopment and pre-mature introduction of the R-3350 was the cause of the engine fires and other power-control problems. Boeing might well have felt the same way as the R-3350s in the first batch of B-29s were giving their crews and Boeing nothing but trouble, some of which resulted in fatal accidents.

During the TWA/Lockheed tests the Wright engines continued to plague the entire project. First, the whole ignition system and harness was found to be faulty and Lockheed accused Wright of not having properly tested it before installing it in the R-3350. After a number of severe backfiring and in-flight engine fire incidents it was discovered that, incredibly, after only a few dozen hours of operation a number of cylinder heads were actually unscrewing from the base of the cylinders. Another area of concern was the overly-long break-in period before the R-3350 would calm down and perform according to the spec. charts.

Upon receiving these reports Wright went right ahead with the necessary changes and re-designs. To its credit, Wright's efforts eventually turned R-3350 into a more reliable and durable engine, but unfortunately all of their fixing and tweaking took a great deal of time and the USAAF's far-from-unlimited patience with the XC-69 project was beginning to wear thin.

Less than two weeks after the first XC-69 flight tests, on 23 February 1943, Eddie Allen was flying the second XC-69 when an engine caught fire during the flight. Applying fire suppressor to the burning engine, Allen thought that he had put the fire out but it had already spread inside the wing and the spar was burning. When the wing structure failed, the aeroplane crashed into a meat-packing plant, killing all on board as well as many on the ground.

Air Material Command (AMC) at Wright Field which controlled the allocation of Wright engines, grounded all further C-69 tests after that fatal crash. This halt in the C-69 project was said to be necessary because of the many problems associated with R-3350; however, at the same time, hundreds of already built R-3350s were being sent to Boeing for installation in B-29s which, understandably, had a much higher Army Air Force priority than C-69.

It was not until mid-May 1943 that C-69 received its new, modified R-3350s. Even so, it was not until 18 June 1943 that C-69 testing resumed, but at first on the ground only. Exhaustive structural pressure tests and intricate weight and balance tests were performed including tests with seventeen water tanks installed within the fuselage which could be filled and emptied with thousands of gallons of water to represent various troop/cargo configurations. Weeks later flight testing resumed with takeoffs and climbs on three and even two engines, various loads fore and aft explored the centre of gravity envelope. The engines which, after all, had been the real problem with C-69 were extensively measured for cylinder-head temperature and for incipient fires.

In addition to on-board flight engineers, four "Automatic Observers" (AO's),similar to today's "black box" were set up to photograph and measure all of the aeroplanes' systems' performance in flight. After a typical test flight sometimes as much as 1,600 feet of film were reviewed and analyzed. In July 1943 fuel tank leaks were investigated for three months and in September maximum gross weight tests up to 90,000 lb. were experimented with, resulting in increasing the flight controls' hydraulic power boost.

As the weeks and months of 1943 passed, C-69s were permitted to fly only in fits and starts with multiple grounding orders issued by AMC. The result of this was that during all of 1943, C-69s were actually flown during no more than three months and during those underwent exhaustive testing. The fact was that while it was certainly helpful and informative to learn the aircraft's physical limits, little to nothing that had to do with C-69's airframe had actually been cause for much, if any, concern. C-69's groundings were caused almost exclusively by serious problems with its R-3350s. The delay caused by testing and retesting those matters which were not truly problems in the first place was, to say the least, a severe setback to the C-69 program.

1944 saw more revised plans for C-69 and as a result the USAAF had only three examples of the aeroplane in its inventory that entire year. The excuse given for the lack of progress in the C-69 project was that Constellation/C-69 was, after all, a new design, and notwithstanding the major problems with the Wright engines as mentioned, it still required that the bugs which are always attendant regarding new aircraft designs be discovered and worked out. Accordingly, C-69 was not permitted to fly beyond the shores of the continental United States. By June 1944 the USAAF "found" 486 separate problems requiring modifications of their C-69s, including a collapsed right main undercarriage strut on 12 July which required new undercarriage forgings to be designed, manufactured and retrofitted into all existing aircraft.

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However frustrating as it must have been to Lockheed and Hughes, etc, all of the seemingly never-ending tests of C-69 which delayed its entry into USAAF's inventory as an operational aircraft also had some positive value. No other aircraft before had been so minutely and carefully scrutinised and measured. When it came time for Connie to fly as it had been intended there was nothing of any importance about her that had not been fixed, tweaked and modified into virtual perfection.

Whilst all of these seemingly endless delays in the C-69 project were occurring, Douglas's DC-4, which had been modified for military cargo and transportation duties with little effort or anxiety in 1943 became the USAAF's main air-lifter, with 1,162 of them built during WWII. DC-4 was powered by four 1,459 hp. Pratt & Whitney R-2000 radial engines which, whilst far less powerful than Wright R-3350, were reliable, had few, if any problems and did not tend to catch on fire. Constellation/C-69 was obviously a far more capable aeroplane than DC-4 in every important way, but all of that was of little importance whilst she remained in an unending testing and tweaking phase. As is always true, that which is wasted may not be recovered.

CONNIE *SHAAAAKES* THE WORLD AND USHERS IN THE MODERN AGE OF AIR-TRANSPORT

Meanwhile, Howard Hughes (remember him?) had a Connie to use for his own amusement when the USAAF gave back their few for civilian testing. However, with regard to how things were going with the USAAF's C-69 project, he was, however, not at all amused. In fact, Hughes and Jack Frye as well as everyone at Lockheed were understandably upset, perhaps furious with the wasteful, negligent and incompetent treatment that the USAAF had given their "baby." They certainly felt that the USAAF had little understanding as to what a precious resource and asset C-69/Constellation could be to them. Accordingly, they set out to teach the USAAF a lesson.

Working feverishly with Lockheed and quickly putting all in order in the second USAAF C-69, they set out to prove that the aeroplane was what they knew it to be, the finest air-transport aircraft in the world, and to embarrass the USAAF for their myopia as well. As it happened, the USAAF was expecting this particular C-69 to be delivered to them at the National Airport in Washington, DC. on 17 April 1944.

Mr. Hughes prepared the second USAAF/TWA C-69 for the flight. First of all, he striped off all of the dull, Army camo paint and repainted the Connie silver with TWA logos and stripes, and with "The TRANSCONTINENTAL Line" painted bold above the passenger windows. Then he, TWA President Jack Frye, a crew of five, plus twelve distinguished passengers, including Constellation's Chief Design Engineer, Clarence "Kelly" Johnson, USAAF Lt. Col. Clarence A. "Shoopy" Shoop, a Mr. Solomon of the Air-transport Authority and no less than Hughes's latest girlfriend, actress Ava Gardner.

Hughes and Frye were going to proceeded to deliver this Connie to the USAAF alright; but what they didn't tell anyone was that they intended to deliver not only the aeroplane, but a big surprise as well.

Orville Wright in the cockpit of C- 69/ Constellation, 26 April 1944.

Life Magazine photo and caption: "Jack Fry lands and taxi's Constellation #2 at Washington, D. C. April 17, 1944. The Historic flight of the Connie."
Note the distinctively civilian livery of this C-69. It was Hughes and Frye's idea to embarrass the Army for so carelessly and negligently handling the whole C- 69 project by painting it in TWA's colors as if to say: "We know what a great aeroplane this is even if you don't."

At 3:56 am Pacific Standard Time, on Monday morning, 17 April 1944 Hughes lifted the Connie off from Lockheed Air Terminal in Burbank (now Bob Hope Airport/ Hollywood Burbank Airport) on a flight of 2,297.5 miles to Washington, D. C. The USAAF was advised of the departure and Washington National Airport control tower personnel expected Connie to arrive some time later that evening. Imagine their surprise when Hughes called in before 2:00 PM to report that they were approaching the airport, and imagine the Army's surprise when their C-69 landed and taxied up to the ramp, not painted in the usual olive drab/ neutral grey of a military aeroplane, but in full TWA regalia.

As a further and surely the most stinging embarrassment for the USAAF, Hughes, Frye and all had just shattered

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Life Magazine photo and caption: "Jack Frye (left) and Howard Hughes (right) disembarking the Constellation after its historic flight."

Howard Hughes (left) and Jack Frye (right) in the cockpit of the record-breaking C-69.

the transcontinental flight record by making the non-stop crossing of 2,297.5 miles in 6 hours 58 minutes at an average airspeed of 331 mph.

Jack Frye later said that they didn't exceed 65% power, except during takeoff and climb, to conserve fuel so that the flight would be non-stop. Connie flew more than 116 mph faster than Boeing's contemporary 307 "Stratoliner" which cruised at 215 mph. More to the point, in 1944 no other nation had a four-engine transport aeroplane that was nearly as fast or had the range of C-69 Constellation. Hughes and all had shown the world what Constellation could do and also tacitly, but most pointedly for that, that the USAAF had let this aeroplane, capable of such spectacular performance, languish unused and neglected.

This may be as good a time as any to mention that Howard Hughes' ability as a pilot has often come into question. Was he a truly skilled pilot or just a publicity-seeking playboy? Of course there is nothing that says he couldn't be both, and he surely was the latter. The great Clarence "Kelley" Johnson, who was on board when Hughes first tested Connie and then later on the record beating Burbank to D.C. flight, was no admirer of Howard Hughes's ability as a pilot. He once stated that, "He (Hughes) damned near killed us both."

The incident that Johnson referred to occurred during the initial Constellation testing. According to Johnson, Hughes was at the controls at around 10,000' and cruising at just under 300 mph when he suddenly fully lowered the flaps. This put the Connie into a deep stall which Hughes was unable to recover from. Falling precipitously and out of control, Lockheed's Chief test pilot, Milo Burcham, who was sitting in the Co-pilot's seat took over the controls from Hughes and was barely able to recover before crashing.

As a sweet note: When Hughes, Frye and all flew the TWA-painted USAAF C-69 back from D.C. to Burbank they did a very thoughtful thing. After having made the appropriate press arrangements, they landed at Wright Field just east of Dayton, Ohio on 26 April 1944 to commemorate the first landing of a C-69/Constellation there. Whilst still in Washington they had also made special arrangements to meet none other than Orville Wright himself, who still lived in his old home in Dayton, and take him for a flight in Connie.

Aged 72, the usually very reclusive and shy Orville Wright, the co-inventor of the first practical aeroplane and the first aeroplane pilot, was excited to fly once again. It is reported that Hughes and Frye left Orville alone in the cockpit and let him fly the Connie by himself for a while. Afterwards Orville told reporters. "I guess I ran the whole plane for a minute, but let the machine take care of itself. I always said that airplanes could fly themselves if you let them alone." It is often apocryphally reported that Orville ironically later also said that Constellation's wingspan was longer than the distance of his first flight. Well, even if he didn't say it, it's true.

Here's something that Orville Wright, who died on 30 January 1948, but who lived to see the early emerging jet age and to see the sound barrier broken on 14 October 1947, really did say in the last years of his life:

"We (he and his brother Wilbur) dared to hope we had invented something that would bring lasting peace to the earth. But we were wrong ... No, I don't have any regrets about my part in the invention of the airplane, though no one could deplore more than I do the destruction it has caused. I feel about the airplane much the same as I do in regard to fire. That is, I regret all the terrible damage caused by fire, but I think it is good for the human race that someone discovered how to start fires and that we have learned how to put fire to thousands of important uses."

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Hughes felt that the aeroplane was now finally and wholly vindicated. From the day of that record flight, "Constellation" became a household name as the world's "Star Airliner." Connie was widely heralded in the press as the biggest, fastest and most beautiful airliner ever built.

Newsreels of it played in movie theatres all over the country and newspapers and magazine published countless articles and stories with photos about the record-breaking flight. As Clarence "Kelley" Johnson, Hall Hibbard, all at Lockheed, Howard Hughes and Jack Frye had always known it would, their Connie captured the public's imagination as a super-sleek, super-quick leap into modernity, ushering in a new age of air-transport.

For the first time people understood that all of the world could be reached by air in luxurious comfort and at speeds previously unimaginable for such a large and capacious aeroplane.[26]

The public's appreciation and admiration for Constellation's spectacular performance capability (for its time) was surely greatly enhanced by its glamorous, ultra-modern shape and overall appearance. I do not think it is too much to say that with this flight that the modern age of air-transport as we know it today was established both in the public's mind and in reality.

THE TIME OF B-29

In April 1939 the USAAC published a formal specification for a bomber capable of delivering 20,000 lb. of bombs to a target 2,667 miles away and capable of flying at a speed of 400 mph.

Douglas, Lockheed and Consolidated, went to work on designs to satisfy it. Boeing's pressurised, nose wheel-undercarriage version of B-17 had been in the works for a while which gave it a head start. Douglas did not submit an entry, and Lockheed, which had created a preliminary design proposal for a "Constellation Bomber," Model 249-58-IO, the XB-30, dropped out of the competition after Boeing's superior XB-29 was announced. Consolidated submitted Model 33, a larger, pressurised version of its B-24 to be powered by Wright R-3350s. This became B-32 "Dominator" which was ultimately much less than a success. Boeing's Model 345, submitted on 11 May 1940 was the winner, becoming B-29 "Superfortress."

After 7 December 1941 the USAAC turned its attention almost exclusively towards developing B-29 to strike Japan from bases in China and later from Japan's inner islands. As predicted, the "sleeping giant" had indeed been awakened. The B-29 project was now well on its way, but C-69, Connie's military designation for the Constellation, an obviously less strategically important project, fell behind. That the choice of engine for both Lockheed's C-69 and Boeing's B-29 was Wright's R-3350 engine was inevitable as it was the most powerful engine available at the time, and also was most unfortunate for Lockheed's Connie.

In April 1944, the same month that Hughes and Co. made the USAAF and the world sit up an take notice of Constellation (See above), the first Boeing B-29s were flown to India. On 5 June 1944 they flew their first combat mission, bombing Japanese rail yards near Bangkok and at other locations in Thailand. This was a test of the aeroplane and its crews, both of which passed with high marks.

The first bombing raid of the Japanese homeland since the Doolittle raid on 18 April 1942 took place on 15 June 1944. 68 B-29s took off from Chengdu, the provincial capital of Sichuan (Szechwan) province in Southwest China and hit the Imperial Iron and Steel Works at Yahata, Japan. Whilst not a particularly effective bombing mission, the lessons learned were soon put into effect and B-29 based at Chinese airfields thereafter bombed Japan eleven times, with occasionally as many as 90 B-29s participating in one raid.

The war in Europe is considered to have ended on 8 May 1945, and on 7 May 1945 in the Commonwealth. With Hitler and the Nazi threat out of the way, all Allied efforts were now trained directly on Japan. I wonder what the Japanese government and military must have been thinking when Germany surrendered. Did they perceive that Japan still had any chance of winning or even fighting to draw with virtually the entire world now focused without any other distraction upon defeating them? Vainglory and an utter failure to see reality for what it was, I suppose.

Once the islands of Tinian, Saipan and Guam were secured by August 1944, and not without with the shedding of much U.S. Marine Corps, Army and Navy blood, air bases for B-29s were built by the Naval Construction Battalions (Seabees) and on 28 October 1944 the first B-29s from island bases bombed the Japanese homeland. As the Japanese Navy and Air forces were essentially taken out the war by the time of and at the Battle of Leyte Gulf, 23 to 26 October 1944, islands even closer to Japan, Iwo Jima and Okinawa, were taken at great human cost and B-29s based there and now much closer to Japan were able to bomb at will with little opposition.

It just may be that Hughes and co. actually did embarrass the USAAF to do something with their C-69s. In the spring of 1945 there was a last gasp attempt by the USAAF to finally put C-69 to good use. The large cargo doors and reinforced floors that had been proposed years before were finally about to be installed. Whilst this further delayed the project, the virtual destruction by this time of the Japanese Army and Naval air forces meant that Lockheed's P-38 was now a much lower priority, and with the coming of B-29, B-17 programmes were over. In the summer of 1945 the war in the Pacific was rapidly coming to a victorious end and it looked as if Lockheed would now have the resources, man and womanpower, and plant space to really go to town with C-69 production as had always been promised. C-69 might finally get its chance.

Well, you may know or guess that this did not happen; but

26 The long-range "Flying Boats" such as Boeing 314 "Clipper" at 188 mph, Sikorsky VS-44 "Excalibur" at 160 mph and Martin M-130 at 130 mph, and even Boeing 307 at 215 mph and Douglas DC-3 at 207 mph seem perfectly antique in comparison to Constellation's blinding 300+ mph cruise (often published as a conservative 313 mph) with non-stop cross-continental/oceanic range.

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this time it wasn't the fault of the USAAF. The blame must go to Lockheed itself in the form of P-80, the first practical U.S. jet fighter. The concept for a jet fighter began at Lockheed in 1943 and was encouraged by the U.S. military establishment after having received secret intelligence concerning Germany's Me-262 jet interceptor. The first XP-80 flew on 8 January 1944 and testing began in earnest. The new technology was exciting but also something of a leap into the unknown. Design errors, broken turbine blades, faulty fuel pumps, etc. caused the deaths of test pilots Milo Burcham (who had also test flown Connie) and USAAF top ace Major Richard Bong, and caused serious injuries to the great Tony LeVier. All was eventually sorted out and by July 1945 80 P-80 were in USAAF service although none saw actual combat before the war ended.

Once again the C-69 project was put on low priority from which it never recovered during the war. After Germany's surrender 7 May 1945, all military resources available were sent to the Pacific to finish the war there, leaving the C-69 project completely bereft of any support in the USAAF.

In August 1945 the war was just about to end with the Atomic bombings of Hiroshima (6 August) and Nagasaki (9 August). On 4 August, however, a single C-69, the USAAF's third, was permitted to fly non-stop across the Atlantic Ocean from New York to Paris for the first time. This it did, and in grand style as well. This Constellation made the crossing in 14 hours and 12 minutes, setting a new world's record. This flight further glorified Connie, but on 19 September this same C-69, whilst being operated by a TWA crew, crashed in a corn field near Topeka, Kansas after an engine fire that could not be extinguished. There were no injuries, but the aeroplane was completely burned. Once again a problem with its R-3350 caused the grounding of all C-69s. Fifteen additional modifications were made to every existing C-69 before they were allowed to fly again.

By the time of Japan's signing of the surrender on 2 September 1945, the USAAF had only eleven C-69s in its inventory and had permanently cancelled any further orders. Almost all of those that the USAAF had, plus those that it had purchased which were still in the factory in various states of completion, were either sold back to Lockheed at a discount or given back to the airline companies who had owned them. All of this was roundly applauded at TWA, Pan Am, United and the rest. They knew what to do with these gems even if the USAAF had demonstrated that it did not.

POST-WAR CONNIE FINALLY SHOWS HER STUFF

In September 1945 the few remaining USAAF C-69s were hurriedly re-designated ZC-69 to indicate an obsolete aircraft. Obsolete indeed. The era of the Constellation was only just beginning.

The first C-69 which Lockheed purchased from the USAAF in 1945 became a test aeroplane, at first in the hands of Howard Hughes and then back to Lockheed's pilot/engineers. It was Lockheed's prescient decision to convert every C-69 it had to L-049 airliner status with the deluxe cabin appointments that Raymond Lowery had designed in 1940

Announced March 1942 by "Skyliner Magazine". Note the underestimation of Connie's actual airspeed and ceiling. The aeroplane model is probably a promotional model and not a wind- tunnel model. Wind-tunnel models do not carry livery, do not have un-powered propellers and are only (rarely) painted to test the viscosity of a particular paint finish.

She certainly is a sexy beauty… and the stewardess looks nice, too. Attractive Stewardesses have been a selling feature in airline travel since the 1930s.

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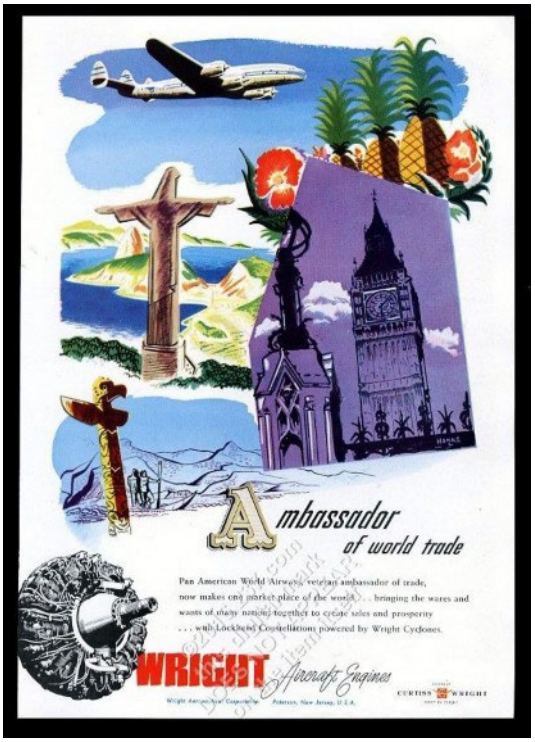
How lovely it must have been to fly in such spacious comfort, especially when compared to today's sardine-can airliner environment.



Even though Wright did eventually get the R-3350 "right", one may well-expect that given the many headaches that this engine gave to them, Lockheed was not amused at their taking any credit for Connie's success. Still, it's a nice ad.

at Howard Hughes' behest. Each of the L-049's cabin pressurization systems were refurbished and enabled. By doing this, Lockheed got the jump on Douglas's pressurized DC-6 by two years.

In early October 1945, the second C-69 returned by the USAAF which was converted to civilian use was sent to the Civil Aeronautics Administration (CAA), the immediate predecessor to the current Federal Aviation Administration (FAA), for certification inspection. The CAA was particularly concerned with in-flight engine fires because of the long, less-than-stellar history of Connie's and B-29's Wright R-3350 engines. New fire detection and extinguishing systems were installed. The CAA also insisted upon even more cabin insulation, heating and air conditioning. Lockheed added more passenger windows and a galley located between the Navigator's compartment and the main cabin for preparing hot meals. The Navigator's compartment could be converted to extra seats, or a lounge with a card table. For long-distance flights this compartment could contain fold-up bunks for off-duty crew. Two lavatories were located at the rear of the cabin and there was a coat closet as well.

For emergency evacuation, a very difficult-to-use rope ladder was to be attached at the rear passenger door and to the left side crew door. Since very few Connie passengers (or crew for that matter) were trained acrobats or trapeze artists, this was not a practical device. After a while, inflatable chutes, similar to those used today, were installed for both the passengers' and the crew's emergency exiting.

It is well to remember that this was the dawn (or perhaps the birth) of the modern airline industry. There was much yet to learn and despite all of these earnest improvements. It took a lot of experience and experiment in the coming years before all important matters were sorted out.

Approved Type Certificate (ATC) #A763 was awarded to

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Very early advertisement encouraging the public to fly, and to do so in a Connie.

Note the empty "Speedpak" behind the right wing, looking like some kind of boat.

I'm not sure what this ad as means by "surplus horsepower". In aeronautical terms any quantity of power beyond that which is required for level flight at a given airspeed (reserve power) is what is available for climbing. Did the public understand this bit of aeronautical jargon? Not bloody likely.

Lockheed Model 49 on 14 October 1945. Constellation was now, for the first time, officially a commercial airliner. All later original-style Connies (L-649, L-749), would be added to this certificate; however, the stretched-body, long-wing Connies (L-1049, L-1649A) would require their own certificates. In late 1945 and for more than three years thereafter Connie's passengers were the only ones who enjoyed fully-pressurized comfort, travelling in a U.S. airliner[27]. They enjoyed smoother flights due to flying above most weather and shorter flights as well due to the high altitudes at which Connie could cruise which enabled higher true airspeeds and direct routes that did not have to fly to avoid

27 TWA's five pressurized Boeing 307 "Stratoliners" which had been drafted by the USAAF for the duration of the war as 75s were returned in 1944 and were sent back to Boeing for rebuilding. Boeing replaced the wings and horizontal tail with those from B-17G, installed more powerful engines as well as the electrical system used on B-29 Superfortress. However, the USAAF had entirely removed all pressurization equipment. TWA resumed 307 service in 1946 with the pressurization equipment not re-installed. Pan Am's three Boeing 307s which had similarly been drafted and similarly returned were not again put into service. It was not until 1 April 1949 that Pan Am's pressurized Boeing B-29-based 377 "Stratocruiser" flew its first commercial flight from San Francisco to Honolulu.

The pressurized Douglas DC-6 did not begin regular commercial operations until February 1948 after having been grounded because of engine fires. In April 1949, American, Delta, Braniff, National and United and began flying DC-6s within the United States. Overseas DC-6 operations included Braniff to Rio de Janeiro, United to Hawaii, and Panagra from Miami to Buenos Aires. At the same time, SAS, Sabena and KLM, and flew DC-6s from New York to Europe.

As a personal note: In my younger days I often flew on a number of DC-6Bs from New York to Miami and back. What I remember most about these flights was that those four R-2800s and their Hamilton-Standard props were so horribly loud and the aeroplane vibrated so much that normal conversation was quite difficult.

On 1 April 1949 Pan Am began flying the pressurized Boeing 377 Stratocruiser on scheduled commercial operations from San Francisco to Honolulu. By December 1949 Northwest was flying numerous scheduled 377 routes in the United States and transatlantic 377 service was provided by BOAC, AOA and Pan Am.

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This ad commemorates C-69s record-breaking flight which was the first C-69 flight permitted beyond the borders of the continental U .S., although it doesn't mention that. (See above for details) Incidentally, the Wright R-3350's Chandler-Evans carburetors were the chief source of the engine fires that were such a problem with this engine. Once they were replaced with fuel injectors, the problem was solved.

mountains or bad weather. It is a curious fact that whilst the Constellation had a most sleek, streamlined airframe, this feature was entirely unnecessary to attain high speed flight in the rarefied air at higher altitudes where parasite drag is of little issue.

As more and more former C-69s and newly built L-049s came into commercial service further modifications were made. The USAAF had re-located their C-69's landing lights from the nose to the long nose-wheel strut. Airline pilots did not like the way that the lights on the nose-wheel strut focused in a very concentrated pattern. The landing lights were therefore installed in the wings on all L-049's and later models.

A more serious conversion was required with regard to steering. All of the C-69s that the USAAF had purchased had free-castering nosewheels. This meant that to turn the Connie on the ground, differential braking was required. As long as the aeroplane was taxiing this was not too much of a problem, but when standing still it was extremely difficult to pivot Connie, a maneuver that tight civilian ramps often required.

Also, it was unhealthy for the nose wheels and tires to pivot when the aeroplane was not moving forward. Lockheed redesigned the nose undercarriage to provide for hydraulic steering by the pilot with a small steering wheel. However, this conversion was not installed until the 83rd L-049 Connie was delivered.

The USAAF had installed a retractable tail skid for use when a C-69 pilot was a bit too enthusiastic about pulling the nose up when landing. This was removed from all civilianized C-69s as airline pilots were expected not to be so careless as to need such an embarrassing device.

All through the late summer/early autumn of 1945 Lockheed was busily getting its assembly lines in order. Now that the former USAAF C-69s were accounted for and well on their way to civilian conversion, new Connies were about to go down the assembly lines, past Lockheed's construction stations and emerge as they had always been intended. By November 1945 Lockheed was able to announce that it would take 89 orders for newly-built L-049s from commercial airlines such as TWA, Pan Am, Eastern, and American Overseas Airlines. Foreign orders came in from the newly liberated and free European nations of Holland (KLM) and Air France.

So, Lockheed was ready to sell Connies to the world's airlines except for one little problem. Remember that contract that Lockheed signed with Hughes Tool Co. /TWA before the war? Oh yeah, that one.

The development of Constellation was to be kept in strict confidence until TWA had received the thirty-fifth aeroplane, and no other airline that purchased the aeroplane could use it for west-to-east or east-to-west transcontinental U.S. flights for a period of two years after TWA received its fortieth Connie. Well, the cat was indeed well out of the bag as far as Constellation's existence was concerned, but the west-to-east or east-to-west transcontinental clause still had full effect and TWA insisted that it

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be honoured.

This meant that any airline which wished to purchase a four-engine airliner before TWA received its fortieth Connie had to purchase a different aeroplane from a source other than Lockheed. Accordingly, Douglas sold a lot of DC-4s to these airlines by default; but as mentioned, the unpressurized DC-4 really could not compete with Connie's spectacular performance. This led directly to Douglas's pressurized DC-6, an enlarged and more powerful DC-4, ultimately powered by Pratt and Whitney R-2800s.

However, airlines such as Pan Am, Eastern Airlines and the short-lived American Overseas Airlines had routes that did not compete with TWA and were not subject to the said contract. On 3 February 1946 Pan Am flew one of Lockheed's first civilianized C-69s from New York to Bermuda, a north to south-east flight that did not violate Lockheed's contract with TWA. This was Connies' first commercial flight.

TWA began non-stop Constellation service from New York to Paris on 6 February, 1946, and followed this with the first Los Angeles/New York regular service on 1 March 1946. These flights took an average of nine hours and fifteen minutes with one stop. The flight from New York to Los Angeles took an average eleven hours, twenty-five minutes also with one stop.

For the first time people, cargo and mail could travel across the U.S. in less than ½ a day. Occasionally, cargo/passengers were reduced and TWA was able to make non-stop transcontinental flights. Regular non-stop coast-to-coast flights commenced in 1953 with the advent of L-1049 "Super Constellation," a redesigned and stretched Connie.

In short order, Eastern Airlines began flying Connies up and down the U.S. east coast, to the Caribbean Islands and further south. Eventually, American Overseas Airlines and Pan Am flew Connies across the Atlantic to many European cities whilst TWA's early Connies covered the U.S. with dozens of routes, connecting all of the major cities and introducing truly modern airline transportation to the U.S. and to the world.

Lockheed, once free of military rules and supervision, offered Constellation to purchasers with three different engine alternatives: the Wright R-3350, the Pratt and Whitney R-2800 and the similar British Bristol Centaurus. Despite the problems that had occurred with the Wright engine, thanks to the crucial B-29 project which used the same engine, R-3350 had been much improved by the end of the war; accordingly, every airline purchased Connie with the Wrights.

The gross weight of L-049s gradually increased as the need to carry more passengers, cargo and fuel became necessary for commercial reasons. To accommodate these increases

Yes, Frankie rode, er, flew on Connie. This is not a Lockheed or a TWA ad (although one might expect that a product-placement deal might have been arranged) but Capitol Records' album designer apparently thought that at showing the elegant, sophisticated Sinatra with the elegant, sophisticated Constellation was a good match.

Possibly the world's greatest music producer/arranger, Sir George Martin, wrote in his autobiography All You Need Is Ears, that whilst he was in Los Angeles visiting the Capitol Records Tower in Hollywood he witnessed some of the recording sessions for the "Come Fly With Me" album. He wrote that he spoke with Sinatra on numerous occasions and that on one of them Sinatra told him that he hated the album cover when producer Voyle Gilmore first showed a paste-up of it to him. Sinatra said that he thought that it looked like an ad for TWA.

The only direct connection between Hughes and Sinatra I could find, aside from when Hughes took over ownership of "The Sands" casino in Las Vegas and would no longer permit Sinatra free markers for gambling, is that they both loved Ava Gardner (at separate times) who reportedly drove each of them mad (at separate times).

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various structural "beefing up" occurred in the wings and fuselage. As each weight increase was approved, a suffix letter was added to the basic L-049 model designation:

- L-049 — 86,250 lb.
- L-049A — 90,000 lb.
- L-049B/C — 93,000 lb.
- L-049D — 96,000 lb.
- L-049E — 98,000 lb.

Suffix letters used on later Constellation models such as "L-749A" and "L-1049B" do not indicate the gross weight of these aeroplanes but only incremental model variants as usual.

Both the Lockheed's and the FAA's original 1945 official designation for Constellation was "49," but it has become more common to see "049" or "L-049" in photo captions and in publications in more recent years, perhaps to more clearly differentiate the first Constellation from the later ones.

L-049 AIRLINE OPERATORS

Nine airlines operated the eighty-eight Lockheed L-049s and converted C-69s which were built, TWA and Pan Am having the bulk of them.

- TWA — 31
- Pan Am — 20
- American Overseas Airlines (AOA) — 7
- British Overseas Airways Corporation (BOAC) — 6
- Royal Dutch Airlines (KLM) — 6
- Intercontinental U.S. Airlines — 4
- Air France — 4
- Capital Airlines — 2
- Lineas Aereas Venezolanas (LAV) — 2

FACTS, LEGENDS AND MYTHOLOGY

Perhaps, like a beautiful woman, it is Connie's uniquely gracious curves and proportions that tend to cause people to revere, venerate and esteem her... and to occasionally exaggerate her accomplishments. Also, like many a beautiful woman, many of the things that are "known" about her are simply myths, mis-truths and mendacities, created and passed along from decade to decade, not in Connie's case with asperity, but with affection and admiration. Connie seems to have attracted legend and myth like no other aeroplane of its kind, or perhaps of any kind.

Here is some of what is fact and what is myth:

1. **HOWARD HUGHES DESIGNED LOCKHEED'S EXCALIBUR/CONSTELLATION**
   Myth: Mr. Hughes was no doubt an inventive and creative genius. Jane Russell's brassiere, yes; but his contribution to Constellation was that of great influence which whilst significant was limited to requesting (suggesting) an aeroplane with certain capacity, range and speed beyond that which already existed, assigning an interior designer, approving its basic conception, and not insignificantly, paying for it. Perhaps Hughes' greatest contribution to Constellation was in his willingness and ability to widely and spectacularly publicise it (and himself), bringing Connie to the public's consciousness and imagination in a way that had not been accomplished with any other aeroplane.

2. **CONSTELLATION WAS THE FIRST PRESSURIZED AIRLINER**
   Myth: Boeing's 1937 307 Stratoliner was.

3. **CONSTELLATION WAS THE FIRST TRICYCLE-UNDERCARRIAGE AIRLINER**
   Myth: Douglas' tricycle undercarriage DC-4, which was developed simultaneously with Connie, flew first on 14 February 1942. Connie's first flight was 9 January 1943.

4. **A CONSTELLATION STILL HOLDS THE RECORD FOR A NEW YORK TO WASHINGTON FLIGHT FROM LIFT OFF TO TOUCH DOWN**
   Fact: An Eastern Constellation L-749 flew from LaGuardia Airport, New York to Washington National Airport in just over 30 minutes, takeoff to landing. This record was set prior to the FAA speed restriction below 10,000 ft.

5. **A CONSTELLATION HOLDS THE RECORD FOR THE LONGEST-DURATION, NON-STOP PASSENGER FLIGHT**
   Fact: During TWA's inaugural London-to-San Francisco flight on 1-2 October 1957, its L-1649A stayed aloft for 23 hours and 19 minutes flying approximately 5,350 miles at an average speed of 229.4 mph.

6. **CONSTELLATION'S CURVACEOUS FUSELAGE IS AIRFOIL-SHAPED TO ENHANCE OVERALL LIFT**
   Myth: The aquatic shape of Connie's fuselage is not traditionally airfoil-shaped and has nothing at all to do with adding lift. Connie did not require such as her P-38-style, high-aspect wings were already more than adequate. Connie's forward fuselage curves just a bit downward to reduce the length of the already long nose undercarriage strut and its aft fuselage curves upward to put the horizontal stabilizer/elevators and those three fins and rudders up and out of the turbulent propeller-wash. A look at the front view of Constellation will bear out the execution of this design concept.

7. **CONSTELLATION WAS THE FIRST "AIR FORCE ONE"**
   Fact: President Dwight D. Eisenhower used three Constellations at different times, but only one of

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President Eisenhower's Lockheed L-749/VC-121A Columbine II when it was in storage and essentially neglected at a depot in the Sonoran Desert of southern Arizona. It was later displayed flying at various airshows and then stored at Marana Airport, Arizona where was restored to flying condition. It is currently completely restored in its "Air Force One" condition and is on display at Bridgewater Air Park, Bridgewater Virginia.

A most precocious TWA Connie landing at Los Angeles six months before it entered commercial service. (Photo from "The Godfather")

them was designated "Air Force One." Because of a traffic-controller's mix-up of identical call numbers, "8610," between an Eastern Airlines flight and President Dwight D. Eisenhower's personal L-749/VC-121A Constellation, Columbine II (named for Colorado's, First Lady Mamie Eisenhower's home state, official flower, the "Columbine") in 1953, an in-flight collision nearly occurred. Thereafter, the Air Force designation for any aircraft carrying a U.S. president was to be identified as "Air Force One." President Eisenhower also upgraded Air Force One's communications technology by adding a telephone and a teletype machine.

8. **CONSTELLATION IS THE FASTEST TRI-MOTOR PISTON AIRLINER**
Fact: On 25 July 1946 Pan Am's L-049 "Clipper America" became the fastest three-engine piston airliner by flying 2,453.89 miles at a cruise airspeed of 213 mph with only three engines attached. How this came about is related below.

9. **ANACHRONY**
In "The Godfather," Don Vito Corleone sends his adopted son, attorney Tom Hagen, to Hollywood to negotiate with a movie producer for a movie role for his godson, singer Johnny Fontane, in the summer of 1945. The on-screen image of Hagen arriving in a TWA Constellation to the strains of "Manhattan Serenade" by Louis Alter, is iconic, but wrong. Commercial Constellation service did not begin until 5 February 1946.

THE STORY OF THE THREE-ENGINE CONSTELLATION

The most famous (or infamous) story surrounding Connie becoming known as "the fastest tri-motor"* occurred on 18 June 1946. The Pan Am "Clipper America," one of the L-049 Constellations that Pan Am had purchased for its transatlantic routes, took off from New York's LaGuardia Airport at 5:00 PM and was in its initial climb-out on a northeast course to Gander, Newfoundland, then on to Ireland and London.

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On board and returning home were no less than Laurence Olivier, his wife Vivien Leigh and members of the Old Vic Repertory Company who, with Olivier, had just finished a triumphant and history-making six-week Shakespearian season on Broadway. At 5,000' and near Willimantic, Connecticut, a small town east of Hartford, Captain Samuel H. Miller noticed that the right-outboard engine was emitting smoke, then flame and was, in fact, on fire. Very quickly thereafter, the motor mount burned through and the engine ripped off of the Connie, landing on a farm in Plainfield, Connecticut but causing no serious damage or injuries.

Captain Miller immediately turned around and headed for Brainerd Field, at Hartford, planning to land on Runway 20, a 4,417' long, 150' wide asphalt runway. En route, he noticed that the drag made by the big hole in the empty and mangled right-outboard engine nacelle was causing his Connie to lose altitude very rapidly. Spotting Windham Airport in Willimantic below, he prepared to land on runway 27, a 4,271' long, 100' wide asphalt runway (not a grass strip as has been occasionally erroneously reported. Willimantic's runway 27 had been lengthened and paved in 1938).

Because the Connie's right-main undercarriage had been damaged when the engine ripped away and would not lower, Captain Miller could not land on the undamaged remainder of the undercarriage and had to make a belly landing. Calling Willimantic on the radio he informed the tower of the emergency and that he intended to land there. He successfully accomplished a flawless belly landing at 6:10 PM, using only 3,000' of Runway 27 (the bare belly of a Connie is a good brake) with no injuries to anyone onboard and no further serious damage to the aeroplane. Olivier and Co. rightfully applauded the landing. They knew a good performance when they saw one.

The passengers safely and calmly disembarked and were met by numerous ambulances and sixty Connecticut State Troopers who were alerted for the impending crash at Windham. As the famous actors assembled at the nose of the stricken Connie, the press arrived. Windham Airport's manager, Arthur Kuhn told the reporters that he had never seen anything like the perfect wheels-up landing that Captain Miller had made. When interviewed, Olivier said that it was the closest escape of his life, including his wartime experiences in the RAF He praised Captain Miller extravagantly and said that all of the passengers owed their lives to him. Vivien Leigh said that she became very frightened when she saw the engine catch fire and depart the aeroplane. She admitted to disliking flying, preferring sea and rail travel instead, but wanted to accompany her husband on the flight. "After all…tomorrow is another day," she sighed. No she didn't, but she might have been thinking it.

Three buses arrived and took the renowned thespians to Brainerd Field where they had a meal and waited for a replacement aeroplane to arrive. Mr. and Mrs. Olivier reportedly ate creamed chicken and mushrooms at the airport restaurant and over 1,000 people watched them and the company of Old Vic board the aeroplane which had come to take them home.

Pan Am's "Clipper America" which Captain Miller bellied in for a perfect landing on 18 June 1946.

So, what of the Connie? Back at Windham a team of experts from the Civil Aeronautics Authority (CAA), an officer of the Connecticut Department of Aeronautics arrived to inspect the scene of the accident and the aeroplane. Mysteriously, two Federal Customs Agents also came to take a top-secret package from the Connie's baggage compartment, the contents of which remaining undisclosed.

Of course, officials from Pan Am arrived at Windham to look after their expensive asset lying wounded on Runway 27. Pan Am was justly nervous about the crowd taking "souvenirs," i.e., essentially anything that could be pried or yanked off of the aeroplane. They hired local military veterans to circle and guard their Connie from the crowd until a solution as to what was going to be done with her was decided.

The next day more than 3,000 people came to Windham to see the aeroplane that Olivier and Leigh had flown on and perhaps to get a glimpse of them as well, although they were long gone by then.

In later times, I think that an aeroplane as large as a Constellation and especially one with only three engines that had just bellied into a landing would be disassembled and trucked back to Pan Am's repair facilities at LaGuardia Airport. This was 1946, however, and Americans were justly flushed with having just won the war (with some help, of course). It was perhaps a less conservative time, a time of more bravado and daring. It may also be that Pan Am, not at all looking forward to the ultra-expense of disassembling, transporting and re-assembling this Constellation, pulled a few of its well-known political strings and convinced the deciding powers (CAA and Connecticut Dept. of Aeronautics) that she should be minimally repaired right there at Windom, and then be permitted to take off and fly to LaGuardia to be closely looked at.

Pneumatic bags filled with compressed air lifted Connie so that the still-operating left-main and nose undercarriage could be lowered and a special rolling truss arrangement put under the right wing in the place of the damaged right-main undercarriage. As there was no hangar large enough for Connie at Windham, she was towed to a special area near their maintenance hangar and repaired there. The right-outboard engine was not replaced and the empty nacelle was smoothly covered over. The preliminary inspection discovered that the fire had started with the right-outboard engine's drive-shaft's take-off used to power the cabin's pressurization system. This system was disconnected for the time being as it would not be needed for the low-altitude, 108 mile flight back to LaGuardia.

Over the next 37 days new propellers were installed, the

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engines and all systems checked, the right-main undercarriage repaired, the airframe gone carefully over and all else done, inspected and passed for temporary, conditional airworthiness. Another large crowd watched the still three-engine Connie "Clipper America" take off from Windom's Runway 27 at 4:30 PM on 25 July 1946. Even with three engines, she only used 2,000' of the runway to lift off. Once back at LaGuardia Airport the Connie was thoroughly checked out in Pan Am's maintenance hangar. The missing engine was not replaced. Pan Am felt that the replacement of the right-outboard engine and any other serious repair would best be done at Lockheed in Burbank, California.

Accordingly, to prepare Connie "Clipper America" for the 2,453.89 mile flight back to California, what was left of the right-outboard nacelle was completely removed from the right wing and any holes, gaps, connections, etc. were smoothly faired with aluminium plates to reduce as much of the drag which that part of the right wing might generate. The three-engine Connie took off from LaGuardia and landed at Burbank Airport eleven and one half hours later without incident. At understandably reduced average cruise airspeed of a bit over 213 mph, this Constellation L-049 became the fastest tri-motor airliner until Boeing's three jet-engine 727.

Captain Samuel H. Miller became Chief Pilot for Pan Am's Atlantic division and on 26 October 1958 he flew a Pan Am Boeing 707 to Paris from then Idlewild International Airport, now Kennedy International Airport, commencing Pan Am's regular jet service between New York and Paris. He later became Pan Am's Vice President for Operations, retiring from that position in 1977. Captain Miller died on 31 August 2001 at age 84 in Bradenton, Fla. where he lived.

*Boeing 377 "Strat" pilots may wish to dispute this, but I'm not referring to four-engine piston aircraft with one engine inoperative. I am not aware of a 377 or any other aeroplane which flew over 2,400 miles with only three of its usual four engines attached to it. In any event, I love Boeing's "Strats," too (and also Fender's).

MILITARY CONNIES

No L-049 Constellations served in the U.S. military after WWII; however, variants of two Constellation models, L-749 and L-1049, did serve extensively in the USAF and U.S. Navy from 12 November 1948, when the military finally came to its senses about her, to 1982. Only a brief mention of this important part of the Constellation story will be told here as our focus is on L-049, and also that the story of Connie in the military is, in itself, worthy of an entirely separate history.

So, now that peace had come on 2 September 1945 (in the U.S.) and vast fleets of B-29's and such were no longer required, the new USAF took a long look at Constellation. The U.S. Navy also took an interest in her and the upshot was that until the end of Constellation production in 1958, of the total of 838 Constellations of all variants built, the U.S. military services purchased 332 (almost 40%) of them.

The USAF designated Connie to be C-121 with various prefixes and suffixes added. U.S. Navy Connies were designated a variety of numbers and letters from R7V-1 to VC-121J. In fact it was the U.S. Navy that is responsible the Turbo-Compound system that upgraded the Wright R-3350s to much higher horsepower. (See above) The Navy intended for the Turbo-Compound R-3350s for their Lockheed P2V-4 "Neptune" patrol bomber, but Lockheed, which needed a more powerful engine for their planned civilian L-1049 "Super Constellation," a larger variant of the original Connie, happily incorporated this new, more powerful version of R-3350 into the programme.

The following is a non-comprehensive list of military Connies:

Air Force Constellations

- **C-121A**
  Initial variant, based on the civil L-749 Constellation. Nine built.

- **VC-121A**
  Six C-121A transports converted to VIP use. Originally designated PC-121A. President Dwight D. Eisenhower's official transport aircraft called Columbine II and was the first "Air Force One."

- **VC-121B**
  Similar to the VC-121A, but with the cargo door replaced by a smaller passenger door. One built.

- **C-121C**
  Initial variant based on the L-1049 Super Constellation. 33 built.

- **VC-121C**
  VIP conversion of four C-121C aircraft.

- **VC-121E**
  Ordered by the United States Navy as a R7V-1 but modified before delivery as a presidential transport for the United States Air Force. President Dwight D. Eisenhower's personal VC-121E, was called Columbine III.

- **YC-121F**
  Two former United States Navy R7V-2s with Pratt & Whitney T-34 turboprop engines transferred to the United States Air Force. Designated L-1249A by Lockheed.

- **C-121G**
  Re-designation of 32 R7V-1 transports transferred from the USN to the Air Force.

- **TC-121G**
  Three C-121Gs converted to airborne warning and control system (AWACS) crew trainers.

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- **VC-121G**
  One C-121G converted to a VIP transport.

Navy Constellations

- **R7O/R7V-1**
  Initial Navy version based on the L-1049. 50 built. Originally designated R7O.

- **R7V-1P**
  One R7V-1 modified for Antarctic service.

- **R7V-2**
  Two transport aircraft similar to the YC-121F. Also designated L-1249A. Two built.

- **C-121J**
  18 remaining R7V-1s redesignated.

- **TC-121J**
  Electronic testbed. One converted.

- **PO-1W / WV-1**
  Two L-749As equipped with radomes and radar similar to the later WV-2s. In 1952 they were Redesigned WV-1 from PO-1W.

- **EC-121K / WV2**
  In 1954 the US Navy begin receiving the first of 142 Super Constellations designated as WV-2 "Warning Star" which was the last Connie to serve in the military. It was retired in 1982.

- **NC-121J**
  Four C-121J aircraft converted to television and radio broadcasting aircraft for use in Vietnam. "Project Jenny" (Blue Eagles) OASU/VX-8/VXN-8

- **VC-121J**
  Four C-121J aircraft converted for VIP use. One operated with the Blue Angels.

Travel by air is generally taken for granted today. We have come to expect to be able to travel at any hour and every day of the year to virtually any inhabited place on the planet, quickly and in relative comfort. Only 80 or so years ago when this story began, a mere flash in the timeline of history, the reality of modern air travel and airliners would have seemed to be the fevered imaginings of science fiction.

I think that it is not too much to give Constellation and L-049 in particular a good part, perhaps the major part of the credit for the development of modern air travel. Swift, capacious, long-legged, and beautiful, Connie stands out as one of aviation's inimitable and most recognizable achievements. Of the 856 Constellations of all types built, only fifty-six Connies of all types still exist in one form or another, few of them flyable and some poor few which have become restaurants, bars and other non-aviation displays.

Neglected and under-appreciated in her infancy, the special and superior qualities that Connie had always possessed shone through brightly when she was finally given leave to do that for which she was created. Constellation would evolve into four further major civilian models throughout the 1950's: L-649, L-749, L-1049 and the ultimate Connie, L-1649A "Starliner," plus numerous military versions of each of these, including an experimental turbine/propeller engine powered version (L-1249) for the Navy in 1954 and for the USAF in 1955. L-049 would be pulled, stretched and enlarged to meet the ever-growing demand to provide seats for more and more passengers, to go faster, higher, carry heavier loads and go farther until Connie became what Howard Hughes, Jack Frye, Clarence "Kelley" Johnson, and Hall Hibbard always knew she was, the ultimate piston-engine air-transport aeroplane. However, the aeroplane that began it, the simpler, smaller and in this writer's opinion, most gracious and beautiful of them all is L-049.

SPECIFICATIONS

Wing span	123 ft 0 in (37.49 m)
Length	95 ft 2 in (29.00 m)
Height	23 ft 8 in (7.21 m)
Wing Area	1,650 ft^2 (153.28 m^2)
Empty Weight	55,345 lbs (25,104 kg)
Loaded Weight	86,250 lbs (39,122 kg)
Max. Speed	365 mph (587.41 km/h) @ 20,000'
Cruising Speed	313 mph (503.72 km/h) @ 20,000'
Service Ceiling	25,500 ft (7,770 m)
Max Range	3,680 miles (5,920 km) with 7,800 lb (3,538 kg) payload
Range Max Payload	2,290 miles (3,685 km) with 18,400 lb (8,364 kg) payload
Powerplant	Four Wright Cyclone R-3350-745C-18BA-1, engines rated @ 2,200 hp (1,640 kw) each

A note about published aircraft specifications: Physical items such as wingspan, weight, etc. are consistent, easily measured and are therefore not controversial matters. However, performance items such as top and cruising speed, range, etc. are variable, changing with density altitude, load, pilot technique and from one identical-looking aeroplane to another.

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One of the unfortunate Connies which ended up as a display/restaurant, or whatever. This one was put up as a rather spectacular if sad display in Florida in the late 1970s.

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DEVELOPER'S NOTES

Throughout the making of this this project, the knowledge that there are only four examples of the original model 049 Constellation left in the world today admittedly bothered me. When examining its history however, the reason for their scarcity is explained; there weren't many original models made and as time passed, most of those in service were upgraded to the next version. It's such a shame considering it's importance that nobody placed just one of these airframes in a museum to preserve since the Constellation has had an enormous impact on aviation.

Prior to this project when we were researching what model to make, it was clear that the vast majority of available information was on the Super Constellation. But when our lead artist on this project Robert Rogalski and I got together to discuss the different models, we both already concluded that, from an aesthetic point of view alone, the original model 049 was the ultimate beauty. It was as if an artist was tasked to create the most beautiful four-engine airplane, and this was his first creation. The lines flow perfectly from the tip of the nose, to the wing tips, to the tip of the tail. It even looks gorgeous when the landing gear and flaps are deployed.

The very first Connie produced had a single speed supercharger, while within the first year of it's service, these engines were upgraded to dual speed superchargers. The upgrades just kept coming in; eventually cutting up the beautifully perfect body and adding more space, more power, and more weight. Since we did not want to touch the body of the original design, we did the very latest version of the original model 049 airplane, which included a dual speed supercharger.

One of the most significant features of the Captain of the Ship Connie is its engine sound modeling. Since there are no flying examples of this model, we used an available Douglas Skyraider that has the same engine and exhaust configuration as the Connie as our engine source. We also used some very advanced audio techniques to model the

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reverberations in the cabin that occur especially when all four of these beastly, 18-cylinder Wright R-3350 Duplex-Cyclone engines come roaring to life. From the first time I heard the sound we were able to create in the simulation, with the new modeling techniques, I couldn't wait to share it with our community. I'm so happy to finally get this four engine beauty into your hands.

For our existing Boeing 377 Stratocruiser veteran customers soon to be flying the Connie, take a moment to go through the features list in this manual to see what has changed in the latest Captain of the Ship release. We hope to incorporate some of these new features in our existing Stratocruiser down the road, but keep in mind that both the Stratocruiser and the Constellation are two very deep, organic, living beasts in their own right. We must approach their designs individually even though, on the surface, you may see similar things, beneath critical numbers, the tolerances, and behaviors are very different. In general, the Connie is a more forgiving airplane to operate. This means Stratocruiser pilots should have less trouble transitioning, but first time Connie pilots will have a bit more challenge flying the Stratocruiser due to it's size, power, and high wing loading.

We are so proud to have added this historic icon to our collection from both a simulation point of view and a pure historical perspective. A2A Simulation's Captain of the Ship Constellation stands as a one of a kind virtual peek into what it was like operating this legendary, but now so rare, unmistakable beauty. Thank you for being an A2A customer, which allowed us to dive deeply into development and create another Captain of the Ship airplane.

SCOTT GENTILE

A2A simulations

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FEATURES

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- **HISTORY COMES ALIVE:** Experience a timeless legend brought to life inside a simulation. Every aircraft is unique: Don't expect all gauges to read the same values, just like the real airplane. And each airplane is persistent.
- **FOUR CREW POSITIONS:** pilot, co-pilot, flight engineer, and navigator. Fully modelled and functioning positions constructed with down to the rivet detail.
- **INTELLIGENT CREW AND RESPONSIVE PASSENGERS:**
  - Your engineer can manage all the systems on the fly, responding to various conditions
  - Copilot calls out critical info
  - Navigator observes and posts findings
  - Flight attendant tirelessly works for both you and the passengers (just like the real world counterparts)
- **UNEXPECTED EVENTS POSSIBLE:** Engines along with other systems including heating, air conditioning, and pressurization can be problematic.
- **CAPTAIN'S CAREER:** Your performance is remembered and can get better, worse, or stay consistent based on your flying abilities and flight management.
- **REAL TIME LOAD MANAGER:** with the ability to load individual passengers, cargo, and fuel or select presets.
- **CUSTOM NAVIGATOR'S MAP:** Zoomable map can be customized to show the desired information. Accessible via keystroke or the Navigators station.
- **DEFAULT AND HISTORIC SPERRY AUTOPILOT:** You can select either autopilot in the sim.
- **AUTHENTIC FUEL DELIVERY INCLUDES PRIMER ONLY STARTS:** You can start the engines properly by using primer with the mixture in the OFF position.
- **AUTO-MIXTURE** that actually performs as intended. Now you can set for "auto-rich" or "auto-lean" and the aircraft fuel to air ratio will be automatically determined and set by the carburetor based upon various factors such as altitude.
- **CUSTOM COCKPIT SYSTEMS AND GAUGES** for the ultimate in realism taken far beyond what is available by default.
- **INERTIA STARTERS:** Start these big beautiful engines by the book using authentic inertia wheel energizing and engagement.
- **FEATHERING PROPS AND AIR STARTS:** Custom physics allows for realistic feathering and air starts without using the starter.
- **DEEP COCKPIT LIGHTING:** Flood, Fluorescent, and gauge lighting modeled.
- **DUAL SPEED SUPERCHARGERS:** Proper supercharger physics and each engine can independently run in either high or low blower.
- **NEW SLIP AND BALL CODE FROM THE T-6:** Enjoy smooth, custom physics in this critical gauge during turning maneuvers.
- **AUTHENTIC FLIGHT STABILITY:** The Connie was known for being a little less stable in pitch than other aircraft, which requires a little more finesse and attention.
- **PISTON COMBUSTION ENGINE MODELING:** Real-world conditions affect system conditions, including engine temperatures.
- **FULLY CLICK-ABLE COCKPITS:** with authentically working systems and gauges.
- **3D LIGHTS 'M'** (built directly into the model)
- **PURE 3D INSTRUMENTATION**
  - Natural 3D appearance with exceptional performance.
  - Smooth movements.
- **FIRE EXTINGUISHER SYSTEM** with fully functioning overheard panel and controls.
- **GROUND POWER UNIT (GPU)** to power systems with engines off and not drain the battery.
- **CABIN PRESSURIZATION SYSTEM CONTROLS:** You control the target altitude and the rate of pressure change and the system authentically displays and manages cabin pressure.
- **THREE DIFFERENT LIVERIES:** including TWA, BOAC, and a C-69 cargo paint.
- **A2A SPECIALIZED BUMP MAPPING AND SPECULAR LIGHTING** on all models.
- **CREW REPORTS** pop-up 2D panel keeps important information easily available.
- **MANAGE TEMPERATURES WITH ENGINE COWL FLAPS AND OIL COOLER FLAPS:** High temperatures can adversely affect engine performance, Serious overheating can cause scoring of cylinder head walls including ultimate failure if warnings are ignored and overly abused.
- **SPARK PLUGS CAN CLOG AND EVENTUALLY FOUL** if engines are allowed to idle too low for too long. Throttling up an engine with oil-soaked spark plugs can help clear them out.
- **EXPERIENCE AUTHENTIC ASYMMETRICAL DRAG** when operating various flap systems in flight.

FOR SIMULATION USE ONLY

QUICKSTART GUIDE

Chances are, if you are reading this manual, you have properly installed the A2A L-049 Constellation. However, in the interest of customer support, here is a brief description of the setup process, system requirements, and a quick start guide to get you up quickly and efficiently in your new aircraft.

SYSTEM REQUIREMENTS

The A2A Simulations L-049 Constellation requires the following to run:

- Requires licensed copy of Lockheed Martin Prepar3D

OPERATING SYSTEM:

- Windows XP SP2
- Windows Vista
- Windows 7
- Windows 8 & 8.1
- Windows 10

PROCESSOR:

2.0 GHz single core processor (3.0GHz and/or multiple core processor or better recommended).

HARD DRIVE:

250MB of hard drive space or better.

VIDEO CARD:

DirectX 9 compliant video card with at least 128 MB video ram (512 MB or more recommended).

OTHER:

DirectX 9 hardware compatibility and audio card with speakers and/or headphones.

INSTALLATION

Included in your downloaded zipped (.zip) file, which you should have been given a link to download after purchase, is an executable (.exe) file which, when accessed, contains the automatic installer for the software.

To install, double click on the executable and follow the steps provided in the installer software. Once complete, you will be prompted that installation is finished.

Important: If you have Microsoft Security Essentials installed, be sure to make an exception for Lockheed Martin Prepar3D as shown on the right.

REALISM SETTINGS

The A2A Simulations L-049 Constellation was built to a very high degree of realism and accuracy. Because of this, it was developed using the highest realism settings available in Lockheed Martin Prepar3D.

The following settings are recommended to provide the most accurate depiction of the flight model. Without these settings, certain features may not work correctly and the flight model will not perform accurately. The figure below depicts the recommended realism settings for the A2A L-049 Constellation.

FLIGHT MODEL

To achieve the highest degree of realism, move all sliders to the right. The model was developed in this manner, thus we cannot attest to the accuracy of the model if these sliders are not set as shown below.

INSTRUMENTS AND LIGHTS

Enable "Pilot controls aircraft lights" as the name implies for proper control of lighting. Check "Enable gyro drift" to provide realistic inaccuracies which occur in gyro compasses over time.

"Display indicated airspeed" should be checked to provide a more realistic simulation of the airspeed instruments.

ENGINES

Ensure "Enable auto mixture" is NOT checked.

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FLIGHT CONTROLS

It is recommended you have "Auto-rudder" turned off if you have a means of controlling the rudder input, either via side swivel/twist on your specific joystick or rudder pedals.

ENGINE STRESS DAMAGES ENGINE

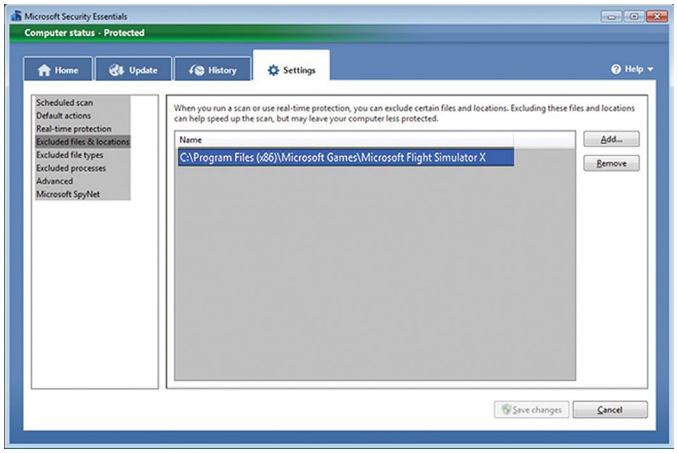
(Acceleration Only). It is recommended you have this UNCHECKED.

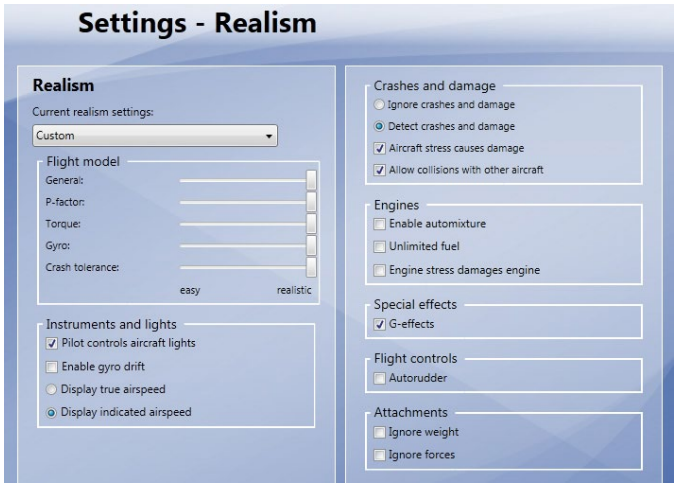
DISPLAY SETTINGS

Under Aircraft, "High Resolution 3-D cockpit" must be checked.

SUPPORT AND QUESTIONS?

Please visit us and post directly to the A2A support and community forums; https://a2asimulations.com/forum/index.php





QUICK FLYING TIPS

- To Change Views Press A or SHIFT + A.
- Keep the engine at or above 800 RPM. Failure to do so may cause spark plug fouling. If your plugs do foul (the engine will sound rough), try running the engine at a higher RPM. You have a good chance of blowing them clear within a few seconds by doing so. If that doesn't work, you may have to shut down and visit the maintenance hangar.
- On landing, once the airplane settles slowly pull back on the yoke for additional elevator braking while you use your wheel brakes. Once the airplane has slowed down you can raise your flaps.
- Be careful with high-speed power-on dives (not recommended in this type of aircraft), as you can lose control of your aircraft if you exceed the max allowable speed.
- For landings, take the time to line up and plan your approach. Keep your eye on the speed at all times.
- Using a Simulation Rate higher than 4× may cause odd system behavior.
- A quick way to warm your engine is to re-load your aircraft while running.
- In warm weather, use reduced power and higher speed, shallow climbs to keep engine temperatures low.
- Avoid fast power reductions especially in very cold weather to prevent shock cooling the engine.

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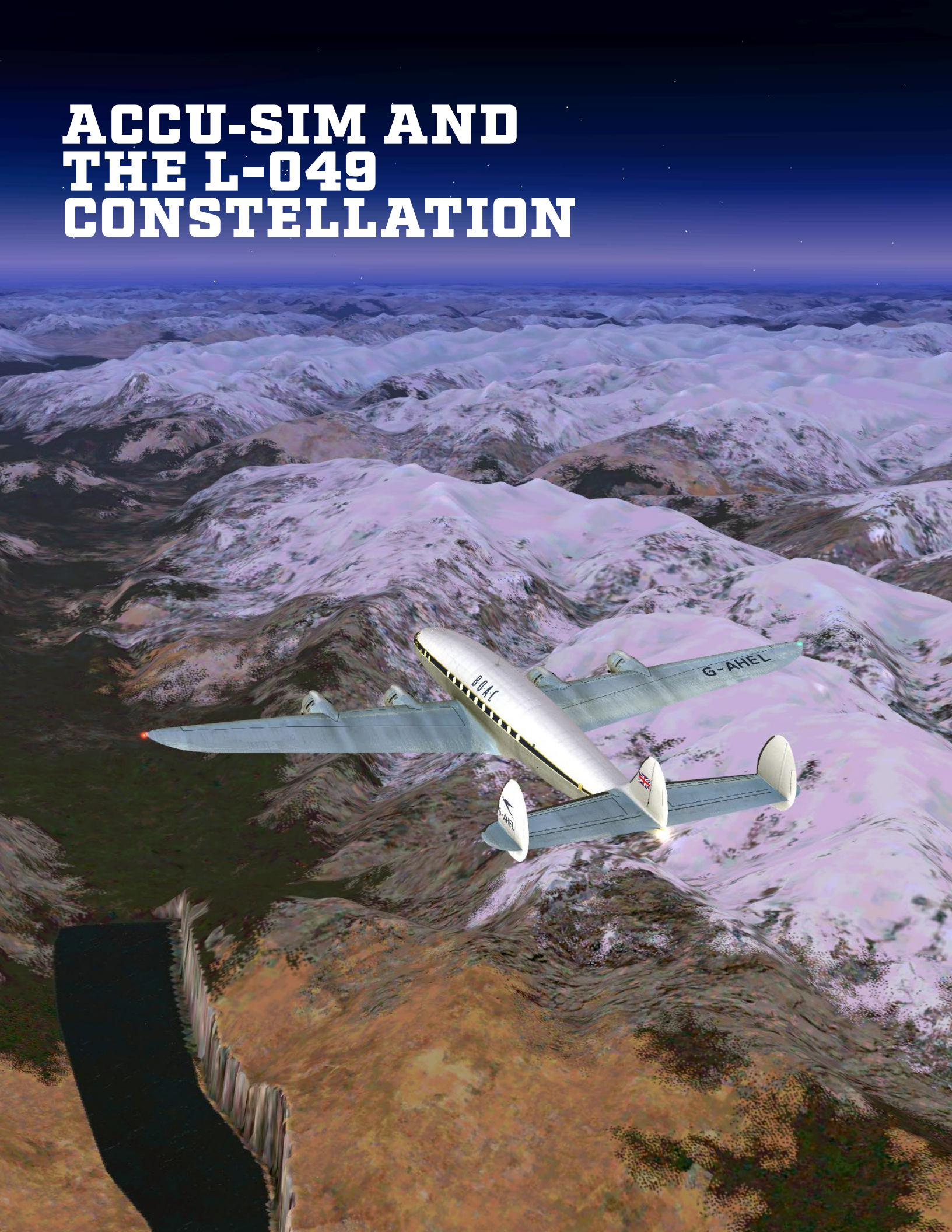
ACCU-SIM AND THE L-049 CONSTELLATION



Accu-Sim is A2A Simulations' growing flight simulation engine, which is now connectable to other host simulations. In this case, we have attached our L-049 Constellation to Microsoft Flight Simulator X and Lockheed Martin's Prepar3D to provide the maximum amount of realism and immersion possible.

WHAT IS THE PHILOSOPHY BEHIND ACCU-SIM?

Pilots will tell you that no two aircraft are the same. Even taking the same aircraft up from the same airport to the same location will result in a different experience. For example, you may notice one day your engine is running a bit hotter than usual and you might just open your cowl flaps a bit more and be on your way, or maybe this is a sign of something more serious developing under the hood. Regardless, you expect these things to occur in a simulation just as they do in life. This is Accu-Sim, where no two flights are ever the same.

Realism does not mean having a difficult time with your flying. While Accu-Sim is created by pilots, it is built for everyone. This means everything from having a professional crew there to help you manage the systems, to an intuitive layout, or just the ability to turn the system on or off with a single switch. However, if Accu-Sim is enabled and the needles are in the red, there will be consequences. It is no longer just an aircraft, it's a simulation.

ACTIONS LEAD TO CONSEQUENCES

Your A2A Simulations aircraft is quite complete with full system modeling and flying an aircraft such as this requires constant attention to the systems. The infinite changing conditions around you and your aircraft have impact on these systems. As systems operate both inside and outside their limitations, they behave differently. For example, the temperature of the air that enters your carburetor has a direct impact on the power your engine can produce. Pushing an engine too hard may produce just slight damage that you, as a pilot, may see as it just not running quite as good as it was on a previous flight. You may run an engine so hot, that it catches fire. However, it may not catch fire; it may just quit, or may not run smoothly. This is Accu-Sim – it's both the realism of all of these systems working in harmony, and all the subtle, and sometimes not so subtle, unpredictability of it all. The end result is when flying in an Accu-Sim powered aircraft, it just feels real enough that you can almost smell the avgas.

YOUR AIRCRAFT TALKS

We have gone to great lengths to bring the internal physics of the airframe, engine, and systems to life. Now, when the engine coughs, you can hear it and see a puff of smoke. If you push the engine too hard, you can also hear signs that this is happening. Just like an actual pilot, you will get to know the sounds of your aircraft, from the tires scrubbing on landing to the stresses of the airframe to the window that is cracked opened.

BE PREPARED – STAY OUT OF TROUBLE

The key to successfully operating almost any aircraft is to stay ahead of the curve and on top of things. Aircraft are not like automobiles, in the sense that weight plays a key role in the creation of every component. So, almost every system on your aircraft is created to be just strong enough to give you, the pilot, enough margin of error to operate safely, but these margins are smaller than those you find in an automobile. So, piloting an aircraft requires both precision and respect of the machine you are managing.

It is important that you always keep an eye on your oil pressure and engine temperature gauges. On cold engine starts, the oil is thick and until it reaches a proper operating temperature, this thick oil results in much higher than

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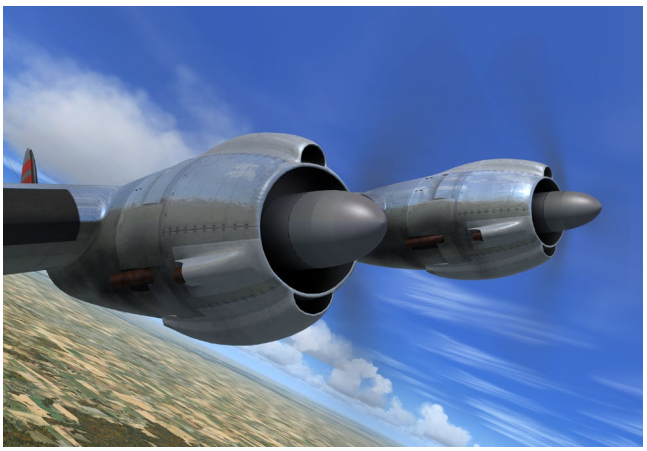
normal oil pressure. In extreme cold, once the engine is started, watch that oil pressure gauge and idle the engine as low as possible, keeping the oil pressure under 100psi.



PERSISTENT AIRCRAFT

Every time you load up your L-049 Constellation, you will be flying the continuation of the last aircraft which includes fuel and oil, along with all of your system conditions. So be aware, no longer will your aircraft load with full fuel every time, it will load with the same amount of fuel you left off when you quit your last flight. You will learn the easy or the hard way to make, at the very least, some basic checks on your systems before jumping in and taking off, just like a real aircraft owner.

Additionally, in each flight things will sometimes be different. The gauges and systems will never be exactly the same. There are just too many moving parts, variables, changes, etc., that continuously alter the condition of the airplane, its engine and its systems.

> **NOTE:** Signs of a damaged engine may be lower RPM (due to increased friction), or possibly hotter engine temperatures.

SOUNDS GENERATED BY PHYSICS

Microsoft Flight Simulator X and Lockheed Martin's Prepar3D, like any piece of software, has its limitations. Accu-Sim breaks this open by augmenting the sound

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system with our own, adding sounds to provide the most believable and immersive flying experience possible. The sound system is massive in this L-049 Constellation and includes engine sputter / spits, bumps and jolts, body creaks, engine detonation, runway thumps, and flaps, dynamic touchdowns, authentic simulation of air including buffeting, shaking, broken flaps, primer, and almost every single switch or lever in the cockpit is modeled. Most of these sounds were recorded from the actual aircraft and this sound environment just breaks open an entirely new world. However, as you can see, this is not just for entertainment purposes; proper sound is critical to creating an authentic and believable flying experience. Know that when you hear something, it is being driven by actual system physics and not being triggered when a certain condition is met. There is a big difference, and to the simulation pilot, you can just feel it.

GAUGE PHYSICS

Each gauge has mechanics that allow it to work. Some gauges run off of engine suction, gyros, air pressure, or mechanical means. The RPM gauge may wander because of the slack in the mechanics, or the gyro gauge may fluctuate when starting the motor, or the gauge needles may vibrate with the motor or jolt on a hard landing or turbulent buffet.

The gauges are the windows into your aircraft's systems and therefore Accu-Sim requires these to behave authentically.

LANDINGS

Bumps, squeaks, rattles, and stress all happens in an aircraft, just when it is taxiing around the ground. Now take that huge piece of lightweight metal and slam it on the pavement. It's a lot to ask of your landing gear. Aircraft engineer's don't design the landing gear any more rugged than they have too. So treat it with kid gloves on your final approach. Kiss the pavement. Anything more is just asking too much from your aircraft.

Accu-Sim watches your landings, and the moment your wheels hit the pavement, you will hear the appropriate sounds (thanks to the new sound engine capabilities). Slam it on the ground and you may hear metal crunching, or just kiss the pavement perfectly and hear just a nice chirp or scrub of the wheels. This landing system part of Accu-Sim makes every landing challenging and fun.

YOUR TURN TO FLY SO ENJOY

Accu-Sim is about maximizing the joy of flight. We at A2A Simulations are passionate about aviation, and are proud to be the makers of both the A2A Simulations L-049 Constellation. Please feel free to email us, post on our forums, or let us know what you think. Sharing this passion with you is what makes us happy.

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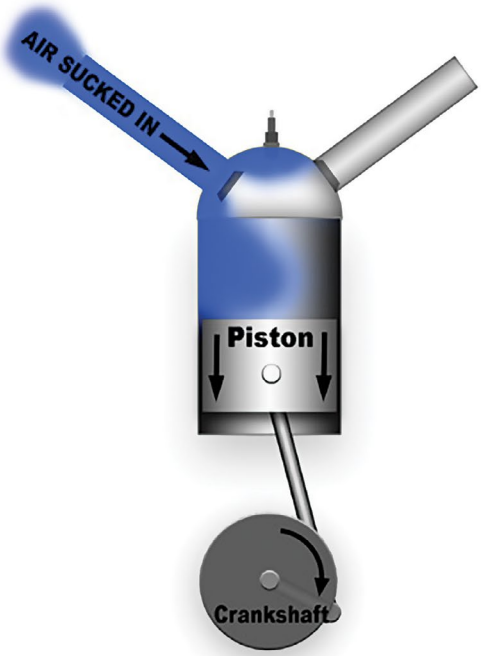
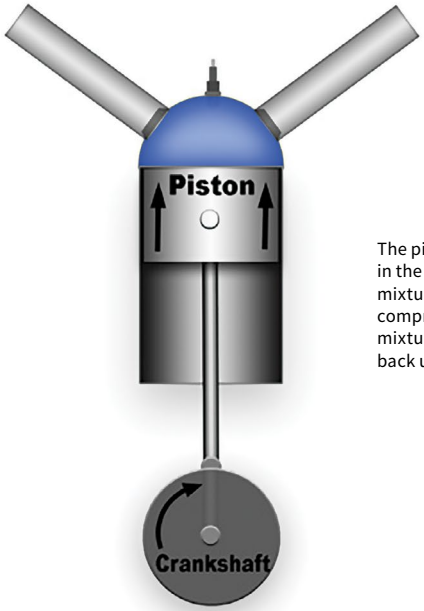
ACCU-SIM AND THE COMBUSTION ENGINE





The piston pulls in the fuel / air mixture, then compresses the mixture on its way back up.

The spark plug ignites the compressed air / fuel mixture, driving the piston down (power), then on its way back up, the burned mixture is forced out the exhaust.

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The combustion engine is basically an air pump. It creates power by pulling in an air / fuel mixture, igniting it, and turning the explosion into usable power. The explosion pushes a piston down that turns a crankshaft. As the pistons run up and down with controlled explosions, the crankshaft spins. For an automobile, the spinning crankshaft is connected to a transmission (with gears) that is connected to a driveshaft, which is then connected to the wheels. This is literally "putting power to the pavement." For an aircraft, the crankshaft is connected to a propeller shaft and the power comes when that spinning propeller takes a bite of the air and pulls the aircraft forward.

The main difference between an engine designed for an automobile and one designed for an aircraft is the aircraft engine will have to produce power up high where the air is thin. To function better in that high, thin air, a supercharger can be installed to push more air into the engine.

OVERVIEW OF HOW THE ENGINE WORKS AND CREATES POWER

Fire needs air. We need air. Engines need air. Engines are just like us as – they need oxygen to work. Why? Because fire needs oxygen to burn. If you cover a fire, it goes out because you starved it of oxygen. If you have ever used a wood stove or fireplace, you know when you open the vent to allow more air to come in, the fire will burn more. The same principle applies to an engine. Think of an engine like a fire that will burn as hot and fast as you let it.

Look at these four images on the left and you will understand basically how an engine operates.

The piston pulls in the fuel / air mixture, then compresses the mixture on its way back up.

The spark plug ignites the compressed air / fuel mixture, driving the piston down (power), then on its way back up, the burned mixture is forced out the exhaust.

AIR TEMPERATURE

Have you ever noticed that your car engine runs smoother and stronger in the cold weather? This is because cold air is denser than hot air and has more oxygen. Hotter air means less power.

Cold air is denser and so provides more oxygen to your engine. More oxygen means more power.

MIXTURE

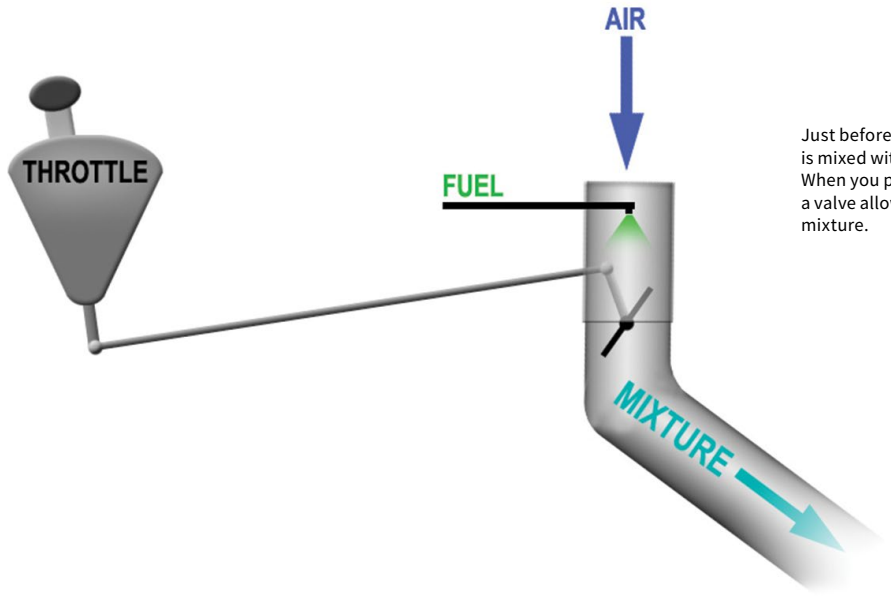
Just before the air enters the combustion chamber it is mixed with fuel. Think of it as an air / fuel mist.

A general rule is a 0.08% fuel to air ratio will produce the most power. 0.08% is less than 1%, meaning for every 100 parts of air, there is just less than 1 part fuel. The best economical mixture is 0.0625%.

Why not just use the most economical mixture all the time?

Because a leaner mixture means a hotter running engine. Fuel actually acts as an engine coolant, so the richer the mixture, the cooler the engine will run.

However, since the engine at high power will be nearing its maximum acceptable temperature, you would use your



Just before the air enters the combustion chamber it is mixed with fuel. Think of it as an air / fuel mist. When you push the throttle forward, you are opening a valve allowing your engine to suck in more fuel / air mixture.

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best power mixture (0.08%) when you need power (take-off, climbing), and your best economy mixture (.0625%) when throttled back in a cruise when engine temperatures are low.

So, think of it this way:

- For HIGH POWER, use a RICHER mixture.
- For LOW POWER, use a LEANER mixture.

THE MIXTURE LEVER

Most piston aircraft have a mixture lever in the cockpit that the pilot can operate. The higher you fly, the thinner the air, and the less fuel you need to achieve the same mixture. So, in general, as you climb you will be gradually pulling that mixture lever backwards, leaning it out as you go to the higher, thinner air.

HOW DO YOU KNOW WHEN YOU HAVE THE RIGHT MIXTURE?

The standard technique to achieve the proper mixture in flight is to lean the mixture until you just notice the engine getting a bit weaker, then richen the mixture until the engine sounds smooth. It is this threshold that you are dialing into your 0.08%, best power mixture. Be aware, if you pull the mixture all the way back to the leanest position, this is mixture cutoff, which will stop the engine.

INDUCTION

As you now know, an engine is an air pump that runs based on timed explosions. Just like a forest fire, it would run out of control unless it is limited. When you push the throttle forward, you are opening a valve allowing your engine to suck in more fuel / air mixture. When at full throttle, your engine is pulling in as much air as your intake system will allow. It is not unlike a watering hose – you crimp the hose and restrict the water. Think of full power as you just opening that water valve and letting the water run free. This is 100% full power.

In general, we don't run an airplane engine at full power for extended periods of time. Full power is only used when it is absolutely necessary, sometimes on takeoff, and otherwise in an emergency situation that requires it. For the most part, you will be 'throttling' your motor, meaning you will be setting the limit.

MANIFOLD PRESSURE = AIR PRESSURE

You have probably watched the weather on television and seen a large letter L showing where big storms are located. L stands for LOW BAROMETRIC PRESSURE (low air pressure). You've seen the H as well, which stands for HIGH BAROMETRIC PRESSURE (high air pressure). While air pressure changes all over the world based on weather conditions, these air pressure changes are minor compared to the difference in air pressure with altitude. The higher the altitude, the much lower the air pressure.

On a standard day (59°F), the air pressure at sea level is 29.92 in. Hg BAROMETRIC PRESSURE. To keep things simple, let's say 30 in. Hg is standard air pressure. You have just taken off and begin to climb. As you reach higher altitudes, you notice your rate of climb slowly getting lower. This is because the higher you fly, the thinner the air is, and the less power your engine can produce. You should also notice your MANIFOLD PRESSURE decreases as you climb as well.

Why does your manifold pressure decrease as you climb?

Because manifold pressure is air pressure, only it's measured inside your engine's intake manifold. Since your engine needs air to breath, manifold pressure is a good indicator of how much power your engine can produce.

Now, if you start the engine and idle, why does the manifold pressure go way down?

When your engine idles, it is being choked of air. It is given just enough air to sustain itself without stalling. If you could look down your carburetor throat when an engine is idling, those throttle plates would look like they were closed. However if you looked at it really closely, you would notice a little space on the edge of the throttle valve. Through that little crack, air is streaming in. If you turned your ear toward it, you could probably even hear a loud sucking sound. That is how much that engine is trying to breath. Those throttle valves are located at the base of your carburetor, and your carburetor is bolted on top of your

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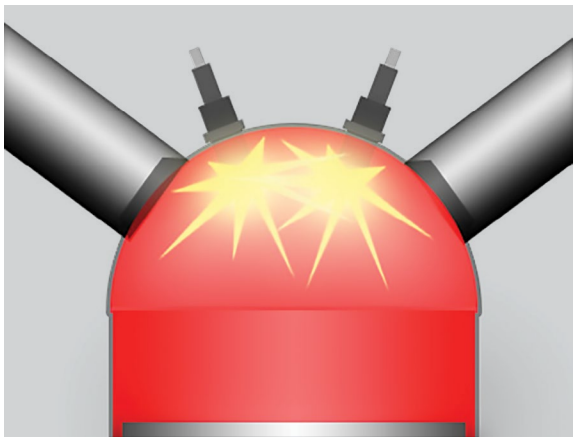
intake manifold. Just below those throttle valves and inside your intake manifold, the air is in a near vacuum. This is where your manifold pressure gauge's sensor is, and when you are idling, that sensor is reading that very low air pressure in that near vacuum.

As you increase power, you will notice your manifold pressure comes up. This is simply because you have used your throttle to open those throttle plates more, and the engine is able to get the air it wants. If you apply full power on a normal engine, that pressure will ultimately reach about the same pressure as the outside, which really just means the air is now equalized as your engine's intake system is running wide open. So if you turned your engine off, your manifold pressure would rise to the outside pressure. So on a standard day at sea level, your manifold pressure with the engine off will be 30".



The air and fuel are compressed by the piston, then the ignition system adds the spark to create a controlled explosion.

IGNITION

The ignition system provides timed sparks to trigger timed explosions. For safety, aircraft are usually equipped with two completely independent ignition systems. In the event one fails, the other will continue to provide sparks and the engine will continue to run. This means each cylinder will have two spark plugs installed.

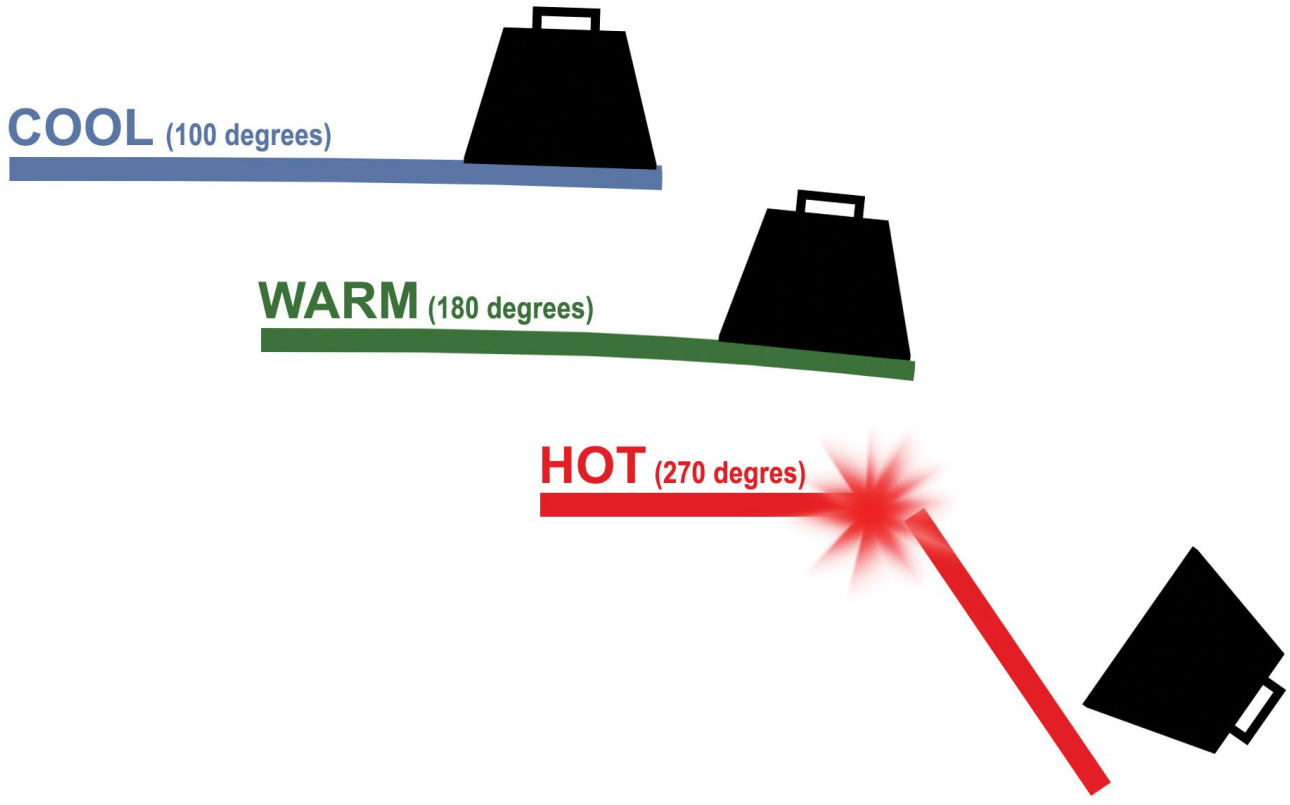
An added advantage to having two sparks instead of one is more sparks means a little more power. The pilot can select Ignition 1, Ignition 2, or BOTH by using the MAG switch. You can test that each ignition is working on the ground by selecting each one and watching your engine RPM. There will be a slight drop when you go from BOTH to just one ignition system. This is normal, provided the drop is within your pilot's manual limitation.

ENGINE TEMPERATURE

All sorts of things create heat in an engine, like friction, air temp, etc., but nothing produces heat like COMBUSTION.

The hotter the metal, the weaker its strength.

Aircraft engines are made of aluminum alloy, due to its strong but lightweight properties. Aluminum maintains most of its strength up to about 150°C. As the temperature



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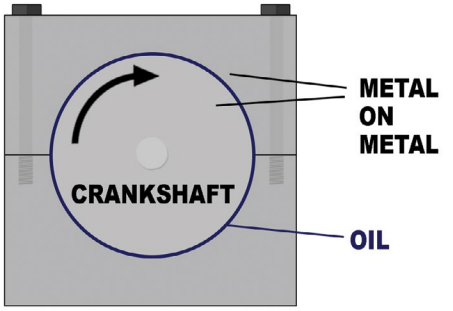


Without the layer of oil between the parts, an engine will quickly overheat and seize.

approaches 200°C, the strength starts to drop. An aluminum rod at 0°C is about 5× stronger than the same rod at 250°C, so an engine is most prone to fail when it is running hot. Keep your engine temperatures down to keep a healthy running engine.

LUBRICATION SYSTEM (OIL)

An internal combustion engine has precision machined metal parts that are designed to run against other metal surfaces. There needs to be a layer of oil between those surfaces at all times. If you were to run an engine and pull the oil plug and let all the oil drain out, after just minutes, the engine would run hot, slow down, and ultimately seize up completely from the metal on metal friction.

There is a minimum amount of oil pressure required for every engine to run safely. If the oil pressure falls below this minimum, then the engine parts are in danger of making contact with each other and incurring damage. A trained pilot quickly learns to look at his oil pressure gauge as soon as the engine starts, because if the oil pressure does not rise within seconds, then the engine must be shut down immediately.

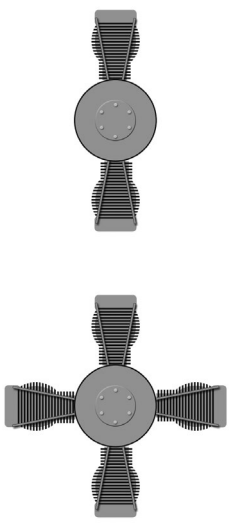
Above is a simple illustration of a crankshaft that is located between two metal caps, bolted together. This is the very crankshaft where all of the engine's power ends up. Vital oil is pressure-injected in between these surfaces when the engine is running. The only time the crankshaft ever physically touches these metal caps is at startup and shutdown. The moment oil pressure drops below its minimum, these surfaces make contact. The crankshaft is where all the power comes from, so if you starve this vital component of oil, the engine can seize. However, this is just one of hundreds of moving parts in an engine that need a constant supply of oil to run properly.

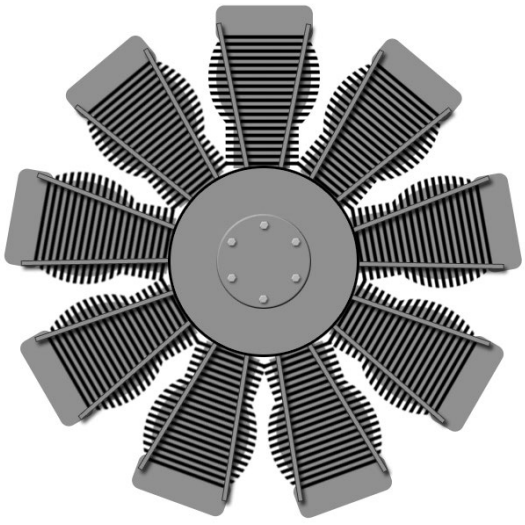
MORE CYLINDERS, MORE POWER

The very first combustion engines were just one or two cylinders. Then, as technology advanced, and the demand for more power increased, cylinders were made larger. Ultimately, they were not only made larger, but more were added to an engine.

Below are some illustrations to show how an engine may be configured as more cylinders are added.

The more cylinders you add to an engine, the more heat it produces. Eventually, engine manufacturers started to add additional "rows" of cylinders. Sometimes two engines would literally be mated together, with the 2nd row being rotated slightly so the cylinders could get a direct flow of air.





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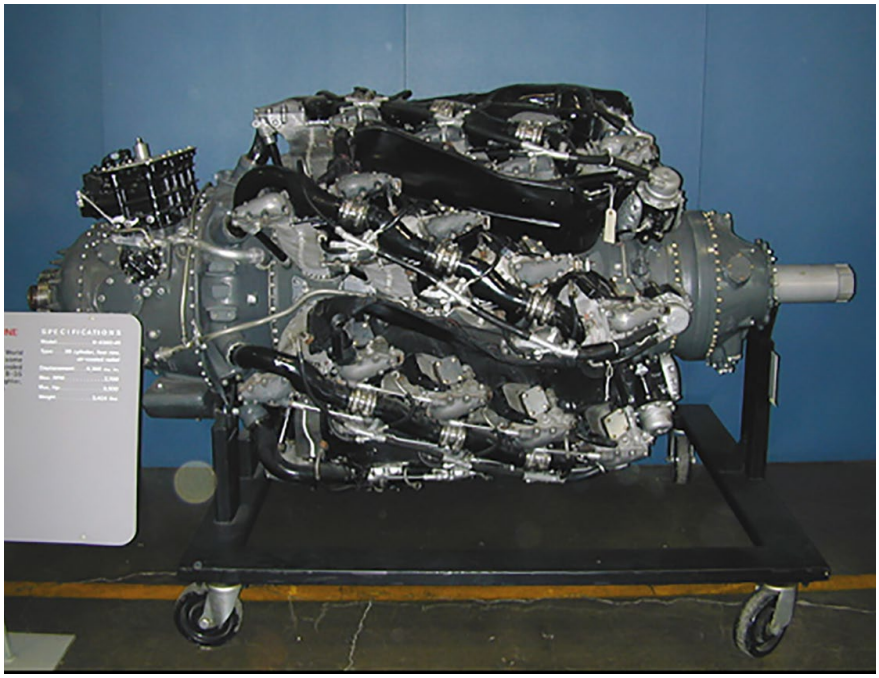


THE PRATT & WHITNEY R-4360

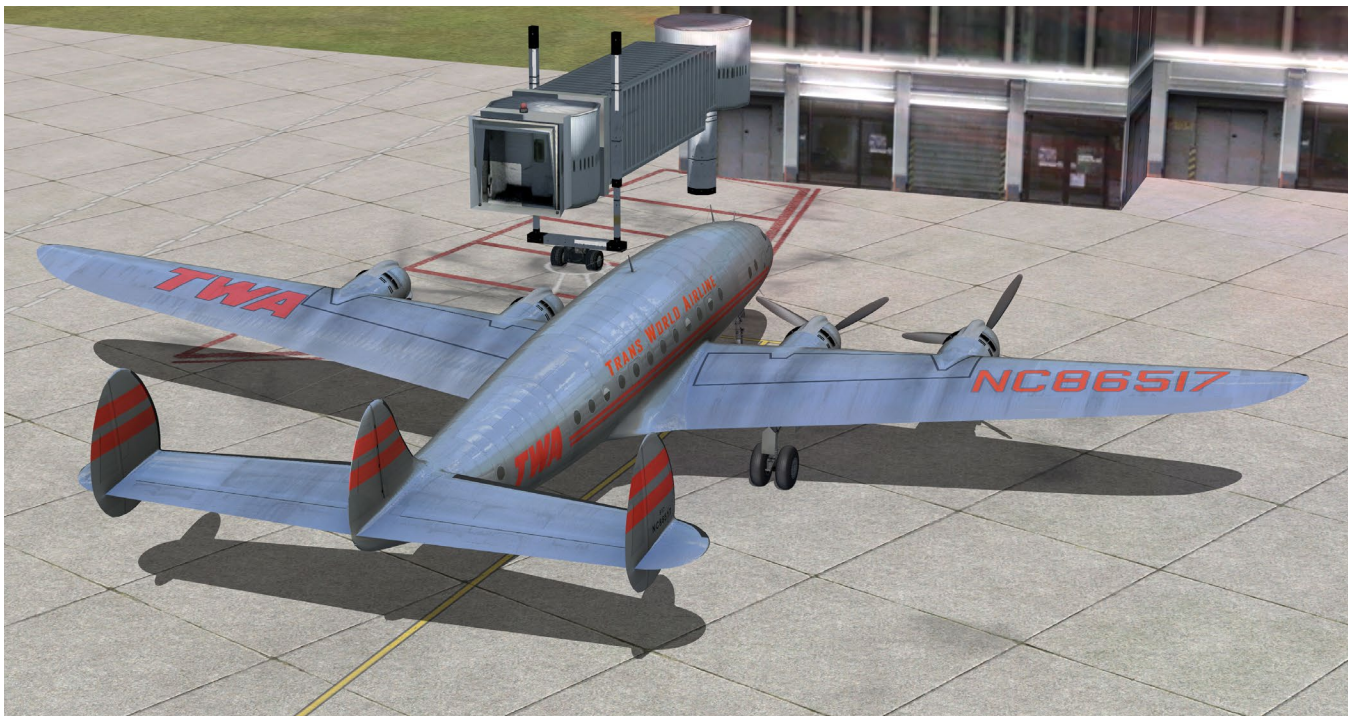
Pratt & Whitney took this even further, creating the R-4360, with 28 Cylinders (this engine is featured in the A2A Boeing 377 Stratocruiser). The cylinders were run so deep, it became known as the "Corn Cob." This is the most powerful piston aircraft engine to reach production. There are a LOT of moving parts on this engine.

TORQUE VS HORSEPOWER

Torque is a measure of twisting force. If you put a foot long wrench on a bolt, and applied 1 pound of force at the handle, you would be applying 1 foot-pound of torque to that bolt. The moment a spark triggers an explosion, and that piston is driven down, that is the moment that piston is creating torque, and using that torque to twist the crankshaft. With a more powerful explosion, comes more torque. The more fuel and air that can be exploded, the more torque. You can increase an engine's power by either making bigger cylinders, adding more cylinders, or both.

Horsepower, on the other hand, is the total power that engine is creating. Horsepower is calculated by combining torque with speed (RPM). If an engine can produce 500 foot pounds of torque at 1,000 RPM and produce the same amount of torque at 2,000 RPM, then that engine is producing twice the horsepower at 2,000 RPM than it is at 1,000 RPM. Torque is the twisting force. Horsepower is how fast that twisting force is being applied.

If your airplane has a torque meter, keep that engine torque within the limits or you can break internal components. Typically, an engine produces the most torque in the low to mid RPM range, and highest horsepower in the upper RPM range.



FOR SIMULATION USE ONLY

PROPELLERS

Before you learn about how different propellers work, first you must understand the basics of the common airfoil, which is the reason why a wing creates lift, and in this case, why a propeller creates thrust.

It is interesting to note when discussing Bernoulli and Newton and how they relate to lift, that both theories on how lift is created were presented by each man not knowing their theory would eventually become an explanation for how lift is created. They both were dealing with other issues of their day.

THE BERNOULLI THEORY

This has been the traditional theory of why an airfoil creates lift. Look at the image below which shows you how the shape of an airfoil splits the oncoming air. The air above is forced to travel further than the air at the bottom, essentially stretching the air and creating a lower pressure, or vacuum. The wing is basically sucked up, into this lower pressure. The faster the speed, the greater the lift.

THE NEWTON THEORY

As the air travels across the airfoil's upper and lower surfaces, lift is created by BENDING the air down with great force at its trailing edge, and thus, the Newtonian force of opposite and equal reaction apply.

WHAT WE DO KNOW (AND WHAT THE PILOT NEEDS TO KNOW)

The airfoil is essentially an air diverter and the lift is the reaction to the diverted air. An airfoil's lift is dependent upon its shape, the speed at which it is traveling through the air, and its angle to the oncoming air (angle of attack)."

It is important that you note that we have deliberately not entered into the details and complete aerodynamics involved with either of the above explanations for lift as they go beyond the scope of this manual.

Unfortunately over time, the Bernoulli theory specifically has been misrepresented in many textbooks causing some confusion in the pilot and flight training community. Misrepresentations of Bernoulli such as the "equal transit theory" and other incorrect variations on Bernoulli have caused this confusion. Rather than get into a highly technical review of all this we at A2A simply advise those interested in the correct explanation of Bernoulli to research that area with competent authority.

The main thing we want to impress upon you here is that when considering lift and dealing with Bernoulli and Newton, it is important and indeed critical to understand that BOTH explanations are COMPLETE EXPLANATIONS for how lift is created. Bernoulli and Newton do NOT add to form a total lift force. EACH theory is simply a different way of COMPLETELY explaining the same thing.

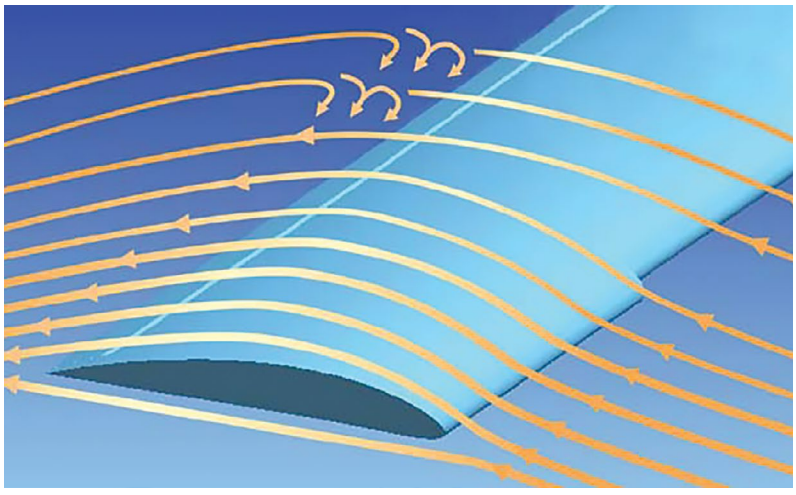
BOTH Bernoulli and Newton are in fact in play and acting simultaneously on an airfoil each responsible completely and independently for the lift being created on that airfoil.

Hopefully we have sparked your interest in the direction of proper research.

WHAT IS A STALL?

In order for a wing to produce efficient lift, the air must flow completely around the leading (front) edge of the wing, following the contours of the wing. At too large an angle of attack, the air cannot contour the wing. When this happens, the wing is in a "stall."

Typically, stalls in aircraft occur when an airplane loses too much airspeed to create a sufficient amount of lift. A typical stall exercise would be to put your aircraft into a climb, cut the throttle, and try and maintain the climb as long as possible. You will have to gradually pull back harder on the stick to maintain your climb pitch and as speed decreases, the angle of attack increases. At some point, the angle of attack will become so great, that the wing will stall (the nose will drop).



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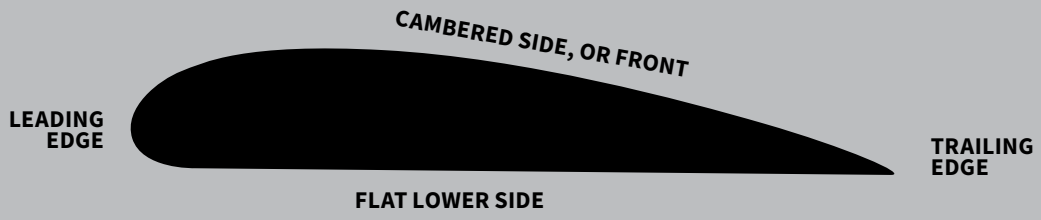
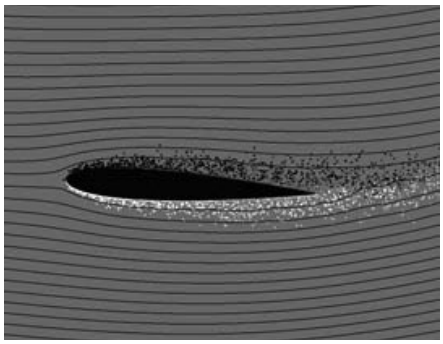
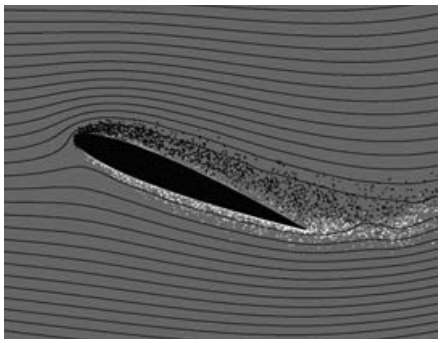
CROSS SECTION OF A PROPELLER BLADE

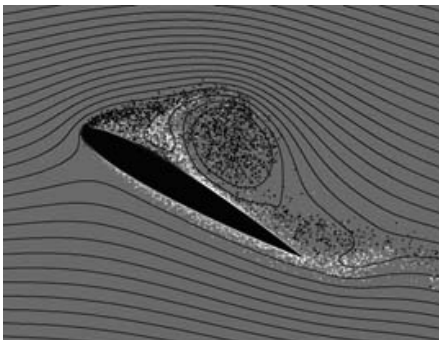




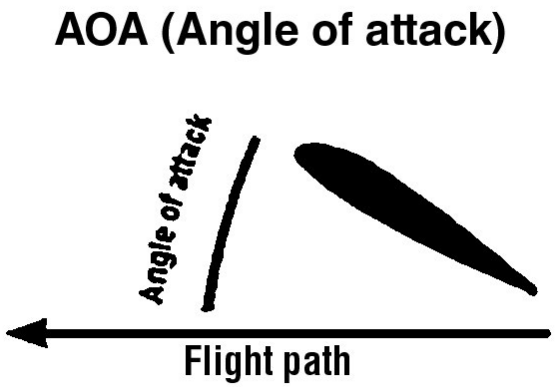
Level Flight. A wing creating moderate lift. Air vortices (lines) stay close to the wing.



Climb. Wing creating significant lift force. Air vortices still close to the wing.



Stall. A wing that is stalled will be unable to create significant lift.



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STALL

The angle of attack has become too large. The boundary layer vortices have separated from the top surface of the wing and the incoming flow no longer bends completely around the leading edge. The wing is stalled, not only creating little lift, but significant drag.

Can a propeller stall?

What do you think? More on this below.

LIFT VS ANGLE OF ATTACK

Every airfoil has an optimum angle at which it attacks the air (called angle of attack, or AoA), where lift is at its peak. The lift typically starts when the wing is level, and increases until the wing reaches its optimum angle, let's say 15–25 degrees, then as it passes this point, the lift drops off. Some wings have a gentle drop, others can actually be so harsh, as your angle of attack increases past this critical point, the lift drops off like a cliff. Once you are past this point of lift and the angle is so high, the air is just being plowed around in circles, creating almost no lift but plenty of drag. This is what you experience when you stall an aircraft. The buffeting or shaking of the aircraft at this stall position is actually the turbulent air, created by your stalling wing, passing over your rear stabilizer, thus shaking the aircraft. This shaking can sometimes become so violent, you can pop rivets and damage your airframe. You quickly learn to back off your stick (or yoke) when you feel those shudders approaching.

Notice in the diagram on the right, how the airfoil creates more lift as the angle of attack increases. Ideally, your wing (or propeller) will spend most of its time moving along the left hand side of this curve, and avoid passing over the edge. A general aviation plane that comes to mind is the Piper Cherokee. An older version has what we call a "Hershey bar wing" because it is uniform from the root to the tip, just like a Hershey chocolate bar. Later, Piper introduced the tapered wing, which stalled more gradually, across the wing. The Hershey bar wing has an abrupt stall, whereas the tapered wing has a gentle stall.

A propeller is basically a wing except that instead of relying on incoming air for lift, it is spinning around to create lift, it is perpendicular to the ground, creating a backwards push of air, or thrust. Just remember, whether a propeller is a fixed pitch, variable pitch, or constant speed, it is always attacking a variable, incoming air, and lives within this lift curve.

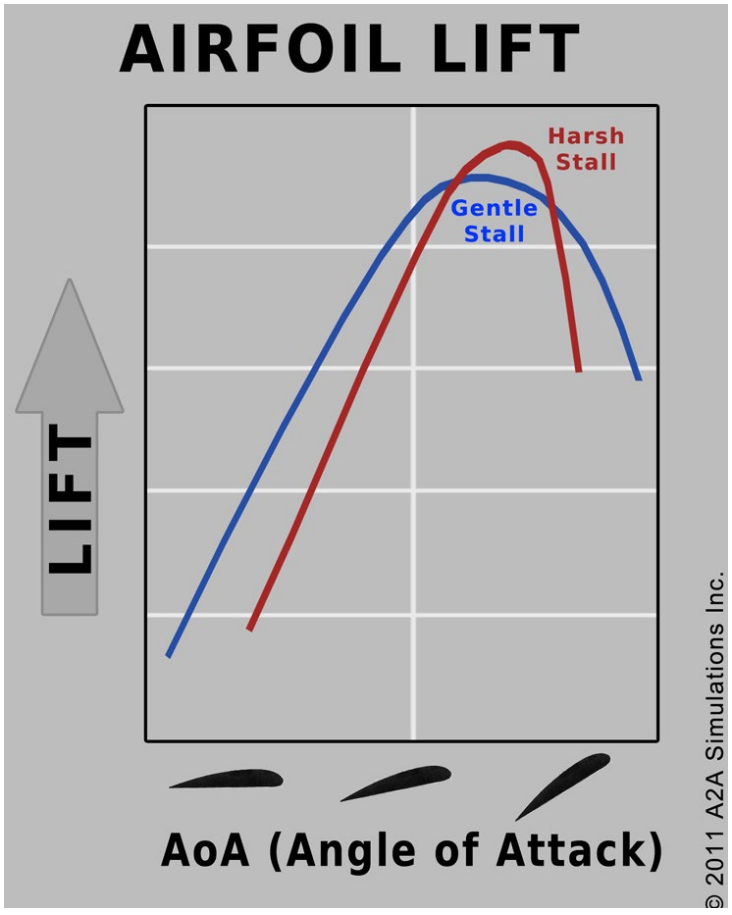
FROM STALL TO FULL POWER

With brakes on and idling, the angle at which the prop attacks the still air, especially closer to the propeller hub, is almost always too great for the prop to be creating much lift. The prop is mostly behaving like a brake as it slams its side into the air. In reality, the prop is creating very little lift while the plane is not moving. This effect is known as prop stall, and is part of the Accu-Sim prop physics suite.

Once done with your power check, prepare for takeoff. Once you begin your takeoff run, you may notice the aircraft starts to pull harder after you start rolling forward. This is the propeller starting to get its proper "bite" into the air, as the propeller blades come out of their stalled, turbulent state and enter their comfortable high lift angles of attack it was designed for. There are also other good physics going on during all of these phases of flight, that we will just let you experience for the first time yourself.

PROP OVERSPEED

A fixed pitch prop spends almost all of its life out of it's peak thrust angle. This is because, unless the aircraft is travelling at a specific speed and specific power it was designed for, it's either operating too slow or too fast. Let's say you are flying a P-40 and have the propeller in MANUAL mode, and you are cruising at a high RPM. Now you pitch down, what is going to happen? The faster air will push your prop faster, and possibly beyond its 3,000 RPM recommended limit. If you pitch up your RPM will drop, losing engine power and propeller efficiency. You really don't have a whole lot of room here to play with, but you can push it (as many WWII pilots had to).



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CAPTAIN OF THE SHIP

During the glory days of aviation, flying wasn't about going from point A to point B, it was an event. Airliners such as the Constellation were literally the largest aviation event there was. These passengers have paid top dollar to fly on the largest, most advanced and most luxurious aircraft. And at the very least, they expect a smooth flight. What they don't expect is an inexperienced, ham-fisted captain at the controls. These passengers expect and deserve the very best.

However there is somebody else on board who also deserves the absolute best from you and your crew, and she may very well be the most important person on this plane. To fill this purpose we are happy to introduce a brand new hostess, Betty.

CAREER SYSTEM

The Career System is based on how well you manage your aircraft systems, quality of flight, and emergencies. In real life, every action we do (or don't do) has consequences that go along with it. This is never truer than when piloting a system-rich, period airliner like the Constellation .

However, as captain, you are not only responsible for the entire aircraft, but for every life on that plane. By law, every person on board that plane must follow the orders of the pilot in command. In fact, the captain has the authority to refuse a direct order from an air traffic controller if he is acting in the interest of the safety of his aircraft. So understand that the captain has the ultimate authority and responsibility for the safety of everyone on board his aircraft.

Training aside, you will find that managing an aircraft with passengers is mostly rooted in common sense.

FOR SIMULATION USE ONLY

Your passengers, like all people, like to be in a comfortable climate, don't like being subjected to sudden forces, and enjoy good food and drink. So when you fly with your Career Module, remember the following (You do not have to remember what is on this list. It's just all common sense you will know instinctively):

- In cold climates, be sure to allow your crew time to heat up the cabin prior to loading passengers
- In hot climates, start the engines a few minutes prior to boarding to cool the cabin down
- If you choose to fly exclusively left seat, give your engineer time to set the systems up and your crew to perform their ground duties before just throttling up and taking off.
- Be easy on your engines from the very start. You are responsible for wear and damage on that plane, so only use the power you need.
- Turn the seat-belt sign on during takeoff, landings, at lower altitudes, transitioning through clouds, and in any expected turbulent conditions. Ensure you turn it off when the flying is smooth.
- Allow your passengers to finish eating a meal before landing.
- When passengers are eating, fly with a feather's touch. It is recommended you keep the plane in a steady flight in smooth air if possible.
- Fly carefully when passengers are sleeping.
- Make coordinated turns. **USE THE BALL!** If you do this correctly, unless someone is looking out the window, they won't even know you are turning.
- Be very careful with the rudder, as it is powerful and can cause all kinds of bad things to happen in the cabin especially when food and drinks are throughout the cabin.

Captain of the Ship

- ▶ Career system based on how well you manage your aircraft systems, quality of flight, and emergencies.
- ▶ Intelligent passengers react to the weather, flight, and cabin conditions.
- ▶ This Is Your Captain Speaking... The captain keeps passengers informed on the flight's progress.
- ▶ A Live Engineer manages systems which allows a true left-seat experience.
- ▶ Virtual flight attendant performs her duties and reports to the crew.
- ▶ Navigator's station with real-time monitoring and calculations of wind and flight conditions.
- ▶ Natural Speech constructs sentences dynamically from a pool of over 1000 sound recordings strong.
- ▶ Accu-Sim physics system shakes the cockpit and airframe based on both external and internal conditions.
- ▶ Real-time passenger loading and unloading
- ▶ Deep systems modeling throughout including oil pressure loss, friction heat, and cabin pressurization failures.
- ▶ Cabin Pressurization Module driven by the dual speed superchargers
- ▶ Climate Control Systems including two Stewart Warner gasoline heaters located in the outboard nacelles, and two automatic cabin air coolers (intercoolers).

FOR SIMULATION USE ONLY

- Plan your descents and don't force fast pressure transitions. This can cause bad ear pain for passengers, including little passengers that cry and can ruin the flight for others.

- Make the absolute best landing you can. This starts with a proper, steady approach. Making landings takes PRACTICE, PRACTICE, PRACTICE. Landing is HARD WORK for even the very best pilots.

- Be calm during emergencies, because your passengers will likely not be, and they will look to you, the captain, to maintain control. Under a critical emergency like a lost engine, engine fire, or pressurization failure, get that plane on the ground safely and your passengers will thank you forever.

- If you are unlucky enough to have a passenger fall seriously ill on your flight, get that plane to the closest appropriate airfield as soon as you can.

- Sometimes a VIP will board the plane. With VIP's come press and attention, so think of it as doubling down in Vegas. Make a good flight, and reap the recognition. Make a bad call, and that will be remembered too.

UNDERLYING INTELLIGENCE SYSTEM

The very core of Captain of the Ship is an intelligent human-like system that watches... and learns. Yes, Accu-Sim doesn't just pull variables from the host program. It observes, and adapts. Why? Well frankly, repetition is boring and a true simulation demands freedom, and freedom of choice is the very essence of a simulation experience. After all, you are the boss, and the very nature of being a leader is making choices.

Now this system is tested and in place, we are able to deliver naturally speaking people, including the captain. Our Accu-Sim sound system includes a Natural Speech module that dynamically constructs sentences on the fly. It pulls from a pool of over one thousand sound recordings strong and produces natural speech. The end result is a captain, co-pilot, navigator, engineer, and even a flight attendant who just speaks. There are no canned captain's call buttons. Your new natural speech captain speaks based on the surrounding conditions, and does so without canned or triggered repetition.

INTELLIGENT PASSENGERS

Passengers react to the weather, flight, and cabin conditions We try hard to simulate all conditions, and not just expected ones, because life is full of surprises. The passenger module was built on top of our famous "Heidi" intelligence module made for our Piper J3. This time, it's not an individual, but more of a crowd mentality. Be smart and keep them comfortable, fly the aircraft well, and be prepared for emergencies, and you will likely have a successful career.

YOU ARE CAPTAIN OF THE SHIP

When you are a captain of a large, luxurious airliner in the world, you carry an enormous responsibility to not only the aircraft itself, but to the passengers and crew. A2A Simulations is proud to reintroduce our Accu-Sim intelligence module, "Captain of the Ship."

THIS IS YOUR CAPTAIN SPEAKING...

Your captain observes the flight, its state, and the surrounding conditions and will report updates to the cabin from time to time. He speaks using natural expressions, rather than canned, triggered recordings.

THE BUCK STOPS WITH YOU, CAPTAIN

You, as the captain, will be remembered and judged by your actions (hopefully not lack of action). The Accu-Sim Career Module is built around this premise. Your reputation is built by repeated and consistent good flying, but there always lurks the unexpected and rare emergency. Those rare unexpected moments are known as a "Captain's Call."

In a completely unexpected, crisis situation, what are you going to do? Are you going to hesitate? Are you going to fumble around with the manuals? Or are you going to get right to it? What if you have a minor pressurization failure? Will you make a death plunge for the lower altitudes where the air is thicker; effectively turning what was a minor situation into a crisis? What if you have a medical emergency in flight? What about a simple problem like a heating failure happening half-way across the Atlantic at 30,000 feet, where the air is sixty below zero?

Most of your flights are not going to have drama, but every experienced pilot knows that unexpected events are lurking in the shadows just waiting to happen. However, you cannot control or prevent these unexpected events. A machine shop that forged a faulty rod that happens to give

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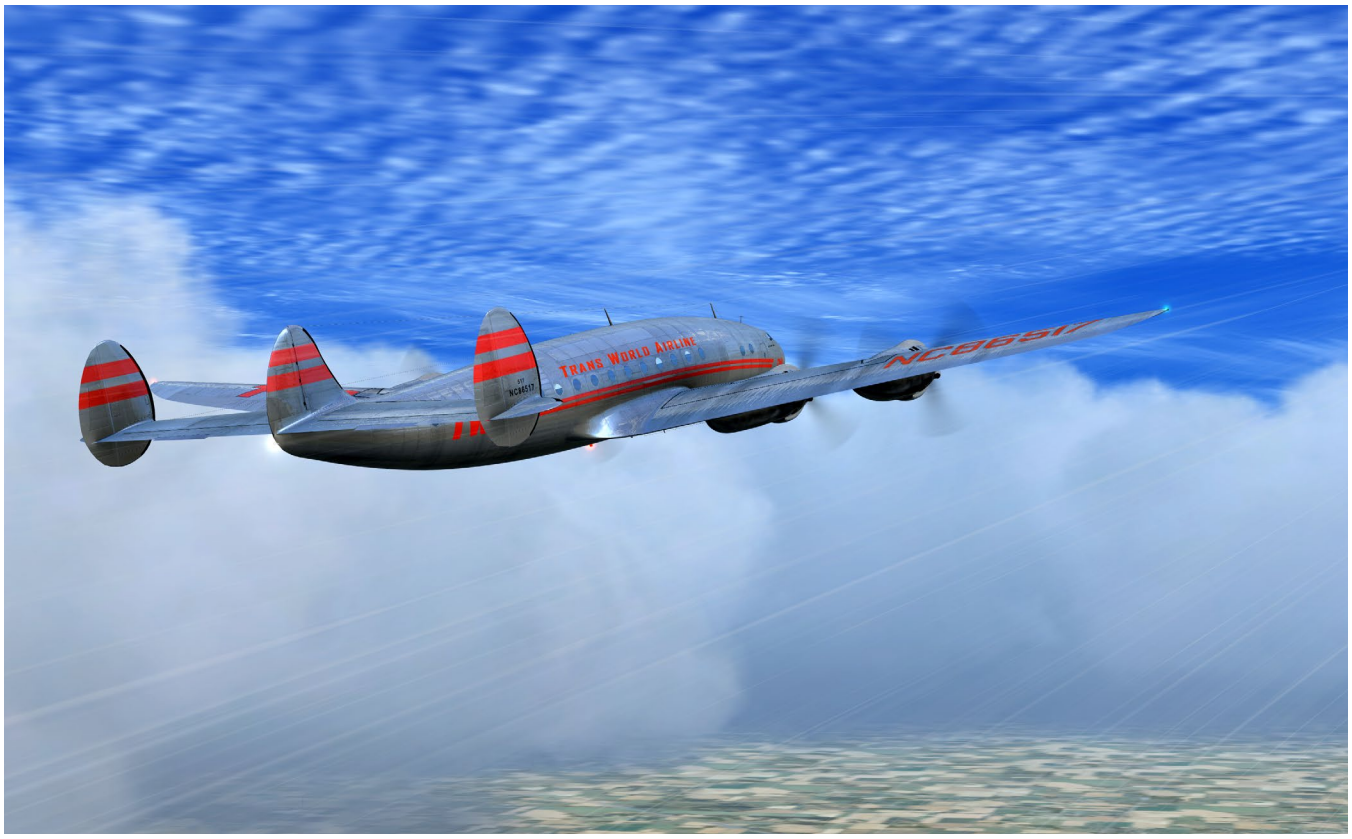

while you are at the controls is not within your control. The mechanic that fails to fasten down an oil line is not in control. All you can do as Captain is to know your aircraft, operate it responsibly, and be prepared for anything that might happen.

And this, we believe, is where the magic comes in with Captain of the Ship, because everything you do is remembered. In real life, the best is brought out in those who are held accountable for their actions. The same thing applies to a simulation. When you are held to account for all of your actions and all of these actions are remembered and together, create your identity and reputation, suddenly it is an entirely new experience.

THE CAPTAIN ALWAYS TAKES FULL RESPONSIBILITY

A lot of you for the first time are going to notice "The Ball." If you are someone who has not cared about this ball before (located on your Turn & Slip gauge), you are going to care about it now. Because this ball will allow you to make perfectly coordinated turns. When you make a coordinated turn, people in the back won't even know you are turning. I am sure you have been in an airplane and suddenly looked out the window and you are looking either straight down at the ground or up in the sky, and before you didn't even know you were turning. Now THAT is a coordinated turn. I am also sure you have been in an airplane and that aircraft is banking, and you know it. Now that is NOT a coordinated turn. That kind of turn is acceptable when people are sitting down and your seat-belt is fastened. An uncoordinated turn like that is not acceptable when people are roaming about the cabin or eating a full course meal. Now, you have to be that experienced pilot.

Let me show you some examples of how our testers are flying differently now. First, on very cold or warm days, they have learned to give their crew extra time to prepare the cabin. This may mean running the body heaters, or starting the engines early and blasting some fresh, cool air into that cabin.

Now if you are a combustion engine mechanic or a prop-aircraft owner, you know that running a combustion engine at its maximum power wears it down much faster than running that same engine at say cruise power, or even climb power. Don't be surprised with Captain of the Ship, if you find yourself taking off with something less than take-off power.

Maybe you were used to raising your flaps quickly after take-off and didn't mind if you sink a little bit, but now **you may think a little differently because there are people in the back.**

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You may even find yourself reaching for that seat-belt sign BEFORE you hit turbulence. Why? Well, maybe because on your last flight you hit turbulence shortly after take-off and the seat-belt sign was off. After that flight, a passenger decided to voice his grievance with the airline. Also, please note that people like a smooth flight when they are eating dinner.

You may find yourself taking the extra time to make a proper approach. This new-found patience may be from the consequences of your last flight making last minute corrections or perhaps a sloppy kick of the rudder to get back onto the glide slope. With every new experience, *BANG!* you've just became a better pilot. Why? - Because you are accountable.

It sounds like a lot perhaps, but you will be surprised just how natural it all comes to you, and you will just remember because it all makes sense in the real world, and now does in the simulated world.

A LIVE ENGINEER

Flying w1ith a live engineer allows you to have a truer left-seat experience. About 6 months of AI coding and testing has gone into breathing true life into a systems engineer who will handle the engineer's panel properly in almost every possible scenario.

It is important that our engineer, Larry, acts not like a computer but like a person, because in real life people manage this aircraft, not computers. While Larry is capable, he is not perfect. If you hand the panel over to him, give him time to go through the systems, checking one by one. He needs to scan the panel with his eyes, needs to think, and make adjustments.

Your engineer actually talks to himself while he works, so as you are flying left seat, you can hear cues of what he is adjusting.

JUST A STEWARDESS?

In many ways, the stewardess (flight attendant) is the most important person on the plane. She does a job that very few people could do well. She is the face of the airline and she is directly responsible for servicing the passenger's needs. She greets people with a smile while boarding and she helps them with all their needs including finding their seat and stowing their luggage. She is also responsible for making sure all passengers understand the minimal safety precautions from showing them where the exits are to how to use oxygen in an emergency.

Once the aircraft is airborne, she continues to work to respond to every need while serving drinks, snacks, and full course meals. On overnight flights, she will will attend to every passenger's need so that they get the most comfortable night's sleep possible. She is on constant alert and takes very few breaks.

Your head stewardess works during a time in aviation when flying was a major event. Additionally, the L-049 Constellation was a large and advanced passenger plane.

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This means just like every crew member aboard this first-class airliner, she is held to the very highest standard.

Just like a highly experienced captain, she is at the very top of her game. Therefore, she deserves the very best from you, her Captain. Give her a smooth flight so the passengers feel safe and comfortable. Be responsible with your climbs and descents, and be sure to alert the cabin with a seat-belt warning before you enter into turbulent conditions.

NAVIGATOR'S STATION

The Navigator's station includes real-time monitoring and calculations of wind and flight conditions. Your navigator gets reports of the wind conditions and determines any cross, tail, or head winds.

He also monitors how the aircraft is behaving and determines what the turbulence level is regardless of what any weather reporting stations may be reporting.

Aircraft time is tracked, basically meaning the time the passengers are on regardless of what time zones you have crossed over. He has a gold pocket watch he keeps on his table that you can look at. Meals are served based on this time, and not local or global time.

PROFESSIONAL AUDIO

A new sound system with over one thousand brand new recordings. Any great sound begins with a great recording, and the highest quality audio can only be captured by industry professional sound engineers using the very finest audio equipment.

First, we visit the aircraft and analyze all of the sounds that it is capable of making, whether it is sitting on the ground or flying through a thunderstorm. Then we isolate and capture hundreds, sometimes thousands of sounds as they occur.

Once back in the studio, the sound then gets processed and entered into our latest Accu-Sim sound engine, where they are driven and even modified by the actual physics

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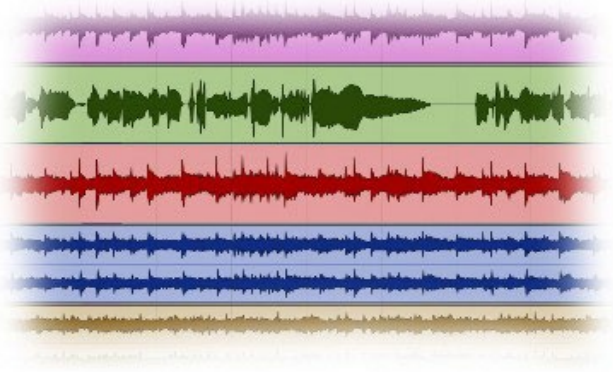


inside our aircraft.

Now when you flick a switch, you hear the actual switch live, on the fly. The same applies to all kinds of levers, buttons, and knobs. Furthermore, these switches and knobs control newly recorded electrical motors and servos. You will hear the actual cowl flap wind up, run, and wind down. Additional motors control the inter-cooler flaps, oil cooler flaps, and oil pump motors as they pulse and whir. You can even open the window and hear the props through the window. You can hear the air as it passes smoothly over your airframe or as it slams into the side or underneath areas of the aircraft. Flying through a thunderstorm is a true audio experience with Accu-Sim. Just be sure to put the seat-belt sign on so your passengers stay safe.

NATURAL SPEECH

Captain of the Ship includes a Natural Speech Module which constructs sentences dynamically from a pool of over 1000 sound recordings strong. For speech to sound natural in a game, simulation, or movie, it always begins with a convincing actor (or actress) captured by sound professionals using high quality microphones. But in today's high tech world, that is where the natural part ends. Those recordings are then digitally processed and placed inside ambient environments to simulate how speech is heard whether it comes over a headset, over a PA system, normal talking behind a closed door, or right next to you.

From there our brand new Accu-Sim sound module constructs sentences on the fly based on actual conditions. This means the captain can update the cabin several times during a flight and always sounds natural and spontaneous.

Your engineer is constantly keeping you updated and instead of hearing the same repeated sentence, you hear natural, live updates. When your head stewardess comes in to serve meals, she reads from the menu on the fly just like we do in real life. Across the board, all talking is managed with this new speech module, which hopefully gives you the immersion of being among thinking individuals.

This is absolutely necessary to make it all sound "natural" to you, the end user.

ACCU-SIM PHYSICS

Accu-Sim physics system shakes the cockpit and airframe based on both external and internal conditions. When the engines start running they vibrate and shake your cockpit. Once the airframe starts to move, ground bumps punch and buck the aircraft through the wheel struts. It shakes, bucks, and strains as it rolls on the ground and ultimately as it takes to the air above. Wind forces can cause your airframe to creak and stress and even the air that passes over the elevator at slow speeds also shakes the aircraft, just prior to the wing completely stalling.

Real-time passenger loading and unloading Every time

FOR SIMULATION USE ONLY

you load your plane, you will get a fresh new load of passengers. Some passengers travel alone, while others travel in groups / families. Clicking on any of the load pre-sets will start a real time loading of your airplane. You can always hit FAST LOAD, and it will still load realistically but will simply do it much faster. Your ground crew and stewardess will also keep you informed of the progress.

You can also see a more accurate status in your CREW REPORTS (SHIFT-2) panel pop up.

DEEPER SYSTEMS MODELLING

Your crew is smart and will usually be able to figure out when things are not right. We have added deeper modelling of the oil system and internal engine pressures. Also, damaged engines can send vibrations through the entire aircraft.

If you notice any of the following, you may be experiencing engine trouble:

- More vibrations than you are used to
- Higher than expected oil temps
- Lower than expected oil pressures
- Lower than expected torque

If you or your crew has determined you have internal engine trouble, it is recommended that you feather the prop and shut the engine down. This is because the engine is at risk of degrading into a possible emergency situation like a sudden engine failure or even worse, a fire. At the very least, if you MUST keep the engine running, use it at the most minimal power possible.

ADDITIONAL SYSTEMS

Some people will notice some new gauges here when compared to our GA and Warbird aircraft, including a pressurization system that uses the pressurized air coming from the engine superchargers. It's a very interesting system to get to know and to use. Your engineer can handle this along with the cooling and heating systems. He can also manage your electrical system, which is all-new in this Captain of the Ship package.

We have also used our latest sound engine to bring this aircraft to life. Every switch, dial, lever, and up to fifteen electrical motors can be simultaneously heard in the cockpit. Add this to all the creaking, rattling, and bucking in this airframe, it becomes an orchestra of sound in the cabin.

CABIN PRESSURIZATION

As you climb into the higher thinner air, it holds less oxygen. To remedy this, a pressurization system is employed to make the air denser, and therefore to being close to its natural density at sea level. Such a system requires an aircraft cabin that is sealed and has minimal leakage.

The Constellation uses the higher air pressure generated by the engine superchargers to increase the cabin air pressure. This requires the superchargers to be running, especially as you fly into the very high, thin air up at higher altitudes.

Trouble occurs most when you expose an average person to rapid changes in pressure. Usually, this is felt in the ears and sometimes head. Aviators can build a tolerance to this, but average "folks" can range from being tolerant to very sensitive to air pressure changes. Babies tend to be very sensitive to these changes as many reading this manual have experienced a crying baby on an airplane.

When manually handling engineer duties, do your best to avoid changes in "cabin altitude" in excess of 300 ft /min and the folks in the back will be comfortable.

CLIMATE CONTROL SYSTEMS

The Climate Control Systems includes two Stewart Warner gasoline heaters located in the outboard nacelles, and two automatic cabin air coolers (intercoolers). There is one cabin thermostat which controls both heaters and coolers.

FOR SIMULATION USE ONLY

2D PANELS

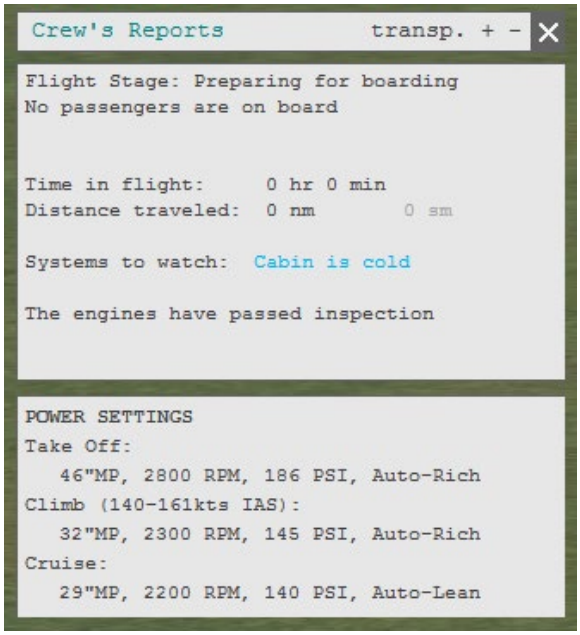
The 2D panels are there to provide the extra functionality needed when there is so much additional information available to you, the pilot.

Each 2D panel is accessed by the key-press combination in parentheses after the 2D panel title. If the default commands listed commands don't work please check the mappings in your host simulator under 'Panel Window 1 to 9'

Crew's Reports (Shift 2)

From the panel, you can view:

- Flight Stage: Status of the flight
- Time in Flight
- Distance Traveled
- Systems to watch
- Recommended Power Settings

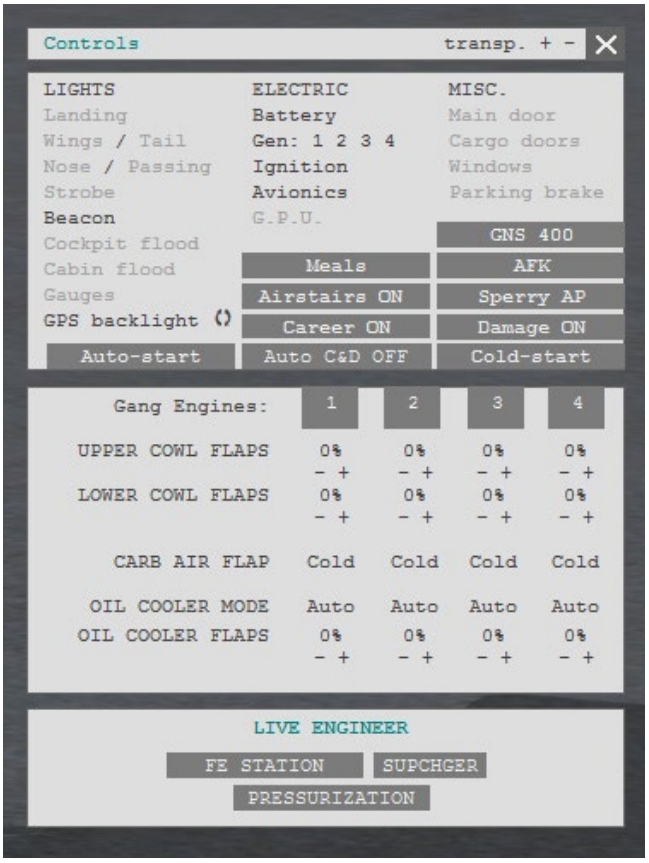


Controls (Shift 3)

Initially designed to provide a means to perform various in cockpit actions whilst viewing the aircraft from an external viewpoint, this control panel now provides quick access to a number of different commands.

From this panel, you can:

- Control electrical systems such as the generators and magnetos.
- Toggle aircraft lighting, both internal and external.
- Open/close the main door, cargo doors and windows.
- Set the parking brake.
- Serve passenger meals.
- Set your status as AFK
- Toggle the airstairs
- Switch between Sperry autopilot and FSX/P3D autopilot.
- Turn on/off Career Mode
- Set Accu-Sim damage on/off
- Auto-Start the engines
- Set the auto Cold and Dark on/off
- Cool the engines for a Cold-Start
- Manage the cowl and oil flaps
- Manage the Live Engineer
- Toggle GPS

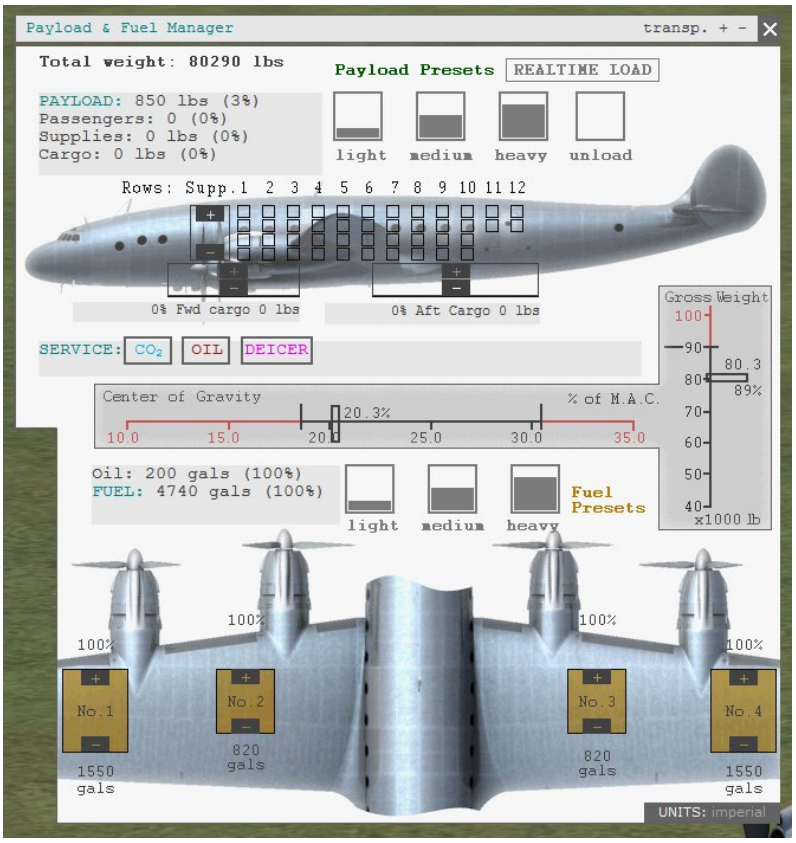


FOR SIMULATION USE ONLY

Payload and Fuel Manager (Shift 4)

The payload and fuel manager not only gives you an overview of your current payload, fuel and oil quantities, it is also an interactive loading screen, where you can:

- Add and remove passengers and baggage with Realtime Load or manually.
- Fill engine CO_2, Oil and de-icer.
- Add or remove fuel from the all tanks.
- Change between viewing weights and measures in imperial or metric format.
- View, at a glance, total aircraft weight, payload weight, Center of Gravity and total fuel quantities.



Pilot's Map (Shift 5)

The pilot's map gives full and easy access to information that may be found on real maps, and allows this information to be accessed from the cockpit, as opposed to using the default map via the drop-down menus.

The accompanying panel to the map allows you to select what information you want to have displayed on the map, from a compass rose to low altitude airways.

Also note that some of the button selections have an increasing amount of information presented with each subsequent button press.

For example, the **APT** (Airport) button will show the following information:

- **APT 1:** Airport ID.
- **APT 2:** Airport name.
- **APT 3:** Airport elevation and runway length.
- **APT 4:** Airport radio frequencies.

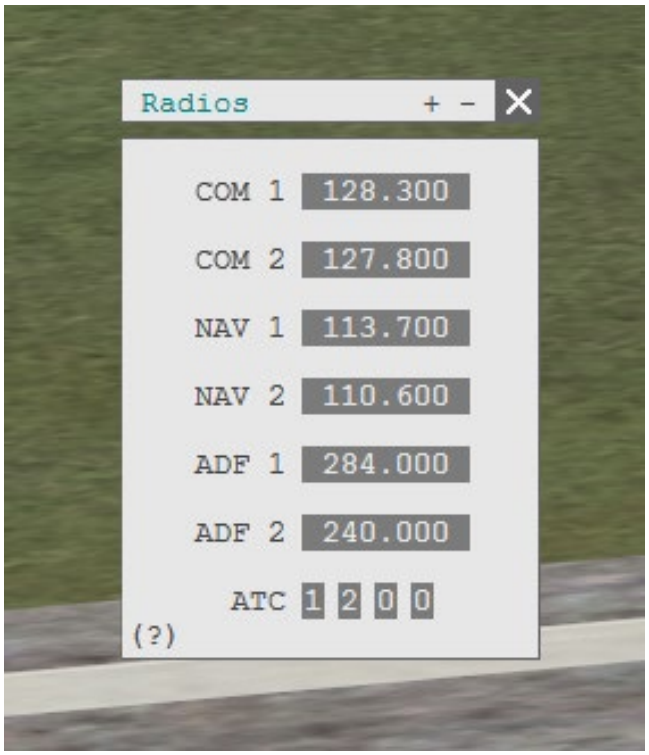
You can also view the Navigators Notes. this includes real-time monitoring and calculations of wind and flight conditions. Your navigator gets reports of the wind conditions and determines any cross, tail, or head winds.

He also monitors how the aircraft is behaving and determines what the turbulence level is regardless of what any weather reporting stations may be reporting.

FOR SIMULATION USE ONLY

Quick Radios (Shift 6)

This small popup panel provides input for your virtual cockpit radios but in a simplified and easy to use manner. This popup features all the amenities of the actual radios but in a singular unit which allows you to control your communication, navigation, ADF and transponder radios from a single source.



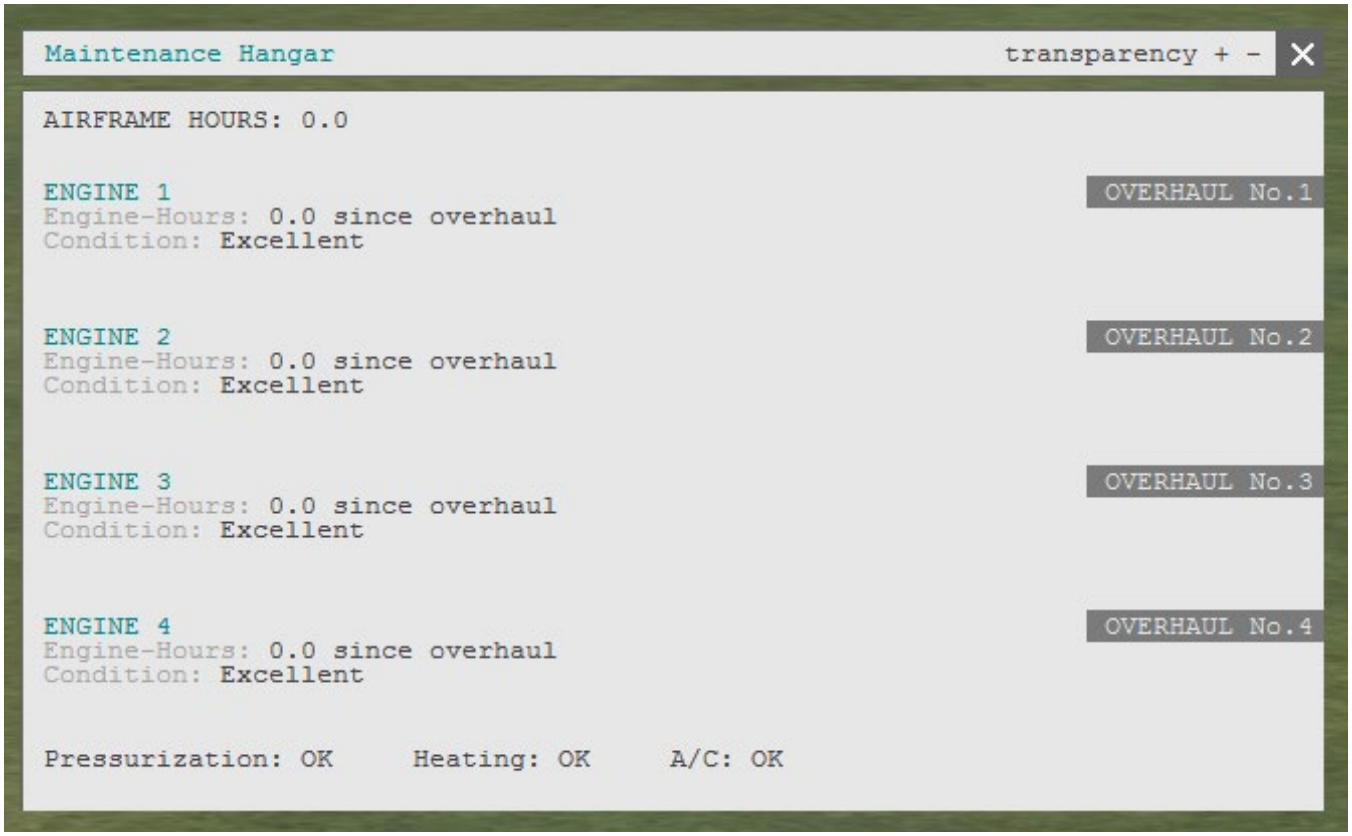
Maintenance Hangar (Shift 7)

The maintenance hangar is where you can review the current state of your aircraft and its major systems. It is one of the core elements to visualizing Accusim at work.

With the invaluable assistance of your local aircraft maintenance engineer/technician, a.k.a. "grease monkey", you will be able to see a full and in-depth report stating the following:

- A summary of the condition of your engines as well as pressurization, heating and cooling systems.
- Total airframe hours, and engine hours since the last overhaul.
- General condition of the engine.
- Important notes provided by the ground crew.

From the maintenance hangar, you can also carry out a complete overhaul for each engine, by clicking the **OVERHAUL**. This will overhaul the engine and replace any parts that are showing signs of wear or damage, with new or re-conditioned parts.



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Engine Selector (shift 8)

Use this panel to select which engine you are controlling. Useful for when you must tweak the performance of each engine and during emergencies.

Captain's Log (shift 9)

If you choose to engage Career Mode this is where your stats and performance is recorded. Check here after every flight and see how you are advancing as a pilot.

EXTERNAL PROGRAMS

Input Configurator

The Input Configurator allows users to assign keyboard or joystick mappings to many custom functions that can't be found in FSX/P3D controls assignments menu. It can be found in the A2A/L049/Tools folder inside your FSX/P3D installation directory.

The upper table is the axis assignment menu. From the drop down list, select joystick and axis you want to assign to each function and verify its operation in the 'preview' column. Mark the 'invert' check box if needed. The lower table is the shortcuts menu. Hover over a function name to bring up a tooltip with additional information.

To make a new shortcut, double click on a selected row to bring up the assignment window. Then press keyboard key or joystick button you want to assign to this function. For keyboard it's also possible to use modifier keys (Ctrl, Shift, Alt).

When done with the assignments, press "Save and update" button. This will instantly update shortcuts for the aircraft. There is no need to restart FSX/P3D or even reset your flight for the changes to take effect, you can adjust shortcuts on the fly.

AIRCRAFT CONFIGURATOR

The Aircraft Configurator enables the user to choose from Various 3rd party GPS systems (Reality XP GNS430, Flight 1 GTN650, Mindstar GNS430, KLN 90B, or stock). Technically, this utility manages the panel.cfg and model.cfg files, so the user doesn't need to manually edit these files. The GPS can be changed with or without a running simulation (FSX or Prepar3D).

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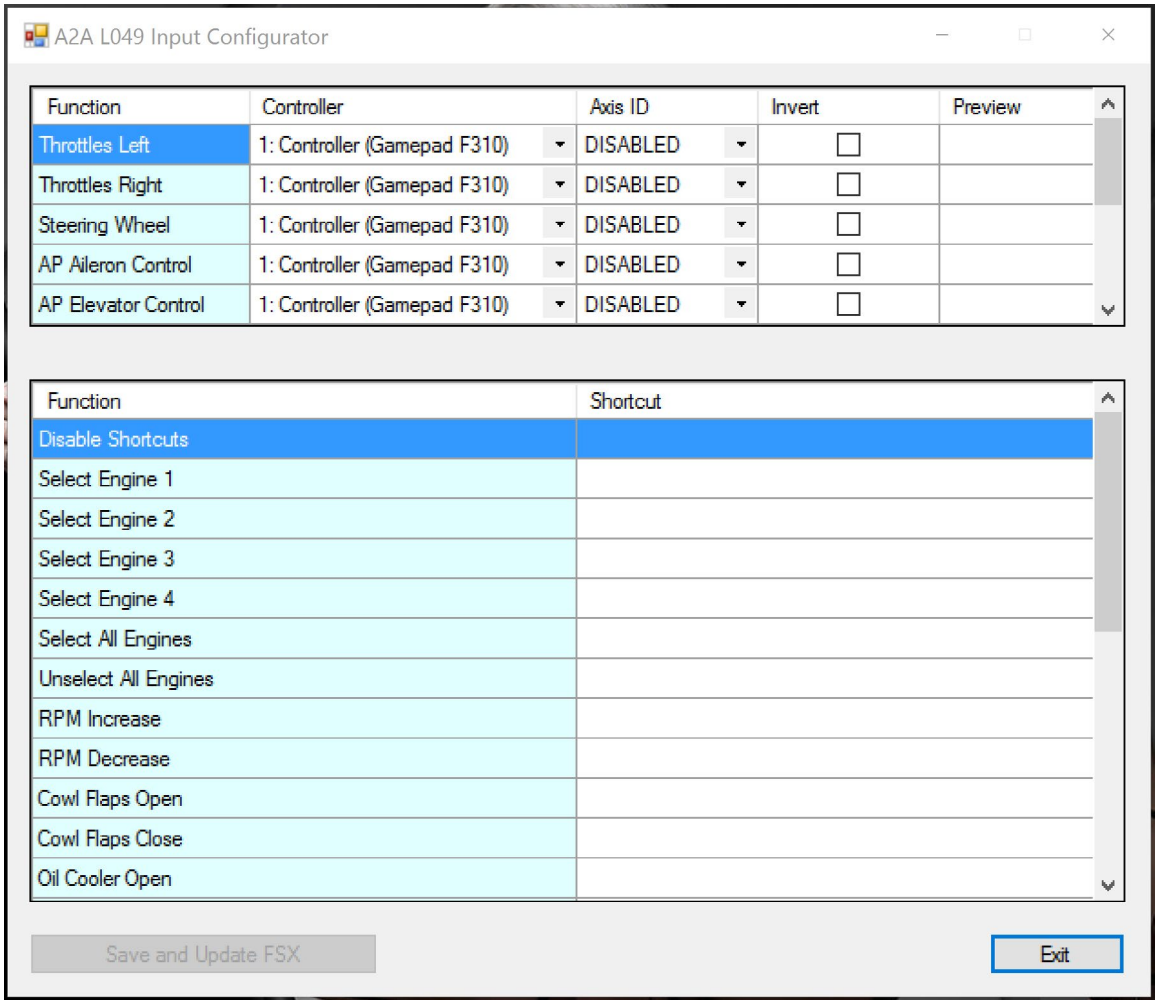
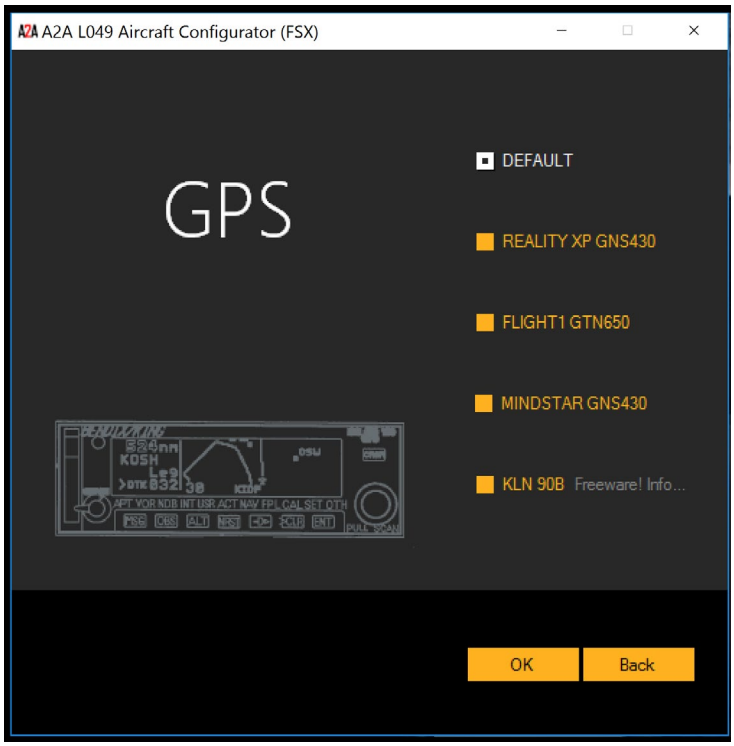




FOR SIMULATION USE ONLY

THE L-049 CONSTELLATION

FOR SIMULATION USE ONLY

The L-049/C-69 is a 44 passenger, low wing land transport monoplane, manufactured by the Lockheed Aircraft Corporation and powered by four Model R-3350 Wright Duplex engines. Hydraulically operated flight control boosters, landing gear, wing flaps, foot brakes, parking brakes, and cabin ventilation controls are provided. Cabin pressurization is provided, capable of maintaining an apparent 8,000 foot pressure altitude in the cabin while the airplane is flying at 20,000 feet. The airplane carries an active crew of five: pilot, co-pilot, flight engineer, radio operator, and navigator. In addition, accommodations are provided for a relief crew of four. Overall dimensions are as follows:

SPAN . . . . . .123 feet
LENGTH. . . . . .95 feet 1 3/16 inches
HEIGHT, at rest . . . . . .23 feet 7 7/8 inches

POWER PLANT

The four R-3350-35 engines are twin row, 18 cylinder, air cooled engines driving 15 foot 2 inch three-bladed Hamilton Standard Hydromatic quick feathering propellers. Early airplanes have engines with single speed blower. Later airplanes have engines with two-speed blowers.

FLIGHT CONTROLS

AILERON, ELEVATOR AND RUDDER

Conventional control column and wheel are provided for ailerons and elevator and conventional rudder pedals are provided for rudders. Rudder pedals are adjustable for leg length by lifting the adjustment levers. Be sure that they are adjusted equally.

CONTROL BOOSTER SYSTEM

Most of the flight control force is provided by hydraulic boost; the remainder is applied by the pilot. Control cables which operate the hydraulic boost mechanisms are directly connected to the control surfaces allowing manual flight control in an emergency. Delivery of hydraulic pressure from the engine driven pumps to the control boost system is assured, before all other hydraulic

FOR SIMULATION USE ONLY

units, should a partial hydraulic failure occur. In case of complete hydraulic failure, two levers on top of the pilot's control stand will disconnect the rudder and aileron boosters and allow manual control. A pull rod to the left of the pilot's control stand will, disconnect the elevator booster and at the same time shift the elevator control linkage to provide a mechanical advantage for manual control of approximately 3 to 1 compared to the normal linkage. Shifting the, linkage allows only ⅓ of the normal elevator travel.

GUST LOCK

Leaving all control boost systems engaged while airplane is parked provides a gust lock.

AUTOMATIC PILOT

The automatic pilot is powered by the secondary hydraulic system. The automatic pilot operates the surface controls through the control boost system and it will not completely control the airplane unless the boost system is operating properly. If the control boost system is inoperative, the automatic pilot may be used to assist the pilot to control the airplane provided hydraulic pressure is available. The gyro instruments are driven by the airplane vacuum system.

TRIM TAB CONTROLS

ELEVATOR — Electrical and manual controls are provided for the two elevator tabs, and a position indicator is installed on the co-pilot's instrument panel. The tabs are Servo as well as controllable.

The tabs are operated electrically by pulling the elevator tab control engaging lever aft to ELECT and pressing one of the two control switches which are located on the left side of the pilot's control wheel. Pressing the forward switch will bring the nose of the airplane up, and pressing the aft switch will bring the nose down.

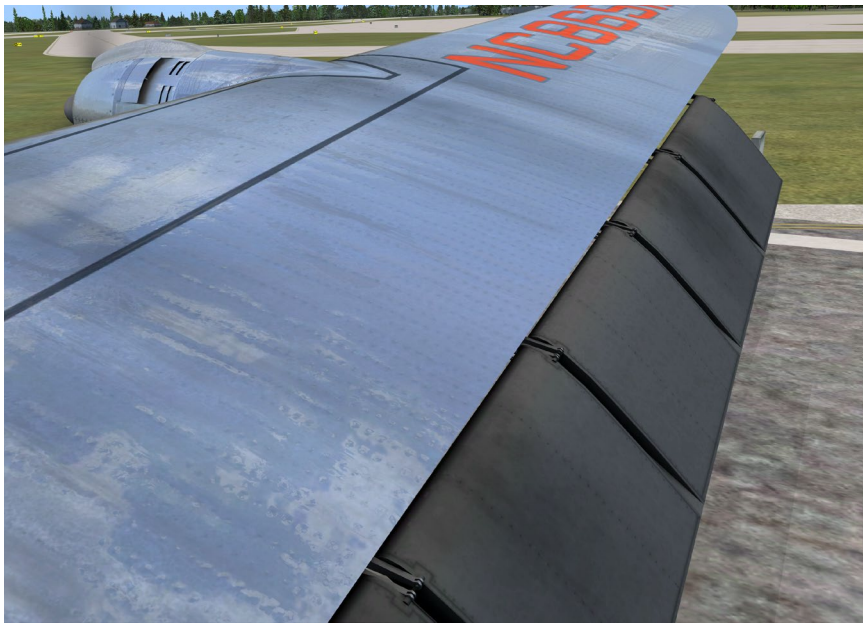
The tabs are operated manually by turning the two interconnected wheels on the pilot's control stand. The tabs cannot be operated manually when the electric motor is engaged.

RUDDER — A crank on the aft side of the pilot's control stand operates the three rudder tabs. Tabs are Servo as well as controllable.

AILERON — A crank on the aft side of the pilot's control stand operates the two aileron tabs. Tabs are Servo as well as controllable.

LANDING GEAR

The tricycle landing gear is hydraulically operated by a control located on the right side of the pilot's control stand. The landing gear control has only UP and DOWN positions. On subsequent airplanes a NEUTRAL position is provided which should be used in flight after the gear is retracted to reduce the vulnerability of the hydraulic system. The tail bumper (if installed) located under the fuselage near the tail extends and retracts with the main gear. A lock is provided so the control cannot be moved to the UP position while the weight of the airplane rests on the landing gear. In case the lock fails to release when the airplane leaves the ground, press in the manual release located inside the small hole just forward of the landing gear lever. Landing gear position is given by the indicator on the co-pilot's instrument panel. When the gear is locked in the landing position, three green lights located on the aft end of pilot's control stand, illuminate and the red flags on the landing gear position indicator disappear. When the gear is NOT locked in landing position and one engine on each side of the airplane is throttled, a warning horn will sound.



WING FLAPS

The wing flaps are hydraulically operated by the control on the pilot's control stand. The flap control quadrant is graduated in percentage extension and the flaps may be extended to any desired position by setting the flap control lever opposite the percentage extension desired. The flaps will remain at the position selected (use the flap position indicator as a check) until the flap control lever is moved, The flaps will then extend or retract to correspond with the new position selected.

FOR SIMULATION USE ONLY

PILOT'S PANELS

1. Wing De-icer Pressure
2. Height Warning Switch and Test Button
3. RMI Needle Selector Switches
4. Altimeter
5. Dual RMI
6. Attitude Indicator
7. Clock
8. Free Air Temperature
9. Airspeed Indicator
10. Omni Bearing gauge/ILS (Instrument Landing System)
11. Vertical Speed Indicator
12. Omnibearing
13. Heading Indicator
14. VOR Selector
15. Suction Gauge
16. Turn Indicator
17. Static Selector
18. Pitot Heat Switch
19. Lighting Switches
20. Radio Switches
21. Nose Wheel Steering
22. Parking Brake

FOR SIMULATION USE ONLY

ENGINE CONTROLS

THROTTLES

Conventional. One set of throttles, located on pilot's control stand, is interconnected with the other set of throttles, located on the engineer's control stand. Throttle friction locks are provided on both the pilot's control stand and on the engineer's control stand. Operation of either lock affects both sets of throttles, and the other lock.

MIXTURE CONTROL

Located only on engineer's control stand. Each of the four controls has three main positions: AUTOMATIC RICH, CRUISING LEAN, and OFF.

SUPERCHARGER CONTROLS

Located only on engineer's control stand.

PROPELLER CONTROLS

GOVERNORS — The propeller governors are controlled by four momentary contact increase-decrease rpm governor switches, located on the engineer's control stand. A master propeller governor switch is mounted on the pilot's control stand, which increases or decreases all four governors simultaneously, regardless of how the engineer's governor switches are operated. The master governor switch is spring loaded to the OFF position. The governor switches operate to change the engine rpm at approximately 100 rpm per second.

GOVERNOR INDICATOR LIGHTS — Four amber indicator lights are provided on the engineer's instrument panel. These lights glow whenever any of the governor switches or the master propeller governor switch is operated and the propeller governor is in either the full increase rpm or full decrease rpm position.

SYNCHROSCOPE — By use of the synchroscope and the synchroscope selector switch and by manipulation of the propeller governor switches, it is possible to synchronize engines numbers two, three, and four with engine number one (left outboard engine).

FEATHERING — The feathering controls are located on the flight engineer's instrument panel and the feathering operations should be performed by the flight engineer.

COWL FLAPS

Four electrically operated cowl flaps are provided for each engine. Two sets of switches on the flight engineer's control stand operate the upper flaps and the lower flaps respectively. Cowl flaps position indicators are located on the flight engineer's instrument panel.

CYLINDER HEAD TEMPERATURE INDICATORS

Cylinder head temperature indicators and a cylinder head temperature selector switch are provided on the flight engineer's instrument panel. The cylinder temperature selector switch has four positions numbered from one to four connected to cylinder heads numbered 1, 5, 14, and 17 respectively.

CARBURETOR HEATERS AND AIR FILTERS

Carburetor heaters and air filters are operated by one set of levers located on flight engineer's control stand. The controls are set to HOT when pulled towards the flight engineer. They are set to COLD when pushed away from the flight engineer. When pushed approximately 10° beyond the COLD position, the levers close a switch which brings the air filters into operation.

CARBURETOR ANTI-ICER

Carburetor anti-icers operated by switches on the shelf to the right of the co-pilot are provided to clear the carburetors in case the carburetor heaters prove ineffective or in case high powers are being used.

BMEP GAGES

BMEP gages installed on the flight engineer's instrument panel are connected to torquemeters located in each engine nose section.

FUEL SYSTEM

Four complete fuel system are provided, connected only by cross transfer lines. Two integral fuel tanks are built into each wing, the inboard tanks each hold 820 U.S. gallons (682 Imp. gallons) and the outboard tanks each hold 1590 U.S. gallons (1325 Imp. gallons) (1207 U.S. gallons [1006 Imp. gallons] each on airplanes 43-10309 and 43-10310). Fuel quantity indicators are installed on the flight engineer's instrument panel.

FUEL TANK SHUT-OFF VALVES

Four valves operated from engineer's control stand are installed to shut off the fuel flow at each tank.

ENGINE FUEL EMERGENCY SHUT-OFF VALVES

Four levers are located on the pilot's overhead panel to shut off the fuel supply to the engines. The same levers operate the engine and hydraulic oil emergency shut-off valves. These valves might not be installed on early airplanes.

FUEL TRANSFER VALVES

These four valves are operated by levers located on floor to left of engineer's seat. They provide means for supplying fuel to any engine from any fuel tank.

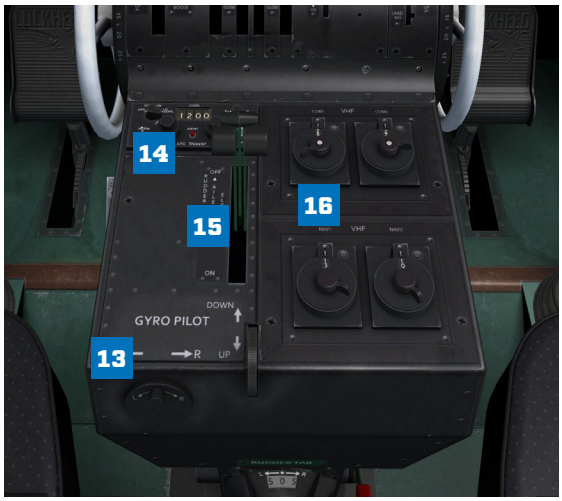
AUXILIARY FUEL PUMPS

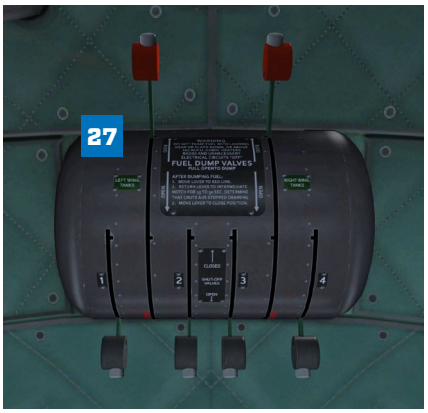
Four switches are located on the flight engineer's panel to control the four electric auxiliary fuel pumps. These pumps are provided for use during take-off, landings and at other times when engine-driven fuel pumps will not maintain 16 lb/sq in. fuel pressure.

FOR SIMULATION USE ONLY

PILOT'S CENTER

1. Dual Manifold Pressure Gauges
2. Dual Tachometer Gauges
3. Autopilot Servo Speeds
4. Autopilot Heading Controls
5. Autopilot Attitude Controls
6. Suction Gauge
7. Elevator Trim
8. Rudder/Aileron Boost
9. Engine Throttles
10. Throttle Lever Lock
11. Master Propeller Governor Switch
12. Flaps Lever
13. Autopilot Controls
14. Transponder
15. Auto Pilot Rudder Servo
16. Radio Dials
17. Elevator Boost
18. Emergency Brakes
19. Rudder Trim
20. Aileron Trim
21. Landing Gear Lever
22. ADF (Automatic Direction Finder) Controls
23. Windshield Wiper/ Heater Switches
24. No Smoking/Seatbelt Light Switches
25. Magneto Switches
26. Fire Extinguisher Control
27. Fuel Tank Valves and Fuel Dump Valves





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FUEL FLOW METER INDICATORS
These are installed on the engineer's instrument panel, are calibrated in pounds of fuel per hour. The meters are located in the primary fuel line just before the carburetors.

ENGINE PRIMERS
These are the electric solenoid type which require 16-19 lb/sq in. fuel pressure to operate properly.

FUEL DUMP VALVES
One retractable dump chute is provided on the lower surface of each inner wing panel connected to both the inboard and outboard tanks. Operation of the two fuel dump control levers located on the pilot's overhead panel, both extends the dump chutes and open the dump valves. The rate of flow is approximately 190 U.S. gallons (158 Imp. gallons) per minute from each dump chute [105 U.S. gallons (87 Imp. gallons) from each outboard tank and 85 U.S. gallons (71 Imp. gallons) from each inboard tank]. Following any emergency dumping of fuel, there are 70 U.S. gallons (58 Imp. gallons) left in the inboard tanks and 30 U.S. gallons (25 Imp. gallons) left in the outboard tanks.

FUEL PRESSURE
Two dual fuel pressure gages are installed on the engineer's instrument panel. Maximum fuel pressure is 19 lb/sq in., minimum 15 lb/sq in., desired 17 lb/sq in. Fuel pressure warning lights located below the pressure gages and on the pilot's instrument panel glow when the fuel pressure falls below 14 lb/sq in.

CARBURETOR VAPOR RETURN SHUTOFF VALVES
Solenoid operated shut-off valves, which are controlled by switches on the engineer's lower control panel, are installed in the carburetor vapor return lines. These valves should be OPEN at all times except when fuel flow readings are being taken.

OIL SYSTEM
One integral oil tank of approximately 50 U.S. gallons (41.5 Imp gallons) usable capacity is installed outboard of each nacelle. Oil quantity indicators are installed on the flight engineer's instrument panel.

OIL PRESSURE
The engines are equipped with two oil pumps, one on the front and one on the rear. Four dual oil pressure gages are installed on the engineer's instrument panel. The gages on the upper panel indicate front pump pressure which should be 40 lb/sq in. maximum, 30 lb/sq in. minimum, desired 35 lb/sq in. The gages on the lower panel indicate rear pump pressure which should be 80 lb/sq in. maximum, 60 lb/sq in. minimum, 25 lb/sq in. permissible at idling speed (550 rpm), desired 70 lb/sq in. Oil pressure warning lights located below the rear pump oil pressure gages glow when the rear oil pressure falls below 50 lb/sq in.

OIL TEMPERATURE
Two dual oil-in temperature gages and two dual oil-out temperature gages are installed on the flight engineer's instrument panel.

OIL COOLER FLAPS
Switches having four positions: AUTOMATIC, OFF, OPEN, and CLOSE are installed on the engineer's control stand. Normally these switches will be left in AUTOMATIC, however, the OPEN and CLOSE positions allow manual setting of the flaps to any desired position, in case of failure of the automatic mechanism. An oil flap position indicator is installed on the flight engineer's instrument panel. The automatic control is set to regulate between 71 ° C (160° F) (flaps closed) and 90° C (196° F) (flaps open). The emergency temperature limit is I05° C (220° F).

OIL DILUTION
Switches are located on the engineer's upper panel. When it is anticipated that the temperature at the next start will be below 5° C (40° F) the oil system should be diluted before stopping the engines.

OIL SHUT-OFF EMERGENCY VALVES
Four levers located on the pilot's overhead panel shut off the engine oil supply. The same levers operate the fuel and hydraulic oil emergency shut-off valves.

HYDRAULIC SYSTEM
The hydraulic system is divided into two parts, the primary system, which operates the flight control boosters, and the secondary system, which supplies all other hydraulic units. Normally the systems work independently, but a cross over line is installed so that in case the primary system pressure fails, the secondary system will supply the flight control boosters. A check valve is installed in this line so that fluid cannot flow in reverse direction, and a restriction control valve is installed in the secondary system downstream from the cross over check valve so that when the boosters require a large flow the restriction control valve will nearly close, thus assuring pressure to the flight controls booster at the expense of all other hydraulic units. Hydraulic pumps on engines number 1 and number 2 supply the primary system and pumps on engines number 3 and number 4 supply the secondary system. Warning lights on the engineer's instrument panel and on the co-pilot's instrument panel illuminate when the pressure at any pump falls below approximately 1325 lb/sq in. Combined fuel hydraulic and engine oil emergency shut-off valves are operated by levers on the pilot's overhead panel. Solenoid operated hydraulic pump shutoff valves are controlled by switches located on the flight engineer's instrument panel. The hydraulic pressure gage on the co-pilot's instrument panel shows primary system pressure which should be between 1500 and 1700 lb/sq in. There is no secondary hydraulic system pressure gage.

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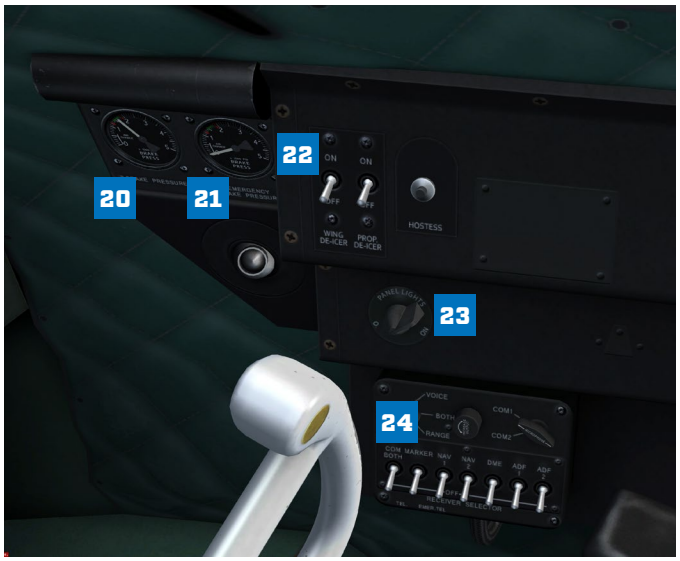

CO-PILOT'S PANELS

1. RMI Needle Selector Switches
2. Clock
3. Altimeter
4. Dual RMI
5. Attitude Indicator
6. Wing Flaps Position Indicator
7. Omnibearing
8. Airspeed Indicator
9. Omni Bearing gauge/ILS (Instrument Landing System)
10. Vertical Speed Indicator
11. Suction Gauge
12. Auto Pilot Oil Pressure
13. Heading Indicator
14. VOR Selector
15. Turn Indicator
16. Outside Air Temperature
17. Hydraulic Oil Pressure
18. Wing De-icer Pressure
19. Wing Flap Warning Test Switch
20. Brake Pressure
21. Emergency Brake Pressure
22. Wing/Prop. De-icer Switches
23. Panel Lights
24. Radio

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BRAKES

The brakes are operated from either the pilot's or co-pilot's station by rotating the top of the rudder pedals forward. The eight brakes are power operated hydraulically and are installed on both sides of each of the four main wheels. Two complete braking systems, except for the brakes themselves, are installed. The brake selector valve is controlled by levers located on both sides of the pilot's control stand.

Parking Brakes are controlled by the lever on the pilot's side panel. To set the parking brakes, move the parking brake lever to ON. To release the parking brake, press the toe brakes.

STEERING MECHANISM

The nose wheel is normally free swiveling to an angle of approximately 45°, but it may be steered. To steer the nose wheel use the nose wheel steering control located on the left side of the pilot's panel.

CAUTION: Use extreme care in power steering the airplane, particularly at speeds above 30 mph.

ELECTRICAL SYSTEM

This airplane is equipped with two complete, 24 volt electrical systems each containing a 200 ampere generator, a voltage regulator, a reverse current relay, a 34 ampere-hour battery, and a power bus. In all normal operation, the systems are operated independently. In general, the number one system supplies the accessories powered with electric motors and the number two system supplies the instruments and lights.

The airplane master switch is located directly over the batteries and is controlled by a lever on the flight engineer's instrument panel.

GENERATOR SWITCHES

These are located on the flight engineer's electrical panel. Turn the switches ON for normal operation.

VOLTMETER

The voltage of either battery or either generator may be read by setting the voltmeter selector switch located on the flight engineer's electrical panel. Choose from Voltage, Battery Voltage or Main Bus Voltage.

AMMETERS

Located on flight engineer's electrical panel indicate the current output by the generators.

LIGHTS

LANDING LIGHTS — are located one on each outer wing panel, and are controlled by switches on the pilot's overhead panel. With the switches ON the lights extend and turn on. With the switches OFF the lights turn off, but remain extended. Never fly above 140 mph unless the landing light switches are in the RETRACT position.

NAVIGATION LIGHTS — These are controlled by switches on the pilot's side panel.

DOOR WARNING LIGHT — Switches are installed on all external doors except emergency exits which operate the door warning light on the co-pilot's instrument panel. Compartment or step lights turn ON when the crew or cargo doors are opened.

WARNING LIGHTS — on the engineer's instrument panels are tested by a switch on the flight engineer's electrical panel.

INSTRUMENT LIGHTS — with adjustable strength UV lighting. These are controlled by switches on the pilot's side panel.

COCKPIT & CABIN FLOOD LIGHTS — These are controlled by switches on the engineer's panel.

ICE ELIMINATING SYSTEM

WING AND TAIL DE-ICER

De-icer boots are provided for the wing and tail. They are turned ON by a switch located on the co-pilot's side panel. When not operating, the boots are held flush with the surface by suction from the vacuum pumps which are operating the instruments. If a leak develops in the boots, shut off the valve on the floor under the navigator's table to turn off the vacuum supply to the boots. The de-icer gauge on the co-pilot's instrument panel is connected to the de-icer distributor valve and indicates proper functioning of the de-icer boots.

PROPELLER ANTI-ICER

One electric pump located in each outboard nacelle delivers anti-icing fluid to the propellers on that side. Turn on full at first to wet the blades, then retard for economy.

CARBURETOR ANTI-ICER AND HEAT

Located in each outboard nacelle are two electric pumps each supplying anti-icing fluid to one carburetor on that side. The pumps are operated at a fixed speed by four momentary contact switches on the engineer's panel. Carburetor ice is indicated by either or all of the following: Carburetor air temperature gage within icing range; free air temperature gage within icing range; manifold pressure falls off; and BMEP gauge falls off. Turn anti-icer pumps off when above instruments show correction. Four carburetor heat control levers are located on the flight engineer's control stand. These control hot air muff valves which are designed to give a temperature rise of at least 32° C (90° F) with a 5° C (40° F) outside air temperature at 65% or greater engine power. Set to HOT if danger of carburetor ice exists except when operating at normal rated power or over. At high power danger of detonation exists and only the carburetor anti-icer should be used.

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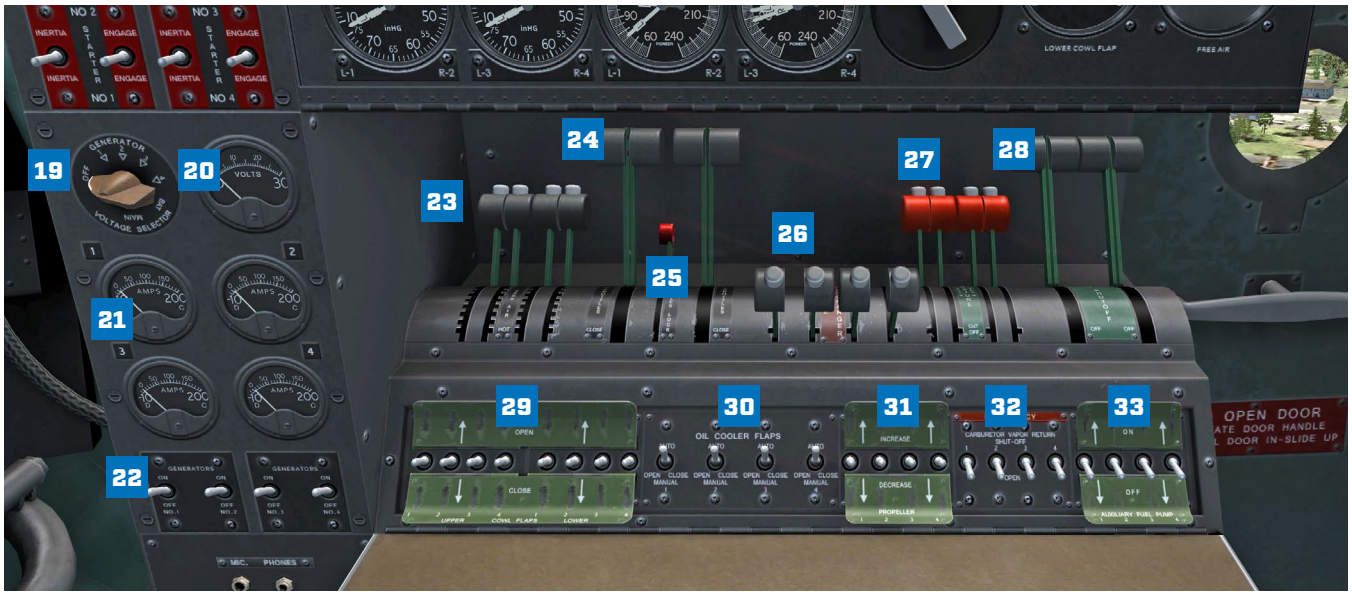

ENGINEER'S PANELS

1. Carburetor Anti-Icer Switches
2. APU Control Panel
3. Warning Lights Test Switch
4. Engine Primer Switches
5. Engine Inertia Starters
6. Engine Tachometers
7. Carburetor Air Temperature
8. Fuel Flow
9. Manifold Pressure
10. BMEP (Torque Pressure)
11. Clock
12. Synchroscope
13. Cylinder Head Selector
14. Cylinder Head Temperature
15. Upper Cowl Flaps
16. Oil Cooler Flaps
17. Lower Cowl Flaps
18. Free Air Temperature
19. Voltmeter Selector
20. Voltmeter
21. Engine Generator Ammeters
22. Generator Switches
23. Carburetor Air Levers
24. Engine Throttles
25. Throttle Lever Lock
26. Supercharger Levers
27. Engine Mixture
28. Fuel Tank Cut-Off Levers
29. Upper and Lower Cowl Flaps Switches
30. Oil Cooler Flap Switches
31. Propeller Governor Switches
32. Carburetor Vapor Return Shut-Off Switches
33. Auxiliary Fuel Pump Switches

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WINDSHIELD ANTI-ICER

Two centrifugal blowers controlled by switches on the pilot's overhead panel force dried cabin air between the windshield glass panels to eliminate frost or fog. The windshield air is dried by desiccators accessible through doors on the pilot's and co-pilot's side panels. The charge in the desiccators should be replaced at frequent intervals. Two electric windshield wipers are provided and controlled by one switch on the pilot's overhead panel. Do not operate wipers on dry glass.

PITOT HEAT

Both pitot heads incorporate a heater element which is operated by a switch on the pilot's overhead panel. Burnout warning lights are provided over each switch.

ANTI-ICER FLUID SUPPLY

All anti-icer fluid is stored in two 20 gallon tanks located one in each outboard nacelle.

VACUUM SYSTEM

Four vacuum pumps are provided, one driven by each engine. The pumps operate in pairs with one pair acting as a standby at all times. The vacuum pump selector valve located on the pilot's side panel selects either the two left pumps or the two right pumps. Failure of a pump is indicated by the vacuum pump warning lights, located on the flight engineer's instrument panel, which glow when the vacuum falls below 4 in. Hg. Check valves protect each pump against failure of another pump. Suction gages are installed on the pilot's and co-pilot's instrument panels. Each gage indicates the suction supplied to the vacuum instruments on its panel.

FIRE EXTINGUISHER SYSTEM

Fire detectors are located at various points in each nacelle and blower section. In case of a nacelle fire, both the pilot's master fire warning light and the flight engineer's warning light corresponding to that nacelle will glow. In case of a blower section fire, the needle on the indicator corresponding to that blower section will become visible. Two carbon dioxide bottles of. 15 pounds capacity each are located on the forward all of the upper cargo compartment. A selector valve and two control handles will deliver carbon dioxide to a manifold in each nacelle. A connection is provided on the right side of I the nose wheel well for an external supply of CO_2 which can be routed to any nacelle by properly setting the selector valve in the flight station. A rupture disc is installed in each,bottle to discharge the CO_2. Overboard should thermal expansion cause a dangerously high pressure in the bottle. The outlets are located under the fuselage aft of the nose wheel well. Red celluloid discs normally cover these openings.

GPS

On optional GPS can be toggled from the Controls 2D Panel (Shift-3).

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ENGINEER'S PANELS CONTINUED

1. Oil Pump Pressure Gauges
2. Fuel Pressure Gauges
3. Propeller Feather Switches
4. Oil In Temperature Gauges
5. Oil Out Temperature Gauges
6. Anti-Icer Fluid Levels
7. Hydraulic Fluid Reservoir
8. Oil Quantity Indicator
9. Fuel Quantity Indicator
10. Cockpit/Cabin flood light switches
11. Master Battery Switch
12. Fire Panel Test Switch
13. Hydraulic Valve Switches
14. Oil Dilution Switches
15. Heater/Cooler Switches
16. Cabin Supercharger Inlet Switches
17. Pressurization Dump Switch
18. Oxygen Pressure Gauge
19. Passenger Cabin Air Temperature
20. Air Flow Indicator Gauges
21. Altimeter
22. Cabin Pressurisation
23. Cabin Pressurization Change Rate
24. Pressurization Goal
25. Change Rate Goal
26. Fuel Crossfeed Levers

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FLIGHT OPERATIONS

Follow these procedures and checklists for all flight operations of your L-049. Most procedures are broken down between Pilot, Co-pilot and Engineer. Emergency procedures will be covered in a later chapter.

ON ENTERING FLIGHT STATION
Check For All Flights

	PILOT	CO-PILOT	ENGINEER
1.			Airplane master switch ON
2.		Landing gear lever — DOWN.	Warning light switch — TEST. Check that all hoods are off lights and check for burned out lights on nacelle fire, vacuum pumps, propeller pitch hydraulic pumps, oil pressure, fuel pressure, cabin pressure, cabin heater fire, cabin heater ignitor and cabin heater fuel, warning lights. Set switch to BRT or DIM.
3.	Controls booster levers — ON.	Set altimeter	
4.	Mechanical elevator control, PUSH to engage elevator booster.		Generator switches — OFF until engines are started.
5.	Elevator tab control lever — MANUAL.		
6.	Elevator and rudder booster emergency control switches — OFF.		Upper and lower cowl flaps switches OPEN.
7.	Automatic pilot engaging levers — OFF.	Fuel dump valves — CLOSED.	Oil cooler switches — AUTOMATIC.
8.	Automatic pilot hydraulic pump motor switch — OFF.	Emergency fuel, engine and hydraulic oil shut-off valve OPEN (usually safetied in OPEN position).	Propeller governor switches hold in INCREASE until propeller governor limit lights illuminate.
9.	Set altimeter		Carburetor air levers — COLD or set to FILTER in dusty air.
10.			Superchargers — LOW.
11.			Mixture — OFF.
12.			Hydraulic pump shut-off switches — OPEN.
13.			Fuel cross transfer valves — OFF.
14.			Carburetor vapor return switches — OPEN.
15.			Check quantities of fuel, oil, hydraulic fluid, and anti-icer fluid.
16.			Set cylinder head temperature selector switch to 1.
17.			Set cabin pressurization controls as required.

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FUEL SYSTEM MANAGEMENT

Take-off and land with each system operating independently, i.e., all tank shut-off valves ON and all fuel cross transfer valves OFF. When carrying less than 3200 U.S. gallons (2670 Imp. gallons) put equal quantities of fuel in each tank and operate each system independently. When more than 3200 U.S. gallons (2670 Imp. gallons) of fuel is carried, operate the two righthand engines from the right-hand outboard tank until fuel quantities in both right-hand tanks are equalized. Repeat the fuel equalizing procedure for left-hand engine operation. Do not equalize fuel on both sides at once. When the fuel quantities in all tanks have been equalized, it will be possible to operate each fuel system independently for the rest of the flight.

CROSS FEED SYSTEM OPERATION

1. OPEN fuel shut-off valve and turn ON auxiliary fuel pump of system supplying fuel.
2. OPEN cross transfer valve of system to supply fuel and of system or systems to receive fuel.
3. CLOSE fuel shut-off valve and turn OFF auxiliary fuel pump of system or systems receiving fuel.
4. Turn OFF auxiliary fuel pump of systems supplying fuel if the engine driven pumps will maintain 15 lb/sq in. fuel pressure.

AUXILIARY FUEL PUMP OPERATION

The auxiliary fuel pump switches should be turned ON during take-off, landing and at other times when the engine driven fuel pumps will not maintain 15 lb/sq in.

STARTING THE ENGINES

	PILOT	CO-PILOT	ENGINEER
1.			Suggested normal starting order 3, 4, 2, 1, to start engines away from cabin door first.
2.			Fuel shut-off valves — ON.
3.			Throttles 1/10 OPEN. Mixture — OFF.
4.			Auxiliary fuel pumps — ON. Check for 15-19 lb/sq in.
5.		Turn fire extinguisher selector to engine to be started.	Starter switch to INERTIA after receiving all clear signal from pilot.
6.	Master ignition switch — ON.		Press primer button 2 to 5 seconds. Don't prime a warm engine.
7.	Individual ignition switches to BOTH after engine has turned at least three blades.		Starter switch to DIRECT.
8.			When the engine is running smoothly, place the mixture control to AUTO RICH and continue to prime only as required.
9.			Quickly return mixture control to OFF if the engine does not continue to run or flooding will result.
10.			Stop the engine if both front and rear oil pressure does not register within 10 seconds.
11.			Start other engines as outlined in the paragraphs above.
12.			Generator switches ON after all engines are started.

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WARM-UP

1. Run the engines at 1000 rpm until the oil temperature reaches 75° C (167°F) or shows a definite increase (10° C or 18° F) and the oil pressure is steady.
2. Leave engine cowl flaps open during warm-up, Closing the cowl flaps will not shorten the warm-up, period and it may damage the engine.
3. Auxiliary fuel pumps OFF (check for 16-19 lb/ sq in. with engine driven pumps only).

ENGINE AND ACCESSORIES GROUND TEST

	PILOT	CO-PILOT	ENGINEER
1.		All warning lights except landing gear should be OFF.	All warning lights except cabin pressure should be OFF.
2.	Suction gage 4 inches Hg.	Suction gage 4 inches Hg.	
3.		Check hydraulic system as follows	Check each engine as follows
4.		Hydraulic system pressure 1700 lb/sq in.	Supercharger to HIGH below 1200 rpm if two speed blower is installed.
5.			Slowly advance throttle to 1800 rpm.
6.		Emergency brake pressure 1700 lb/sq in.	Supercharger to LOW firmly and without hesitation during shift. Note reduction in manifold pressure indicating shift has been accomplished.
7.		Extend and retract flaps.	Hold propeller governor switches in DECREASE position until propeller governor limit warning light illuminates. (Engine front oil pressure will fluctuate while propeller pitch is changing.)
8.			Note 1100 rpm then hold propeller governor switch in INCREASE position until propeller pitch limit warning light illuminates again. NOTE: This check is necessary to insure warm oil in the propeller dome and thus reduce the amount of surging with change in power.
9.	Check magnetos on request of flight engineer. Maximum normal drop is 100 rpm on going from both to one magneto.		Increase to 2200 rpm but do not exceed 30 inches Hg. and request pilot to check magnetos. Engines must operate smoothly on either magneto.
10.			When not familiar with engine condition check take-off power — 2800 rpm and 46 inches Hg. CAUTION: Do not operate at this power for more than 2 or 3 seconds while standing still.
11.			Reduce throttle. Notify pilot when all engines have been checked.
12.	Call control tower for clearance.	Door warning light — OFF.	If icing conditions prevail, set carburetor heat to HOT, until just before take-off.

FOR SIMULATION USE ONLY

TAXIING

	PILOT	CO-PILOT	ENGINEER
1.	In order to cut in the generators it is recommended that the airplane be taxied and steered with the inboard engines. Use the brakes only when necessary. If desired, or in an emergency, if the brakes should fail, the nose wheel steering mechanism should be used to steer the airplane. Avoid high speed taxiing and excessive movement of the nose wheel. The rolling inertia of the airplane resists turning and may cause sideway skipping of the nose wheel at high speed.	Watch hydraulic pressure and notify pilot if it drops below 1500 lb/sq in.	Notify pilot if engine operation is not normal.
2.	The airplane has no tendency to ground loop and can be turned to either side while taxiing at a fast rate. However, the radius of turn must be lengthened as the speed increases. At 30 mph, the minimum allowable radius of turn is 120 feet and at 50 mph the minimum allowable radius of turn is 300 feet.		

TAKE-OFF

	PILOT	CO-PILOT	ENGINEER
1.	Refer to the TAKE-OFF CLIMB AND LANDING CHART on page XXX for take-off distance to be expected.		
2.		Surface controls booster — ON.	Generator switches — ON.
3.		Automatic pilot engaging levers — OFF.	
4.		Door warning light — OFF.	Carburetor heat COLD, or FILTER in dusty air. NOTE: If icing conditions exist, clear carburetor by a run-up with the carburetor heat on HOT, return control to COLD and request co-pilot to turn ON carburetor anti-icer during take-off if signs of carburetor icing appear.
5.		Elevator tab control lever — ELECT.	Superchargers — LOW.
6.		Elevator tabs set 5° nose up.	Mixture — AUTOMATIC RICH.
7.		Wing Flaps — UP. Note: Up to 60% flaps may be used to assist take-off if the airplane is heavily loaded or if the runway is short.	Fuel shut-off valves — ON.
8.		Hydraulic pressure 1500 to 1700 lb/sq in.	Fuel cross transfer valves — OFF.
9.			Carburetor vapor return switches — OPEN.
10.			Cowl flaps both upper and lower — 1/2 open. In hot weather open all flaps fully. No buffeting will be experienced with fully open cowl flaps.
11.			Oil coolers — AUTOMATIC.
12.			Propeller governor switches — INCREASE until propeller governor limit lights go ON .
13.			Auxiliary fuel pumps — ON.
14.			Recommended cylinder head temperature — between 180° C and 232° C (356° F and 450° F) at start of takeoff run.

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TAKE-OFF

	PILOT	CO-PILOT	ENGINEER
15.	Close side window.	Close side window.	
16.	Release parking brake and taxi into takeoff position. Roll a few feet straight down the runway to straighten the nose wheel. Use all the available runway for take-off. Co-pilot: Elevator and rudder booster emergency control switches — ON.		
17.	Hold airplane with brakes and advance throttles to 30 or 40 in. Hg.		
18.	Release brakes and advance throttles to 46 in. Hg. Engine speed 2800 rpm maximum.	Watch manifold pressure gages and if the pressure falls off on any engine, inform the pilot and flight engineer.	Watch cylinder head temperatures and open cowl flaps if 260° C (500° F) is exceeded.
19.	Keep airplane straight. Raise nose gear off ground at approximately 80 mph.		Watch BMEP gages and be prepared to feather corresponding engine if conditions require such action.
20.	When airplane is clear of ground, direct co-pilot to retract landing gear.	Retract landing gear at command from pilot.	
21.	When landing gear. is up and locked, direct co-pilot to raise wing flaps if extended. Flaps retract slowly enough so that loss of lift is not dangerous.	Raise wing flaps at command from pilot.	

FOR SIMULATION USE ONLY

ENGINE FAILURE DURING TAKE-OFF

	PILOT	CO-PILOT	ENGINEER
1.	Failure of an engine during take-off may not be noticed immediately except for a resultant swing. If a swing develops, and there is room to close the throttles and stop the airplane, this should be done.	Watch manifold pressures during take-off.	Be prepared to feather an engine at command of pilot.
2.	If it is necessary to continue with take-off even though one engine has failed, hold the airplane straight by immediate application of rudder and necessary throttling of opposite engine if the airspeed is below the minimum for rudder control. (Approx. 110 mph for outboard engine failure.) Gain speed as rapidly as possible. See that the landing gear is up, or coming up, and direct flight engineer to feather the dead propeller. Retrim as necessary.	Check to see that gear is on the way up.	Feather propeller at command of pilot.

CLIMB

	PILOT	CO-PILOT	ENGINEER
1.	Direct flight engineer to take over engines.	Move the elevator and rudder booster emergency control switches to OFF.	At command from pilot, reduce to power for climb.
2.	Trim for best climbing airspeed.		Always use AUTO RICH mixture for climb.
3.			Watch cylinder head temperatures and if over 248° C (475° F) open cowl flaps more or if fully open request pilot to increase airspeed.
4.			Shut the four auxiliary fuel pumps OFF if the engine pumps alone will maintain at least 16 lb/sq in. fuel pressure.
5.			When climbing to high altitudes, shift supercharger to high blower at appropriate altitude.
6.			If desired turn on cabin pressurization equipment.

FLIGHT OPERATION

	PILOT	CO-PILOT	ENGINEER
1.	When climb has been completed, level off and direct the flight engineer to reduce power to the cruising power required by the flight plan.		At command of pilot, reduce manifold pressure and rpm to the cruising power.
2.	Engage automatic pilot if desired.		
3.			Set mixture controls to CRUISE LEAN if allowable.
4.			When possible, obtain the desired cruising power in low blower. The high blower fuel consumption is slightly greater at equal powers.

FOR SIMULATION USE ONLY

AUTOMATIC PILOT

The automatic pilot (gyropilot) equipment consists of a directional gyro control unit, a bank and climb gyro control unit, a mounting unit and a servo unit, together with the necessary accessories for the proper working of the equipment as a whole. When the automatic pilot is set to fly the airplane in a straight, level course, and this attitude is disturbed by a gust of wind or otherwise, the gyros in the control units operate the air pick-offs so that a difference of pressure is obtained across the diaphragm in the air relays. This causes the balanced oil valves to open and allow oil to flow to the servo unit. This oil is under pressure and moves the piston in the servo in the direction that will cause a corrective movement of the airplane's control surface. This movement causes the airplane to assume its original straight, level flight position.

When a maneuver is desired, the indices on the control units are moved slowly by the knobs until the maneuver is complete. When the indices are moved, a difference in pressure across the diaphragm in the air relays will result. This will operate the balanced oil valves and allow hydraulic fluid to flow to the servo. The servo will then move the controls so that the desired maneuver is performed.

The Sperry A-3 autopilot is equipped with a proportional bank adapter. It is an automated device used to give the airplane the correct amount of bank for any desired turn, optionally added to some Sperry installations. It is mounted in the back of pilot's instrument panel and forms a part of the of the automatic pilot installation, so it's not visible from the cockpit. In addition to automatically banking the airplane for any turn, this device also automatically provides "up elevator" during the turn so as to compensate for loss of altitude which would otherwise occur. The principle of operation is essentially as follows:

When the rudder is moved (in order to make a turn) the rudder follow up cable moves, causing the rudder shaft in the proportional bank adapter to rotate. This shaft, by being geared to the aileron shaft and also to the elevator shaft in the proportional bank adapter, transmits a certain amount of correction to the elevator and aileron follow-up cables, which in turn move the respective surfaces.

AUTOPILOT OPERATION

1. Trim airplane to fly "hands off."
2. See that speed control valves are open. Set at 3 if best setting is not known.

> **NOTE:** The speed valves control the rate at which the automatic pilot moves the controls and reacts to bring the airplane back on course. In general, the speed valves should be left open unless there is oscillation present in which case the valves should be closed sufficiently to stop the oscillation.

> **CAUTION:** Turning any of the three speed valves to its OFF position locks the corresponding control surface in whatever position it happens to be and should be avoided.

3. Set rudder follow-up card to match directional gyro card by turning rudder knob or the remote control for the rudder knob located on the pilot's control stand.
4. Set aileron follow-up index to match bank index by turning aileron knob.
5. Set elevator follow-up index to match elevator alignment index by turning elevator knob or the remote control for the elevator knob located on the pilot's control stand.
6. Engage the automatic pilot slowly by moving the three servo activation levers.
7. After the autopilot takes over, it may be necessary to rotate rudder, aileron and elevator knobs slightly to get exact course and attitude.
8. Disengage the autopilot every 2 hours and retrim airplane. This is necessary to compensate for changes in flight altitude, power and load shifts which affect the trim.
9. Periodically check on directional gyro units, which have a slight amount of normal precession. Check with compass regularly.
10. To make course changes, rotate the rudder knob slowly and smoothly. The proportional bank adapter will cause the aileron and elevator to move accordingly to better coordinate a turn.

GENERAL FLYING CHARACTERISTICS

CONTROLLABILITY — The hydraulic boost control system makes the airplane easily controllable by one man in all allowable maneuvers. Normal turns may be made with the use of ailerons alone and satisfactory turns may be made with rudders alone although the resulting yaw may be unpleasant to the rear passengers. The airplane is controllable and handles well at low speeds down to and including the stall.

STABILITY — The airplane has good stability characteristics. It is stable at all approved center of gravity positions 18% to 32% gear down.

TRIM CHARACTERISTICS — Rudder and aileron trim tabs normally require adjustment only during partial engine failure. Elevator trim tabs require the normal small adjustments with changes in power, airspeed, and center of gravity position. There is little or no change in elevator trim up to approximately 60% flap extension. From 60% to 100% flaps the trim tabs should be adjusted slightly to hold the nose up.

TO INCREASE POWER IN FLIGHT

1. Mixture AUTO RICH if maximum cruising power is to be exceeded.
2. Propeller governor switches. Hold in INCREASE until new rpm is reached. Speed changes approximately 100 rpm per second.
3. Throttles to the new manifold pressure.

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TO DECREASE POWER IN FLIGHT

1. Throttles to the new manifold pressure.
2. Propeller governor switches. Hold in DECREASE until new rpm is reached.
3. Re-adjust throttles if necessary.
4. Mixture CRUISE LEAN if permissible.

SUPERCHARGER OPERATION

SHIFTING FROM LOW TO HIGH BLOWER

1. Partially close throttle so that the desired high blower manifold pressure will not be exceeded.
2. Hold propeller governor switch to DECREASE to obtain 1500 to 1800 engine rpm.
3. Set mixture control to AUTO RICH.
4. Move supercharger control rapidly from LOW position to HIGH position and lock.
5. Hold propeller governor switch to INCREASE to obtain desired rpm.
6. Readjust throttle if necessary.
7. Set mixture control to CRUISE LEAN if permissible.

SHIFTING FROM HIGH TO LOW BLOWER

1. Set mixture control to AUTO RICH.
2. Move supercharger control rapidly to LOW position and lock.
3. Readjust rpm setting as necessary to obtain the desired power.
4. Readjust throttle to obtain desired manifold pressure.
5. Set mixture control to CRUISE LEAN if permissible.

Blower ratio changes should not be made at intervals of less than five minutes in order to provide opportunity for dissipation of heat generated during clutch engagement.

Since, for the same power, fuel economy is worse in high blower do not use high blower if the required power is available in low blower.

MANEUVERS PROHIBITED

All acrobatics, spins, and banks in excess of 60 degrees.

Do not exceed the following accelerometer readings in banks or pullouts from a dive.

Gross Weight (lbs)	Maximum Allowable Accelerometer Reading	
	Pullout	Pushover
86,250	2.5	1.1
82,000	2.6	1.2
72,000	3.0	1.3
62,000	3.5	1.4

STALLS

The stalling characteristics of this airplane are good. Sufficient warning is given of all stalls in the form of buffeting which first occurs five to ten mph above the stalling speed. The warning is given sooner with flaps up than with flaps down. There is little or no tendency to roll in any stall either with flaps and gear up or down or with power on or off. Aileron control is available at all speeds down to and including the stall. When the airplane is stalled it "mushes" straight forward. Occasionally a slight tendency to roll will be noticed. Use rudders to stop the roll. The nose will drop slightly and then come up again if an attempt is made to hold the airplane in the stall.

The approximate ship indicated stalling speeds with power off are as follows:

GROSS WEIGHT (lbs.)	STALLING SPEEDS (IAS)	
	Gear and Flaps Down	Gear Down and Flaps Up
57,000	69	88
67,500	74	96

SPINS

The airplane normally shows no tendency to spin from a stall or slow steeply banked turns and should not be intentionally forced into a spin under any condition. The airplane was not designed for the loads imposed on the structure during spin conditions, and structural failure will result if a spin is attempted.

ACROBATICS

All acrobatics are strictly prohibited.

DIVING

Due to the aerodynamic cleanliness of this airplane it picks up speed very rapidly in a dive and only very shallow diving angles are permissible without exceeding the maximum permissible indicated diving speed which is 364 mph (320 mph when de-icer boots are installed).

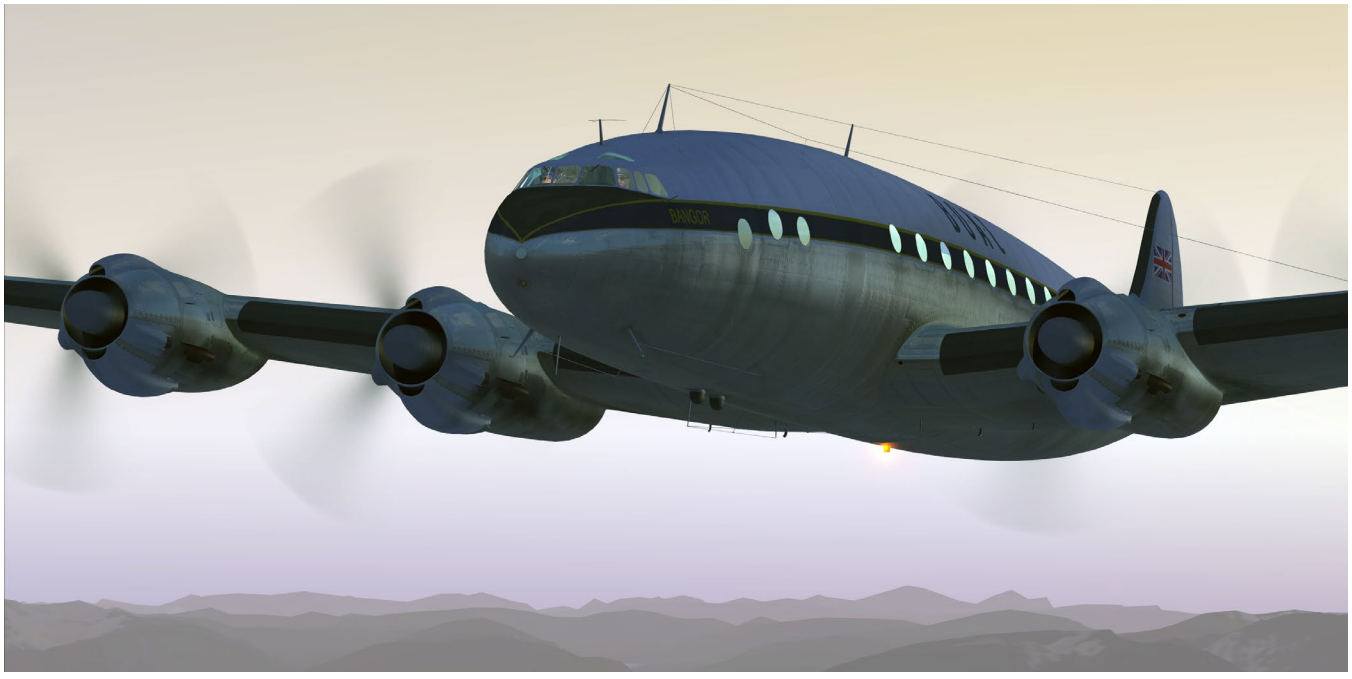
Trim changes experienced in a dive are quite normal.

Control forces are light considering the size of the airplane, hence, reasonable caution should be exercised in pulling out of a dive or in high speed maneuvers so as not to exceed allowable load factors.

FOR SIMULATION USE ONLY

DESCENT

	PILOT	CO-PILOT	ENGINEER
1.	Set altimeter to Kollsman reading of field.	Set altimeter to Kollsman reading of field.	Set cabin altimeter to Kollsman reading of field.
2.	If cabin pressure controls are adjusted by the flight engineer, descent may be made at any rate not exceeding value calculated by flight engineer.		If cabin is pressurized, set the vertical speed knob as desired (400 to 600 ft. min. recommended) and set the pressure altitude knob to the Kollsman reading of field.
3.	If cabin is not pressurized do not exceed a rate of 400 to 600 ft/min. for passenger comfort.		Calculate maximum allowable rate of airplane descent.
4.	Adjust automatic pilot for descent or disengage it. If the automatic pilot is disengaged and the airplane has a separate automatic pilot hydraulic system, turn OFF the pump motor.		Do not exceed cruising powers.
5.	Never exceed an indicated air speed of 364 mph (320 mph with de-icer boots installed) in a glide. NOTE: ln cold weather, avoid overcooling the engines by descending with gear down, power on and at reduced airspeeds.		Close cowl flaps to maintain normal cylinder head temperatures.
6.	Move throttles frequently to dear the engines and prevent the throttles from freezing if icing conditions exist.	Operate carburetor anti-icers if there is any sign of carburetor icing.	If danger of carburetor ice exists, set carburetor heat controls to HOT.
7.	Notify radio operator to retract trailing antenna.		



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APPROACH

	PILOT	CO-PILOT	ENGINEER
1.	Contact control tower by radio for landing clearance. WARNING: Do not land when there is more than 900 U. S. gallons (749 Imp. gallons) of fuel in either outboard tank.	Hydraulic pressure 1500 to 1700 lb/sq in. NOTE: If hydraulic system has failed refer to emergency operation of flight controls, landing gear, flaps and brakes. Engineer: Mixture-AUTO RICH.	Mixture-AUTO RICH.
2.		Emergency brake pressure 1500 lb/sq in. NOTE: If emergency brake pressure is low, move brake selector lever to EMER for a few seconds to bring up the pressure. Return the brake lever to NORMAL.	Supercharger-LOW.
3.	Disengage automatic pilot, and turn OFF pump motor if the airplane has a separate automatic pilot hydraulic system.	Check to see that the hydraulic hand pump selector valve is FORWARD so that the brake accumulator may be pumped up in an emergency.	Set fuel shut-off valves and fuel cross transfer valves to insure plenty of fuel for emergency takeoff. NOTE: If all tanks contain at least 50 gallons, set all fuel shut-off valves ON and all fuel cross transfer valves OFF.
4.	Reduce airspeed below 146 mph and direct co-pilot to extend landing gear.	Extend landing gear when directed by pilot and leave the lever in the DOWN position. Note that landing gear indicator shows gear down and locked and warning lights are ON (green). If gear is not down and locked, the warning horn will sound if one throttle on each side of the airplane is closed.	
5.	Direct co-pilot to lower flaps 40%.	Lower flaps as directed by pilot.	
6.	Adjust trim tabs as required, using electrical system.	Turn wing de-icers OFF if operating.	
7.	Approach at 120 mph, power on or off; and when landing is assured, direct co-pilot to lower flaps completely.	Lower flaps completely at command of pilot.	
8.	Move the rudder and elevator booster emergency control switches to ON.		

LANDING

	PILOT	CO-PILOT	ENGINEER
1.	Order co-pilot to call off airspeeds as required.	Call off airspeeds when directed by pilot.	During final stages of approach set the propeller governors for maximum rpm.
2.	Set the main wheels down first (approximately 100 mph) and hold the nose wheel off the ground until the speed reduces to 70 mph. Ease nose wheel to the ground and apply brakes smoothly and evenly. Do not apply brakes hard until nosewheel is on the ground. At all normal center of gravity positions the nose wheel can be kept off the ground with such ease that a deliberate attempt must be made to get the nosewheel on the ground soon enough so that brakes		
3.	Order wing flaps raised as soon as the ship is practically stopped.	Raise wing flaps when directed by pilot.	Set cowl flaps full open.
4.	When taxiing is completed, place chocks under wheels, but do not set the parking brakes until they are cool. (Cool enough to touch.)	Move the elevator and rudder booster emergency control switches to OFF.	

FOR SIMULATION USE ONLY

APPROACH AND LANDING WITH PARTIAL ENGINE FAILURE

	PILOT	CO-PILOT	ENGINEER
1.	With three engines operating or with one engine on each side operating land in the normal manner.	Follow through on the controls with the pilot and be prepared to assist if necessary.	
2.	With only one engine or with two engines on one side operating, it is not possible to maintain altitude with both gear and flaps extended. Directional control is impossible below 125 mph with two engines on one side operating at take-off power and the other two propellers feathered. NOTE: If engines number 3 and 4 are dead, the emergency landing gear extension, flap extension and brake systems must be used. If engine number 1 and/or number 2 are dead it may be possible to use the normal landing gear and flap extension systems if no maneuvers are attempted so that the control boosters do not demand hydraulic power.	Watch carefully for signs of carburetor icing or other irregular operation and take corrective measures if necessary.	
3.	Direct co-pilot to lower landing gear.	Lower landing gear at command of pilot. Use emergency extension system if necessary.	
4.	Direct co-pilot to lower flaps 50%.	Lower flaps at command of pilot. Direct another crew member to operate emergency flap extension system if necessary.	
5.	Get in good position for a normal approach. Crank the rudder tabs back to zero. Regulate glide path with power from live engines and remaining flap travel.		
6.	When approach is assured, have the co-pilot extend flaps completely if hydraulic operation is still available. Close throttles and proceed with a normal landing.	Lower flaps completely if directed by pilot.	

FOR SIMULATION USE ONLY

CROSS WIND LANDING

	PILOT	CO-PILOT	ENGINEER
1.	Make approach slightly lower and longer than normal in order to allow time to establish a heading that gives a ground track in line with the runway.	Same as normal landing.	Same as normal landing.
2.	Keep the wings level. No skidding necessary.		
3.	Just prior to ground contact, align airplane with runway.		
4.	Land with nose wheel close to ground and immediately after landing, lower nose wheel to ground and apply brakes to decrease the roll. NOTE: This procedure will make it easier to keep the airplane from turning into the wind.		

EMERGENCY TAKE-OFF IF LANDING IS NOT COMPLETED

	PILOT	CO-PILOT	ENGINEER
1.	Open throttles to takeoff manifold pressure. Be prepared to counteract a strong nose-up tendency caused by application of power.	Raise landing gear.	Open cowl flaps.
2.	As soon as airspeed is above 120 mph and all obstacles are cleared, direct co-pilot to raise flaps. Keep airspeed under 146 mph until flaps are completely retracted.	Retract flaps as directed by pilot. Flaps retract slowly enough so that loss of lift is not dangerous.	Adjust power as directed by pilot.

STOPPING THE ENGINES

	PILOT	CO-PILOT	ENGINEER
1.		Move brake lever to EMER and check for 1700 lb/sq in. emergency brake pressure.	OPEN the cowl flaps .and idle engines at 600 to 800 rpm until cylinder head temperatures are below 149 ° C (300° F).
2.			Stop engine in normal manner. Increase engine speed to 1000 to 1200 rpm and hold for one-half minute to obtain optimum scavenging of engine oil and pull mixture control to OFF.
3.			If air temperature is expected to be below 5° C (40° F.) at next start, operate oil dilution system.
4.		When engines stop turning, move individual and master ignition switches to OFF.	

BEFORE LEAVING PILOT-S COMPARTMENT

	PILOT	CO-PILOT	ENGINEER
1.	Leave control boost levers ON to act as a gust lock.	Turn all switches OFF.	Turn all valves and switches OFF.
2.	All radio equipment OFF.		Cowl flaps may be closed when cylinder head temperatures are below 120 ° C (248 ° F).
3.	Set parking brake or have wheels chocked. Moor the airplane if weather conditions make it advisable.	Check brake selector lever to EMERGENCY.	Have landing gear pins and pitot tube covers installed before leaving vicinity of airplane.

FOR SIMULATION USE ONLY

CABIN PRESSURE

Always equalize the cabin and outside pressure before landing. If necessary to remove any remaining pressure by setting the Pressure Regulator Override to OPEN.

HEATING SYSTEM

Normal operation of the heating system is automatic. The system consists of the following main functional units:

1. Two Stewart Warner gasoline heaters located in the outboard nacelles: These heaters burn a small part of the fuel vapor from the engine induction system and exhaust back into the induction system. Each heater is equipped with one automatic and one manual ignitor and an electric motor driven valve for control of the fuel flow. Warm air from the heaters is forced into the cabin by the cabin superchargers, therefore, the inflow and outflow manual valve controls must be in the BOTH OPEN (forward position) and the outboard engines must be operating to obtain heat.

2. Two automatic cabin air coolers (intercoolers).

OIL DILUTION

The oil dilution system is installed primarily to facilitate the starting of cold engines. Before stopping the engines, when a cold weather start is anticipated, dilute the engines as follows:

1. Idle the engine until the oil temperature falls to about 40° C (104° F).
   Note: The fuel used by the oil dilution system is taken from the suction side of the engine driven fuel pump.
2. Dilute at idling speed (1000–1200rpm). Avoid spark plug fouling. A short acceleration period of 10 seconds at the end of the dilution run is usually sufficient to clear the spark plugs.
3. Maintain an oil temperature of less than 50° C (122° F) and an oil pressure above 15 pounds per square inch. If the oil temperature rises above, or the oil pressure falls below these limits, shut down and allow the engine to cool.
4. If the air temperature is expected to be between 4° C and -12° C (40° F. and 10° F.) the dilution time should be at least 4 minutes. If colder weather is anticipated at the next start, refer to the table below for dilution time.
5. To properly dilute the oil in the propeller domes, the propeller INC and DEC control should be operated throughout its complete range several times. Since this airplane is equipped with Hamilton Standard Hydromatic propellers, the propeller feathering button should be depressed near the end of the dilution period, long enough to give a maximum drop of 400 rpm, then pulled out. Repeat this operation several times. This will displace the undiluted oil from the feathering lines which would congeal and prevent feathering, and will provide diluted oil from the hopper so that emergency feathering may be accomplished under extreme cold weather conditions.
6. A complete re-dilution of the engine is required only after one half hour or more of engine operation at normal operating temperatures, as this is the time required to boil off the gasoline.

OIL DILUTION TABLE

Anticipated Ground Temp.	Time (min.)
4° to -12 ° C (40° to +10° F)	4
-12° to -29 ° C (+10° to -20°F)	6
-29° C and below (-20° F and below)	9

Hold dilution switch on for indicated time, stop engine, release dilution switch.

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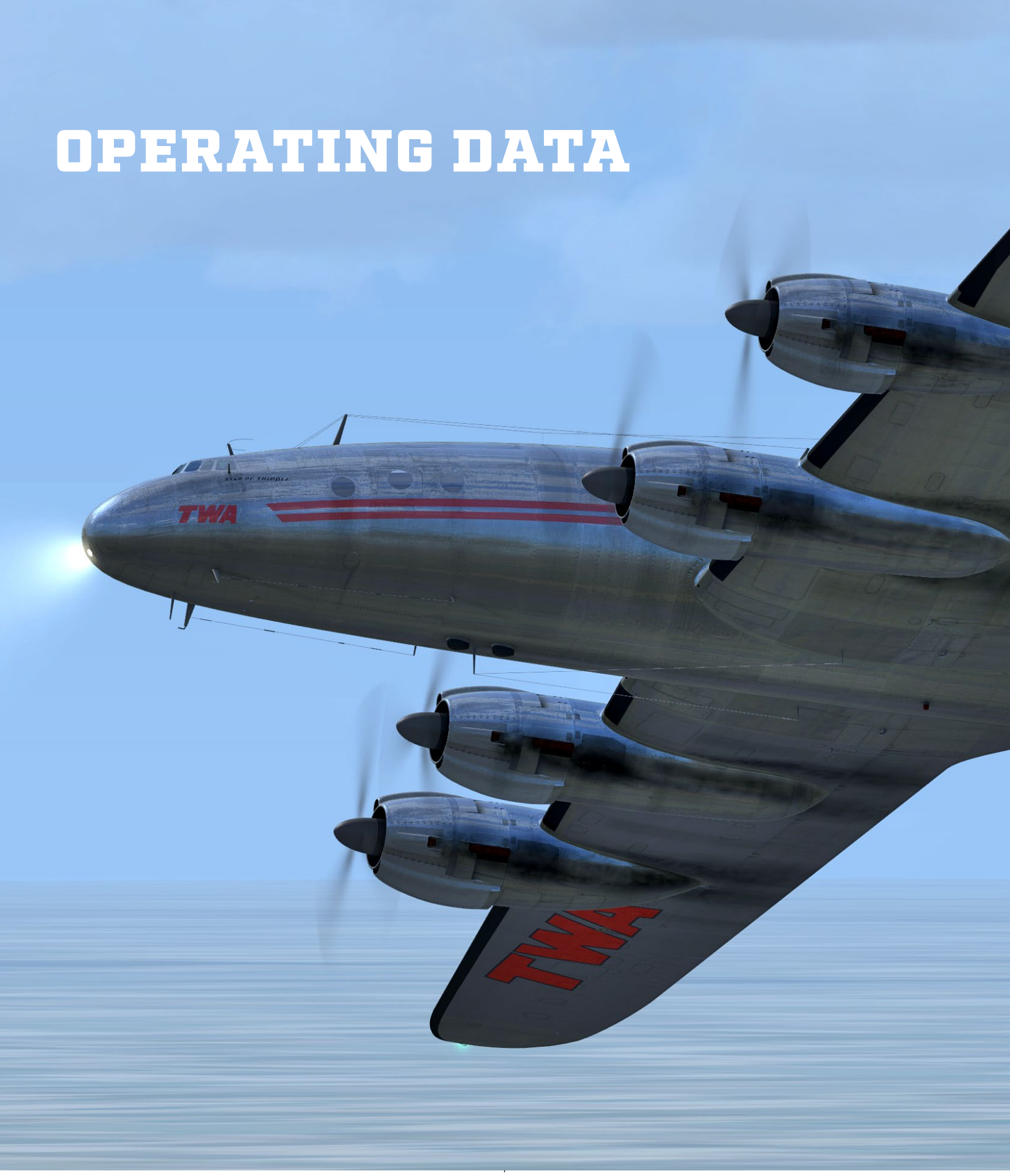
OPERATING DATA



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AIRSPEED LIMITATIONS

Condition	Max. Allowable IAS (mph)
Diving (if de-icer boots are not installed)	364
De-icer boots· operating	275
De-icer boots not operating	320
Level flight: 72,000 lbs gross weight	310
Level flight: 82,000 lbs gross weight	285
Landing gear extended	146
Flaps extended	146
Retracting flaps from beyond 85% extension with emergency system	120
Landing lights extended	140
Dumping fuel	160

CLIMB DATA

DENS ALT	Climb Power Data		Climb Performace				
	BMEP	RPM	IAS (knots)	Distance (n.m.)	Time (min.)	Fuel Used (lbs.)	Fuel Used (gal.)
21,000	145	2300	161	118	38	2410	402
20,000	145	2300	161	110	36	2270	378
19,000	145	2300	161	102	34	2130	355
18,000	145	2300	161	96	32	1990	332
17,000	145	2300	161	86	30	1860	310
16,000	145	2300	161	82	28	1730	288
15,000	145	2300	161	76	26	1600	268
14,000	145	2300	161	69	24	1480	246
13,000	145	2300	161	64	23	1360	227
12,000	145	2300	161	57	21	1250	208
11,000	145	2300	161	52	19	1150	192
10,000	145	2300	161	47	17	1050	175
9,000	145	2300	161	42	16	950	158
8,000	145	2300	161	36	14	850	142
7,000	145	2300	161	33	12	760	127
6,000	145	2300	161	27	11	660	110
5,000	145	2300	161	23	9	570	95
4,000	145	2300	161	17	8	480	80
3,000	145	2300	161	14	6	380	64
2,000	145	2300	161	9	4	290	48
1,000	145	2300	161	5	3	200	33
S.L.	145	2300	161	—	1	110	18

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POWER SETTINGS

	DENS ALT	Power Setting		Hourly Fuel Consumption			92,000		88,000		84,000	
		RPM	BMEP	lbs/Eng	lbs/ Total	Gal/ Total	IAS (kts)	TAS (kts)	IAS (kts)	TAS (kts)	IAS (kts)	TAS (kts)
High Blower	24,000	2200	118	535	2140	357					161	236
	23,000	2180	119	530	2120	353					163	235
	22,000	2160	120	530	2120	353					164	233
	21,000	2120	122	525	2100	350					166	231
	20,000	2080	125	520	2080	347					168	230
	19,000	2060	126	520	2080	347					169	228
	18,000	2020	129	520	2080	347					171	227
	17,000	2000	130	515	2060	343					173	225
	16,000	1960	132	510	2040	340					175	224
	15,000	1940	134	510	2040	340					177	223
Low Blower	14,000	2080	125	495	1980	330	173	215	176	218	179	222
	13,000	2040	127	490	1960	327	175	214	178	217	181	221
	12,000	2000	130	485	1940	323	177	213	180	216	182	219
	11,000	1940	134	480	1920	320	179	212	181	214	183	216
	10,000	1900	137	480	1920	320	181	211	183	213	185	215
	9,000	1860	140	475	1900	317	182	209	185	212	187	214
	8,000	1840	141	475	1900	317	184	208	186	210	188	212
	7,000	1840	141	475	1900	317	185	206	187	208	189	210
	6,000	1840	141	475	1900	317	187	205	189	207	191	209
	5,000	1840	141	475	1900	317	188	203	190	205	192	207
	4,000	1840	141	475	1900	317	190	202	192	204	194	206
	3,000	1840	141	475	1900	317	191	200	193	202	195	204
	2,000	1840	141	475	1900	317	193	199	194	200	196	202
	1,000	1840	141	475	1900	317	195	198	196	199	198	201

1. Do not exceed 145 BMEP or 36” MAP in LOW BLOWER, or 140 BMEP or 34” MAP in HIGH BLOWER during cruise.
2. Chart applicable to 049 aircraft with R3350-C18BA3 or R3350-C18BA4 engine, HS 6801A-0 prop and using normal source.
3. Airspeeds shown are for 25% cowl flaps, 33% oil cooler flaps and aftercooler scoops closed. Adjust IAS for other position as follows:

Cowl Flap Pos.	25%	37%	40%	50%	60%	70%	100%
IAS Change	0	-3	-4	-8	-12	-16	-28

Oil Cooler Flap Pos.	0%	33%	60%	80%	100%
IAS Change	0	0	-1	-2	-3

Prim. Aftercooler LT.	OFF	ON	ON
Sec. Aftercooler LT.	OFF	OFF	ON
IAS Change	0	-1	-2

4. With cabin compressors operative, #4 engine limited to 5 BMEP less than values shown.

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80,000		76,000		72,000		68,000		64,000		DENS ALT
IAS (kts)	TAS (kts)	IAS (kts)	TAS (kts)	IAS (kts)	TAS (kts)	IAS (kts)	TAS (kts)	IAS (kts)	TAS (kts)	
165	242	167	245	170	250	173	254	174	255	**24,000**
167	241	169	242	171	247	174	251	175	252	**23,000**
168	238	170	241	173	245	175	248	177	251	**22,000**
169	236	171	238	174	243	176	245	178	248	**21,000**
170	233	173	237	175	240	178	244	179	245	**20,000**
172	232	174	234	177	238	179	241	180	243	**19,000**
174	230	176	233	178	236	180	238	181	240	**18,000**
175	229	178	232	180	235	182	237	183	238	**17,000**
178	228	180	231	183	234	184	236	185	237	**16,000**
180	227	182	229	184	232	186	235	187	236	**15,000**
181	225	183	227	185	229	187	232	188	233	**14,000**
183	223	185	226	186	227	188	229	189	230	**13,000**
184	221	186	223	187	225	189	227	190	228	**12,000**
186	220	187	221	189	223	190	225	192	227	**11,000**
187	218	189	220	190	221	192	223	193	225	**10,000**
188	215	190	218	192	220	193	221	194	222	**9,000**
190	214	192	217	193	218	194	219	195	220	**8,000**
191	212	193	214	194	215	195	217	196	218	**7,000**
193	211	194	212	195	213	196	214	197	215	**6,000**
194	209	195	210	197	212	198	213	199	214	**5,000**
196	208	197	209	198	210	199	211	200	212	**4,000**
197	206	198	207	199	208	200	209	201	210	**3,000**
198	204	199	205	201	207	202	208	203	209	**2,000**
200	203	201	204	202	205	203	206	204	207	**1,000**

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CONSTANT POWER CRUISE

Ref No.	Item	Ambient MAP Run-UP	Take-Off Five Minutes	METO	Normal Climb	Alternate Climb	Cruise	Descent	Idle
1.	**RPM**	Max. Variation: 150 RPM between engines	2,600 ≠ 50 – 25	2,400	2,300	2,200	2,300 Max.	As Required	600 ≠ 50
2.	**MAP**	Amb. MAP	46.5”	43.5” Max. L.B. 43” Max. H.B.	34” Max. L.B. 33” Max. H.B.	34.4” Max. L.B. 33” Max. H.B.	36” Max L.B. 34” Max H.B.	As Required	19” – 20” @ Sea Level
3.	**BMEP**	110 Min.	200 Max. L.B.	197 Max. L.B. 177 Max. H.B.	145 Max. L.B. 145 Max. H.B.	150 Max. L.B. 146 Max. H.B.	145 Max. L.B. 140 Max. H.B.	As Required	Off Scale
4.	**Fuel Flow/#/ HR/ENG**	650-750 Approx.	Approx. 1650	Approx. 1420	850-970	850-970	10% ML Min.	As Required	Off Scale
5.	**CHT**	232°C	232°C	218°C	204°C	204°C	204°C	204°C	232°C
	Cowl FLap	100%	50%	50%	Note 1	Note 1	25% Min. Drag	25% Min. Drag	100%
6.	**Oil in Temp.**	104°C Max. 40°C Min.	104°C Max. 70-85°C Desired 40°C Min.	104°C Max. 70-85°C Desired 70°C Min.	104°C Max. 70-85°C Desired 70°C Min.	104°C Max. 70-85°C Desired 70°C Min.	104°C Max. 70-85°C Desired 70°C Min.	104°C Max. 70-85°C Desired 70°C Min.	104°C Max.
7.	**Nose Oil Press.**	25# to 65#	25# to 65#	25# to 65#	25# to 65#	25# to 65#	25# to 65#	25# to 65#	15# Min.
8.	**Rear Oil Press.**	50# to 90#	60# to 90#	50# to 90#	50# to 90#	50# to 90#	50# to 90#	50# to 90#	15# Min.
9.	**Fuel Press.**	1# to 23#	19# to 23#	19# to 23#	19# to 23#	19# to 23#	19# to 23#	19# to 23#	19# to 23#
10.	**BHP**	—	2200	2000 L.B. 1800 H.B.	1400	1400		As Required	—

1. During Climb, cowl flaps should be set for maximum performance provided CHT is below 204°C.
2. If desired oil "IN" temp. range cannot be maintained, investigation of cause should be made.
3. Before run-up, oil "IN" temp. should show a definite rise.
4. No minimum CHT for T.O. if engine operation smooth.
5. Do not make more than two blower shifts within a five minute interval.
6. If CHT exceeds 232°C on take-off, make engineering note in M-768 describing conditions.
7. No specific max. on Oil "OUT" temp. Normal spread above Oil "IN" temp. is 20°-30°C.
8. With CHT selector installed, #1 Position is #17 CHT and #2 Position is #2 CHT. #3 adn #4 position are inoperative being modified to continuous reading CHT indicators, with #17 CHT on left portion of indicator.

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EMERGENCY OPERATIONS

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ENGINE FAILURE DURING FLIGHT
STOPPING THE ENGINE

1. Retard throttle on dead engine.
2. Push dead engine feathering button.
3. Place mixture control in IDLE CUT-OFF.
4. Move engine fuel emergency shut-off valve to OFF.
5. Shut OFF auxiliary fuel pump.
6. Close cowl flaps. NOTE: If the shut-down is for practice purposes, neglect the following steps. Restart according to the instructions below. Restart before the oil temperature becomes dangerously low. During cold weather, be careful of congealing oil in the propeller hub. If the shut-down is permanent, proceed as follows:
7. Ignition switch OFF when engine stops.
8. Cowl flaps 1, 4 OPEN for minimum drag. (This is the faired position.)
9. Trim airplane as necessary. Remember it is always safer to make turns away from the dead engine. Turns made into the dead engine should be of large radius and should not be attempted at slow speeds.
10. Fuel, hydraulic, and engine oil shut-off valves CLOSED.
11. FUEL DISTRIBUTION — If engine fuel shut-off valves are incorporated, use any fuel tank as desired. If these valves are not installed and if the shutdown was due to fire, or if it is known that a dangerous leak exists in the fuel line of the dead engine, turn the tank shut-off valve OFF and do not attempt to use the fuel in that tank. If no danger exists, use the fuel in the tank as desired to operate the other engine.
12. Check the oil cooler flap control in AUTOMATIC.
13. Change the vacuum pump selector valve, the instrument group selector valve or the turn and bank selector valves if necessary, to maintain four to five inches of Hg for vacuum instrument operation.

FOR SIMULATION USE ONLY

RE-STARTING THE ENGINE
PREPARING THE ENGINE FOR STARTING.

1. Check cowl flaps CLOSED.
2. Check tank shut-off valve ON.
3. Check fuel cross-transfer valve OFF.
4. Auxiliary fuel pump ON if altitude requires.
5. Check fuel, hydraulic and engine oil shut-off valves ON.
6. Check oil cooler flap switch in AUTOMATIC.
7. Hold propeller governor switch in DECREASE rpm until the propeller warning light glows.
8. Throttle 1/10 to 1/4 OPEN depending on the altitude.
9. Ignition ON. If the engine has not been operated for 1/2 hour do not turn on the switch until the engine has made several revolutions during unfeathering to prevent engine damage due to possible liquid accumulation in the lower cylinders.

STARTING THE ENGINE.

1. PRESS and HOLD the propeller feathering button until rpm reads 800 to 1000.
2. Mixture control to AUTO RICH. (Ignition switch must be ON first.)
3. Make sure the oil temperatures and oil pressures are within operating limits before synchronizing with other engines.

FIRES IN FLIGHT

Nacelle fire warning lights on the flight engineer's and pilot's instrument panels.

NACELLE FIRES

If a nacelle fire warning light glows and circumstances advise stopping the engine, proceed as follows:

1. Throttle CLOSED.
2. Push the propeller feathering button.
3. Mixture OFF.
4. Fuel tank shut-off valve OFF.
5. Boost pump OFF.
6. After the propeller has completely feathered, turn the fuel, oil, and hydraulic oil shut-off valve OFF.
7. Ignition OFF.
8. Cowl flaps OPEN.
9. Set the fire extinguisher selector valve and pull one handle.
   NOTE: Do not attempt to divide the charge of one bottle between two engines.
10. The pilot or co-pilot will inform the flight engineer as to the results obtained with the first CO_2 bottle and advise pulling the second charge if necessary.
11. Open the emergency exits, lower the landing gear, and land as soon as possible in order to determine the cause of the fire and correct the condition before continuing the flight.

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AIRPLANE MASTER SWITCH

This switch should be pushed FORWARD just prior to a crash landing to minimize the fire hazard from the electrical system.

GROUND LANDING WITH WHEELS RETRACTED

If forced to land where no prepared runway is available, it will be better, in most cases, to land with the wheels retracted.

USE OF POWER

Power is valuable when controlling the airplane at low speeds.

1. If the landing is caused by fuel shortage, land before the tanks are completely dry.
2. If the landing is not caused by fuel shortage it may be desirable to dump the fuel and land before the reserve is used up. If the fuel was dumped, be sure the controls are moved to CLOSE just before landing.

LANDING

Bring the airplane in tail low and as slow as possible. Use approximately 80% flaps. If landing in enemy territory, push the IFF radio destructor buttons and use the incendiary grenade before leaving the airplane. If landing in friendly territory, pull the recognition radio plug, on the radio rack, just before contact to save the equipment from destruction.

1. Mixture controls — OFF.
2. Master ignition switch — OFF.
3. Airplane master switch — OFF.

DUMPING FUEL

If it is necessary to dump fuel proceed as follows:

1. See that the flaps are fully retracted.
2. Turn OFF all radio equipment.
3. Reduce the air speed to 160 mph or less.
   WARNING: Failure to follow the above steps may result in an explosion or fire.
4. Move the dump controls to OPEN. Fuel will be discharged from each chute at the approximate rate of 190 gallons per minute, but the tanks will not be drained. (70 gallons will be left in each inboard tank and 30 gallons in each outboard tank.)
5. When all of the fuel possible or the desired quantity has been dumped, move the controls against the stops at the intermediate position. This should close the valves. Wait about 10 seconds for the fuel to drain from the chutes and then move the controls to CLOSE in order to seat the valves as tightly as possible. Return the controls to the intermediate position. This will partially extend the chutes and permit any fuel that may leak through the valves to drain to the outside.

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