The Incredible Complexity of Commercial Aviation

Suspect all of you have flown on commercial airliners, but, have you ever thought about how complex the modern commercial aviation industry really is?

In this course we will discuss how current commercial airplanes are designed, manufactured and sold to and operated by the Airlines worldwide and what role various US Government Agencies, the Federal Aviation (FAA), National Transportation Safety Board (NTSB), Transportation Security Association (TSA) & other agencies outside the USA who play a big part in maintaining aviation safety, worldwide.

We will also describe some of the advances in airliner technology over the years that have further contributed to the safety and effectiveness within today's commercial aviation industry, plus a lot more.

We will also discuss a bit about the Boeing 737 MAX issues as well as the effects of COVID 19 on the airline industry

The Incredible Complexity of Commercial Aviation

1. ***All the amazing numbers and a bit of history***

2. Regulations and Agencies
FAA, CAB, NTSB, TSA, ATA, IATA, ICAO, EASA how they have advanced to keep us safe.
ETOPS. – Extended Twin Engine Range

3. Aircraft design and certification
Safety records, performance improvements, engines.
Basics of aerodynamics of flight, typical commercial flight.
Airliners near ready for Service.

4. Aircraft manufacturing
Manufacturers, wood to composites, outsourcing, engines & introducing new airliners from Boeing, Airbus & the competition from China & Russia.

5. Airline operations
History, scheduling, fees, labor, fuel, catering, sales , introducing new airplanes.

6. Aircraft maintenance and Airports
FAA regulations, aircraft check levels, component repairs, problem feed back to FAA and manufacturers.
Major airports' traffic, ownership, fees, regulations, employment.

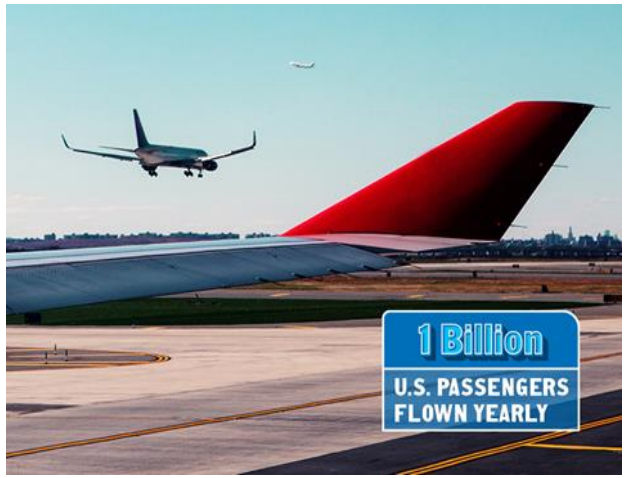
***7.Air traffic control*,737 MAX issues and the effects of Covid19 on the commercial airline industry**
FAA operations, purpose, system description the Next Gen system.

8. Future of Commercial Aviation
What is next in commercial aviation, UDF, new fuels, Supersonic Transport, more advanced materials, or?

Session 1

All the Amazing Numbers and a Bit of History

Commercial Aviation Numbers

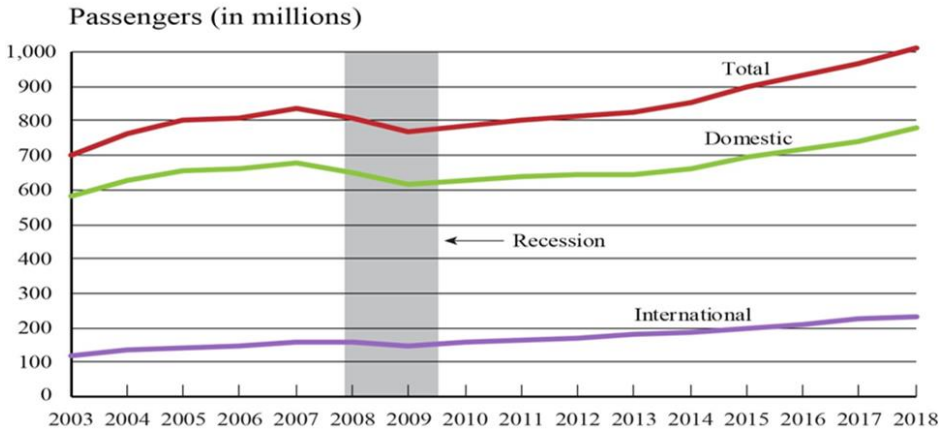


Commercial Aviation Numbers

All the Amazing Numbers

- Over a recent 20 year period aviation fatalities has reduced by 94% in the United States.
- 2017 was the safest year in Commercial Aviation Worldwide according to the Bureau of Aircraft Accidents with no reported fatalities
- In 15 years there will be 44,000 Commercial Airplanes, active in the world
  - In 2017 number was 23, 600
- Atlanta's Airport is currently the busiest in the world
  - At peak time, (Thanksgiving) there are 9,000 airplanes active in one day
- Today's typical commercial airliner has four million parts and will travel 100 times the distance to the moon and back before it exceeds its life limitation
- At a max overhaul there are generally 1,600 major components removed for inspection, accepted and or repaired or replaced
  - This will occur several times in the total life of a typical current airplane

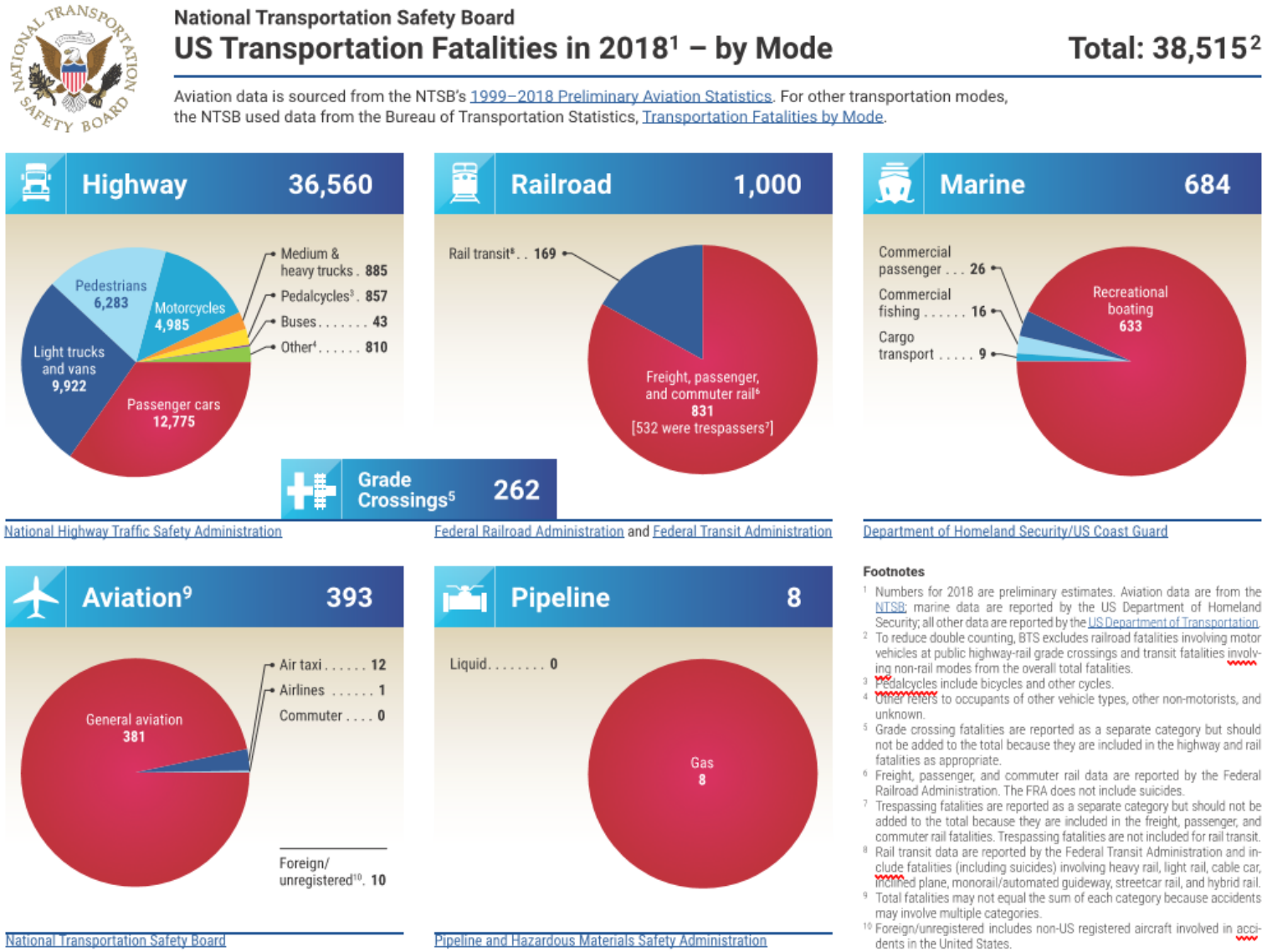
- A **Boeing 747** uses approximately 1 gallon of fuel every second(5 gallons of fuel per mile)
  - 36,000 gallons during a 10 hour flight
- In flight oxygen masks are designed to last ~ 15 minutes -enough time to reduce the aircrafts altitude to a safe level of ~ 11,000 feet
- U.S. and foreign airlines serving the U.S. carried an all-time high of 1 billion system wide passengers in 2018
  - 4.8 percent more than the 965.4 million of 2017 the previous record



All the Amazing Numbers

- The chance of an accident is little more than one in a million
- Fatal accidents occurred once every 200,000 flights in the 50s and 60s
- **Now, fatal accidents only occur once every two million flights**
- It's been more than a decade since fatalities topped 1,000 in a given year, something that would regularly happen from the 1960s until the turn of the century
- Data from the United States Statistics Department:
  - You are **80 times** more likely to die by choking on food
  - And **95 times** more likely to be killed by gunfire in the USA than dying in an airplane crash.
- If your plane is involved in some type of accident, there is a 95% chance of survival based on studies of past commercial aircraft accidents
  - This information is from a report dated in 2001
- For all transportation fatalities from 2012 to 2018, a mere 1% were the result of air travel
- **"Air travel is the safest mode of mass transportation**
- **Based on the accident rate over the last few years, you would have to fly on average once a day every day for 22,000 years before you would perish in a U.S. commercial aviation accident**
- **In 1998 there were more than 10 million departures and not one fatality aboard a commercial aircraft."**
  - Source FAA

All the Amazing Numbers



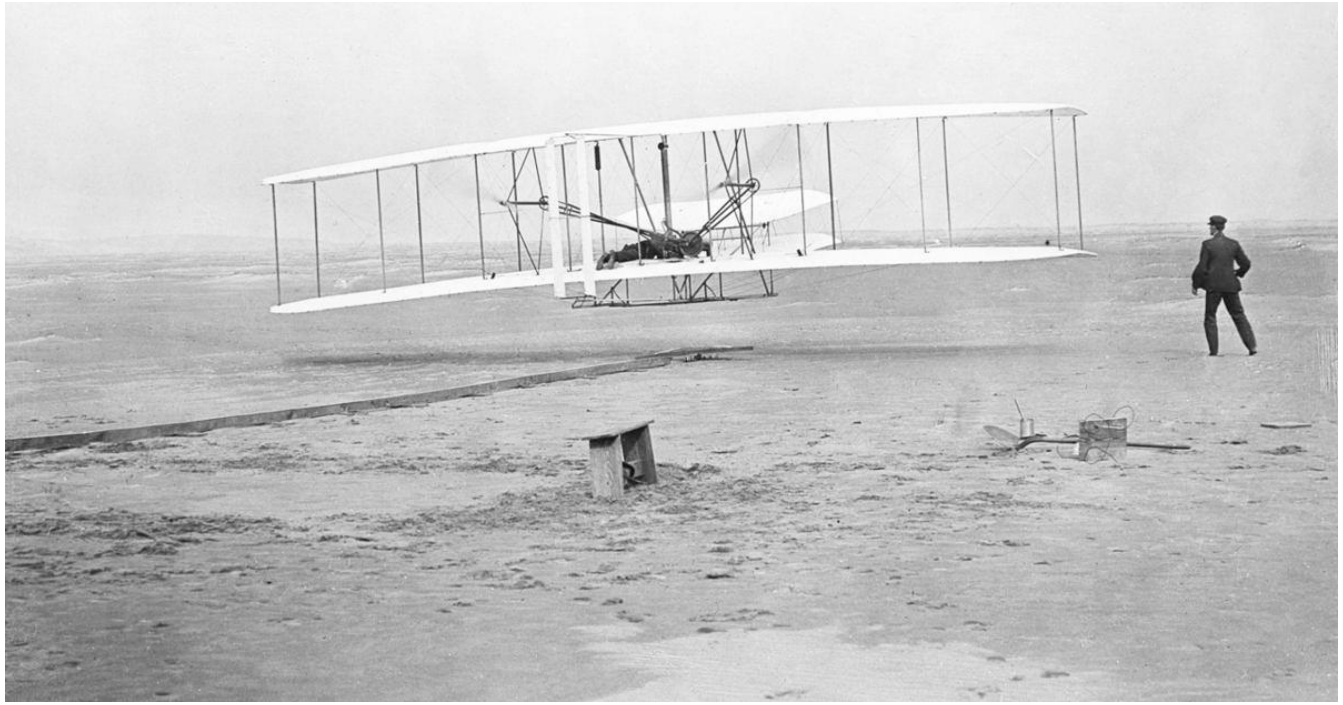
All the Amazing Numbers

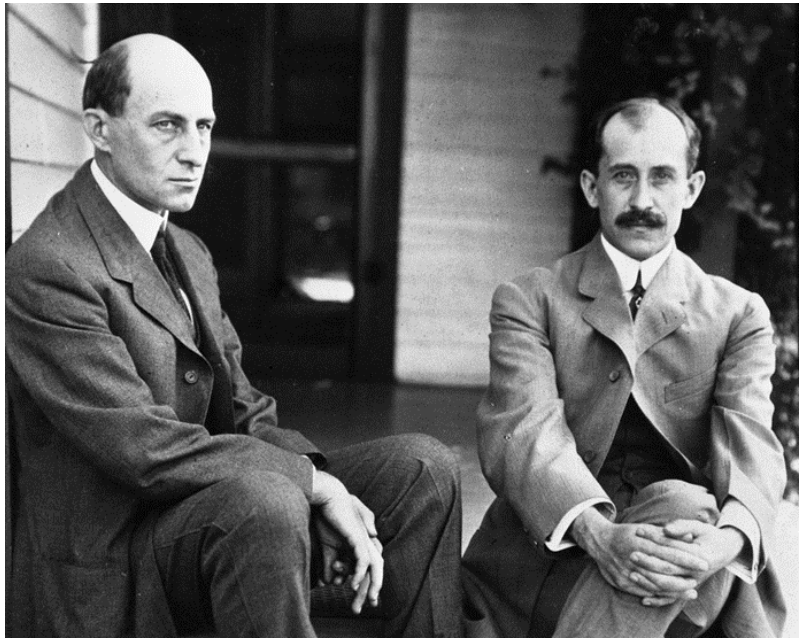
- 2017 in China ~600 million people flew compared to 62 Million in 2000 ~ *a 10x growth in 17 years*
- In 2019 China's Airline's accounted for 22% of the purchase of commercial airliners from **Boeing** *and* **Airbus**
- **The International Air Transport (IATA)** recently predicted that the number of worldwide travelers will *increase from the 2016's 3.8 Billion number to 7.2 Billion in 15 years*
- By 2024 China will overtake the US as the number 1 country in air travelers and India will overtake Britain in the third spot the following year
- **Boeing** is projecting the need for new airliners to reach 39,000 by 2040
  - 15,000 needed for Asian markets, alone

- The top 4 Airlines in terms of serving other countries are as noted below:
- *1*. Turkish Airlines – 120 different countries
- 2. Air France - 93
- 3. Qatar Airways - 86
- 4. British Airways – 82
- USA's United is seventh on the current list

A Bit of Aviation Histo*ry*

December 17, 1903 - Orville Wright makes the first heavier than air manned flight at Kitty Hawk, NC. The plane, made of wood, wire, and cloth, traveled 120 feet and flew for 12 seconds.





Wilbur and Orville Wright

How it was designed and built 8:32 Minutes

https://www.youtube.com/watch?v=LigpsX1KoQE&t=201s

A Bit of Aviation Hist*ory*

- In 1908, **Wilbur Wright** travelled to Europe, and gave a series of flight demonstrations at Le Mans in France
- The major French aviation experimenters were astonished by the clear superiority of the Wright Brothers' aircraft, particularly its ability to make tight controlled turns
- 1909 saw the widespread recognition of powered flight as something other than the preserve of dreamers and eccentrics
- July 25, 1909 **Louis Blériot** won worldwide fame by winning a £1,000 prize offered by the British Daily Mail newspaper for a flight across the English Channel
- August 1909 half a million people, attended one of the first aviation meetings, the Grande Semaine d'Aviation at Reims

- The years between World War I and World War II saw great advancements in aircraft technology
- Airplanes evolved from low-powered biplanes made from wood and fabric to sleek, high-powered monoplanes made of aluminum and now composites
- After World War I, many American pilots became barnstormers, flying into small towns across the country and showing off their flying abilities, as well as taking paying passengers for rides
- Air shows sprang up around the country, with air races, acrobatic stunts, and feats of air superiority
- The air races drove engine and airframe development, the **Schneider Trophy**, for example, led to a series of ever faster and sleeker monoplane designs

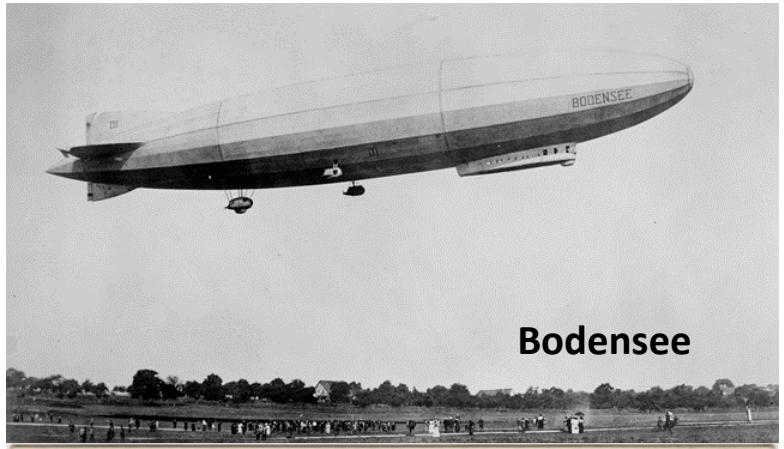
Curtiss JN-4

Airbus A320

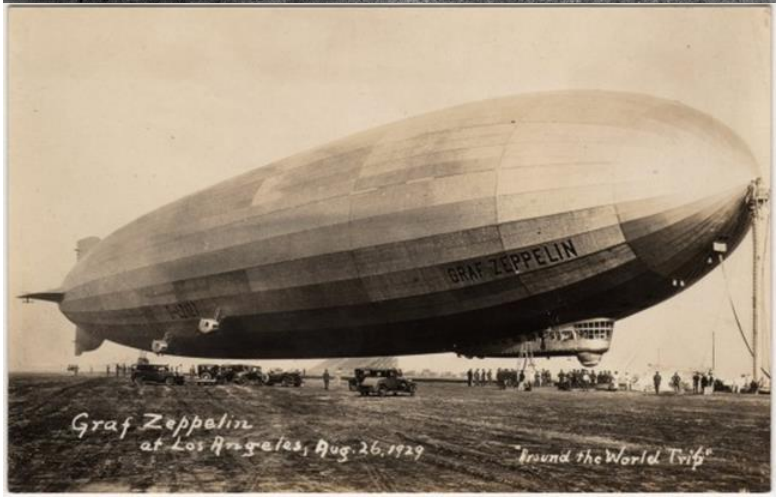
A Bit of Aviation History

World's first passenger airline

- November 16, 1909 **DELAG** (*Deutsche Luftschiffahrts-Aktiengesellschaft*, or German Airship Transportation Corporation Ltd) was established, as an offshoot of the Zeppelin Company
- DELAG airship **Bodensee** began scheduled service between Berlin and southern Germany in 1919
  - The flight from Berlin to Friedrichshafen took 4-9 hours, compared to 18-24 hours by rail
- DELAG offered the world's first transatlantic passenger service, using **LZ-127 Graf Zeppelin** to make scheduled flights between Germany and South America beginning in 1931



Bodensee



Graf Zeppelin crossed the South Atlantic 136 times before being retired after the **Hindenburg** disaster in 1937

A Bit of Aviation History

- **May 23, 1926**, **Western Air Express** inaugurated the "first scheduled airline passenger service" in the U.S., flying the nation's first commercial airline passenger from Salt Lake City to Los Angeles

- **WAE** began flying on Apr 17 as the fourth carrier to begin operations under a *new air mail contract system* that became the major source of income for the era's small but growing airline industry

- **May 21-22,1927** – **Charles Lindbergh** makes the first non-stop solo transatlantic flight from NY to Paris
- He covered, 3,600-statute-miles in the 33 ½-hours (107 mph) in a single-engine purpose-built Ryan monoplane, the *Spirit of St. Louis*
- It was the first transatlantic flight between two major cities, and the longest transatlantic flight by almost 2,000 miles
  - John Alcock and Arthur Brown made the first nonstop flight across the Atlantic in 1919 landing in Ireland
- The flight exited people about aviation and was a major turning point in the advancement of aviation

https://www.youtube.com/watch?v=nypXkhomHqE ***Lindbergh historic flight 4.5 Minutes***

A Bit of Aviation History

Boeing Model 80 America's first airliner designed specifically for passenger comfort and convenience (first flight July 27,1928)
Its fuselage was made of welded-steel tubing covered with fabric.

The **Model 80** carried 12 passengers in a cabin appointed with leather upholstery, reading lamps, forced-air ventilation, and hot and cold running water.

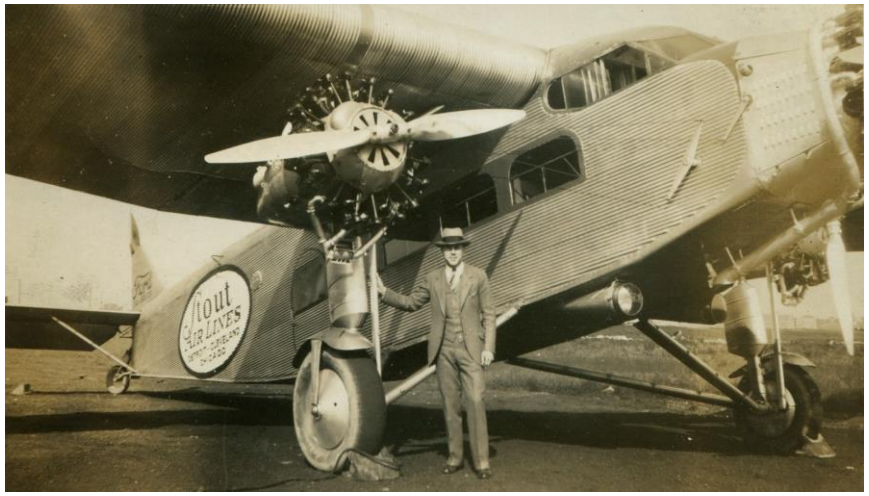
Model 80A (first flight Sept. 12, 1929)

(10) flew for **Boeing Airlines**

Wing Span: 80 feet
Length: 56 feet 6 inches
Gross weight: 17,500 pounds
Cruising speed: 125 mph
Range:460 miles
Ceiling:14,000 feet
Power: Three 525-horsepower P&W Hornet engines
3 crew, 18 passengers, 898 pounds of cargo

A Bit of Aviation History

- In the US, **Stout Airways** was the first to employ stewards in 1926, working on **Ford Trimotor** planes between Detroit and Grand Rapids, Michigan
- **Western Airli**nes (1928) and **Pan American World Airways** (Pan Am) (1929) were the first US carriers to employ stewards to serve food
- The first female flight attendant was a 25-year-old registered nurse named **Ellen Church**
- Hired by **United Airlines** in 1930, she also first envisioned nurses on aircraft
- Other airlines followed suit, hiring nurses to serve as flight attendants, then called "stewardesses" or "air hostesses", on most of their flights



A Bit of Aviation History

- **Amelia Earhart (**1897-1937) became the most famous female flyer in the world
- She set numerous aviation records:
  - **1922**—Feminine altitude record of 14,000 feet
  - **1928**—First woman to fly across the Atlantic as a passenger in the Fokker F.VII *Friendship*
  - **1929**—Feminine speed record
  - **1930**—Feminine speed record
  - **1931**—First woman to fly an autogiro
  - **1931**—Autogiro altitude record of 18,415 feet
  - **1932**—*First woman (and only the second person) to fly solo and nonstop across the Atlantic. Also first person to cross the Atlantic twice by air*
  - **1932**—First woman to fly solo and nonstop across the United States
  - **1933**—Reset her transcontinental record
  - **1935**—First person to fly solo from Honolulu, Hawaii, to the U.S. mainland (Oakland, California)
  - **1935**—Speed record between Mexico City and Washington, D.C.
  - **1935**—First person to fly solo from Mexico City to Newark, New Jersey

- May 21, 1937, **Amelia Earhart** and navigator **Fred Noonan** began a round-the-world flight, beginning in **Oakland, California**, and traveling east in a twin-engine Lockheed Electra
- July 2, 1937, they took off from Lae, New Guinea,
- Their next destination was Howland Island in the central Pacific Ocean, some 2,500 miles away
- But Earhart never arrived on Howland Island

Boeing 307 Stratoliner

- In 1935, **Boeing** designed a four-engine airliner based on its **B-17** heavy bomber then in development
- First land-based airliner to use flight engineer
- It used the wings, tail, rudder, landing gear, and engines from their production B-17C with a new, circular cross-section fuselage of 138 in diameter designed to allow cabin pressurization
  - Allowed flight at up to 20,000 ft with cabin pressure equivalent to ~8000 ft
- It entered service with **Pan Am** in 1940
- Also operated by **Transcontinental and Western Air**
- Production halted by World War II after 10 aircraft were produced

Crew: two pilots, flight engineer, two cabin crew

Capacity: 38 passengers in daytime, 25 by night

Length: 74 ft 4 in **Wingspan:** 107 **Height:** 20 ft 9.5 in **Gross weight:** 45,000 lb

Powerplant: 4 × Wright GR-1820-G102A radial engines, 1100 hp

Maximum speed: 241 mph **Cruise speed:** 215 mph

Range: 2,390 mi

Douglas DC-3

- Design work began in 1934 at the insistence of **C.R. Smith**, president of **American Airlines**
- The first **DC-3** built was the Douglas Sleeper Transport — also known as Skysleepers by airline customers — and it was the height of luxury
- Fourteen plush seats in four main compartments could be folded in pairs to form seven berths, while seven more folded down from the cabin ceiling
- The plane could accommodate 14 overnight passengers or 28 for shorter daytime flights
- The first was delivered to **American Airlines** in June 1936, followed two months later by the first standard 21-passenger **DC-3**
- November 1936, **United Airlines**, which had been a subsidiary of **Boeing** until 1934, became the second **DC-3** customer

Crew: two **Capacity:** 21–32 passengers

Length: 64 ft 8 in **Wingspan:** 95 ft 2 in **Height:** 16 ft 11 in

Gross weight: 25,200 lb **Fuel capacity:** 822 gal

Powerplant: 2 × Pratt & Whitney R-1830-S1C3G Twin Wasp 14-cyl. air-cooled two row radial piston engine, 1,200 hp

Maximum speed: 230 mph, at 8,500 ft **Cruise speed:** 207 mph

Service ceiling: 23,200 ft Range 2,125 mi

Production: 607 DC-3 and 10,048 C-47/C53

A Bit of Aviation History

Howard Hughes and **TWA**

- Howard Hughes (1905-1976)was a millionaire at 18 he inherited the family business, Hughes Tool which manufactured drill bits for the oil industry
- Hughes went to Hollywood where he pursued movies and aviation
- Hughes World War I flying epic, "Hell's Angels," made Hughes a major player in Hollywood
- In 1933, he founded the **Hughes Aircraft Company**, and hired engineers to build fast planes for him to fly
- In September of 1935, he flew the **H-1 Racer** plane 351 miles per hour, the fastest speed on record
- Then he flew around the world in three days
- Howard Hughes became a household name in aviation

Howard Hughes and the H-1 Racer

Howard Hughes and **TWA**

- In 1939, Jack Frye, the president of **TWA** urged Hughes to quietly buy up TWA stock -he took over the company
- Hughes approached **Lockheed** to build a new plane that would outperform TWA's Boeing Stratoliners
- The result was the **Lockheed Constellation** (developed in absolute secrecy) –entered service 1945
  - Total produced 856
  - The pressurized cabin provided passengers with a more comfortable flying experience
  - Lower drag at altitude enabled the plane to cruise faster than its competitors
- Hughes made TWA into an international carrier competing with Pan Am
- 1960 Hughes was forced out of TWA
- He sold his shares in the airline for $547 million, making Hughes one of the richest men in the world

Crew: 5 flight crew, varying cabin crew **Capacity:** typically 62–95 passengers

Length: 116 ft 2 in **Wingspan:** 126 ft 2 in

Height: 24 ft 9 in **Max takeoff weight:** 137,500 lb

Powerplant: 4 × Wright R-3350-DA3 Duplex-Cyclone 18 cylinder air-cooled radial piston engines, 3,250 hp

Maximum speed: 377 mph **Cruise speed:** 340 mph at 22,600 ft

Range: 2,300 to 6,100 mi **Service ceiling:** 24,000 ft

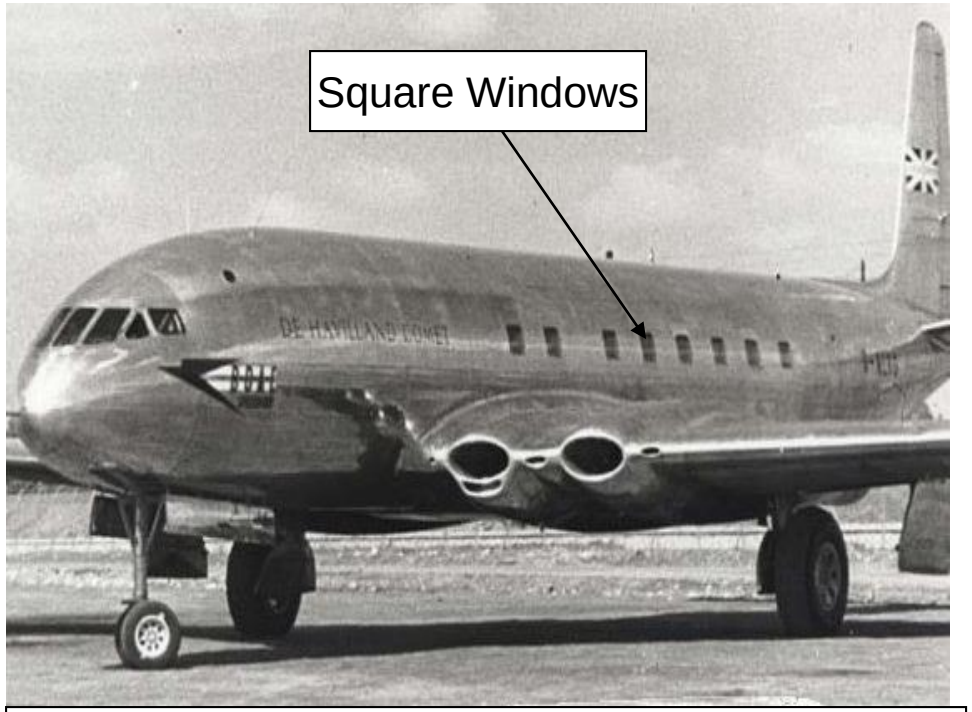
A Bit of Aviation History

- Perhaps more than any other individual, **Juan Trippe** is responsible for the development of the commercial airline industry in the 20th Century
- He thought that flying should be affordable for everyone - not just the wealthy
- Backed by rich friends, Trippe opened the offices of Pan American Airways in 1927
- Taking advantage of his connections with the political elite, he got Pan Am the first U. S. government air mail routes to the Carribean
- Pan Am was guaranteed all of the airmail contracts to the Far East as Pan Am began service across the Pacific
- Pan Am Clippers crossed the Pacific making stops at Wake Island (1939-1948)

Boeing 314 “Clipper”- ten aircraft produced

1952

- **DeHavilland DH.106 Comet I** awarded first certificate of airworthiness for jet airliner



Maximum speed: 500 mph
Range: 3,225 mi (2,800 nm)
Service ceiling: 40,000 ft

- The **Comet** first flew in 1949
- Early Comet models suffered from catastrophic metal fatigue, causing a string of well-publicized accidents
- The Comet was withdrawn temporarily and redesigned
- The Comet 4 series subsequently enjoyed a long and productive career of over 30 years, but sales never fully recovered

Crew: 4 **Capacity:** 56-109 pax
Length: 112 ft
Wingspan: 115 ft
Loaded weight: 162,000 lb
Powerplant: 4× Rolls-Royce Avon Mk 524 turbojets, 10,500 lbf

A Bit of Aviation History

- **Trippe** thought **Pan Am** could benefit from the development of large long- range commercial jetliners
- Pitting one manufacturer against the other, **Trippe** lured both **Boeing (707)** and **Douglas (DC-8)** into the jet building business
- Both companies benefited, but Pan Am was ultimately was the big winner
- **Trippe** got the large new jet he wanted the Boeing **707** (EIS 1958)
- **Pan Am** soon had an unheard of 90% occupancy on its fleet of jets
- **DC8** (EIS 1959)**United Airlines** and **Delta Airlines**
- **Trippe** was a driving force for “the airline jet age”

707


DC-8

A Bit of Aviation History

- **Trippe**'s goal since the end of World War II was to make air travel affordable for the masses
- He envisioned a jumbo jet, a true oceanliner of the air
- **Trippe** sold **Boeing** on his idea for a new “jumbo jet” the **747** (EIS 1970)
- The **747** was a huge gamble for Trippe, and Boeing, which was driven to the brink of bankruptcy developing it
- Competing airlines were forced to keep pace with **Pan Am** and orders for the **747** soon came pouring in
- The **747** was the last in a long line of airplanes that **Juan Trippe** insisted had to be built

A Bit of Aviation History

- **Trippe**'s goal since the end of World War II was to make air travel affordable for the masses
- He envisioned a jumbo jet, a true oceanliner of the air
- **Trippe** sold **Boeing** on his idea for a new “jumbo jet” the **747** (EIS 1970)
- The **747** was a huge gamble for Trippe, and Boeing, which was driven to the brink of bankruptcy developing it
- Competing airlines were forced to keep pace with **Pan Am** and orders for the **747** soon came pouring in
- The **747** was the last in a long line of airplanes that **Juan Trippe** insisted had to be built

- When **Trippe** retired in 1968, **Pan Am** was flying to 85 nations in 6 continents
- **Trippe** died in 1981, his vision of a world where more people flew for less money had become a reality
- **Pan Am** collapsed in 1991, the victim of management errors and increased competition

A Bit of Aviation History

Jet Clipper America, THE BOEING 707-121 WHICH OPENED THE COMMERCIAL JET AGE FOR THE U.S., IS CHRISTENED ON OCTOBER 16, 1958 BY FIRST LADY MAMIE EISENHOWER, WITH JUAN TRIPPE, NOW PAN AM CHAIRMAN, LOOKING ON AT WASHINGTON NATIONAL AIRPORT. TEN DAYS LATER, THE CLIPPER INAUGURATED JET SERVICE, FLYING NEW YORK TO PARIS.

October 16, 1958 - First Lady Mamie Eisenhower and Pan Am Chairman Juan Tripe christen the Boeing 707-121, the plane that inaugurated *the Commercial Jet Age* for the United States with its flight from New York to Paris

September 8, 1959 - A Pan Am Boeing **707**, the first American-built jet airliner to land in Britain, lands in London

- 10 crew members and 23 passengers made the historic trip from New York

October 30, 1983 Trans World Airlines last scheduled **707** flight by a US carrier

- 707s remained in scheduled service by airlines from other nations for much longer

A Bit of Aviation History- **Boeing 787 "Dreamliner"**

- **Boeing 787** was designed in 2000
- Delivered to **All Nippon Airways(ANA)** September 2011
- First Boeing "fly by wire" airplane
- First commercial composite structure airliner
- The fastest recorded commercial revenue flight Feb. 2019 when a Boeing 787 was aided by a Jet stream of **231** miles per hour
  - Where ~ 525 miles per hour is normal the airliner recorded speeds of **800** mph ground speed
- Longest non stop flight- Tahiti International Airport to Paris-Charles de Gaulle- 9,765 miles in just under 16 hours

- After **Boeing** began the **787** design using composite structures **Airbus** followed suit with the **A350**

A bit of Aviation History-Airbus A380

- The **Airbus A380** is the world's largest passenger airliner
- The original plan was for **Airbus** and **Boeing** to go into the full design and build of this amazing aircraft, but Boeing dropped out of the agreement as it planed to focus more on the 747,737 and 787 markets
- **Airbus** studies started in 1988 and the project was announced in 1990 to challenge the dominance of the Boeing 747 in the long- haul market
- **Airbus** launched the €9.5 billion ($10.7 billion) **A380** program on December 19,2000
- The first flight was 27 April 27, 2005
- Difficulties in electrical wiring caused a two-year delay and the development cost ballooned to €18 billion

- It was first delivered to **Singapore Airlines** on 15 October 15, 2007 and entered service on October 25th
- Production peaked at 30 per year in 2012 and 2014
- **Airbus** concedes that its $25 billion investment for the aircraft cannot be recouped
- On 14 February 2019, after **Emirates** reduced its last orders in favor of the **A350** and the **A330neo**
- Airbus announced that **A380** production would end by 2021

Next Session

- ***Regulations and Agencies***
- *FAA, CAB, NTSB, TSA, ATA, IATA, ICAO, EASA* how they have advanced to keep us safe
- ETOPS – Extended Twin Engine Range