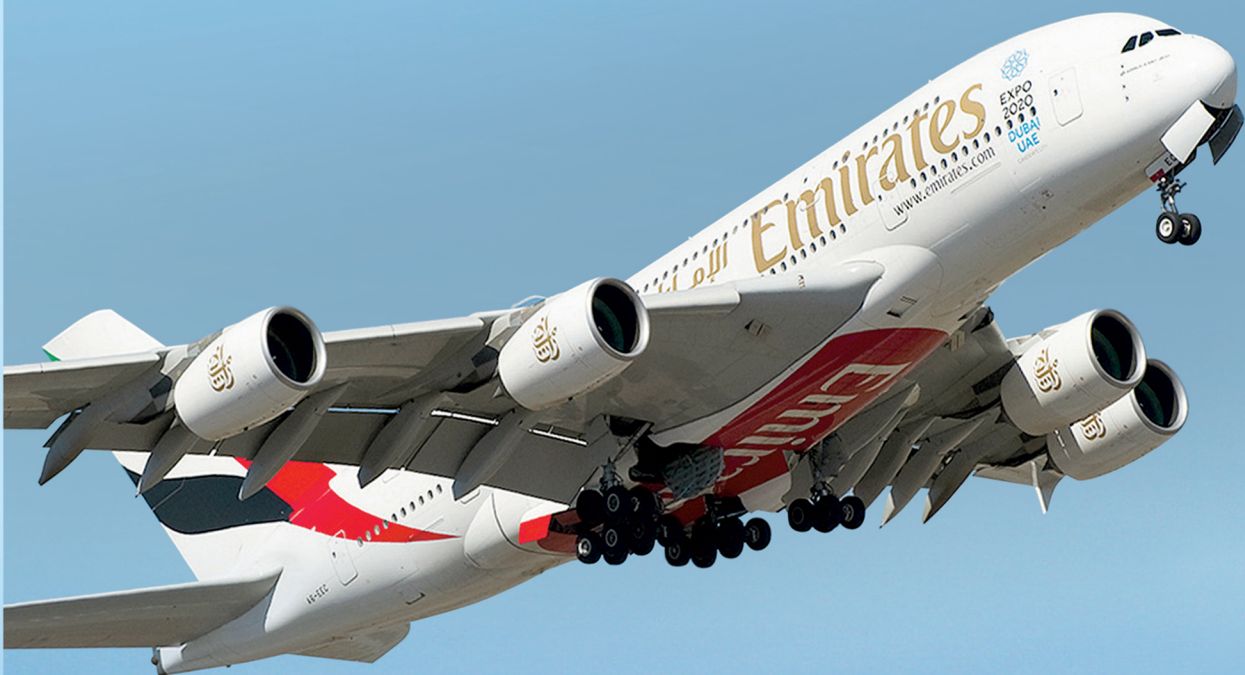


THE
AIRBUS
A380
A HISTORY



GRAHAM M. SIMONS

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Introduction

'The Boeing 747 was the flagship of the twentieth century; the A380 is the flagship of the twenty-first century'. So said John Leahy, Chief Operating Officer - Customers and Chief Commercial Officer of Airbus before the assembled media at New York's John F Kennedy Airport. The occasion was the arrival of the first Airbus A380 to touch down on American soil when MSN007 arrived on 19 March 2007.

That day not one but two A380s touched down on either side of the continent within minutes of each other and in many ways was the culmination of years of hard work, commercial fear and political infighting.

The hard work was that it was the result of years of incredible effort put in by thousands of Airbus employees and their suppliers. The commercial fear was the amazing gamble taken by Airbus and its parent EADS in building such an aircraft and the political infighting involved not only Airbus' great rivals the Boeing Aircraft Corporation, but also the American political establishment and rabid jingoistic flag-waving from the American media.

The Airbus A380 may not be the prettiest of airliners - beauty is definitely in the eye of the beholder, and it must be admitted that that title probably goes to either Concorde, Comet or the Lockheed Constellation, but it is certainly the most technologically advanced.

Airbus began as as a *Groupement d'Interet Économique* - Economic Interest Group or GIE - organisation on 18 December 1970. It was formed by a government initiative between France, Germany and the UK that originated in 1967 and was intended to be a consortium of European aviation firms to compete with American companies such as Boeing, McDonnell Douglas, and Lockheed.

The Americans - and in particular Boeing - could and would not believe that the Europeans dared to challenge their dominance. They just did not take the fledgling Airbus seriously. But then in April 1978 Airbus received an order for twenty-

three wide-bodied A300s from Eastern Airlines. This gave much needed credibility.

With the launch of the narrow-bodied A320 in the early 1980s Airbus was really going head-to-head with the Boeing 727 and 737 and with McDonald Douglas and their DC-9 derivations. But it was more than that, for the new Airbus A320 was equipped with a fly-by-wire flight control system that was generationally streets ahead of anything the Americans were using on their airliners.

It was not long before Airbus were making huge inroads into the market - McDonald Douglas started to struggle, and Boeing started to scream 'foul' over what they saw as illegal government subsidies and loans to the Europeans, conveniently forgetting that they had received Federal and State tax breaks and beneficial military cross funding and research on their civil projects that went back as far as the early 1950s with the Boeing 367-80, that was the two-generation precursor to the 707, 720, 727 and 737.

On 30 September 1968, the first of their 747 'jumbo-jets' was rolled out of the Everett assembly building before the world's press and representatives of the 26 airlines that had ordered the airliner, which had come out of a losing entrant in the contest for the USAF's 'Cargo Experimental Heavy Logistics System' aircraft. Since that moment Boeing had enjoyed a monopoly in the large, wide-bodied airliner market.

The emergence of a whole raft of ultra large airliner studies in the late 1980s and early 1990s saw a plethora of acronyms: UHCAs, VLCTs, NLAs.... and that's not counting the 7X7s and A3XXs!

Airbus came out with their own designs, Boeing proposed a number of their own completely new designs along with new versions of their 747. The two companies were working alone, then together, then on their own again.

The whines from Seattle and Chicago about subsidies kept surfacing only to appear to be apparently settled, only to flare up again.

Eventually, Boeing pulled out of any co-operation and Airbus went on alone.

The design work was incredible, the cost phenomenal, the logistics a planning nightmare - but eventually all was overcome and the design took to the skies.

Just as with Concorde before it, it was not long before the doom-mongering environmental campaigners came out of the woodwork, as demonstrated by this piece from 2006: *'Over 90% of residents will be disturbed by noise from the new A380 Super Jumbo, according to a survey by a London council. The news came as the world's largest commercial airliner flew into Britain for the first time, visiting Heathrow for airport compatibility tests.'*

The Airbus A380 is being promoted by its manufacturers as an 'environmentally friendly' aircraft, claiming that it will be 'a 'good neighbour' at even the most noise-sensitive airports around the world.'

But aviation campaigners have warned that the A380 will be 'one of the noisiest beasts in the sky'.

Media reports have also highlighted potential problems with 'wake vortices' from the giant aircraft sucking roof tiles off houses, throwing other aircraft off course and causing delays to planes waiting to take off.

Local residents in Hounslow are now voicing concerns that the Super Jumbo will have a significant impact on the levels of noise pollution in the London Borough of Hounslow.

According to a Hounslow Council survey conducted in the run up to Noise Action Week (May 22 to 26), 92% of people living in the borough think residents will be disturbed, bothered or annoyed by noise from the new aircraft.

Responding to the news, Hounslow's Head of Environmental Strategy, Rob Gibson, said: 'It is clear from our survey that the vast majority of residents are concerned that the A380 will have a negative impact on the environment.'

'Any testing done today will do nothing to allay those fears, as well as being meaningless because the aircraft will not be carrying passengers. Airbus should come clean and publish proper test results showing the noise impact and vortex effects of a fully laden A380.'

One has to wonder where people like this got

their information from, for it has been proven that the A380 is the quietest airliner around by a large margin.

Then there was the strange matter of how the media reported some of the problems Airbus had with the A380. The world's press was flooded with wall-to-wall reports on the early wiring problem, the weight issues, the QANTAS engine failure and a defect, located in the wings, relating to brackets that attached the wing ribs to the wing's metal skin. The press seemed to take great delight in splashing every problem to the public's attention.

Strange though that the early problems with battery fires on the Boeing 787 Dreamliner received little to no press attention until one spectacularly caught fire at London Heathrow.

Strange also that the mainstream media failed almost to a man to report that cracks had been discovered in over forty ship-sets of wings for the 787 Dreamliner under construction by Mitsubishi Heavy Industries.

Those in the industry know that both designs have no more or no less teething problems than previous new aircraft models being introduced and many claim that it is the omnipresence of social media information in today's age simply makes the information available on a global basis while in times past only aviation personnel and specialized media got hold of such details, and then by and large kept it to themselves to avoid alarming the general public. But the question remains, why one scattered across the press and not the other?

Before anyone complains that none of the dimensions mentioned in this book are in metric, this goes back to aeronautical engineer Roger Béteille, one of the key players in the formation of the Airbus consortium. It was he who decided that English should be the working language of Airbus and that measurements should not be metric because of the simple reason that most airlines already had American built aircraft.

The A380 has gone from strength to strength, in terms of sales, performance, quietness and passenger appeal - this is the story so far!

Graham M Simons
Peterborough
June 2014.

Chapter One

Genesis of a Giant

During the summer of 1988, a group of Airbus engineers led by Jean Roeder started work on the secret development of an ultra-high-capacity airliner, termed, not unsurprisingly, the Ultra High Capacity Aircraft - the UHCA - to both complete its own range of products and in an attempt to break the dominance that the Boeing Company of the USA had enjoyed in this particular market segment since the early 1970s with its model 747.

Roeder had been given approval for further evaluations of the UHCA after a formal presentation to the President and CEO Jean Pierson of Airbus in June 1990. The megaproject was announced at the 1990 Farnborough Air Show in the UK, with the goal stated as being 15% lower operating costs than the 747-400 - the design used as the benchmark. Airbus organised four teams of designers, one from each of its partners - Aérospatiale, Deutsche Aerospace AG, British Aerospace and Construcciones Aeronáuticas Sociedad Anónima (CASA) - to propose new technologies for its future aircraft designs. The designs would be presented in 1992 and the most competitive designs would be used.

In January 1993, The Boeing Company and a number of companies in the Airbus consortium started a joint feasibility study of an aircraft known as the Very Large Commercial Transport (VLCT), with a supposed intention of forming a partnership to share the limited market. This was abandoned two years later, Boeing's interest having declined because their analysts thought that such a product was unlikely to cover the projected \$15 billion development cost. It seems that Boeing - having seen in principal what 'the opposition' was thinking, decided to pursue stretching its own 747 design, at the same time pushing the suggestion that air travel was already moving away from the hub and spoke system that consolidated traffic into large aircraft - a concept that Boeing themselves had promulgated for many years - was now towards more non-stop routes that could be served by smaller machines.

Eighteen months later - in June 1994 - Airbus announced its plan to develop a very large airliner, designated the A3XX. Their designers had

considered several designs, including a blended side-by-side combination of two fuselages from the A340, which was Airbus's largest jet at the time. From 1997 to 2000, as the East Asian financial crisis darkened the market outlook, Airbus refined its design, targeting a 15–20% reduction in operating costs over the existing Boeing 747-400 benchmark. After extensive market analysis the A3XX design converged into a double-deck layout that provided more passenger volume than a traditional single-deck design, to be operated in line with traditional hub-and-spoke theory as opposed to the point-to-point theory of the Boeing 777 at the time Boeing's latest product.

Going back in time...

However, the 1990s were by no means the start of the story. Double-deck aircraft - or very large commercial aircraft - have been around since the 1920s, initially often taking the form of flying boats. One of the earliest was the German Dornier company, itself a very early forerunner to the European Aeronautic Defence and Space Company N.V. (EADS) with their Do.X. At the time this huge flying boat was the largest, heaviest, and most powerful aircraft in the world. First conceived by Dr. Claudius Dornier in 1924, planning started in late 1925 and after over 240,000 work hours it was completed in June 1929. Only the Soviet Tupolev ANT-20 '*Maxim Gorki*' land-plane of a few years later was physically larger between the two world wars, but was not as heavy as the Do.X, at 53 metric tons maximum takeoff weight versus the Do.X's 56 tonnes.

The Do.X was a semi-cantilever monoplane and had an all-duralumin hull, with wings composed of a steel-reinforced duralumin framework covered in doped linen fabric. It was financed by the German Transport Ministry and built in a specially designed plant at Altenrhein, on the Swiss portion of Lake Constance, in order to circumvent the Treaty of Versailles which forbade any aircraft exceeding set speed and range limits to be built in Germany after World War One.

The aircraft was initially powered by twelve 524 hp Siemens-built Bristol Jupiter radial engines (six tractor propellers and six pushers), mounted in six tower nacelles on the wing. The nacelles were joined by an auxiliary wing whose main purpose was to stabilize the mountings. The air-cooled Jupiter engines were prone to overheating and proved to only be able to lift the Do.X to an altitude of 425 metres. The engines were supervised by an engineer, so the pilot would ask the engineer to adjust the power, in a manner similar to that used on maritime vessels. After completing 103 flights in 1930, the Do.X was refitted with 610 hp Curtiss Conqueror water-cooled 12-cylinder inline engines. Only then was it able to reach the altitude of 500 metres necessary to cross the Atlantic. Dr. Dornier designed the flying boat to carry 66 passengers long distance or 100 on shorter flights.

The luxurious passenger accommodation approached the standards of transatlantic liners. Although often referred to as a 'double deck aircraft', in fact the Do.X had three decks. On the main deck was a smoking room with its own bar, a dining salon, and seating for the passengers which could also be converted to sleeping berths for night flights. Aft of the passenger spaces was an all-electric galley,

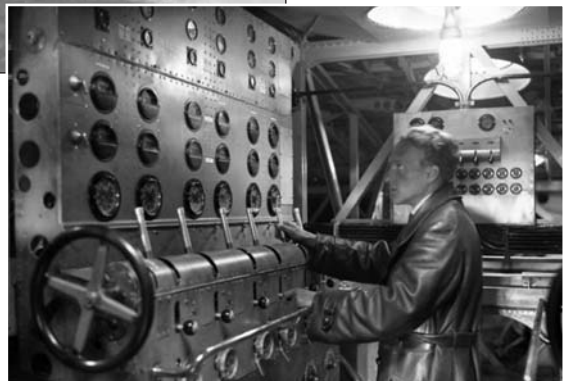
lavatories, and cargo hold. The cockpit, navigational office, engine control and radio rooms were on the upper deck. The lower deck held fuel tanks and nine watertight compartments, only seven of which were needed to provide full flotation.

The Flugschiff, or 'flying ship' as it was called, was launched for its first test flight on 12 July 1929, with a crew of fourteen. From this point on, there are some doubts as to exactly what happened when – some sources say that in order to satisfy sceptics, on its 70th test flight on 21 October there were 169 souls on board; 150 passengers - mostly production workers and their families, a few journalists, ten aircrew and nine 'stowaways', who did not hold tickets. The flight set a new world record for the number of persons carried on a single flight, a record that was not broken for the next 20 years. After a takeoff run of 50 seconds the Do.X slowly climbed to an altitude of only 200 metres. Allegedly, as a result of the ship's size, passengers were asked to crowd together on one side or the other to help make turns. It flew for 40 minutes. Other sources – such as *Flug Revue* - claimed that it was the 42nd flight and lasted 53 minutes. A surviving historical film shows '*..fliegt mit 170 personen*' at a maximum speed of 170 km per hour before finally alighting back on Lake Constance.



Above: The Dornier Do.X under tow, but with at least four of the twelve Curtiss Conqueror engines turning.

Right: the engineers station inside the fuselage of the Dornier Do.X. As can be seen, the engine gauges and throttles were grouped in pairs, with which the engineer responded to instructions from the pilots.



To introduce the airliner to the potential United States of America market, the Do.X took off from Friedrichshafen in Germany on 3 November 1930, under the command of Friedrich Christiansen, for a transatlantic test flight to New York. The somewhat convoluted route took the Do.X to

the Netherlands, England, France, Spain, and Portugal. The journey was interrupted at Lisbon on 29 November, when a tarpaulin made contact with a hot exhaust pipe and started a fire that consumed most of the port wing. After sitting in Lisbon harbour for six weeks while new parts were made and the damage repaired, the flying boat continued - with several further mishaps and delays- along the Western coast of Africa so that by 5 June 1931 it had reached the Cape Verde Islands, from which it crossed the Atlantic to Natal in Brazil, where the crew were greeted as heroes by the local German émigré communities.

The flight continued north to the United States, finally reaching New York on 27 August 1931, almost nine months after departing Friedrichshafen – probably the longest time ever between departure and arrival for an Atlantic crossing! The Do.X and crew spent the next nine months there as its engines were

overhauled, and thousands of sightseers made the trip to Glenn Curtiss Airport - now LaGuardia Airport - to tour the leviathan of the air. The economic effects of the Great Depression dashed Dornier's marketing plans for the Do.X, however, and it departed from New York on 21 May 1932 via Newfoundland and the Azores to Müggelsee, Berlin where it arrived three days later and was met by a cheering crowd of 200,000 people.

Germany's original Do.X was turned over to Deutsche Luft Hansa, the national airline at that time, after the financially strapped Dornier Company could no longer operate it. After a successful 1932 tour of German coastal cities, Luft Hansa planned a Do.X flight to Vienna, Budapest, and Istanbul for 1933. The voyage ended after nine days when the flying boat's tail section tore off during a botched, over-steep landing on a reservoir lake near the city of Passau.



Above: The Dornier Do.X is seen low in formation with two other flying boats - thought to have been taken during the 1932 tour of German coastal cities.



Left: The interior of the Do.X, showing the internal structural bracing and the four-abreast seating!

While never a commercial success, the Dornier Do.X was the largest heavier-than-air aircraft of its time, a pioneer in demonstrating the potential of an international passenger air service. A successor, the Do-XX, was envisioned by Dornier, but never advanced beyond the design study stage.

Three Do.Xs were constructed in total: the original operated by Dornier, and two other machines based on orders from Italy - both Italian boats were based at the seaplane station at La Spezia, on the Ligurian Sea. Both orders originated with SANA, then the Italian state airline, but were requisitioned and used by the Italian Air Force primarily for prestige flights and public spectacles.

The British Contribution.

In the immediate pre-war years there were a number of other notable double-deck aircraft such as the Shorts 'C' Class flying boats of Great Britain's

Imperial Airways and the Boeing 314 Clippers.

The Short 'C' Class - also known as the 'Empire flying boat' was a family of medium range four engined monoplane passenger and mail carrying flying boats, of the 1930s and 1940s, that linked together the outposts of the empire between Britain and the British colonies in Africa, Asia and Australia as well as providing service between Bermuda and New York City.

The origins of the Empire boats lay in an Air Ministry requirement for passenger and mail carriers that could provide air mail service to the colonies in Africa and Australia.

The Empire flying boat was officially known as the C-class by Imperial Airways and each aircraft operated by them was given a name beginning with C. The first aircraft, G-ADHL *Canopus*, was completed in June 1936 and launched on 3 July. A total of 42 Empires boats

Right: Cockpit of the S.23. Left of the control wheel there is an altimeter with an airspeed indicator below. The readout of the directional gyro is visible immediately above with a turn indicator beneath with a clock, variometer and gyro compass. Co-pilot has four oil pressure gauges at the top of his panel with vertical column-reading engine speed indicators mounted in pairs. Basic flight instruments were duplicated. Central at the very bottom of the picture are the airscrew pitch levers.



Below: The second of the S.23 Empire Flying Boats to be built, G-ADHM, beached next to RAF Short Singapore Mk.III, K6918. To facilitate beaching, the S.23 had special undercarriage legs that could be floated into position and attached while the boat was still in the water. A beaching trolley was then attached to the aft step and the vessel drawn ashore backwards.





21 July 1939 and Golden Hind is being readied for its first flight at Rochester. The S.26 flying-boats were fitted with De Havilland three-bladed constant-speed metal airscrews in place of the controllable-pitch two-position propellers of the smaller S.23.

Right: The forward passenger lounge of the prototype, S.23 G-ADHL Canopus. This offered rather spartan but nevertheless comfortable accommodation.



were built, all at Short's Rochester factory.

The first series of the Short Empires, the S.23, could carry 5 crew, 17 passengers, and 4,480 lb of cargo at a maximum speed of 174 knots and were powered by four 920 hp Bristol Pegasus radials.

The Short Empire was designed to operate along the Imperial Airways routes to South Africa and Australia, where no leg was much over 500 miles. After the design was finalized and production was started it was realised that it would be desirable to offer a similar service across the Atlantic. The range of the S.23 was such that they could not provide a true trans-Atlantic service, so two boats - *Caledonia* and *Cambria* - were lightened, given long range fuel tanks and experimented with in-flight refuelling so they could make the trip but that meant they could carry fewer passengers and cargo.

The S.30 series were fitted with the more

efficient, but lower power 890 horsepower Bristol Perseus sleeve valve engines and had a strengthened airframe allowing the take off weight to be increased to 46,000 pounds, giving a range of 1,500 miles. *Cabot*, *Caribou*, *Clyde* and *Connemara* were fitted with in-flight refuelling equipment and extra fuel tanks so they could be used for a regular trans-atlantic airmail service.

Initially, they were designed for a 40,500 lb gross weight but by 1939 aircraft were strengthened for 53,000 lb. Wartime experience in operating at overload resulted in the realisation that the Empires could take off at considerably higher weights than the conservative maxima provided by Shorts and, although the last Empire crossings to America were made in 1940 (by *Clare* and *Clyde*), many more flights were made on the long, demanding and vital over-water Lisbon-Bathurst flights.

A completely new flying boat, designed as an enlarged Short C-Class Empire flying boat, also incorporating features from the Short Sunderland, the S.26 G class was produced for year-round use on the North Atlantic route (although it was used instead between the UK and West Africa). Of similar appearance to the C-class boats but about 15% larger in all dimensions with the more powerful Hercules engines and an improved hull design, they had a wing span of 134 feet and a length of 101 feet. Three aircraft were built for Imperial Airways, subsidised by the Air Ministry in anticipation of military use.

Greater use of extrusions in the structure, rather than bent sheet sections, compared to the C-Class aircraft, helped to keep the weight down. It was powered by four 1,400 hp Bristol Hercules sleeve valve radial engines, and it was designed with the capability of crossing the Atlantic without refuelling, and was intended to form the backbone of Imperial Airways' Empire services. The plan was for the first aircraft to make long range runs, the second would operate medium length (2,000 miles) flights with a dozen passengers, and the third would make short range (1,000 miles) trips with 24 passengers. It could fly 6,000 miles unburdened, or 150 passengers for a 'short hop'.

On 21 July 1939, the first aircraft, (G-AFCI *Golden Hind*), was first flown at Rochester by Shorts' chief test pilot, John Lankester Parker. On 24 February 1940, the second (G-AFCJ *Golden Fleece*) flew, and the third (G-AFCK *Golden Horn*) flew on 8 July 1940.

French efforts

Over in France - and based on the same specifications as the Potez-CAMS 161 for a large trans-ocean flying boat for Air France, the Loiré et Olivier works started in 1936 with the design of a similar six-engine large flying boat



Above: the Potez-CAMS 161 on its beaching trolley.



Left: the Société Nationale de Constructions Aéronautiques du Sud-Est SE-200.03 F-BAIY seen in flight. It made its first flight on 2 April 1946 and was tested for the French navy until it made a bad landing on 18 October 1949 and scrapped.

under the designation H-49 with the name *Amphitrite*. After nationalisation of LeO as SNCASE (Société Nationale de Constructions Aéronautiques du Sud-Est), the H-49 was re-designated as the SE-200. Just like the Potez-CAMS 161 it was a modern all-metal flying boat fitted with six of the most powerful engines available. The SE-200 had a twin vertical tail layout and two fixed wingfloats with a double deck inside the hull for accommodation of up to 40 passengers and a crew of 8. The French government ordered in 1938 four SE-200s for the Air France transatlantic route, but when the war broke out none of these were completed at the Marignanne works near Marseille. After the armistice, construction on all the machines continued. The SE-200.01 made its first flight on 11 December 1942 from Lake Berre with the civil registration F-BAHE. It was named *Rochambeau*, although it is not certain this name was ever carried on the fuselage nose. The SE-200.01 was confiscated by the Germans and later ferried to Friedrichshafen carrying German Luftwaffe markings 2D:UT. On 17 January 1944 it was destroyed during an allied air raid, when moored on Lake Constance together with the Potez-CAMS 161 and the Laté 631.01.

American Clippers

The Boeing 314 Clipper came slightly later than the 'C' Class - This was a long-range flying boat produced by the Boeing Airplane Company between 1938 and 1941 and was comparable to the



Left: the spacious flight deck of the Boeing 314. A navigator, radio operator and flight engineer worked in an area behind the two pilots.

Below: Pan American Airways' NC18604 Atlantic Clipper gets airborne.

Bottom: Passengers lounge in the spacious fuselage of this unidentified 314.



British Short S.26. Twelve Clippers were built for Pan American Airways, three of which were sold to BOAC in 1941 before delivery.

The 314 was a response to PAA's request for a flying boat with unprecedented range capability that could augment the airline's trans-Pacific Martin M-130. Boeing's bid was successful and on July 21 1936, Pan American signed a contract for six. Boeing engineers adapted the cancelled XB-15 bomber's 149 feet wing, and replaced the original 850 horsepower Pratt & Whitney Twin Wasp radial engines with the more powerful 1,600 horsepower Wright Twin Cyclone. Pan Am ordered an additional six aircraft with increased engine power and a larger carrying capacity of 77 daytime passengers as the Boeing 314A.

The huge flying boat was assembled at Boeing's Plant 1 on the Duwamish River and then towed to Elliott Bay for taxi and flight tests. The first flight was on 7 June 1938, piloted by Edmund T. 'Eddie' Allen. Originally built with a single



vertical tail, Allen found that he was unable to keep the aircraft flying straight, due to inadequate directional control. The aircraft was returned to the factory and fitted with the endplates on the ends of the horizontal tail in place of the single vertical fin. This too was found to be lacking and finally the centreline vertical fin was restored.

Internally, the 314 used a series of heavy ribs and spars to create a robust fuselage and cantilevered wing. This sturdy structure obviated the need for external drag-inducing struts to brace the wings. Boeing also incorporated Dornier-style

sponsons into the hull structure. The sponsons, which were broad lateral extensions placed at the water line, on both the port and starboard sides of the hull, served several purposes: they provided a wide platform to stabilize the craft while floating on water, they acted as an entryway for passengers boarding the flying boat and they were shaped to contribute additional lift in flight. With weight an extremely sensitive concern, passengers and their baggage were weighed, with each passenger allowed up to 77 pounds free baggage allowance (in the later 314 series) but then charged \$3.25 per lb for exceeding the limit. To fly the long ranges needed for trans-Pacific service, the 314 carried 4,246 US gallons of fuel. The later 314A model carried a further 1,200 US gallons. To quench the radial engines' thirst for oil, a capacity of 300 US gallons was required.

Pan Am's Clippers were built for one-class luxury air travel, a necessity given the long duration of transoceanic flights. The seats could be converted into bunks for overnight accommodation; with a cruise speed of only 188 miles per hour, many flights lasted over twelve hours. The 314s had a lounge and dining area, and the galleys were crewed by chefs from four-star hotels. Passengers were provided with separate male and female dressing rooms, and white-coated stewards served five and six-course meals with a silver service. Although the transatlantic flights were only operated for three months in 1939, their standard of luxury has been rarely matched by heavier-than-air transport; they were a form of travel for the super-rich, at \$675 return from New York to Southampton, comparable to a round trip aboard Concorde. Most of the flights were transpacific with a one-way ticket from San Francisco to Hong Kong, via the 'stepping-stone' islands posted at \$760 (or \$1,368 round-trip).

The first 314, *Honolulu Clipper*, entered regular service on the San Francisco-Hong Kong route in January 1939. A one-way trip on this route took over six days to complete. Commercial passenger service lasted less than three years, ending when the United States entered World War Two in December 1941.

At the outbreak of the war in the Pacific, the *Pacific Clipper* was en-route to New Zealand. Rather than risk flying back to Honolulu and being shot down by Japanese fighters, it was decided to fly west to New York. Starting on 8 December 1941 at Auckland, New Zealand, the *Pacific Clipper* covered over 8,500 miles via such exotic locales as Surabaya, Karachi, Bahrain, Khartoum and Leopoldville. The *Pacific Clipper* landed at Pan American's LaGuardia Field seaplane base at 7:12 on the morning of 6 January 1942.

The *Yankee Clipper* flew across the Atlantic on a route from Southampton to Port Washington, New York with intermediate stops at Foynes in Ireland, Botwood in Newfoundland, and Shediac in New Brunswick. The inaugural trip occurred on 24 June 1939.

The Clipper fleet was pressed into military service, the flying boats being used for ferrying personnel and equipment to the European and Pacific fronts. American military cargo was carried via Natal, Brazil to Liberia, to supply the British forces at Cairo and even the Russians, via Teheran. Since the Pan Am pilots and crews had extensive expertise in using flying boats for extreme long-distance, over-water flights, the company's pilots and navigators continued to serve as flight crew. In 1943, President Franklin D. Roosevelt traveled to the Casablanca Conference in a Pan-Am crewed Boeing 314. Winston Churchill also flew on them several times adding to the Clippers' fame during the war.

NC18603 - Boeing 314 Yankee Clipper of Pan American Airways System at its moorings in 1939.
(Photo: Authors collection)



American War Efforts

Also in the USA, in 1942, the US War Department was faced with the need to transport war materiel and personnel to Britain. Allied shipping in the Atlantic Ocean was suffering heavy losses to German U-boats, so a requirement was issued for an aircraft that could cross the Atlantic with a large payload. Due to wartime priorities, the design was further constrained in that the aircraft could not be made of metal.

The aircraft was the brainchild of Henry J Kaiser, a leading Liberty ship builder. He teamed up with aircraft designer Howard Hughes to create what would become the largest aircraft built at that time. It was designed to be capable of carrying 750 fully equipped troops or one M4 Sherman tank. The original designation 'HK-1' reflected the Hughes and Kaiser collaboration.

The HK-1 contract was issued in 1942 as a development contract and called for three aircraft to be constructed under a two-year deadline in order to be available for the war effort. Seven configurations were considered including twin-hull and single-hull designs with combinations of four, six, and eight wing-mounted engines. The

final design eclipsed any large transport then built. To conserve metal, it would be built mostly of wood; hence, the 'Spruce Goose' epithet tagged on the aircraft by the media, a nickname that Howard Hughes detested. It was also referred to as the Flying Lumberyard by some critics.

While Kaiser had originated the 'flying cargo ship' concept, he did not have an aeronautical background and deferred to Hughes and his designer, Glenn Odekirk. Development dragged on, which frustrated Kaiser, who blamed delays partly on restrictions placed for the acquisition of strategic materials such as aluminum, but also placed part of the blame on Hughes' well-known insistence on perfection. Although construction of the first HK-1 took place 16 months after the receipt of the development contract, Kaiser withdrew from the project.

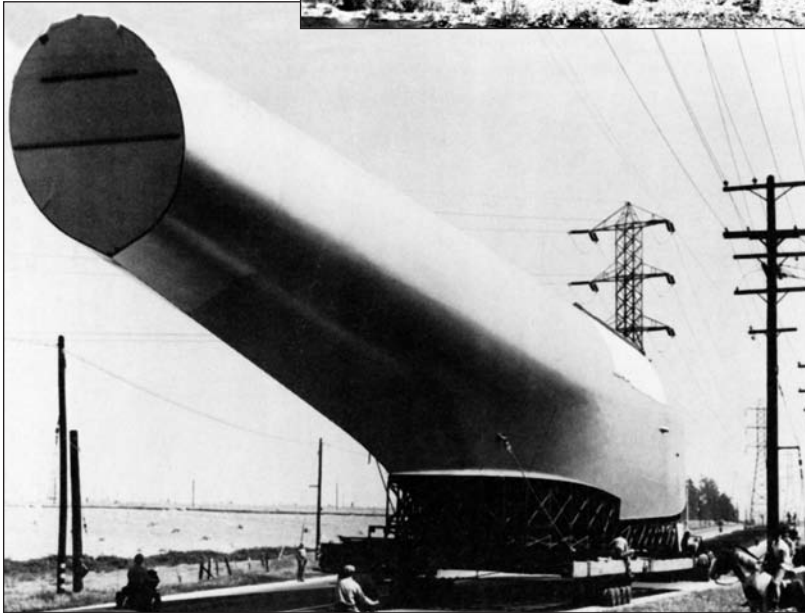
Hughes continued the programme on his own under the designation 'H-4 Hercules', signing a new government contract that now limited production to one example. Work proceeded slowly, with the result that the H-4 was not completed until well after the war was over. It was built by the Hughes Aircraft Company at Hughes

The Hughes H-4 Hercules lies in Long Beach harbour undergoing last minute preparations before taxi trials. The size of the aircraft is not really noticeable in this picture. (Photo: Authors collection)



Moving the pieces of Howard Hughes' huge flying boat brought its own problems - here wing sections were trucked from the Hughes Aircraft Company plant in Culver City along a Redondo Beach highway en route to the graving dock on Terminal Island Long Beach for assembly.

The hull received a police escort and power cables had to be moved as it progressed along the Roosevelt Highway in San Pedro. (Photos: Authors collection)



Airport, location of present day Playa del Rey, Los Angeles, California, employing the plywood-and-resin 'Duramold' process – a form of composite technology – for the laminated wood construction, which was considered a technological tour de force. It was shipped on streets to Pier E in Long Beach, California by a company specialising in house moving. The Spruce Goose was moved in three large sections consisting of the fuselage and each wing, and a fourth smaller shipment containing the tail assembly parts and other smaller assemblies. After final assembly a hangar was erected around the flying boat with a ramp to launch the H-4 into the harbor.

In 1947, Howard Hughes testified before the Senate War Investigating Committee over the

usage of government funds for the aircraft. During a Senate hearing on August 6, 1947 Hughes said: *'The Hercules was a monumental undertaking. It is the largest aircraft ever built. It is over five stories tall with a wingspan longer than a football field. That's more than a city block. Now, I put the sweat of my life into this thing. I have my reputation all rolled up in it and I have stated several times that if it's a failure I'll probably leave this country and never come back. And I mean it'.*

On November 2, 1947, following a break in the Senate Hearings during which Hughes returned to California he began taxi tests on the H-4. His crew included Dave Grant as co-pilot, two flight engineers, Don Smith and Joe Petralli, 16 mechanics, and two other flight crew. In addition, the H-4 carried a number of invited guests from the press corps and additional industry representatives.

After the first two taxi runs, four reporters left to file stories, but the remaining press stayed for the final test run of the day. After picking up speed on the channel facing Cabrillo Beach, the Hercules lifted off, remaining airborne at 70 feet off the water and a speed of 135 miles per hour for around a mile. At this altitude and with the aircraft still in



Two views of the interior of the Hughes H-4 Hercules

Left: Looking towards the rear of the H-4 on the day before it flew.

Below: Howard Hughes watches Shell Bowen work on the radio panel. He flew a lot with Hughes, but was not on board during the one and only flight of the H-4. (Photos: Authors collection)

ground effect Hughes proved to his detractors his masterpiece was flight-worthy, thus vindicating the use of government funds. Nevertheless, the H-4 never flew again. Its lifting capacity and ceiling were never tested.

It was during the senate hearings that Howard Hughes revealed some of the mathematical facts behind building very large aircraft in a simple, clearly understood way – facts and calculations that would have an impact in the future. ‘We have discovered a great, great deal about the design and building of big airplanes’ he said. ‘For example, it has long been considered that the bigger the airplane is, the more efficient it is. We have discovered, and I believe it to be quite important as a discovery – we have discovered that is not the fact.

‘If I may be technical for just a minute. The body of the airplane becomes more efficient as it is larger. Now the reason for that is obvious. The skin area, which determines the drag, goes up as the square of the size; whereas the volume, which determines the cargo or passengers it can carry, the volume goes up as the cube.

‘You can see that the cube will exceed the square, and therefore the carrying capacity will be greater in relation to drag as size goes up. But on the other hand, we have discovered that wing



design is quite different, and that as the wing becomes larger, it weighs more per square foot than a smaller wing. In other words, a wing of 320-foot span, built according to the same design criteria, will weigh more in relation to its size than a smaller wing.

‘Now, a point is reached, apparently, where the loss in wing efficiency, that is, in relation to its weight, exceeds the gain in body efficiency, and where those two lines cross, apparently, it is not desirable to build a bigger ship.

‘Now, this one may have actually exceeded that point, but at least we will find out. And we have already found out a good deal in that direction. Now that, of course, is of some value. I think it is of considerable value in the design of further planes’.

Immediately after the successful flight of the

flying boat everyone understood *Time* magazine's terse headline: 'It Flies!' The November hearing was an anticlimax. Senator Brewster had gone gunning for big game-Hughes and the connection with President Roosevelt. The committee instead bagged Brig. Gen. Bennett Meyers, whose financial misdeeds were uncovered during the Hughes investigation.

Partisan dissension delayed release of the Senate committee report of the Hughes investigation until April 1948, and even then it was fully approved by only the Republican members of the committee. The main conclusions of the report regarding the HK-1 flying boat were that the project, *'...which produced no planes during the war, was an unwise and unjustifiable expense as a wartime project. The manpower, facilities, and public funds devoted to it during the war were wasted at a time when military planes were urgently needed The conclusion is inescapable that the decision of the War Production Board was influenced because of the wide and favorable public acceptance of the proposal of Henry I. Kaiser for the mass production of huge cargo planes which Kaiser claimed would overcome the existing submarine menace to ocean transportation.'*

The aircraft never flew again. Some have suggested that Hughes was afraid of it – while others closely connected with it suggest that there was nothing wrong at all.

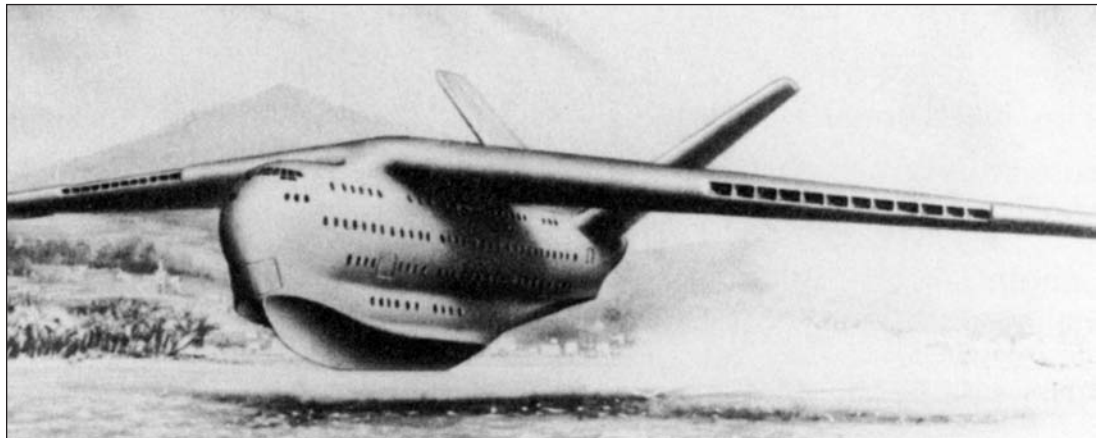
Evidently, however, the flying boat did have its weaknesses. According to one of Hughes's mechanics, *'Maybe one of the reasons why they didn't fly it again was there was a little fluctuation in the tail, and maybe it wasn't beefed up enough to suit him.'* Another mechanic said, *'There was a lot of little damage. I don't know whether I should*

say it or not, but there was. That's when they went out into the wing and put little metal stiffeners in there to hold the glue joints together. A lot of angles snapped loose. I guess the whipping of the wing is what did most of that.'

The H-4 Hercules may have been the largest flying boat ever built, but it certainly was not the largest ever conceived. This may well have been the Saunders-Roe P192 - a giant of an aircraft that had been proposed following a scheme by a consultant for the P&O Shipping Company what wanted an enormous 1,000 seat airliner with accommodation similar to a luxury liner.

It was easily the largest aircraft ever seriously designed in Britain, the P192 'Queen' was enormous in every way; it was twice as long as a Boeing 757: 318 feet, and had a wing span - 313 feet - nearly half that again of a Boeing 747. The fuselage was of constant diameter, being 33 feet across, and the design also featured two large 'v' tails that stretched 88 feet high above the keel. Power was to be provided by twenty-four Rolls-Royce Conway jet engines of 18,500lb thrust, which were positioned within huge delta wings mounted above the fuselage. The engine bays were to be titanium, and big enough so as to be able to work on the engines in flight. Not that this would be needed; cruise power of 86% RPM could have been maintained with up to six engines shut down at once. Thus any engine changes could wait till the craft returned to its base at the end of the week. There were to have been split flaps below the engine exhausts. The engines themselves were to be mounted well outboard, clear of hull spray, and breathing through extra intakes on top of the wing when the machine was on the water. The main intakes were opened only in flight. There were 'hydroflaps' in the rear fuselage for good water

The Saunders Roe P192, supposedly named 'Queen' - it allegedly had five decks, 40 stewards and 53 toilets!



maneuverability; and interconnected spoilers and ailerons for roll control, as on the Boeing 707. All controls were fully powered.

There was to be a flight crew of seven, plus service staff including forty cabin stewards. The flight deck, or control deck, was of immense proportions, more akin to the bridge of a luxury liner.

The accommodation was laid out over five decks to enable passengers to eat and sleep on board, with lounges and bars. It included some fifty-three toilets and a purser's office. Seating was to have been divided into six-passenger compartments, as in old-fashioned sleeper trains, with the seats converting into sleeping berths at night. First-class passengers even had separate bars and dining rooms, lounges and dressing rooms. There was an elaborate galley from whence food was to be conveyed to the upper-decks by elevator. The crew had sleeping accommodation

in the lowest deck inside the keel.

Designed for what was then the all-important Australian route, it was envisaged that, like the great liners, passengers would take-off from Southampton Water and then stop in Fanara in Egypt, Karachi, Calcutta (for a halfway stop), Singapore, and Darwin, before arriving in Sydney forty-eight hours later. The legs between Karachi and Calcutta, and Singapore and Darwin, were designed for sleep periods, while at the other stops, refuelling would have taken place while meals were served. The all-up weight of this massive design was 1,500,000lb

Double Deck land machines - Boeing

It is hard to decide which was the first land aircraft with double-deck features, but an early example was the Boeing 377, also called the Stratocruiser, a large



The flight deck of the Boeing 377 was roomy - someone once said it was like flying the bay window of your house!

Pan American World Airways' N1041V Clipper Yankee rests between flights at Dusseldorf, Germany. (Photo: Authors collection)





The main cabin (left) and lower lounge area of the Stratocruiser. (Photos: Authors collection)



long-range airliner built after World War Two. As was usual with many of the Boeing designs, the company used military projects and contracts to provide development of comparative civil designs - the 377 was developed from the C-97 Stratofreighter, itself a military derivative of the B-29 Superfortress used for troop transport. The Stratocruiser's first flight was on 8 July 1947.

Released in the late 1940s, the aircraft was powered by four piston engines, driving tractor propellers. It had a pressurized cabin, which was a relatively new feature to transport aircraft at the time, and two decks. Airlines were able to make transoceanic flights easier and faster with the new aircraft, which enabled easier international travel to places such as Hawaii.

The Stratocruisers did not have great reliability, mainly due to chronic problems with the four 28-cylinder Pratt & Whitney Wasp Major radial engines and their associated four-blade propellers.

Like the C-97, the 377 was developed towards the end of World War Two by adapting an enlarged upper fuselage onto the lower fuselage and wings, which were essentially the same as those of the B-50 Superfortress, itself the high-performance evolution of the B-29 Superfortress bomber. The 377 was larger and longer-ranged than the Lockheed Constellation and Douglas DC-6, with nonstop transatlantic range eastbound. Production ended in 1950.

The 'inverted-figure-8' double-deck fuselage design provided 6,600 cubic feet of interior space where the lower deck had a smaller diameter than the upper deck. It offered seating for over 100 passengers, or sleeping berths for up to 28

berthed and five seated passengers. It first flew on 8 July 1947. It had the speed and range to span ocean routes, enabling flying from New York to Hawaii in less than 24 hours. Pressurisation (previously introduced on the Boeing Stratoliner and also designed into the B-29) allowed sea-level cabin pressure at 15,500 foot altitude. At 25,000 feet passengers enjoyed a 'cabin altitude' of only 5,500 feet.

Despite a service record remembered for a number of disasters arising from propeller blade failures, the Stratocruiser was one of the capable post-war propeller-driven transports, and certainly among the most luxurious. Only 55 were built as airliners, joined eventually by the reconditioned prototype. Another 60 of this general design, with significant engineering differences, were built as C-97 military transports, but most were built as KC-97 tankers.

The Stratocruiser flew premier services to Hawaii, across both the Pacific and Atlantic Oceans, and elsewhere in the world. It was one of the few airliners with a double-decker seating arrangement (another was the French Breguet Deux-Ponts) until the arrival of the 747, though some airlines did have lower-level lounges on their L-1011 TriStar aircraft. The upper deck of the Stratocruiser was for 55–100 passenger seats or 28 sleeper berths, while the lower deck had a lounge and bar. Passengers could walk down and get a drink on the long flights, once the aircraft levelled off at cruising altitude.

In the late 1950s these aircraft were starting to become superseded by jets such as the De Havilland Comet, Boeing 707 and Douglas DC-8. A few survived to be sold to smaller airlines, used



The Air France's 'Deux Ponts' F-BASO seen between flights.



as freighters or converted into a specialised freighter called a Guppy.

French double-deckers

Breguet of France began design work on their Model 761 two-deck airliner in 1944. It was decided that a medium range airliner with seating for over 100 passengers would be built. The design envisaged using readily available engines with the aim of ease of manufacture and an early first-flight date. The design was known as Project 76-1.

The 761 featured a cantilever wing set at mid-height on the bulky fuselage. The retractable tricycle landing gear featured dual-wheel main units. The empennage, high on the rear fuselage had twin fins and rudders. The prototype was powered by four 1,580 hp SNECMA built Gnome-Rhône 14R radial engines.

The prototype was followed by three Br.761S pre-production aircraft powered by 2,020 hp Pratt & Whitney R-2800-B31 radial engines. These were fitted with 12 feet 1½in diameter Hamilton Standard propellers. The aircraft successfully completed their trials incident-free. Their first

flights were in 1951 or 1952. They also included a vestigial central fin. The French Government ordered 12 production aircraft, the Breguet 76-3 which were later redesignated Br.763. Six aircraft were to be operated by Air France and the other six by the Ministry of Transport. The 763 had more powerful engines, an 1.20 metres larger wingspan, strengthened wings and three-crew flight deck (earlier aircraft had four crew). The 763 first flew on 20 July 1951 and entered service with Air France during autumn 1952.

Air France aircraft had accommodation for 59 passengers on the top deck, and 48 on the lower deck, although the aircraft was capable of carrying 135 passengers in a high-density layout.

Projects to build versions powered with British engines (for possible United Kingdom buyers) did not come to fruition. These projects would have been the 766 (with the Bristol Hercules radial engine), and the 767 with British turboprop engines.

The first Br.761 entered service with Air Algérie in 1952 as a cargo aircraft, only to be withdrawn early the next year. The Breguet Br.763 Provence entered service with Air France on 10 March 1953. The



One of the two Lockheed R6V Constitutions seen in flight low over the California coastline.

Both machines were retired from the US Navy in 1953. The first was stored at Litchfield Park, Arizona. It was purchased and flown to Las Vegas, but was never put into civilian service, being used as a billboard to advertise Alamo Gasoline and eventually scrapped.



inaugural route was Lyon - Algiers. It was used on European routes from Paris, mainly to the Mediterranean, but occasionally to London. Domestic routes included Paris to Lyon, Marseille and Nice.

The US Military also came up with a number of designs - Lockheed Aircraft designed the R6V Constitution as a large, propeller-driven, double-decker transport aircraft developed from 1942 onwards by Lockheed as a long-range, high capacity transport and airliner for the US Navy and Pan American Airways. Initially designated the Lockheed Model 89, the Constitutions were identified as R6O until 1950.

Pan Am was involved in the study because such an aircraft had potential use as a commercial airliner. This transport would carry 17,500 pounds of cargo 5,000 miles at a cruising altitude of 25,000 feet and a speed greater than 250 mph. The aircraft would be fully pressurized and large enough so that most major components could be

accessed and possibly repaired in flight. For instance, tunnels led through the thick wings to all four engines.

The aircraft was designed by a team of engineers led by Willis Hawkins and W A Pulver of Lockheed and Commander E. L. Simpson, Jr. of the Navy. The name Constitution was given to the project by Lockheed president Robert E Gross. The Constitution design had a 'double bubble' fuselage, the cross section of which was a 'figure eight'. This unorthodox design, originally created in 1937 by Curtiss-Wright's chief aircraft designer George A Page Jr and first introduced with the Curtiss C-46 Commando, utilized the structural advantages of a cylinder for cabin pressurisation, without the wasted space that would result from a single large cylinder of the same volume.

The original contract from the Bureau of Aeronautics called for 50 Constitutions for a total price tag of \$111,250,000. On VJ Day, however,

the contract was scaled back to \$27,000,000 for only two aircraft. Only two of the aircraft were ever built, both prototypes.

The Constitution had operational difficulties which prevented it from meeting its original design objectives. The large airframe needed more power than the four Pratt & Whitney R-4360s could deliver. The engines also had cooling problems. While this could be compensated for by flying with engine cooling gills partially open, it increased drag and therefore decreased the overall range.

The Navy operated the two Constitutions through the end of the 1940s and into the 1950s. By 1949, however, the Navy announced that it could no longer afford to operate them, and offered them to airlines on a five-year lease. There was no interest from airlines in using the Constitutions

(the airline version was named the Model 189), so the Navy retired both aircraft in 1953. They went into storage at Litchfield Park, Arizona in 1955. Both aircraft and 13 spare engines were sold for \$97,785. Lockheed proposed the Model 389 and Model 489 airliners based on the Constitution, which would have accommodated up to 169 passengers. Neither of these 'paper' projects received much interest from civil operators.

The Convair XC-99, 43-52436, was a prototype heavy cargo aircraft built by Convair for the United States Air Force. It was the largest piston-engined land-based transport aircraft ever built, and was developed from the B-36 bomber, sharing the wings and some other structures with it. The first flight was on 23 November 1947 in San Diego, California, and after testing it was delivered to the Air Force on 23 November 1949.

Design capacity of the XC-99 was 100,000 lb of cargo or 400 fully equipped troops on its double cargo decks. A cargo lift was installed for easier loading. The engines face rearward in a pusher configuration.

In July 1950 the XC-99 flew its first cargo mission, designated 'Operation Elephant'. It transported 101,266 pounds of cargo, including engines and propellers for the B-36, from San Diego to Kelly Air Force Base in San Antonio, Texas, a record it would later break when it lifted 104,000 lb from an airfield at 5,000 feet elevation. In August 1953, the XC-99 would make its longest flight, 12,000 miles, to Rhein-Main Air Base, Germany, by way of Bermuda and the Azores. It carried more than 60,000 lb each way. It attracted much attention everywhere it flew.

The US Air Force determined that it had no need for such a large, long-range transport at that time, and no more were ordered. The sole XC-99 served until 1957, including much use during the Korean War. It made twice weekly trips from Kelly



The Convair XC-99 - a civilian version - the Model 37 - was offered, but never built. It is seen here in the early colour scheme, without the nose-radar fitted and huge single wheel landing gear.

Above: the lower deck, looking towards the tail with opening lower fuselage doors.

